Mitigation Measure M-GCC-7
Attachment "A"

Part 1 of 3: Climate Action Reserve

PREFACE

During the Village 13 Project's implementation phase and prior to the County's issuance of Project-related grading and building permits, the County shall reference and use Mitigation Measure M-GCC-7 Attachment "A" to determine whether the Project is proposing to use eligible carbon offset project types to meet its CEQA mitigation obligations under mitigation measures M-GCC-7 and M-GCC-8. This Preface describes the contents of Attachment "A."

Mitigation Measure M-GCC-7 Attachment "A" contains copies of the manuals used by the Climate Action Reserve, American Carbon Registry and Verra to administer their carbon offset programs. Each manual contains the foundational principles and standards deployed by the registries to ensure that their carbon offset programs achieve high standards of environmental integrity. As such, the manuals contain generally applicable GHG reduction accounting guidelines; rules and procedures for carbon offset project registration, implementation, and verification; and, standards for the development of protocols and methodologies. The registries' program manuals are updated from time to time; reference should be made to the current iteration of each manual, as needed.

Mitigation Measure M-GCC-7 Attachment "A" also contains all of the carbon offset protocols and methodologies of these three registries that the County has determined to be eligible for use when reducing GHG emissions pursuant to mitigation measures M-GCC-7 and M-GCC-8 of the Village 13 Project's EIR. While the following bulleted summary is not an exhaustive listing of the types of information contained in protocols and methodologies, each of the Attachment "A" protocols and methodologies routinely provide the following type of information:

- A description of the specific carbon offset project type, and associated definitional parameters;
- Eligibility rules pertaining to project location, start date, the crediting period, the additionality tests, and regulatory compliance;
- A description of the GHG assessment boundary and rules for quantifying both baseline and project emissions; and,
- Project monitoring and reporting requirements, including related verification standards.

The County of San Diego has reviewed and determined that the protocols and methodologies included in Attachment "A" establish and require carbon offset projects to comply with standards designed to achieve additional, real, permanent, quantifiable, verifiable and enforceable reductions. In making this determination, the County reviewed the registries' program manuals, the registries' websites (which provide additional background information on each protocol and methodology, including comments from interested members of the public and experts in the field), and the registries' protocols and methodologies included herein. As such, when implementing mitigation measures M-GCC-7 and M-GCC-8, the Village 13 Project shall procure offsets only from the carbon offset project types authorized by the Attachment "A" protocols and methodologies.

The Attachment "A" protocols and methodologies are periodically updated by the registries, pursuant to their established processes, in response to public comments, on-the-ground experience, and technological, scientific and regulatory developments. Updates ensure no reduction in efficacy

and environmental integrity, in accordance with the registries' program manuals. Related iterations of the protocols and methodologies for the carbon offset project types listed herein may be used. However, protocols and methodologies for carbon offset project types that are not listed herein cannot be utilized by the Village 13 Project, absent additional evaluation and action by the County of San Diego.

MITIGATION MEASURE M-GCC-7
ATTACHMENT "A"

TABLE OF CONTENTS

PART 1 OF 3: CLIMATE ACTION RESERVE

Reserve Offset Program Manual
(November 12, 2019)

Coal Mine Methane Protocol

Forest Protocol

Grassland Protocol

Nitric Acid Production Protocol

Nitrogen Management Protocol

Organic Waste Composting Protocol

Organic Waste Digestion Protocol

Ozone Depleting Substances Protocol

Rice Cultivation Protocol

Urban Forest Management Protocol

Urban Tree Planting Protocol

U.S. Landfill Protocol

U.S. Livestock Protocol

Climate Forward Program Manual
(March 2, 2020)

Dairy Digester Project Forecast Methodology

Mature Forest Management Forecast Methodology

Reforestation Forecast Methodology

***** *As provided in mitigation measures M-GCC-7 and M-GCC-8, the protocols and methodologies, and other related documents contained in this Attachment are periodically updated by the registries, pursuant to their established processes, in response to public comments, on-the-ground experience, and*

TABLE OF CONTENTS

technological, scientific and regulatory developments. Related iterations of the protocols and methodologies for the carbon offset project types listed herein may be used during the mitigation implementation phase. However, protocols and methodologies for carbon offset project types that are not listed herein cannot be utilized, absent additional County evaluation and action.

CLIMATE ACTION RESERVE

Reserve Offset Program Manual

November 12, 2019

NOTE TO USERS:

From time to time, the Climate Action Reserve updates this manual. Please make sure you are using the latest version, available at www.climateactionreserve.org.

For information, comments or questions, please email reserve@climateactionreserve.org.

Climate Action Reserve
www.climateactionreserve.org

Released November 12, 2019

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Reserve Offset Program Manual

1 Introduction 1
1.1 The Climate Action Reserve 1
1.2 Reserve Program Principles 2
2 Program Level GHG Reduction Accounting Guidelines 3
2.1 General Approach, Principles, and References 3
2.1.1 Standardized Offset Crediting 3
2.1.2 Reference Standards 4
2.2 GHG Accounting Principles 4
2.3 Project Definition 5
2.3.1 Project Types 6
2.4 Project Eligibility Criteria 6
2.4.1 Additionality Determinations 6
2.4.2 Project Location 10
2.4.3 Project Start Date 10
2.4.4 Project Crediting Period 11
2.4.5 Bundling of Projects 12
2.4.6 Regulatory Compliance and Environmental and Social Safeguards 12
2.5 Defining the GHG Assessment Boundary 14
2.5.1 Physical Project Boundaries 15
2.5.2 Leakage Accounting 16
2.6 Quantifying GHG Reductions 16
2.6.1 Global Warming Potentials for Quantifying GHG Reductions 16
2.6.2 Estimating Baseline Emissions 17
2.6.3 Quantifying Project Emissions 17
2.6.4 Quantification Methods 17
2.6.5 Calculating GHG Reductions or Removals 18
2.6.6 Immediate Crediting for Future Avoided Emissions 19
2.7 Project Monitoring 19
2.8 Ensuring Permanence of GHG Reductions 20
2.8.1 Maintenance and Disposition of the Buffer Pool 20
2.9 Avoiding Double Counting of Emission Reductions 21
3 Program Rules and Procedures 23
3.1 Reserve Offset Program Manual 23
3.1.1 Revisions to the Reserve Offset Program Manual 23
3.2 Start Date 23
3.3 Project Registration 24
3.3.1 Fee Structure Summary 24
3.3.2 Account Registration 24
3.3.3 Project Submittal 26
3.3.4 Requests for Variances from Protocol Requirements 26
3.3.5 Project Listing 27
3.3.6 Attestation of Title 28
3.3.7 Attestation of Voluntary Implementation 28
3.3.8 Attestation of Regulatory Compliance 28
3.3.9 Conflict of Interest Evaluation and Initiation of Project Verification 28
3.3.10 Approval of Verification and Project Registration 29
3.3.11 Project Completion 29
3.3.12 Record Keeping 29

3.3.13 Publicly Available Information....30
3.4 Project Verification....30
3.4.1 Validation....31
3.4.2 Reporting Period and Verification Period....31
3.4.3 Initial Verification and Registration....32
3.4.4 Subsequent Verification....33
3.4.5 Zero-Credit Reporting Period (ZCRP)....34
3.4.6 Zero-Credit Reporting Period Verification....35
3.4.7 Verification Deadline Extension Request....36
3.5 Stakeholder Input for Individual Projects....36
3.5.1 Local Stakeholder Consultations....36
3.5.2 Feedback and Grievance Process....37
3.6 Climate Reserve Tonnes (CRTs)....37
3.6.1 Issuance of CRTs....38
3.6.2 Over-Issuance of CRTs....38
3.6.3 Transfer of CRTs....38
3.6.4 Retirement of CRTs....39
3.6.5 Holding and Retirement of CRTs on Behalf of Other Parties....39
3.6.6 Transferring Credits from the Reserve....39
3.7 Transferring Projects into the Climate Action Reserve....39
3.8 Transferring Projects from the Climate Action Reserve....40
3.9 Transferring Projects between Account Holders in the Reserve....40
3.10 Relationships to Other GHG Programs....41
3.10.1 Voluntary Carbon Offset Programs....41
3.10.2 The California Compliance Offset Program....41
3.10.3 The California Low Carbon Fuel Standard Program....42
3.10.4 The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)....42
3.10.5 Green-e Climate....43
4 Project Protocol Development Process....44
4.1 Screening Process....44
4.1.1 Issue Paper....45
4.1.2 Scoping Meeting....45
4.2 Development Process....45
4.2.1 Workgroup Assembly....45
4.2.2 Options Paper....46
4.2.3 Draft Protocol for Workgroup Review....46
4.2.4 Public Review Period and Public Workshop....46
4.2.5 Board Approval....46
4.2.6 Ongoing Public Feedback and Comments....46
4.3 Revisions to Project Protocols....47
4.3.1 Policy Revisions....47
4.3.2 Program Revisions....47
4.3.3 Grace Period for Registration under Prior Protocol Versions....47
4.3.4 Errata and Clarifications....48
4.4 Communication with the Public....48
5 Glossary....49

1 Introduction

The voluntary carbon market has the potential to significantly facilitate efforts to reduce greenhouse gases in the atmosphere and to help mitigate climate change. At the same time, there has been a great need for increased environmental integrity, transparency, rigor, and accuracy in this market. The Climate Action Reserve (Reserve) was created to meet this need by providing a rigorous set of protocols, guidelines, and tools to support the voluntary carbon market. The Reserve is intended to increase certainty and build confidence in the greenhouse gas (GHG) reduction market on the part of investors, project developers, the environmental community, and the public.

The Reserve Offset Program Manual summarizes the Reserve's overarching principles, its general project accounting guidelines, and its rules and procedures for registering projects and creating offset credits for the voluntary market. It also describes the process used by the Reserve to develop protocols for determining the eligibility of, and quantifying reductions from, carbon offset projects.

Detailed information on the Reserve's general operating procedures and verification program can be found in the following documents:

- Climate Action Reserve User Guide
  http://www.climateactionreserve.org/open-an-account/
- Climate Action Reserve Terms of Use
  http://www.climateactionreserve.org/open-an-account/
- Climate Action Reserve Verification Program Manual
  http://www.climateactionreserve.org/how/program/program-manual/

Guidance in this Reserve Offset Program Manual is limited to the Reserve's program serving the voluntary carbon market. For information on the Reserve's role as an Early Action Offset Program and Offset Project Registry for the California Compliance Offset Program, please see the following resources:

- Climate Action Reserve California Compliance Offset Program website
  http://www.climateactionreserve.org/how/california-compliance-projects/
- California Air Resources Board Compliance Offset Program website
  http://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm

1.1 The Climate Action Reserve

The Climate Action Reserve is an offsets program working to ensure integrity, transparency, and financial value in the North American carbon market. It does this by establishing regulatory-quality standards for the development, quantification, and verification of GHG emission reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRTs) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emission reductions associated with projects are real, permanent, and additional, thereby instilling confidence in the environmental benefit, credibility, and efficiency of the U.S. carbon market.

At the heart of the Reserve is a publicly accessible web-based system where owners and developers of carbon offset projects can register project information along with verification

reports demonstrating GHG emission reductions. Emission reductions are verified as CRTs, which provide title assurance and unique serial number identifiers to assure that each metric ton is counted and retired only once.

The Reserve uses a rigorous, open, and comprehensive process for developing all of its protocols. The Reserve's primary focus is on accurate and conservative GHG accounting to ensure that the emission reductions it certifies are real, permanent, additional, verifiable, and enforceable.

1.2 Reserve Program Principles

The Reserve's program rules and procedures, eligibility criteria, and quantification and verification protocols are designed to ensure that GHG emission reductions certified by the Reserve are:

- **Real:** Estimated GHG reductions should not be an artifact of incomplete or inaccurate emissions accounting. Methods for quantifying emission reductions should be conservative to avoid overstating a project's effects. The effects of a project on GHG emissions must be comprehensively accounted for, including unintended effects (often referred to as "leakage").
- **Additional:** GHG reductions must be additional to any that would have occurred in the absence of the Climate Action Reserve, or of a market for GHG reductions generally. "Business as usual" reductions – i.e., those that would occur in the absence of a GHG-reduction market – should not be eligible for registration.
- **Permanent:** In order to function as offsets to GHG emissions, GHG reductions must effectively be "permanent." This means, in general, that any net reversal in GHG reductions used to offset emissions must be fully accounted for and compensated through the achievement of additional reductions.
- **Verified:** GHG reductions must result from activities that have been verified on an *ex post* basis. Verification requires third-party review of monitoring data for a project to ensure the data are complete and accurate.
- **Owned Unambiguously:** No parties other than the registered project developer must be able to reasonably claim ownership of the GHG reductions.

In addition, the Reserve strives to ensure that the offset projects it registers are **not harmful**. Project activities should not cause or contribute to negative social, economic or environmental outcomes and ideally should result in benefits beyond climate change mitigation. Projects are encouraged to identify, measure, and report on any non-GHG benefits of the project activities, such as alignment with the United Nations' Sustainable Development Goals or other identified co-benefits.[1]

Finally, the Reserve strives for **practicality**, by integrating rigorous requirements with time- and cost-minimizing steps for project developers. Practicality involves alleviating potential barriers to GHG project implementation without compromising credibility.

[1] More information on the UN Sustainable Development Goals may be found at: https://sustainabledevelopment.un.org/sdgs.

2 Program Level GHG Reduction Accounting Guidelines

The Reserve develops protocols specifying eligibility criteria and detailing steps to estimate, monitor, and verify GHG reductions achieved by specific types of projects. While each project protocol contains guidance specific to individual project types, Reserve protocols also adhere to general project accounting principles. This section describes the Reserve's standardized project accounting guidelines that are the foundation for all project protocols.

2.1 General Approach, Principles, and References

The Reserve strives to develop protocols that are "standardized" in nature, meaning they apply standardized factors and eligibility rules to the extent possible while maintaining sufficient rigor and accuracy. In addition, the form and content of Reserve protocols follow internationally established accounting principles and standards.

2.1.1 Standardized Offset Crediting

A core objective of the Climate Action Reserve is to adopt "standardized" approaches to offset crediting. Standardized offset crediting has two main elements:[2]

1. Determining the eligibility and additionality of projects using standard criteria, rather than project-specific assessments.
2. Quantifying GHG emission reductions using standard baseline assumptions, emission factors, and monitoring methods.

The main goal of standardized offset crediting is to minimize the subjective judgment required in evaluating whether a project should receive credit for emission reductions, and in determining how much credit it should receive. Compared to project-specific assessment and analysis, standardized crediting reduces transaction costs for project developers, alleviates uncertainties for investors, and increases the transparency of project approval and verification decisions. Furthermore, the Reserve believes that appropriately designed standardized protocols can be as rigorous as project-specific approaches in ensuring additionality and environmental integrity (see Section 2.4.1 below for further discussion of standardized additionality tests).

Three challenges with standardized crediting are worth noting. First, developing standardized methods for determining additionality and estimating baselines requires significant upfront research and analysis. In order to avoid the need for extensive data collection and analysis on a project-by-project basis, the Reserve invests significant time and resources to establish credible benchmarks and emission factors that can be applied to similar projects throughout an entire industry or sector. The Reserve may frequently build off existing project-specific methodologies, but in general will augment these methodologies with further analysis to establish standardized tests and metrics.

Second, because "business as usual" activities can vary significantly across different geographic areas, standardized benchmarks and factors for one region will not necessarily be appropriate for other regions. Therefore, standardized protocols will almost always apply to a specific, limited geographic area. Every Reserve protocol specifies the geographic region(s) to

[2] For further reference, see Broekhoff, D., 2007. *Expanding Global Emissions Trading: Prospects for Standardized Carbon Offset Crediting*. International Emissions Trading Association, Geneva.

which it applies. In adapting protocols for other geographic regions, the Reserve engages in a full stakeholder process designed to assess and incorporate region-specific benchmarks and factors.

Third, not all possible offset project types are equally amenable to standardized crediting.[3] For some types of projects, determining additionality and estimating baseline emissions cannot be done credibly and accurately on a standardized basis. In general, the Reserve will avoid developing protocols for these project types. Alternatively, the Reserve may incorporate project-specific methods or variables into standardized protocols as appropriate, or limit the scope of protocols to address only activities and conditions for which standardized approaches are feasible.

2.1.2 Reference Standards

The Reserve's offset project protocols are designed to be consistent with the principles, requirements, and guidance of two overarching standards for project-based GHG accounting:[4]

- International Organization for Standardization (ISO) 14064, Part 2
- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) Greenhouse Gas Protocol for Project Accounting

Both standards contain consistent general requirements for quantifying reductions in GHG emissions (or increases in carbon sequestration) that result from project-based activities, including requirements for:

1. Establishing GHG accounting boundaries
2. Estimating baseline emissions
3. Determining project-case emissions
4. Monitoring project activities

Although the ISO and WRI/WBCSD standards are largely consistent in their basic requirements, they have different terminologies and structures. Reserve protocols may utilize terminology from either or both standards depending on circumstances. The structure and general content of Reserve protocols are presented in the remainder of this section.

2.2 GHG Accounting Principles

There is now strong international consensus around a core standard set of overarching principles to guide decisions about the accounting, quantification, and reporting of project-based GHG reductions. These consensus principles are listed and defined in both the ISO and WRI/WBCSD standard referenced above. Definitions of these principles differ slightly between the two standards; the Reserve interprets the principles as follows in developing its protocols:

[3] *Ibid*.
[4] International Organization for Standardization, 2019. *ISO 14064, Part 2*: *"Specification with guidance at the project level for quantification, monitoring, and reporting of greenhouse gas emission reductions or removal enhancements."* International Organization for Standardization, Geneva, Switzerland; World Resources Institute and World Business Council for Sustainable Development, 2005. *The GHG Protocol for Project Accounting*, World Resources Institute, Washington, DC.

- **Relevance:** Data, methods, criteria, assumptions, and accounting boundaries should be chosen based on their "intended use." For the Reserve, this means protocols are designed around standardized, practical approaches to GHG accounting while still adhering to other core accounting principles.
- **Completeness:** All relevant information should be considered when developing criteria and procedures, and all relevant GHG emissions and removals should be accounted for. Reserve protocols comprehensively identify the GHG sources, sinks, and reservoirs affected by project activities and require accounting for all significant changes in GHG emissions or removals that may result from a project. Where there are multiple baseline possibilities, protocols must thoroughly address identification and quantification methods for each possibility.
- **Consistency:** Data, methods, criteria, and assumptions should allow meaningful and valid comparisons of the GHG reductions achieved by different projects. Reserve protocols are standardized to apply consistent GHG accounting and monitoring methods to all projects of the same type. Reserve protocols are also designed to reflect similarly rigorous and conservative accounting methods and assumptions for all project types.
- **Transparency:** Sufficient information should be disclosed to allow reviewers and stakeholders to make decisions about the credibility and reliability of GHG reduction claims with reasonable confidence. Access to sufficient and appropriate GHG-related information is critical for assuring users of the Reserve that a project's GHG reduction claims are credible. To this end, the Reserve uses an open, consultative process for developing protocols; makes protocols publicly available; requires regular, rigorous, and complete reporting from registered projects; and provides a publicly accessible database detailing all relevant information used to quantify GHG reductions for each registered project. In addition, the Reserve's standardized protocols reduce ambiguities associated with how project-related information is interpreted.
- **Accuracy:** Uncertainties and bias should be reduced as far as is practical. Greater accuracy in estimating GHG emissions and reductions will help ensure credibility of GHG reduction claims. Reserve protocols require that quantification of GHG reductions and monitoring of GHG emissions and other variables be conducted within acceptable levels of uncertainty. All GHG reduction estimates must pass rigorous review by an independent verification body. Where accuracy is difficult to achieve, Reserve protocols will err on the side of being conservative with GHG reduction estimates.
- **Conservativeness:** Conservative assumptions, values, and procedures should be used to ensure that GHG reductions are not over-estimated. Reserve protocols employ conservative estimation methods whenever data and assumptions are uncertain and measures to reduce uncertainty would be impractical.

2.3 Project Definition

A GHG project is a specific activity or set of activities intended to reduce GHG emissions, increase the storage of carbon or enhance GHG removals from the atmosphere.[5] A GHG project is considered to be a "carbon offset" project if the GHG reductions or removals it generates are used to compensate for GHG emissions occurring elsewhere.[6] Projects that meet

[5] World Resources Institute (WRI), World Business Council for Sustainable Development (WBCSD), 2005. *The GHG Protocol for Project Accounting*. World Resources Institute, Washington, D.C.
[6] Offset Quality Initiative, 2008. *Ensuring Offset Quality: Integrating High Quality Greenhouse Gas Offsets Into North American Cap-and-Trade Policy*. Available at: http://www.offsetqualityinitiative.org/.

the Reserve's standards are issued emission reduction or removal credits, and those credits act as offsets when they are certified and retired in the Reserve's online registry. The Reserve's primary purpose is to certify GHG reductions as carbon offsets.

Every Reserve protocol clearly defines the type of activity (or activities) that constitute a GHG reduction project. A clear project definition ensures that GHG quantification methods prescribed by the protocol are applied only where they are relevant and appropriate. The "project definition" section of each protocol specifies the kinds of activities that must be undertaken to reduce GHG emissions (or increase removals), the required conditions that must be met for these activities, and the necessary elements of project design and implementation.

2.3.1 Project Types

The Reserve only registers GHG projects that follow project protocols that have been developed by the Reserve. In other words, only projects meeting the requirements of project protocols that have been approved and adopted by the Reserve's Board are eligible for registration on the Reserve. The Reserve may establish linkages with additional programs in the future to allow other projects to be registered.

Approved project protocols and information on additional project protocols in development are available for download at http://www.climateactionreserve.org/how/protocols/.

2.4 Project Eligibility Criteria

Eligibility criteria specify essential characteristics a project must have in order to register with the Reserve, as well as the conditions under which the Reserve will issue CRTs to a project. In Reserve protocols, eligibility criteria serve three main purposes:

1. To ensure that baseline estimation methods and emission factors prescribed by the protocol are relevant and appropriate. Reserve protocols use standardized baseline estimation methods that are calibrated to specific geographic regions; to be eligible, projects must be located in an appropriate geographic region.
2. To ensure that projects are "additional." To test for additionality, the Reserve employs objective criteria designed to distinguish additional projects from those that would have happened anyway (i.e., in the absence of an offset market). These criteria fall into two categories: (1) a legal requirement test, and (2) a performance standard test. These tests are explained and described further below.
3. To ensure that projects adhere to all applicable laws and do not cause adverse environmental, social or economic impacts.

Generally, the Reserve seeks to specify eligibility criteria that are as standardized and objective as possible. This means that criteria will be designed to require a minimum amount of subjective judgment in determining whether a project is eligible.

2.4.1 Additionality Determinations

Within existing carbon offset programs, there are two basic approaches to determining "additionality": project-specific and standardized. The Reserve applies a standardized approach to determining additionality, where performance standards and other conditions or criteria that projects must meet in order to be considered additional are determined by the Reserve. These standards and criteria are established separately for each project type and are designed to exclude non-additional (or "business as usual") projects from eligibility. In all cases, projects that

are required by law or regulation are excluded. Other criteria and conditions are specified in each project protocol.

This approach differs from some other offset programs, where additionality is assessed using information and analysis specific to each project (see Box 1). It avoids the need to subjectively interpret individual project developers' assertions about additionality and sends a clear signal to market participants about which projects will be eligible and which ones will not. Like any testing method, however, it is potentially subject to error. The Reserve strives to establish rigorous standards for additionality that serve to exclude the vast majority of non-additional projects. At the same time, the Reserve acknowledges that no system of testing for additionality is perfect, and it reserves the right to update and modify additionality criteria over time in light of new data and information.

Box 1. Project-Specific vs. Standardized Additionality Tests

Project-specific approaches to determining additionality seek to assess, by weighing certain kinds of evidence, whether a project in fact differs from a hypothetical baseline scenario in which there is no carbon offset market. Generally, a project and its possible alternatives are subjected to a comparative analysis of their implementation barriers and/or expected benefits (e.g., financial returns). If an option other than the project itself is identified as the most likely alternative for the "business as usual" (or "baseline") scenario, the project is considered additional. The Kyoto Protocol's Clean Development Mechanism (CDM), a global carbon offset program for projects in developing countries, requires project-specific additionality tests.

Standardized, or performance-based, approaches to additionality evaluate projects against a consistent set of criteria designed to exclude non-additional projects and include additional ones on a sector-wide basis. For example, standardized tests could involve determinations that a project:

- Is not mandated by law
- Exceeds common practice
- Involves a particular type of high-performing technology
- Has an emission rate lower than most others in its class (e.g., relative to a performance standard)

From a regulatory perspective, standardized performance-based additionality tests are advantageous in that they are less subjective and administratively easier to implement than project-specific tests. Additionally, they can reduce transaction costs for project developers, alleviate uncertainties for investors, and increase the transparency and consistency of regulatory decisions. For further discussion of these two approaches, see Broekhoff, D., 2007. *Expanding Global Emissions Trading: Prospects for Standardized Carbon Offset Crediting*. International Emissions Trading Association, Geneva.

The Reserve incorporates standardized additionality tests in all of its protocols. These tests generally have two components: a legal requirement test and a performance standard test.

2.4.1.1 Legal Requirement Test

Projects are very likely to be non-additional if their implementation is required by law. A legal requirement test ensures that eligible projects (and/or the GHG reductions they achieve) would not have occurred anyway in order to comply with federal, state or local regulations, or other legally binding mandates. A project passes the legal requirement test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions

or other legally binding mandates requiring its implementation, or requiring the implementation of similar measures that would achieve equivalent levels of GHG emission reductions.

In Reserve protocols, the specific provisions of the legal requirement test may differ depending on the project type. During protocol development, the Reserve performs a review of existing and pending regulations to identify any specific regulatory requirements that would mandate the implementation of project activities covered by the protocol. If such requirements are identified, then project activities in relevant jurisdictions may be categorically excluded from eligibility.

In addition, Reserve protocols require project developers to review and determine whether federal, state or local regulations and other legal requirements (including local agency ordinances or rulings) require the implementation of their project. This review is always required at the time a project is registered and may be required each verification period thereafter depending on the protocol. Generally, Reserve protocols will stipulate the following:

- Project monitoring plans must include procedures that the project developer will follow to periodically ascertain and demonstrate that the project passes the legal requirement test.
- Project developers must submit a signed Attestation of Voluntary Implementation form stipulating that the project is not required by law.

2.4.1.2 Performance Standard Test

Projects that are not legally required may still be non-additional if they would have been implemented for other reasons, e.g., because they are attractive investments irrespective of carbon offset revenues. Performance standard tests are intended to screen out this potential set of projects. In developing performance standards, the Reserve considers financial, economic, social, and technological drivers that may affect decisions to undertake a particular project activity. Standards are specified such that the large majority of projects that meet the standard are unlikely to have been implemented due to these other drivers. In other words, incentives created by the carbon market are likely to have played a critical role in decisions to implement projects that meet the performance standard.

Although performance standard tests do not require individual project assessments of financial returns and implementation barriers, they are designed to reflect these factors in determining which projects are additional. Projects that pass a performance standard test should be those that – in the absence of a carbon offset market – would have insufficient financial returns or would face other types of insurmountable implementation barriers.

In Reserve protocols, performance standards may be specified in several ways:

- *Emission rate thresholds*. For some project types, a performance standard may be specified in terms of a rate of GHG emissions (usually per unit of production of some product or service, e.g., tonnes of CO_2 per megawatt-hour). Generally, the threshold rate would be based on a level of performance that is significantly better than average for the industry or sector. Projects that have lower emission rates than the threshold, for example, would be considered additional.
- *Practice- or technology-based thresholds*. Performance standards may also be specified in terms of a specific practice or technology that is rarely or never implemented in the absence of a carbon offset market. Such standards are generally based on surveys of

the market penetration rates of candidate practices or technologies. Projects employing a qualifying technology or practice are automatically considered additional.

- *Other qualifying conditions or criteria*. Performance standards may also incorporate, or be based on, other specific qualifying conditions that a project must meet in order to be considered eligible. Conditions may include characteristics related to the project site, specifications for a particular eligible technology or practice, or other contextual factors. Projects meeting the conditions would be considered additional.

Several specifications may be combined in a single performance standard test. For example, a protocol may define a performance standard in terms of a specific type of technology that has an emission rate below a certain threshold and is implemented at an eligible project location.

Performance standard tests are developed through extensive analysis of standard practices and technology deployment in industry sectors related to a project type. They may also be based on an assessment of "typical" financial, implementation, and operating conditions facing a certain type of project. Most Reserve protocols contain an appendix explaining and summarizing the analyses undertaken to establish the protocol's performance standard.

The Reserve has no predefined threshold for determining an acceptable performance standard. Rather, establishing performance standards involves balancing the need to restrict eligibility for non-additional projects with the goal of allowing additional (and otherwise eligible) projects to participate. Setting a threshold always involves making tradeoffs between these two goals and may also involve considerations about the size of the market for carbon credits and the potential supply of reductions available from certain project types.[7] See Box 2 for further discussion and a hypothetical example.

[7] For further discussion of setting thresholds and establishing the parameters for additionality tests, see Trexler, M., D. Broekhoff, and L. Kosloff, 2006. "A Statistically-Driven Approach to Offset-Based GHG Additionality. Determinations: What Can We Learn?" in *Sustainable Development Law & Policy*, Volume VI, Issue 2, Winter 2006.

Box 2. Determining Acceptable Performance Standard Thresholds

A common rule of thumb for establishing performance standards is that they should make eligible only technologies or practices that are not "common practice." However, "common practice" is often difficult to define. Instead of adopting a simple rule for defining "common practice" (as a threshold market penetration rate, for example) the Reserve requires setting performance standards based on an overall assessment of the market for GHG reductions and the risk of crediting too many non-additional reductions.

For example, suppose a particular emission-reducing technology has a market penetration rate of five percent. Colloquially, such a technology would not be considered "common practice." However, if a threshold were established allowing all instances of this technology to be eligible for offset crediting, we could expect existing users of the technology to apply for credit despite the fact that they were employing it already, without any incentives from the carbon market. This will have consequences for the integrity of the carbon market. Whether such consequences are serious depends on the potential supply of reductions from this technology compared to overall demand for reductions. If five percent of the market would result in hundreds of millions of tonnes of GHG reductions, for example, then a simple technology-based threshold would be too lenient, and the Reserve would explore using additional criteria that could further exclude "business as usual" instances of the technology despite its relative rarity. If five percent of the market would result in only a few thousand tonnes of GHG reductions, then the Reserve may consider a simple technology-based threshold acceptable.

2.4.2 Project Location

Projects throughout the United States are eligible to be registered with the Reserve. Some project types are also eligible in Mexico. Project developers should check the project location eligibility requirements specified in each project protocol.

2.4.3 Project Start Date

In general, the start date for a project will correspond to the start of the activity that generates GHG reductions (sometimes referred to as "start of operations"). Specific requirements for determining the start date of a project are contained in each protocol.

The Reserve limits the eligibility of projects according to their start dates. Start date restrictions are intended to accommodate "early actors" for a period of time following the adoption of new protocols, but to otherwise restrict eligibility to new projects. The Reserve's general policy is as follows:

1. For qualifying projects that have not previously been listed or registered on a greenhouse gas registry or program:

    a. For a period of 12 months following the adoption by the Reserve Board of any new protocol, the Reserve will accept projects for listing with start dates (as defined in the protocol) that are no more than 24 months earlier than the date of the Reserve protocol's adoption. These are considered pre-existing projects.

    b. After the 12-month period following the date of the Reserve protocol's adoption, the Reserve will accept projects for listing with start dates (as defined in the protocol) that are no more than six months prior to the date on which they are submitted. A project submitted within six months of its start date is considered a "new" project.

2. For qualifying projects that have previously been listed or registered on a greenhouse gas registry or program:

    a. Projects with start dates (as defined in a relevant Reserve protocol) on or after January 1, 2001 but more than 24 months earlier than the date of adoption of a relevant new Reserve protocol – and which were listed or registered with another registry or program at least 24 months earlier than the date of adoption of the new Reserve protocol – may apply for transfer to the Reserve. These are considered pre-existing projects.

    b. Projects with start dates (as defined in a relevant Reserve protocol) that are no more than 24 months before and no more than 12 months after the date of adoption of a relevant new Reserve protocol – and that were listed or registered with another registry or program no more than 12 months after the date of adoption of the new Reserve protocol – may apply for transfer to the Reserve.

    c. Projects with start dates (as defined in a relevant Reserve protocol) that are more than 12 months after the date of adoption of a relevant new Reserve protocol, and that were listed or registered with another registry or program within six months of the project start date, may apply for transfer to the Reserve.

The Reserve considers a protocol to be "new" if it:

- Covers an entirely new project type not covered by any of the Reserve's existing protocols;
- Creates a wholly new category of eligible projects under an existing protocol (in which case only the new project category would qualify for a 12-month period of "early actor" eligibility); or
- Significantly expands the geographic coverage of the protocol (in which case only projects in newly covered geographic areas would qualify for a 12-month period of "early actor" eligibility).

If a new version of a protocol is adopted (e.g., updating from Version 1.0 to Version 2.0), this does not necessarily mean it will be considered a "new" protocol.

2.4.4 Project Crediting Period

The project "crediting period" defines the period of time over which a project's GHG reductions are eligible to be verified as CRTs. In general, the start of a project's crediting period will correspond to its start date.

The length of a project's crediting period is defined in each project protocol. For most non-sequestration projects registered with the Reserve, there is a 10-year crediting period that may be renewed one time for a maximum of two 10-year crediting periods. For sequestration projects, the crediting period may be up to 100 years. Refer to each project protocol for specific details on allowable crediting periods. A non-forest project may end its crediting period at any time prior to the limit specified in the protocol, but must abide by any monitoring requirements necessary to ensure permanence, if applicable.

If a project wishes to apply for eligibility under a renewed crediting period, it must do so by re-submitting project submittal forms no sooner than six months before the end of the project's

ongoing crediting period and paying the project submittal fee. The project must meet all of the eligibility requirements of the most current version of the applicable protocol at the time of re-submittal to be eligible for a renewed crediting period.

Note that projects registered under early protocol versions that do not have provisions for a second crediting period can apply for one under the most current version of the protocol, if the most current version allows for a second crediting period.

Notwithstanding any pre-defined crediting period, projects that become required by law will not be eligible to receive CRTs for the reductions they generate, unless otherwise specified in the protocol. Thus, in most cases, if a project becomes subject to a regulation, ordinance or permitting condition that effectively requires its implementation, the project can no longer be considered additional and its crediting period will be terminated. The crediting period will likewise be terminated if the emission sources affected by a project are included under an emissions cap (e.g., under a state or federal cap-and-trade program) or GHG emissions from the project/project site are directly regulated by a local, state or federal agency. As specified in each protocol, emission reductions may be reported to the Reserve until the date that a regulation or emissions cap takes effect.

Details on the allowable crediting period as well as crediting period renewals for each type of project recognized by the Reserve are contained in each protocol.

Once a project has reached the end of its crediting period(s) and is no longer being issued CRTs, the project is considered "completed." Although the project is completed, project information remains publicly available through the Reserve software indefinitely.

2.4.5 Bundling of Projects

Only certain types of Reserve-recognized GHG projects may be bundled for registration and reporting purposes. Generally, each GHG project, as defined by the project definition and/or project boundary (described in each protocol), must register separately with the Reserve. However, protocols for certain project types may allow project boundaries to span multiple activities or locations. For example, the Livestock Project Protocol covers centralized manure digesters by allowing the project boundary to include all individual livestock operations that contribute manure to the centralized processing facility, as well as the centralized facility itself. The Reserve has also developed aggregation guidelines for U.S. and Mexico forest projects, which allow forest inventory and verification requirements to be streamlined for individual projects. Grassland projects may go through joint verification and reporting by participating in the cooperative option described in that protocol.

Project developers should check specific project protocols and associated guidance documents for direction on whether and how joint reporting and verification is allowed.

2.4.6 Regulatory Compliance and Environmental and Social Safeguards

The Reserve requires project developers to demonstrate that their GHG projects will not undermine progress on other environmental issues such as air and water quality, endangered species and natural resource protection, and environmental justice. When registering a project, the project developer must attest that the project was in material compliance with all applicable laws, including environmental regulations, during the verification period. The project developer is also required to disclose any and all instances of non-compliance – material or otherwise – of the project with any law to the Reserve and the verification body.

If a project or project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to "acts of nature" or due to administrative or reporting issues (such as an expired permit without any other associated violations or tardiness in filing documentation) are not considered material and will not affect CRT crediting. If it is determined that a project was out of compliance after CRTs have been issued, CRTs may be cancelled for the time period of non-compliance.

A violation is considered to be "caused" by a project or project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the project developer shall disclose the violation to the verifier.

In addition, individual protocols may contain requirements designed specifically to ensure environmental and social safeguards. Individual protocols may allow for project developers to report measures taken to avoid negative impacts. Individual protocols may also encourage project developers to report on the potential environmental co-benefits of their projects, such as reductions in other air pollutants, improvements in water quality, enhancement of wildlife habitat, etc.

In developing environmental and social safeguard criteria and requirements for specific protocols, the Reserve applies the following general principles:

Common Agency

Environmental and social harms will only be considered in determining project eligibility[8] to the extent that they can be attributed to the same agents (e.g., project developers, implementers or operators) in charge of implementing the project. Harms that may occur concurrently with a project, but are caused by other actors, will not be a factor in determining eligibility. The agents responsible, individually or collectively, for implementing projects will be determined during the protocol development process in consultation with stakeholders.

Proximity

Only environmental and social harms directly associated with a project activity (i.e., either physically or causally proximate) will be considered:

- Harms directly caused by project activities, regardless of where the harms physically occur, will be a factor in determining eligibility.
- Harms physically proximate to project activities but not directly caused by those activities may also be considered in determining eligibility if they are caused by agents responsible for project implementation. Such harms will be considered only if the agents are *required by the relevant protocol* to be involved in project implementation. Required agents will be specified in the Reserve's protocols, e.g., as part of the project definition or definition of eligible "project developers." If an agent is allowed, but not required, to be involved in project implementation, then physically proximate harms caused by that agent will not be considered (even if such an agent is directly involved with a particular project).

[8] Either initial eligibility or eligibility to receive credits.

- Harms caused by agents in charge of implementing a project that occur at sites or facilities not linked or co-located with the project will *not* be a factor in determining eligibility.

Both agency and proximity of effects will be considered in the protocol screening and development processes to identify and set clear standards for the application of this policy.

In determining whether environmental and social harms are occurring, the Reserve will use the following criteria:

Legal Obligation

The Reserve will rely first and foremost on legal requirements within the jurisdiction(s) where the project is implemented. Project agents that are found to be out of material compliance with applicable laws, regulations or other legal mandates that apply to the project itself or activities proximate to the project will be penalized.

"Do No Harm" Beyond Legal Requirements

In some cases, the Reserve may determine, in consultation with stakeholders, that existing legal requirements are insufficient to guarantee protection against important environmental and social harms. In these cases, the Reserve may include additional criteria in protocols to ensure that projects will not give rise to these harms, or may screen out certain project types or activities from eligibility under a protocol altogether.

The Reserve coordinates with government agencies and environmental representatives to ensure that its climate-oriented projects complement other environmental policies and programs.

2.5 Defining the GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs)[9] that must be assessed in order to determine the total net change in GHG emissions caused by a GHG reduction project.[10] GHG Assessment Boundaries are defined for each type of project activity addressed in a Reserve protocol.

The GHG Assessment Boundary is not a boundary related to a project's physical location. Instead, it encompasses all SSRs that could be significantly affected by a project activity, regardless of where such SSRs are located or who owns or controls them. A comprehensive and clearly defined GHG Assessment Boundary is required in order to provide a complete accounting of the net GHG reductions achieved by a project. All SSRs within the GHG Assessment Boundary are included in the calculation of GHG reductions.

SSRs are only included in the GHG Assessment Boundary if a project activity will have a *significant* effect on their associated GHG emissions or removals. The Reserve determines significance based on an assessment of the range of possible outcomes for a relevant SSR.

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[9] Terminology is from International Organization for Standardization, 2005. *ISO 14064, Part 2*: *"Specification with guidance at the project level for quantification, monitoring, and reporting of greenhouse gas emission reductions or removal enhancements."* International Organization for Standardization, Geneva, Switzerland.

[10] See World Resources Institute and World Business Council for Sustainable Development, 2005. *The GHG Protocol for Project Accounting*, World Resources Institute, Washington, DC.

There is no numerical threshold for significance. Inclusion or exclusion of SSRs is determined for each protocol based on the principles of completeness, accuracy, and conservativeness, and the need for practicality (e.g., related to measurement and monitoring costs). In general, relevant SSRs will only be excluded from the GHG Assessment Boundary if:

1. Projects are likely to reduce GHG emissions (or increase removals) at a SSR, so that excluding the SSR would be conservative (i.e., doing so would result in an underestimation of total net GHG reductions for the project); or
2. The total increase in GHG emissions from *all* excluded SSRs is likely to be less than five percent of the total GHG reductions achieved by a project.[11]

For each included SSR, the protocols:

- Identify whether the SSR is present in the baseline, project case or both
- Identify whether and how GHG emissions, removals or storage from the SSR will be measured, calculated or estimated
- If GHG emissions, removals or storage will be estimated, justify why values will be estimated rather than measured (or calculated from other measurements

Each protocol contains a table that:

- Lists all SSRs potentially affected by a project
- Explains or describes the SSR
- Indicates whether each SSR is included in the GHG Assessment Boundary
- Justifies instances where an SSR is excluded from the GHG Assessment Boundary
- Briefly describes how GHG emission values for the SSR will be determined, and justifies instances where such values will be estimated

Most protocols also contain a schematic diagram showing how different SSRs are related to each other and indicating which SSRs are included in or excluded from the GHG Assessment Boundary.

The Reserve does not restrict the GHGs that may be considered within the GHG Assessment Boundary. Any gas that has been determined by the IPCC to have a radiative forcing effect on the atmosphere may be considered for inclusion in a protocol. Reserve protocols may address gases other than the six GHGs regulated under the Kyoto Protocol (i.e., CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs).

2.5.1 Physical Project Boundaries

For some types of projects, it is necessary to define a physical boundary for a project in addition to a GHG Assessment Boundary. Physical boundaries are defined in terms of the physical area affected by a project activity and possibly specific equipment or facilities involved. Protocols will only require identification of a physical boundary where a physical boundary is necessary to quantify the magnitude of GHG emissions, removals or storage associated with one or more SSRs included in the GHG Assessment Boundary. The primary example would be forest

[11] If excluding SSRs is unavoidable for practical reasons, then calculation and estimation methods related to included SSRs must be made suitably conservative in order to avoid overestimating total net GHG reductions.

projects, where the amount of carbon stored by a project depends on the area of land on which the project activity takes place.

2.5.2 Leakage Accounting

The term "leakage" is often used to refer to unintended increases in GHG emissions that may result from a GHG reduction project. Generally, leakage occurs at SSRs that are physically distant from the project itself or otherwise outside the project's physical boundaries. Because the Reserve requires the definition of a comprehensive GHG Assessment Boundary – which must include any and all SSRs associated with significant GHG emissions, regardless of their physical location – Reserve protocols generally do not require an explicit and separate accounting for "leakage" effects. Instead, all effects of a GHG reduction project – both positive and negative – are accounted for without distinguishing one kind of effect from another. This does not mean that Reserve protocols neglect or ignore what other methodologies or protocols identify as "leakage."

Where helpful for conceptual understanding, Reserve protocols may organize SSRs according to whether they are associated with a project's "primary" or "secondary" effects. A project's primary effect is its intended effect on GHG emissions (i.e., intended GHG reductions). Secondary effects are unintended effects on GHG emissions, often associated with leakage.[12]

2.6 Quantifying GHG Reductions

GHG emission reductions are quantified by comparing actual project GHG emissions to baseline GHG emissions. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary that would have occurred in the absence of the project (assuming the project is additional and would not have happened anyway). Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions. For sequestration projects, the formula is reversed: the baseline carbon sequestration rate is subtracted from the project carbon sequestration rate.

For most protocols, GHG emission reductions must be quantified and verified on at least an annual basis. Project developers may choose to quantify and verify GHG emission reductions on a more frequent basis if they desire and if the protocol allows it. The length of time over which GHG emission reductions are quantified is called a "reporting period." The length of time over which GHG emission reductions are verified is called a "verification period." Under some protocols, a verification period may cover multiple reporting periods (see Section 3.4.2).

2.6.1 Global Warming Potentials for Quantifying GHG Reductions

Under the Climate Action Reserve's offset project protocols, projects convert quantities of non-CO_2 greenhouse gases (GHGs) into a quantity of CO_2-equivalent (CO_2e) using the 100-year global warming potential (GWP) values from the Intergovernmental Panel on Climate Change (IPCC).[13] Reserve project protocols currently reference the Fourth Assessment Report (AR4) of the IPCC, released in 2007. At the time that the Reserve was launched, the AR2 was the most

[12] The terms "primary effect" and "secondary effect" are from the World Resources Institute and World Business Council for Sustainable Development, 2005. *The GHG Protocol for Project Accounting*, World Resources Institute, Washington, DC.

[13] Assessment Reports of the IPCC may be accessed at: https://www.ipcc.ch/reports/

widely-used source for GWP values, underpinning activities under the Kyoto Protocol, as well as the U.S. EPA's GHG reporting and inventory efforts. At this time, the IPCC AR4 has become the industry standard for most applications relevant to the Reserve's voluntary offset protocols. All projects using Reserve protocols – regardless of version – shall use AR4 GWP values. While it is the Reserve's policy for protocols to take precedence over the Reserve Offset Program Manual in instances where the standards conflict, this policy is an exception to that rule. In future protocol updates, the Reserve will make clear that GWP values are not fixed and may be updated at a later date. Note that this policy may be superseded by a future policy memo as GHG accounting practices progress. It is anticipated that the program will move to application of the GWP values from the Fifth Assessment Report (AR5) in the near future, in accordance with industry best practice.

2.6.2 Estimating Baseline Emissions

Baseline emissions are always subject to uncertainty because they are counterfactual, i.e., they are an estimate of GHG emissions or removals that would have occurred in the absence of the project. Depending on the project type and SSRs involved, many methods can be used to try to estimate baseline emissions. The Reserve uses standardized baselines in its protocols to the extent possible, meaning that the same conservative assumptions, emission factors, and calculation methods are applied to all projects. Standardized baseline approaches seek to avoid case-by-case analysis of individual projects while maintaining overall levels of quantification accuracy and environmental integrity. Within Reserve protocols, however, project-specific calculations and emission factors may be used wherever necessary to ensure accuracy, or where standardized methods would result in estimates that are overly conservative in a large number of cases.

Standardized baselines are developed by considering broad trends (economic, technological, regulatory, and policy) in the industry or sector relevant to a project type and determining what future "business as usual" alternative activities are likely to be. To develop standardized baselines, the Reserve works with stakeholders to determine the most likely alternative technologies or practices. In many cases, a single practice, activity or technology is assumed to be the common baseline alternative for a class of project activities. In some cases, the performance threshold developed for additionality may also be used as an emissions baseline. After establishing a standard baseline alternative, the Reserve develops specific quantification steps, calculation methods, and formulas to estimate baseline emissions, incorporating site-specific data where appropriate. Depending on the project type, baseline emission estimates may either be fixed at the outset of a project, or they may be regularly updated using actual data collected during the project's operation (used to infer baseline conditions).

2.6.3 Quantifying Project Emissions

Project GHG emissions are quantified based as much as possible on actual measurements of project activity performance. GHG emissions for each SSR may be measured directly, or calculated from measurements of parameters from which GHG emissions can be derived. For SSRs where direct or indirect measurements are too costly or infeasible, project GHG emissions may be estimated using standard assumptions or models.

2.6.4 Quantification Methods

The Reserve develops methods to calculate baseline and project emissions that meet an acceptable level of accuracy. As a general rule, methods should ensure 95% confidence that actual emissions are within +/- 5% of measured or calculated values, although required levels of

accuracy will often depend on the specific magnitudes involved and their materiality. Methods may employ one or more of the following approaches:

- **Emission factor** approaches use input data multiplied by specific emission factors that approximate emissions per unit of the input. The factors are derived from research or model simulations and they are typically categorized by variables such as geographic location, local climate data, tree species, equipment standards, etc.
- **Dynamic models** estimate processes that cause GHG emissions (or biological carbon sequestration). Model users input specific parameters and the model generates emission or removal estimates. Research studies identify the parameters as important drivers of emissions or removals. Sometimes the parameter may be chosen from data provided by the Reserve or they may need to be measured at the project location.
- **Direct emission measurement** uses special instruments that monitor the flow of GHGs from the source into the atmosphere. This involves instrumentation and monitoring of GHG emission sources onsite.

2.6.4.1 Quantification Uncertainty and Conservativeness

Where cost-effective methods for quantifying GHG emissions or carbon storage yield uncertain estimates (e.g., greater than a five percent range), it may not be possible to accurately quantify baseline or project emissions. In these cases, Reserve protocols must use conservative assumptions and/or parameter values that will tend to underestimate, rather than overestimate, total GHG reductions and removals.

2.6.5 Calculating GHG Reductions or Removals

GHG reductions are calculated by periodically comparing the baseline to the project over a certain time period, usually one year.

The general formula for calculating GHG reductions is:

GHG Reductions = Baseline Emissions – Project Emissions

Positive GHG reductions are achieved when the project results in lower GHG emissions to the atmosphere over a certain time period compared to what would have happened absent the project activity.

For biological carbon sequestration projects, the general formula for calculating GHG removals is:

GHG Removals = (Incremental Project Sequestration – Incremental Baseline Sequestration) + (Baseline Emissions – Project Emissions)

Positive GHG removals are achieved when the project results in more carbon sequestered in biological carbon stocks over a certain time period than would have been in the absence of the project activity.

2.6.6 Immediate Crediting for Future Avoided Emissions

In accordance with recognized principles for carbon offset quality, the Reserve has upheld a general policy against "forward crediting" of GHG emission reductions. Forward crediting occurs when credits are issued for GHG reductions before such reductions have occurred and before the activities that caused such reductions have been verified.[14] Subject to certain conditions, however, the Reserve does credit reductions upfront when a verified action results in the immediate avoidance of a future stream of GHG emissions. Please see the Reserve's policy memo on this subject, available at http://www.climateactionreserve.org/how/program/program-manual/.

Separate from its *ex post* offset crediting program, the Reserve has developed a program, Climate Forward, for the purpose of recognizing and crediting anticipated future streams of emission reductions. This program specifically issues GHG emission reduction credits (not offsets) on an *ex ante* basis. Climate Forward provides a practical solution to companies and organizations seeking cost-effective mitigation of anticipated (i.e., future) operational and/or project-related GHG emissions. Climate Forward facilitates investments in GHG reduction activities that are practical, scientifically-sound, transparent, and aligned with forward-looking mitigation needs. For more information, please visit the Climate Forward website at https://climateforward.org/.

2.7 Project Monitoring

Monitoring of GHG projects is required in order to determine project performance, quantify actual GHG emissions, and in some cases, calibrate baseline emissions estimates. Under all Reserve protocols, GHG reductions are quantified only based on actual project monitoring data. Monitoring requirements are specified in each protocol and include provisions for:

- Monitoring GHG emissions or removals associated with SSRs within the GHG Assessment Boundary
- Monitoring other data related to assumptions underlying GHG emissions and/or carbon stock estimates
- Documenting data storage and quality assurance/quality control (QA/QC) measures
- Ensuring all project components are operated in a manner consistent with the manufacturer's recommendations
- Ensuring all monitoring instruments are calibrated and maintained as specified by the manufacturer

The Reserve requires a monitoring plan to be established for all monitoring and reporting activities associated with a project. The monitoring plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in each protocol have been met and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. Monitoring plans must cover all aspects of monitoring and reporting contained in a protocol and must specify how data for all relevant parameters will be collected and recorded. Each protocol specifies in a table the parameters that must be monitored and how data for each parameter must be acquired (e.g., from measurement, calculation, approved references or operating records).

[14] Offset Quality Initiative, 2008. *Ensuring Offset Quality: Integrating High Quality Greenhouse Gas Offsets Into North American Cap-and-Trade Policy,* p. 10. Available at: http://www.offsetqualityinitiative.org/.

At a minimum, a monitoring plan must stipulate the frequency of data acquisition; a record keeping plan; the frequency of instrument field check and calibration activities; and the role of individuals performing each specific monitoring activity. Monitoring plans should include QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision.

Finally, monitoring plans for most protocols must include procedures that project developers will follow to ascertain and demonstrate that the project passes the legal requirement test for additionality.

2.8 Ensuring Permanence of GHG Reductions

Because CO_2 and other GHG emissions remain in the atmosphere for very long periods of time, offsetting reductions in GHG emissions must effectively be permanent. The Reserve defines "permanence" as being equivalent to the radiative forcing benefits of removing CO_2 from the atmosphere for 100 years. Some types of offset projects, however, cause GHG reductions by removing CO_2 from the atmosphere and storing it in a reservoir (e.g., in trees or other organic materials, or in geologic formations). In these cases, there is a risk that CO_2 may be re-emitted to the atmosphere, leading to a "reversal" of GHG reductions. A reversal occurs when the total amount of CO_2 stored by a project becomes less than the total number of CRTs issued to the project. This can happen, for example, if some or all of the trees associated with a forest project are destroyed by fire, disease or intentional harvesting.

The Reserve requires that reversals be compensated for in order to ensure the integrity of CRTs and to maintain their effectiveness at offsetting GHG emissions. Specific rules and conditions for reversal compensation are detailed in individual protocols. Generally, the Reserve requires that CRTs be retired in proportion to any reversals, such that the total number of issued CRTs does not exceed the total quantity of CO_2 stored by a project over a sufficiently long period of time.

In some individual protocols, the Reserve may offer the option of "Tonne-Year Accounting" as an alternative mechanism to ensure the permanence of CRTs related to reversible emission reductions. In those cases, the protocol will specify when a project is subject to reversal risk, and how any reversal is to be quantified and compensated.

2.8.1 Maintenance and Disposition of the Buffer Pool

The Reserve maintains a buffer pool composed of credits from project types with identified risk of unavoidable reversal. Credits within the buffer pool from different project types are functionally distinct, despite the buffer pool being administered in one comprehensive account in the Reserve registry. For example, grassland credits in the buffer pool will be used to compensate for reversals of grassland projects, while forest credits in the buffer pool will be used to compensate for reversals of forest projects. Similarly, credits that have been granted eligible status for use in programs outside of the Reserve, but for which the Reserve follows a formal eligibility or qualification process, will be used to compensate for reversals of credits with the same status. The Reserve will retire credits out of the buffer pool to compensate for reversals on a First In First Out (FIFO) basis, after identifying which credits meet the aforementioned criteria for reversal compensation.

Buffer pool contributions are established by each protocol, in accordance with the best available literature. In the highly unlikely event that the buffer pool does not contain sufficient supply of

credits for a certain project type or program eligibility qualification to compensate for identified, unavoidable reversals for that same project type or program eligibility qualification, the Reserve may opt to retire buffer pool credits of another type. If the aggregate buffer pool still is not sufficient for addressing any identified unavoidable reversals, a situation the Reserve believes to be close to impossible (or indicative of an environmental catastrophe hard to imagine), the Reserve will assess the situation and pursue one or more of the following options depending on what is most suitable:

- Require an increased buffer pool contribution from existing projects
- Revise reversal risk ratings within relevant protocols upwards for future reporting to compensate for the unavoidable reversals
- Purchase and retire an adequate amount of similar credits through the Reserve's Blind Trust
- Consult with affected project developers to determine an appropriate course of action

2.9 Avoiding Double Counting of Emission Reductions

Double counting is "a situation in which a single greenhouse gas emission reduction or removal is counted more than once towards achieving climate change mitigation. Double counting can occur through double issuance, double use, and double claiming."[15] The Reserve program guards against each form of possible double counting in different ways. The combination of these safeguards should mitigate the risk of double counting in all its forms.

The first layer of safeguards to avoid double counting is applied at the level of project protocols. The initial safeguard is through the process for screening project protocols for development and adoption by the Reserve. Section 4.1 provides details regarding the selection of project types with low risk of double counting. The next safeguard to avoid double counting is via the act of protocol development. During this process, decisions are made regarding the determination of additionality and the defining of the GHG Assessment Boundary. Both of these processes can reduce the risk of double counting where project activities or GHG sources are covered by other programs.

The next layer of safeguards is implemented at the program level. When a project is submitted for listing with the Reserve, staff conduct a review of other carbon project registries to ensure that the project is not seeking GHG credits for a concurrent period of time. There are specific circumstances under which a project may be listed in multiple registries at the same time without risk of double counting. For example, a project may have transferred to the Reserve from another registry without any temporal overlap in crediting. When a project is submitted for registration, following review of the verification report, Reserve staff will once again conduct a review of other carbon project registries. Project developers also sign a legal Attestation of Title prior to each registration. Through this form they attest, and thus accept liability, that the relevant emission reductions are not registered in any other program, or in the Reserve under another project.

The registry itself is designed to mitigate the risk of double counting through transparency. Each CRT has a unique serial number, identifying, among other things, the location of the project, the relevant protocol, and the vintage year of the GHG reductions. All issuances and retirements

[15] *Guidelines on Avoiding Double Counting for the Carbon Offsetting and Reduction Scheme for International Aviation*. June 2019. Available online at: https://www.adc-wg.org/.

are immediately public. Cancellations for other programs are made public. Any user may review all CRT retirements and view the serial numbers, as well as the reason for retirement. In addition, verification reports are made public, providing an additional source of detailed information regarding the generation of the GHG reductions.

Additional guidance will be added to this document at a later date to address the risk of double claiming between international reporting mechanisms under the Paris Agreement and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), once the international community provides more details on how these commitments will be implemented.

3 Program Rules and Procedures

3.1 Reserve Offset Program Manual

This manual contains details on the Reserve's program, policies, and requirements. Users of the Reserve program, including verification bodies, are subject to the requirements and guidance specified in the most recent version of the Reserve Offset Program Manual. The Reserve Offset Program Manual is considered effective as of the date it is posted on the Reserve website. All account holders and verification bodies are notified when an update to the Reserve Offset Program Manual is released, and the manual is available on the Reserve's Program Manuals and Policies webpage at http://www.climateactionreserve.org/how/program/program-manual/.

3.1.1 Revisions to the Reserve Offset Program Manual

Between updates, the Reserve may release policy memos that update or replace guidance in the Reserve Offset Program Manual or protocols. These memos are considered effective on the date they are posted on the Reserve website; users of the Reserve program and verification bodies must follow the guidance specified in the memo from that date forward. All account holders and verification bodies are notified when a policy memo is released, and memos are posted on the Reserve's Program Manuals and Policies webpage at http://www.climateactionreserve.org/how/program/program-manual/.

In most cases, the contents of the memos are incorporated into the next update of the Reserve Offset Program Manual.

3.2 Start Date

In general, the start date for a project corresponds to the start of activity that generates GHG reductions or removals. Specific requirements for determining the start date of a project are contained in each protocol. Project start date is used in determining project eligibility and initiates a project's crediting period.

Although the project start date is defined by each protocol, the date that begins the project's initial verification period is not. A project must begin its initial verification period on the project start date. This ensures that all project emissions within the GHG Assessment Boundary are accounted for from the project start date until the end of its crediting period.

It is possible that a project developer may not have implemented the appropriate monitoring or QA/QC procedures per the protocol on the project start date. Regardless, the project developer must still begin the initial verification period on the project start date. The project developer shall claim no emission reductions for any time period that the project cannot meet the data, monitoring or QA/QC requirements of the protocol. The verification body must confirm with reasonable assurance that project emissions were not greater than baseline emissions during a verification period, including the time period from the project start date until the protocol requirements were met. Verification bodies shall perform a review of project documentation and calculations for such a time period and may use professional judgment when assessing available project documentation.

If the verifier cannot confirm with reasonable assurance that project emissions were less than or equal to baseline emissions for the verification period, the Reserve will make a determination of action on a case-by-case basis.

3.3 Project Registration

This section summarizes the administrative steps a project developer must follow to register a project with the Climate Action Reserve. The timing of project registration may be independent of its start date. In other words, projects may be submitted after they begin operation (subject to the eligibility restrictions on the project start date described above) or before they begin operation. However, the steps outlined in this section must be followed in order for the Reserve to issue CRTs to a project.

Detailed information on the Reserve's software operating procedures, including step-by-step instructions for creating accounts, entering information, receiving CRTs, and transferring CRTs among accounts can be found in the Reserve's User Guide: http://www.climateactionreserve.org/how/program/documents/.

3.3.1 Fee Structure Summary

The Reserve imposes required fees that are charged to account holders during the project registration process (Sections 3.3.2 to 3.3.13). A summary of those fees is below:

Reserve Account Fees (Effective July 1, 2017) [16]	
Account Setup Fee	$500
Account Maintenance Fee (annual per project)	$500
Account Re-activation Fee	$500
Project Owner Account Setup Fee (for aggregated projects/cooperatives only)	$200
Project Owner Account Maintenance Fee (annual, for aggregated projects/cooperatives only)	$80
Project Submittal Fee under a Reserve Project Protocol (per project)	$500
Project Variance Review Fee (per request)	$1350
Project Transfer Fee (per project transferred between account holders, paid by the transferee)	$500
Project Registration Extension (per request)	$200
CRT Issuance Fee (per CRT issued)	$0.19
CRT Transfer Fee (per CRT transferred between account holders, paid by the transferor)	$0.03
Retirement (per CRT retired)	no charge

3.3.2 Account Registration

As a first step, an account must be set up with the Reserve. Account registration only needs to occur once; any number of projects can be registered under the same account.

[16] All fees in this table are limited to the Reserve's voluntary offset program. Fees related to the Reserve's work as an Offset Project Registry (OPR) under the California Cap-and-Trade system can be found at http://www.climateactionreserve.org/how/program/program-fees/

Any person or organization may apply for a Reserve account regardless of location or affiliation. Account applications are completed through the Reserve software. Along with completing an online application, each user must also agree to the legal Terms of Use for the Reserve. The Terms of Use binds users of both the Reserve software and the program itself to the terms laid out in the protocols, the Reserve Offset Program and Verification Manuals, and the Operating Procedures as modified from time to time. The Terms of Use document can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

When a new account is approved by the Reserve, the account holder will receive an invoice for the account maintenance fee. Payment is due within 30 days of approval to avoid cancellation of the new account.

Account management can be shared between the account owner and another party provided a Designation of Authority form has been completed (see Section 3.3.2.2).

3.3.2.1 Types of Accounts

There are six types of accounts in the Reserve:

1. **Project Developer**. An account type for organizations that wish to register projects that generate GHG reductions or removals. This account type can also be used to transfer and manage CRTs. Users of this account type are also able to function as project aggregators or cooperative developers, enabling the management of CRTs on behalf of multiple projects formally registered as part of an aggregation or cooperative, as allowed under certain protocols.
2. **Trader/Broker/Retailer**. This type of account allows the transfer and management of CRTs, but not registration of projects.
3. **Verifier**. An account type for verification bodies that have been trained and authorized by the Reserve to verify projects. There is no annual account fee for verification bodies.
4. **Reviewer**. This account type is only for those who have been asked by the Reserve to serve as a project reviewer. There is no annual account fee for reviewers.
5. **Client**. This type of account is for any individual or entity that wishes to retire CRTs but not develop its own projects.
6. **Project Owner (limited)**. This account type is designated for use by project participants participating in a cooperative or aggregate according to protocol-specific rules and procedures. This account type allows the registration of projects that are formally part of a cooperative or an aggregation. It is intended for use when the owner of the GHG reduction rights (the Project Owner) is not the entity carrying out project development activities in the registry system. This account type may also be used for limited transfers of CRTs under the terms and restrictions imposed by the relevant project protocol and/or aggregation guidance and does not include privileges for retiring CRTs.

The public also has the ability to view information on the Reserve, but an account is not needed to view publicly available information.

3.3.2.2 Designation of Authority

A project developer and trader/broker/retailer account holder may designate an agent to access the Reserve software on their behalf.

Account holders must complete the Designation of Authority form to specify agents besides themselves who will have access to all information contained in their account. An example of an account holder agent would be a technical consultant hired by the project developer to manage a project on their behalf.

An account holder agent will have all the rights and responsibilities of the account holder and will also be bound by the Reserve Terms of Use. The Designation of Authority form can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

3.3.3 Project Submittal

Project developers must complete and upload the appropriate project submittal forms for the project type and pay a project submittal fee to the Reserve. Submittal forms are specific to the project type and include project descriptions and preliminary information used to assess eligibility. The submittal forms for each type of project are available for download at http://www.climateactionreserve.org/how/program/documents/. A project is considered "submitted" when all of the appropriate forms have been completed, uploaded and submitted through the Reserve software.

3.3.4 Requests for Variances from Protocol Requirements

The Reserve will allow variances from protocol requirements only where Reserve staff determines that such variances are acceptable. Variances are only granted for deviations from requirements related to monitoring or measuring of GHG reductions or removals. The Reserve will not consider variances related to project eligibility criteria, or to the general methodological approaches for quantifying GHG reductions or removals specified in a protocol.

Reserve protocols are standardized documents developed through a transparent, stakeholder-driven process during which public input is solicited and considered thoroughly. Through this process, a single set of requirements and methodologies is established for all projects. If a requested variance diverges significantly from the approved methodology in a protocol, in that it requires extensive analysis of site-specific features and/or employs concepts not fully vetted through public consultation, the variance will be denied.

Variance requests that affect eligibility rules or methodological approaches cannot be granted, but if a request appears to have merit and may have application beyond a single project, it may be a candidate for future work and inclusion in future protocol revisions. Therefore, while a variance may not be approved at the time of submittal, the Reserve may elect to initiate work to explore the issue further if the resolution may be extrapolated, standardized, and used to inform future protocol revisions. If a future version of a protocol addresses the request for variance in such a way that the project would meet the requirements of the revised protocol, the project may be re-submitted and will not be deemed ineligible because of start date requirements (i.e., that the project must be submitted within six months of the project start date – see Section 2.4.3).

To submit a variance request, the project developer must complete and submit a Request for Project Variance form and pay the associated fee. No variance request will be considered until the project in question has been formally submitted to the Reserve. Each variance request is only applicable to a single project. A project developer seeking a similar variance on multiple projects must still submit a variance request for each project.

Upon receipt of the appropriate documentation and payment of the invoice, the Reserve will review the variance and will provide explicit, written acceptance to the project developer if the variance is approved. Decisions on variances are considered *sui generis* and are not precedent-setting. The Reserve retains the right to reject a variance, request further documentation or impose additional constraints and/or discount factors on the proposed monitoring or measuring methods. There is no process to appeal the denial of a variance; the decision to approve or deny a variance request lies solely with the Reserve. If the Reserve approves a variance request, a letter describing the variance granted will be sent to the project developer and will be made publicly available.

The Reserve also maintains a publicly-accessible Variance Tracking Log, which provides a summary list of all variance requests approved by the Reserve. The variance log can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

The Request for Project Variance form can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

3.3.5 Project Listing

Once the project submittal fee has been received, the Reserve reviews the forms to determine whether they are complete and conducts a preliminary assessment of the project's eligibility according to the eligibility criteria set forth within the appropriate project protocol. Once this review is satisfactorily completed, the project is "listed" and made publicly available on the Reserve. Project verification activities cannot begin until a project is listed. Review of submitted forms will generally take no more than 10 business days.

Note that a project may be verified against the protocol version in place at the time of project submittal as long as the project is verified by its verification deadline (see Section 3.4.2). As long as a project meets it verification deadline, a project developer is not required to verify against a new protocol version, even if one becomes effective in between the time a project is submitted and registered. Project developers always have the option, however, of voluntarily choosing to verify against the most recent version of a protocol at any time.

Listing a project does not constitute a validation or verification of the project or its eligibility; it is a preliminary review of project information provided to the Reserve by the project developer. It is not a final determination of the eligibility of the project, nor does it guarantee CRT issuance or CRT ownership. Project registration and CRT issuance is contingent upon the submission and approval of all required forms and documents for a particular project type, including, but not limited to:

- Attestation of Title (see Section 3.3.6)
- Attestation of Voluntary Implementation (see Section 3.3.7)
- Attestation of Regulatory Compliance (see Section 3.3.8)
- NOVA/COI form (see Section 3.3.9)
- Verification Report, Verification Statement, and List of Findings

The required forms and documents for registration under each project type can be found at http://www.climateactionreserve.org/how/program/documents/.

3.3.6 Attestation of Title

All project developers must submit a signed Attestation of Title form indicating that they have exclusive ownership rights to the GHG reductions or removals associated with the project and for which the Reserve will issue CRTs. In addition, the project developer agrees that ownership of the GHG reductions or removals will not be sold or transferred except through the transfer of CRTs in accordance with the Reserve Terms of Use policies.

This form shall be signed and submitted after the conclusion of each verification period for a project, as specified in each protocol. Note that the entity/individual signing the Attestation of Title (and the other attestation forms) must be the account holder who submitted the project. Projects will not be registered unless the account holder and signatory to the attestation forms match.

The Attestation of Title form can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

3.3.7 Attestation of Voluntary Implementation

All project developers must submit a signed Attestation of Voluntary Implementation form that confirms the project was implemented and established voluntarily and continues to operate as such. The project developer attests that at no time was the project required to be enacted by any law, statute, rule, regulation or other legally binding mandate by any federal, state, local or foreign governmental or regulatory agency having jurisdiction over the project.

This form is signed and submitted after the conclusion of each verification period (unless otherwise exempted by the protocol under which the project is registered). The Attestation of Voluntary Implementation, along with activities detailed in the project's monitoring plan, are the primary mechanisms by which the project passes the legal requirement test, as specified in each protocol.

The Attestation of Voluntary Implementation form can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

3.3.8 Attestation of Regulatory Compliance

All project developers must sign and submit an Attestation of Regulatory Compliance form after the conclusion of each verification period, as specified in each protocol. By signing this form, the project developer attests to the project's compliance status throughout the project verification period. The form identifies specific dates during the verification period over which the project was in material compliance with all laws. In addition, the form confirms that the project developer has disclosed to its verification body in writing any and all instances of non-compliance of the project with any law. The Attestation of Regulatory Compliance form and the accompanying disclosure to the verification body of non-compliance events are the primary mechanisms by which the project passes the regulatory compliance eligibility criterion, as specified in each protocol.

The Attestation of Regulatory Compliance form can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

3.3.9 Conflict of Interest Evaluation and Initiation of Project Verification

As described in Section 3.4, the Reserve requires third-party verification of all GHG reductions by an ISO-accredited and Reserve-approved verification body. Once the project developer has

selected a verification body, the verification body must submit a Notice of Verification Activities and Conflict of Interest (NOVA/COI) evaluation form to the Reserve at least 10 business days prior to the commencement of verification activities. This form includes the scope of proposed verification activities and other required information used to assess the potential for conflict of interest between the verification body and the project developer. In order for verification activities to begin, the Reserve must determine that the potential for conflict of interest between the project developer and the verification body is low or can be mitigated. The conflict of interest evaluation must be completed before verification activities can begin. The NOVA/COI form is available for download at http://www.climateactionreserve.org/how/program/documents/.

Once the conflict of interest evaluation is complete, the project developer must upload the required attestations and enter project data into the Reserve software, and then submit the project for verification. Required data is described in each protocol, and can include project information, monitored GHG emissions data, estimated GHG emission reductions, and other data required by the project monitoring guidelines. Once the project has been submitted by the project developer, the Reserve software automatically notifies the verification body that the project is ready for verification.

The verification body then reviews the project data in the Reserve software, performs verification activities, conducts site visits as needed, and verifies that the listed project has fully complied with the appropriate project protocol and that the GHG reductions or removals have been appropriately quantified. The verification body then submits a Verification Report, Verification Statement, and List of Findings through the Reserve software.

3.3.10 Approval of Verification and Project Registration

Once the verification body completes the Verification Statement, Verification Report, and List of Findings, the project developer reviews the verification body's documents and then formally submits the project to the Reserve for final approval of the verification. The Reserve reviews the submission for completeness, reviews the Verification Statement, Verification Report, and List of Findings, and either approves the verification or requests a re-submittal of one or more components. Upon approval, the project developer receives an invoice for the issuance of CRTs generated by the project.

A project becomes "registered" the first time it is verified and accepted by the Reserve. The status of the project then changes from listed to registered in the Reserve software. See Section 3.4 below and the Reserve Verification Program Manual for further information about the project verification cycle.

3.3.11 Project Completion

A project is considered "completed" when it is no longer reporting to the Reserve. A project may be considered completed because it reaches the end of its crediting period(s), becomes ineligible or the project developer voluntarily chooses not to continue reporting. The reason for the completed status is noted in the Reserve system. Once a project is completed, project information remains publicly available indefinitely.

3.3.12 Record Keeping

According to the Terms of Use, the Reserve has the right to examine, audit, and obtain copies of users' records from the most recent 12-month period. The Reserve does not anticipate this being a routine need, but rather a rare event to verify the accuracy of any attestation, transfer or

statement, or to review account holders' performance of obligations under the protocols, the Terms of Use or the Reserve's Operating Procedures.

Project developer account holders on the Reserve must also maintain copies of all relevant records related to their projects and associated account usage for the time period specified in each protocol.

3.3.13 Publicly Available Information

The Reserve is intended to serve both account holders and the interested public. To this end, information about each project registered with the Reserve is accessible to the public. This openness and transparency provides interested parties with valuable information and helps instill confidence in the Reserve and enhance the credibility of the offset credits it certifies.

The public and all account holders can access the following information online:

- **Participating companies.** Organizations that have an active Reserve account (address or contact information is not disclosed).
- **Projects.** Projects that are listed or registered with the Reserve. Rejected project submittals and projects that are de-listed prior to registration and/or CRT issuance are not displayed; however, information will be made publicly available indefinitely for any project to which CRTs have been issued, regardless of whether the project is completed, terminated or transferred to another program.
- **Project CRTs issued.** Projects for which CRTs have been issued along with the quantity of CRTs issued to each project. Current CRT balances in individual accounts are not automatically displayed.
- **Search of CRT serial numbers.** The Reserve software allows searching for a CRT serial number by batch number or block start or end numbers. This search feature is designed for someone who wants to see details about a given CRT batch (for example, a CRT buyer). It cannot be used to search every CRT issued for a company or project. Search results include whether the CRTs are active or retired and, if retired, the time and date of retirement.
- **Accounts disclosed to public.** Active or retired CRT balances that account holders have chosen to be shown to the general public.
- **Retired CRTs.** Displays the CRTs that have been retired by account holders.

Information that is never shared with the public includes:

- Company street addresses
- Company phone, fax or email addresses
- Internal company information, like billing addresses
- Any person's contact information

Account holders' contact information is not used by the Reserve except to notify users of important system occurrences and policy updates and is not shared with other parties.

3.4 Project Verification

The Reserve requires periodic third-party verification of all GHG projects, as specified in each project protocol. This provides an independent review of data and information used to register CRTs. For every project, a third-party verification body reviews documentation, monitoring data,

and procedures used to estimate GHG reductions or removals. The verification body submits a Verification Statement and Verification Report that provide the basis for determining the quantity of CRTs that can be issued to the project. The Reserve makes these documents publicly available. Verifiers conducting verification activities for projects listed or registered on the Reserve must be trained by the Reserve or its approved designees and employed by or subcontracted to an accredited verification body. A list of accredited verification bodies is available at http://www.climateactionreserve.org/how/verification/connect-with-a-verification-body/.

Verification bodies follow guidelines set forth in the Reserve Offset Program Manual and Verification Program Manual, as well as rules and procedures described in the specific verification guidance that is included in each project protocol.

3.4.1 Validation

Validation involves determining the project methodology and a project's eligibility to generate GHG reductions or removals. Unlike some other offset programs, the Reserve does not require that validation be conducted. Eligibility criteria and methodologies for emission reduction calculations are built into the Reserve protocols. Because the Reserve's eligibility criteria are mostly standardized, determination of eligibility is usually straightforward and requires minimal interpretative judgment by verification bodies. The first time a project is verified, verification bodies are required to affirm the project's eligibility according to the rules defined in the relevant project protocol. Project developers may choose to have a project verified without verifying CRTs for issuance in order to establish its eligibility for registration and provide more certainty to potential CRT buyers or sellers. However, when a project developer is seeking to register CRTs, a full verification must be conducted. See the Verification Program Manual for more information.

3.4.2 Reporting Period and Verification Period

GHG emission reductions are generally quantified and verified on an annual basis. Some protocols allow project developers to verify GHG emission reductions on a more frequent or less frequent basis if they desire. The length of time over which GHG emission reductions are quantified and reported to the Reserve is called a "reporting period." The length of time over which GHG reductions are verified is called a "verification period." Under some protocols, the reporting period and the verification period are identical, and no distinction is made between these terms (the protocol may refer only to a "reporting period"). Other protocols distinguish between the two and the maximum period for each is specified. Note that some protocols may allow the verification period to cover multiple reporting periods. However, the end date of a verification period must always correspond to the end date of a reporting period.

CRTs are issued according to the quantity of verified reductions achieved during a verification period, regardless of the period's length.

Reporting periods must be contiguous; there can be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.[17] Gaps in monitoring data or activity must be included in reporting periods and verified accordingly. The verification body must confirm that no reductions are claimed for any period for which a gap in monitoring data exists or for which a project was non-operational.

[17] There is an exception to this requirement for projects under the U.S., Article 5, and Mexico Ozone Depleting Substances Project Protocols. Under those protocols, reporting periods need not be contiguous.

3.4.3 Initial Verification and Registration

A project must complete verification within 12 months of the end of its initial reporting period. To satisfy this verification deadline, the project developer must submit a completed Verification Report and signed Verification Statement to the Reserve.

For project types that require annual verification at a minimum, the Verification Statement and Report may cover a maximum of 12 months of project activity, with the following exceptions. A pre-existing project (see Section 2.4.3) undergoing its initial verification and registration with the Reserve may submit a Verification Statement and Report that cover multiple years, back to the project's start date. This data is considered "historic data." Historic data may only be registered during a pre-existing project's initial verification with the Reserve. The Reserve also allows project developers to register more than 12 months of data during a project's initial verification period while still meeting the 12-month verification deadline (based on the maximum initial reporting period specified by each protocol), or register a project's initial verification period as a zero-credit reporting period (see Section 3.4.5).[18]

A project is considered "registered" when the project has been successfully verified by an approved third-party verification body, submitted by the project developer to the Reserve for final approval, and accepted by the Reserve.

A project that fails to meet its initial verification deadline must re-submit under the latest version of the applicable protocol. Projects that do so are not subject to the start date requirements in Section 2.4.3, provided that the project met all applicable requirements at the time of initial submittal.

If a project misses its initial verification deadline, the project is "de-listed"[19] in the Reserve software and is no longer viewable by the public. The Reserve will contact the project developer to inform them they must re-submit under the latest version of the protocol within 60 calendar days of notification.

If the project developer re-submits the project within 60 calendar days, the project is "re-listed"[20] under the same project ID and the project maintains its original start date. The project is given a new listing date.

If the project developer fails to re-submit within 60 calendar days, the project is cancelled. The project developer could still re-submit the same project at a later date, but it would be assigned a new project ID and would have to meet all the requirements of the applicable protocol, including start date requirements.

Projects that successfully re-list must submit either 1) a Verification Statement and Verification Report or 2) a Zero-Credit Reporting Period Acknowledgment and Election form within 12 months of re-submittal, with the following exceptions. Forest, urban forest, and nitrogen

[18] Forest and urban forest projects are not eligible for zero-credit reporting periods.
[19] "De-list" is not a phase in the Reserve software. De-listed projects will no longer appear to the public in the software.
[20] "Re-list" is not a phase in the Reserve software. Projects will be identified as "listed" in the software with the same project ID.

management projects are not eligible for zero-credit reporting periods and therefore must complete initial verification within 12 months of re-submittal.

If a re-listed project misses the deadline above, the project is cancelled. Again, the project developer could still re-submit the same project at a later date, but it would be assigned a new project ID and would have to meet all the requirements of the applicable protocol, including start date requirements.

3.4.4 Subsequent Verification

After a project is registered, a Verification Statement and Verification Report must be submitted within 12 months of the end of each subsequent verification period. The maximum allowed length of a verification period is specified in each protocol. For example, a Verification Statement and Report for GHG reductions achieved between January 1, 2015 and December 31, 2015 would have to be submitted by December 31, 2016. The only exception to the verification deadline is if the project developer has successfully applied for an extension or is taking a zero-credit reporting period (see Section 3.4.5 below).

The Reserve makes account holders aware of upcoming verification deadlines for projects in their account. Project developers that miss this verification deadline are notified and given the choice to:

A) cancel the project; or
B) continue the project by initiating verification using the latest version of the relevant protocol.

Once notified that the verification deadline has passed, a project developer has six months to choose one of the options above. If no choice is communicated to the Reserve within six months, the project is cancelled.

If a project developer chooses Option B, they are required to submit a Zero-Credit Reporting Period Acknowledgment and Election form and a monitoring report to retroactively cover the time period since the end date of the last successful verification period (see Section 3.4.5). Thus, the project developer acknowledges that CRTs will not be issued for any GHG reductions or removals achieved by the project since its last successful verification. They are also required to verify the project to the latest version of the relevant protocol.

A project utilizing Option B maintains its original project start date, and thus maintains the crediting period defined by that start date. This option may be used across two crediting periods should the project protocol allow for that.

If a verification period spans two crediting periods and there is a more recent version of the protocol that must be used for the renewed crediting period (see Section 2.4.4), the project developer can either be issued CRTs for two verification periods by completing separate verifications for each crediting period, or can be issued CRTs for one verification period that spans two crediting periods if they choose to verify the entire verification period to the more current protocol version.

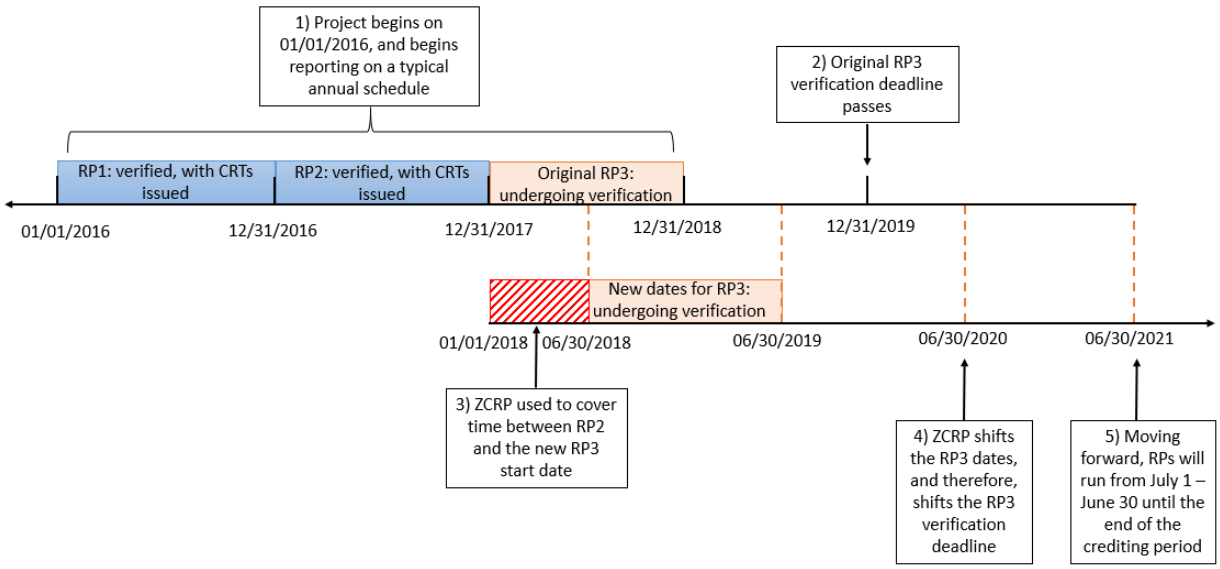
3.4.4.1 Subsequent Verification for Forest, Urban Forest, and Nitrogen Management Projects

The only exceptions to the options regarding a missed verification deadline detailed above are for forest, urban forest, and nitrogen management projects, as these project types are not eligible for a zero-credit reporting period. If a registered forest, urban forest, or nitrogen management project misses a subsequent verification deadline, project account activities will be suspended until the verification is complete. The project developer has 36 months from the end of the reporting period(s) being verified to complete verification. Otherwise, the project will be terminated.

3.4.5 Zero-Credit Reporting Period (ZCRP)

To provide flexibility for project developers in instances where verification is not practical or economical for a specific reporting period/verification period, developers of projects *other than forest, urban forest, and nitrogen management projects* may choose to delay verification on the condition that they acknowledge no CRTs will be issued for any period of time that falls outside the standard window for completing verification of project information and monitoring data. Such a period is referred to as a "zero-credit reporting period." In such cases, zero-credit reporting periods can be used to cover any time that falls between reporting periods that undergo verification. For most eligible project types, the maximum length of a verification period is 12 months, allowing CRTs to be issued only for GHG reductions achieved up to 24 months prior to submission of a Verification Report. See Figure 1 below for an example of a project using a ZCRP to cover time that falls between reporting periods, in order to extend the deadline for submission of a Verification Report.

Figure 1: Zero-Credit Reporting Period for a Project with a 12 Month Maximum Verification Period



For any zero-credit reporting period, the project developer must sign a Zero-Credit Reporting Period Acknowledgment and Election form (Acknowledgment and Election form) acknowledging that CRTs will not be issued for any GHG emission reductions or removals achieved by the project during the zero-credit reporting period. Along with the Acknowledgment and Election

form, the project developer must also submit a monitoring report to the Reserve that covers data for the zero-credit reporting period.

The Acknowledgment and Election form and monitoring documents shall be submitted via the Reserve software within 12 months of the end date allowed for a verification period (i.e., by the verification deadline). The monitoring report is not a publicly available document. The Acknowledgment and Election form is made public. The Acknowledgment and Election form and monitoring report are required in order to meet the regular documentation requirements of the Reserve program and ensure the continuation of a project's crediting period. CRTs for subsequent verification periods will not be issued until these documentation requirements are met. The submission of the monitoring report for a zero-credit reporting period will satisfy the requirement for contiguous reporting in Section 3.4.2.

If neither a Verification Report nor an Acknowledgment and Election form is submitted within 12 months of the end date allowed for a verification period, the project is either de-listed or cancelled (see Section 3.4.3, 3.4.2, and 3.4.4). Under certain circumstances, after a project has been de-listed or cancelled, it may re-enter the program, using zero-credit reporting periods to cover the time period when the project was not actively reporting. This is also possible in cases where the failure to maintain contiguous reporting has extended through the end of the crediting period if allowed by the relevant project protocol. In these cases, the zero-credit reporting period may cover a period of time spanning two crediting periods, and the second crediting period will be considered to have begun on the day following the end date of the initial crediting period. There is no limit to the amount of time a zero-credit reporting period may cover, and a project may have contiguous zero-credit reporting periods. Project developers may also declare a project's initial verification period as a zero-credit reporting period.

The Acknowledgment and Election form and project-specific monitoring report templates can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

3.4.6 Zero-Credit Reporting Period Verification

To ensure that project emissions were not greater than baseline emissions during a zero-credit reporting period, monitoring data collected during the zero-credit reporting period must be verified the next time the project undergoes verification. While the project is not required to conform to the protocol's monitoring and QA/QC procedures during a zero-credit reporting period, the verification body must be able to confirm with reasonable assurance that project emissions were less than baseline emissions during the zero-credit reporting period. Project developers shall provide project documentation and calculations for zero-credit reporting period emissions to the verifiers.

More information on the verification of zero-credit reporting periods can be found in the Verification Program Manual and the relevant project protocols. If the verifier cannot confirm with reasonable assurance that project emissions were less than or equal to baseline emissions, the Reserve will make a determination of action on a case by-case basis.

The Reserve views a zero-credit reporting period as a separate reporting period from the one undergoing verification for CRT issuance; to that end, the zero-credit reporting period should not be represented as part of the verification period that will be issued CRTs. For example, the dates of the verification period being issued CRTs shall not include the dates of the zero-credit reporting period. Similarly, for attestations that specify a beginning and end date, the time period

should not include the zero-credit reporting period (i.e., Attestation of Regulatory Compliance, Attestation of Voluntary Implementation).

3.4.7 Verification Deadline Extension Request

The Reserve allows project developers to request a project verification deadline extension. No extension requests are granted unless the project has commenced verification and has undergone the site visit for the current verification period (if applicable)[21] and all outstanding invoices for the project and account holder have been paid. The following extensions may be granted:

- Forest (U.S. and Mexico), grassland (U.S. and Canada), and urban forest projects may be granted a 12-month extension.
- Livestock (U.S. and Mexico), landfill (U.S. and Mexico), and nitrogen management projects may be granted a six-month extension.
- All other project types may be granted a 30-day extension if the account holder can demonstrate to the Reserve's satisfaction that they will miss the deadline due to extraordinary circumstances. The Reserve holds the right to determine what rises to the level of an extraordinary circumstance.

To submit a request, account holders must submit a completed Request for Verification Deadline Extension form and requested documentation to the Reserve and pay a $200 review fee. The form must be received by the verification deadline.

The Request for Verification Deadline Extension form can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

3.5 Stakeholder Input for Individual Projects

Direct and indirect stakeholder interaction is an integral part of the process for developing offset project protocols (see Sections 4.2 and 4.4). This includes comment periods that are open to the general public. At the project level, interactions generally involve those stakeholders with a commercial interest in the projects (e.g., facility owners, project developers, verifiers, consultants, CRT buyers, regulators, etc.). This section details avenues for non-commercial stakeholders to interact with the Reserve in relation to individual projects (rather than project protocols).

3.5.1 Local Stakeholder Consultations

Every Reserve protocol includes requirements to ensure that credits are only issued for emission reductions at projects that are in compliance with applicable regulations, and do no net environmental harm. In some cases, offset projects may have the potential to create social impacts on the local community, either positive or negative, which may not be appropriately handled by other, existing government structures. In those cases, the individual protocol may include additional requirements for local stakeholder consultations. In addition, every protocol development process, as well as every major protocol update, involves at least one public

[21] If the registration extension is being requested for a non-site visit year, evidence must be provided to show that the project developer has provided requested documentation to the verification team to allow them to commence the desk review.

comment period, with a public webinar. Local stakeholders are welcome to participate in any of these public events.

For example, the Mexico Forest Protocol provides social safeguards through prescriptive guidance about obtaining free, prior, and informed consent; meeting notification, participation, and documentation; and project governance. This ensures that the local community is able to participate in the offset project.

3.5.2 Feedback and Grievance Process

For any project type, it is possible that a stakeholder may want to contact the Reserve to provide feedback, either positive or negative. For general feedback or inquiries, stakeholders may contact the Reserve at reserve@climateactionreserve.org, or call the Reserve office at (213) 891-1444. For questions or comments related to a specific protocol, current points of contact are listed on our website at http://www.climateactionreserve.org/contact-us/.

The Reserve strives to avoid adopting protocols for activities that present a risk of negative environmental or social impacts. However, if a stakeholder has a grievance about a specific project, the initial point of contact would be the same as described above. The staff member receiving this initial contact will collect as much information as possible from the stakeholder about the specific project and grievance. This will then be communicated to the senior management at the Reserve, including the President. The specific action taken will depend on the nature of the grievance.

- For cases of a potential over-issuance, Reserve staff will conduct a thorough review and analysis, then ensure that the system is "made whole," according to the process detailed in Section 3.6.2 below.
- For disputes related to ownership of the GHG emission reductions, the Reserve senior management and legal counsel will review the positions and documentation of the parties involved and determine the appropriate owner (based on existing Reserve guidance related to ownership of GHG emission reductions), as well as whether any additional action against the project or the project developer is warranted. The Reserve will not be party to any disputes where the involved parties pursue actions beyond the Reserve issuing a determination as previously described.
- For grievances related to potential negative social or environmental impacts related to a Reserve project, which are not in violation of existing regulations (and thus handled by the relevant government agency), the Reserve senior management will conduct a finding of facts and consider the stakeholder's position. Such instances may be referred to the Board of Directors for a decision on project eligibility.

3.6 Climate Reserve Tonnes (CRTs)

In the Reserve, GHG reductions and removals are recognized as Climate Reserve Tonnes or CRTs, which are equal to one metric ton of carbon dioxide equivalent (CO_2e) reduced or sequestered. After projects are registered, CRTs are issued based on the GHG reduction or removal amount reported by the project developer and confirmed by an approved verification body. CRTs are issued only on an *ex post* basis (i.e., after verification that reduction activities have actually occurred) and only for GHG reductions or removals that occur within the project crediting period. For transparency, each CRT has a unique serial number with embedded information that identifies the project type, location, developer, and vintage. The unique serial number persists as CRTs are transferred between accounts or are retired and become offsets.

3.6.1 Issuance of CRTs

CRTs are issued by the Reserve for actual GHG reductions or removals achieved by a project, as determined in approved Verification Reports. Once a project is registered and the project's account holder pays the appropriate CRT Issuance Fee, CRTs for verified GHG reductions or removals are released into the account holder's primary CRT account. CRTs will not be issued until the CRT Issuance Fee is received by the Reserve. CRTs can then be transferred to another Reserve account holder's account, moved into one of the project account holder's other accounts or retired.

An account holder can only hold or retire CRTs in its account for which it is the sole holder of legal title and Beneficial Ownership Rights, except as permitted under Section 9 of the Terms of Use.

3.6.2 Over-Issuance of CRTs

In the event that the Reserve determines that GHG reductions or removals for a project were incorrectly quantified or reported, such that the number of CRTs issued to the project account holder was in excess of the correct number according to the requirements of the applicable protocol, it is primarily the project account holder's responsibility to compensate for the over-issuance of CRTs.

The Reserve will notify the project account holder of the over-issuance, including the basis for its determination, and the number of CRTs to be surrendered for cancellation or authorized to be withheld from issuance as further described below. The Reserve shall determine, at its sole discretion, which option or combination of options a project account holder may use; this will be determined on a case-by-case basis and detailed in the over-issuance notification.

Within 30 days, the project account holder must:

1. Surrender CRTs for cancellation; and/or
2. Provide written authorization to the Reserve to withhold CRTs from future issuances to the project.

If the project account holder fails to satisfy its obligations within 30 days, the Reserve may:

1. Cancel CRTs held by the project account holder;
2. Withhold from issuance CRTs otherwise issuable to the project account holder; and/or
3. Purchase CRTs from third parties at the project account holder's expense and cancel them.

The project account holder may dispute the over-issuance determination using the dispute resolution provisions set forth in Section 11(c) of the Climate Action Reserve Terms of Use.

3.6.3 Transfer of CRTs

In order to transfer CRTs to another party, that party must have an approved account with the Reserve. There is a transfer fee to transfer CRTs from one account holder to another ($0.03 per CRT charged to the transferor). The transfer is conducted via the software between the two account holders; the Reserve does not play a role in the transfer.

Note that the Reserve does not function as a trading system or commodity exchange. The sale or purchase of CRTs takes place outside of the Reserve. Account holders may record sales by

using the Reserve to move CRTs from one account to another. However, the Reserve makes no warranties concerning, and has no control over, the legal ownership of CRTs that may be held in individual accounts.

3.6.4 Retirement of CRTs

CRTs may be "retired" to indicate that the emission reductions or removals they represent have been used to satisfy a voluntary GHG emission reduction claim or to offset other emissions. To support such claims, CRTs are taken out of circulation so that they cannot be used to support any further claims. The Reserve retires CRTs by transferring them to a locked retirement account where they remain permanently and in perpetuity, precluding further use or transfer to other parties. Each account holder has its own associated retirement account. Information about retired CRTs is publicly available and includes details like project type, location, serial number, date issued, reason for retirement, etc. to support the transparency of the offsets within the Reserve. There is no charge to retire CRTs.

For the greatest level of transparency, Account Holders are encouraged to provide complete details of the purpose of the CRT retirement in the "Retirement Reason Details" field.

3.6.5 Holding and Retirement of CRTs on Behalf of Other Parties

In some circumstances, an account holder may hold and retire CRTs on behalf of one or more third parties. See Section 9 of the Reserve Terms of Use for related requirements.

3.6.6 Transferring Credits from the Reserve

Offset credits may be transferred to other GHG registries and offset programs under processes that are specific to the receiving registry/program.

3.6.6.1 VCS

CRTs may be exported to a Verified Carbon Standard (VCS) registry and converted into Verified Carbon Units (VCUs). Transfers may be initiated by any account holder with active CRTs. The account holder initiates this process as they would a CRT transfer. Once the transfer is accepted by the VCS registry administrator, the Reserve processes the transfer and VCUs are issued on the VCS registry. The exported CRTs have "converted to VCUs" noted as the cancellation reason in the Reserve software and public reports.

3.6.6.2 The California Compliance Offset Program

The Reserve is an approved Offset Project Registry (OPR) under the California Compliance Offset Program. Projects wishing to receive credits under one of the ARB's approved Compliance Offset Protocols (COPs) may do so through the Reserve's project registry. Registry Offset Credits (ROCs) are issued to projects in the Reserve's registry that have been listed under a COP. Following the issuance of ROCs, project proponents may request issuance of ARB Offset Credits (ARBOCs) from the California Air Resources Board. Upon approval, the Reserve is notified, and ROCs are cancelled and then re-issued as ARBOCs in the Compliance Instrument Tracking System Service (CITSS). The exported ROCs have "ARB" noted as the cancellation reason in the Reserve software and public reports.

3.7 Transferring Projects into the Climate Action Reserve

Existing projects that have been registered with other carbon offset programs may be transferred to the Reserve if they meet, and are successfully verified against, the Reserve's protocol requirements, and if they meet the project start date requirements detailed in Section

2.4.3. Such projects must submit a Registry Project Transfer Form, available for download at http://www.climateactionreserve.org/how/program/documents/. The Registry Project Transfer Form requires additional information and documentation to determine the status of the project and any offset credits issued for it under other programs.

The project developer must also provide the Reserve with a signed Project Transfer Letter before CRTs for that project are issued by the Reserve. The letter must be sent to the administrator of the other program where the project was registered, confirming that no further emission reductions or removals for the project will be verified or registered under the other program.

Transferred projects are considered pre-existing projects and thus are able to register more than 12 months of data during their initial verification with the Reserve (see Section 3.4.2). Transfer projects are also subject to contiguous reporting, which means that a project's initial verification period with the Reserve must be contiguous with the end of the last verification period under the program from which the project is transferred.

The crediting period for a transferred project will be reduced by the length of time that has elapsed since the project start date, as defined by each protocol.

Note that while projects can be transferred from another program to the Reserve, previously issued credits from another program cannot be transferred to the Reserve. Furthermore, projects that generated offset credits in the past but were never registered on a carbon offset registry cannot be registered with the Reserve.

3.8 Transferring Projects from the Climate Action Reserve

Projects may be transferred from the Reserve to other GHG registries and offset programs. To transfer a project, the developer shall provide a signed Project Transfer Letter to the Reserve specifying the effective date of transfer and confirming that no further emission reductions or removals for the project will be verified or registered with the Reserve.

Once a project is transferred, no future reductions or removals from that project will be registered as CRTs. Project information and previously issued CRTs will remain in the Reserve system under their given serial numbers. Previously issued CRTs may be transferred to other accounts on the Reserve system and retired on the Reserve system, as long as the project developer maintains an account with the Reserve. Section 3.6.3 of this manual describes how to transfer CRTs to other Reserve accounts.

3.9 Transferring Projects between Account Holders in the Reserve

Projects may be transferred between project developer account holders within the Reserve program. The project developer transferee (the project developer who is acquiring the project) must submit an Account Holder Project Transfer form and pay $500 per project transfer. The Reserve will review this form and the project will then be transferred to the new account holder. The original account holder will no longer have access to restricted (non-public) project information.

The Account Holder Project Transfer form can be downloaded at http://www.climateactionreserve.org/how/program/documents/.

3.10 Relationships to Other GHG Programs

The Climate Action Reserve operates as a stand-alone voluntary offset registry. However, the Reserve program does interact with other GHG programs in various ways. Relationships with several, major programs are detailed in this section.

3.10.1 Voluntary Carbon Offset Programs

Registration of projects using project protocols developed by the Reserve is limited to the Reserve's voluntary offset program and other carbon offset programs that have pre-existing agreements in place with the Reserve. If a project developer is seeking crediting under a project protocol developed by the Reserve under a different program, it is the project developer's responsibility to notify the Reserve and to ensure that there is such a pre-existing agreement in place.

It may be possible for a voluntary Reserve offset project to be simultaneously listed under another voluntary offset program, provided that there is no overlap in the GHG Assessment Boundaries of the relevant protocol(s) or methodology. All project developers wishing to take advantage of any such opportunity should seek guidance from the Reserve, and staff of the other voluntary offset program, as early as possible in that process, to ensure best chances for approval and avoidance of any double counting. Reserve staff will work directly with the project developer, and likely also staff from the other voluntary program in question, to ensure there is no double counting in such circumstances. Generally speaking, where GHG accounting boundaries do not overlap, it may be possible for a project to enroll in multiple offset programs, undertake one set of activities, and receive crediting from those multiple programs. However, such a determination shall be made on a case-by-case basis for each combination of Reserve protocol and external protocol or methodology.

3.10.1.1 The Verified Carbon Standard

The Reserve is the first recognized independent GHG offset program under the Verified Carbon Standard, a global standard and program for approval of credible voluntary offsets. As an approved VCS program, offset projects that meet the Reserve's protocols can generate VCS credits, known as VCUs. CRTs issued by the Reserve can also be converted to VCUs and transferred to a VCS registry (see Section 3.6.6). However, VCUs cannot be converted to CRTs; only projects registered with the Reserve using Reserve protocols are able to generate CRTs.

For more information on Verra's VCS Program, visit https://verra.org/project/vcs-program/.

3.10.2 The California Compliance Offset Program

The California Air Resources Board (ARB) administers a Compliance Offset Program for use under the state's economywide cap and trade program for GHG emissions. The project registry functions for this program are administered by approved Offset Project Registries (OPRs). The Reserve is an approved OPR. Projects wishing to receive credits under one of the ARB's approved Compliance Offset Protocols (COPs) may do so through the Reserve's project registry. Reserve staff are experts in the OPR procedures, as well as the application of the COPs, most of which are adapted from the Reserve's voluntary offset protocols. The Reserve issues Registry Offset Credits (ROCs), which are ultimately canceled and then reissued by the ARB as ARB Offset Credits (ARBOCs). The Reserve does not issue ARBOCs and does not have a connection with the Compliance Instrument Tracking System Service (CITSS) (the registry used by the Western Climate Initiative for tracking compliance instruments). In

instances where a project does not seek the issuance of ARBOCs for a given reporting period, the project may retire the ROCs for voluntary purposes (see Section 3.6.4) or seek the conversion of ROCs into CRTs.

For information on the Reserve's role as an Early Action Offset Program and Offset Project Registry for the California Compliance Offset Program, please see the following resources:

- Climate Action Reserve California Compliance Offset Program website http://www.climateactionreserve.org/how/california-compliance-projects/
- California Air Resources Board Compliance Offset Program website http://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm

3.10.3 The California Low Carbon Fuel Standard Program

The California Air Resources Board (ARB) administers a Low Carbon Fuel Standard (LCFS) Program for use under the state's plan for reducing GHG emissions. Certain project types that are eligible for CRTs and ROCs under the Reserve's voluntary and compliance offset project registry programs are also potentially eligible to receive LCFS credits for the generation and delivery of transport fuels (such as biogas) into California. This includes livestock anaerobic digestion projects and landfill gas capture and destruction projects. The Reserve does not issue or verify LCFS credits. Nor can CRTs or ROCs be directly converted into LCFS credits. However, in some cases the process of verifying and registering offsets through the Reserve may be a component of the project's process toward receiving and verifying LCFS credits. In cases where a Reserve offset project is also seeking LCFS credits, Reserve staff will work with ARB staff and the project developer to ensure that CRTs or ROCs are appropriately cancelled to reflect overlapping issuance in the LCFS program. In instances where a project cancels some, but not all ROCs from a given reporting period, in order to receive benefit in the LCFS program, the project may be able to retire the remaining ROCs or seek the conversion of those ROCs into CRTs.

In all cases, project developers must disclose to their verifiers the existence of any additional crediting or payment programs in which the project is participating concurrently with its registration through the Reserve.

3.10.4 The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

The International Civil Aviation Organization, a special body of the United Nations, has resolved to mitigate the growth in GHG emissions from international aviation beyond 2020 through the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The offsets portion of this program is designed to be decentralized, allowing for airlines to comply with their offsets obligations via retirement of eligible emission units issued by approved GHG programs.

As of this writing, no GHG programs have been approved by ICAO, and details around qualification of eligible emission units are not settled. The Reserve has applied for its offsets program to be approved for use by airlines to comply with CORSIA. At a later date, this document will be updated to reflect the process by which CRTs may be qualified and retired for use in CORSIA, including procedures to avoid double claiming of emission reductions.

For more information on CORSIA, please visit https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx.

3.10.5 Green-e Climate

Green-e Climate is a "global third-party certification program for carbon offsets," operated by the Center for Resource Solutions (CRS). This program could be viewed as a "meta" certification, applying its label to offsets issued by specific GHG programs it has decided to endorse. The Climate Action Reserve's voluntary offsets program is one such endorsed program. Thus, CRTs may be certified as Green-e Climate carbon offsets. Regardless of this additional certification, CRTs remain within the Reserve's registry, with the original serial numbers and no additional requirements from the Reserve program.

For more information on the CRS's Green-e Climate program, visit https://www.green-e.org/programs/climate.

4 Project Protocol Development Process

The Reserve is committed to producing high quality GHG project accounting protocols, and to this end uses an intensive multi-stakeholder process to develop its project protocols. This approach integrates extensive data collection and analysis with review and input from a diverse range of experts and stakeholders. Reserve staff guides this process to ensure that final protocols adhere to the principles outlined in Section 1.2. This process produces high quality, well-vetted, and credible protocols based on best practices from national and international standards. This section details the Reserve's unique and rigorous project protocol development process.

4.1 Screening Process

The Reserve uses an internal screening process to identify candidate project types with good potential for offset protocol development. The Reserve takes into consideration a number of issues when assessing a project type for further development, including:

- Does the project type create direct or indirect emission reductions? All else equal, the Reserve will focus on project types that result in direct reductions. Direct emission reductions are generally easier to verify because the sites where they occur can be directly monitored. When emission reductions occur at sites or sources owned by the project developer, there is also less risk that an entity other than the project developer will claim ownership of the reductions. Thus, these projects are unlikely to be at risk for double counting or ownership issues.

- How amenable is the project type to standardized additionality and baseline determinations? For some types of projects, it is difficult to credibly and accurately determine additionality and estimate baseline emissions on a standardized basis. In general, the Reserve will avoid developing protocols for these project types. Alternatively, the Reserve may incorporate project-specific methods or variables into standardized protocols as appropriate, or limit the scope of protocols to address only activities and conditions for which standardized approaches are feasible.

- What is the likelihood that the sector where the project activity occurs will be covered under a future cap-and-trade system? Since issuing offset credits for reductions that occur at capped emission sources would result in double counting, the Reserve prefers to focus on projects affecting GHG emissions that are unlikely to be capped.

- What are the total potential GHG reductions that could result from this type of project? As it takes significant effort and resources to produce a standardized project protocol, there should be large and geographically diverse potential reduction opportunities.

- Are there potential positive or negative environmental or social impacts from this type of project activity or the operations, facilities or sectors with which this type of project may be associated? Negative effects should be avoided. All else equal, the Reserve will prioritize sectors and project types that can create significant co-benefits for the habitats and communities where projects take place. Where necessary, the Reserve will also consider developing additional criteria for ensuring environmental and social safeguards.

- Are there existing methodologies or protocols that could serve as a starting point? Standardized protocols are more easily developed where sound scientific methods already exist to determine baselines and quantify emission reductions.

- Are there high quality datasets to evaluate "business as usual" activities for the sector in which the project activity occurs? Setting performance thresholds and other standardized tests for additionality requires defensible data on the current state of the sector.

Once the internal screening process is complete, project types with good potential are either explored more fully through the development of an issue paper or the Reserve holds a scoping meeting to engage stakeholders in further evaluating what types of activities should be targets for protocol development.

4.1.1 Issue Paper

An issue paper evaluates the feasibility and desirability of developing a protocol (or set of protocols) for a particular project type. It assesses possible issues with developing a standardized protocol for the project type, including an evaluation of potential approaches to GHG emission quantification; exploration of options for defining eligible project activities; evaluation of approaches to setting project boundaries; and assessment of the availability of datasets and other pertinent information. It also assesses the environmental and social impacts associated with prospective project activities, as well as potential impacts from the operations, facilities or sectors with which project activities may be associated. Issue papers are prepared by researching existing sector methodologies and datasets and consulting sector experts. After completion, the issue paper may be sent to interested parties (industry experts, environmental groups, state agencies, academics) for review and comment.

4.1.2 Scoping Meeting

Interested parties may be invited to a scoping meeting to discuss protocol development options and challenges for the project type in question. At the scoping meeting stage, the Reserve will generally propose a series of activities within the project type category for which specific accounting and verification standards could be developed. Feedback from the scoping meeting is used to determine whether the Reserve will move forward in developing a protocol, and which activities the protocol should encompass.

4.2 Development Process

After a project type is identified, the Reserve follows a rigorous multi-stakeholder consultation process to develop an appropriate protocol.

4.2.1 Workgroup Assembly

To initiate the project protocol development process, the Reserve assembles a balanced multi-stakeholder voluntary workgroup, drawing from industry experts, state and federal agencies, environmental organizations, and other various stakeholders. Workgroups are assembled by invitation, but all parties are encouraged to express their interest in participating in the workgroup process. Throughout the protocol development process, the workgroup provides expert review and direct input into the development of the project protocol.

Interested stakeholders that are not on the workgroup can still participate in the workgroup process as "observers." Any individual is welcome to be an observer to a protocol development

process. Observers can listen to workgroup meetings via conference call, but are not solicited for comments or feedback until the public review period.

4.2.2 Options Paper

Where appropriate, the Reserve may develop an options paper to further address and lay out different approaches for key elements of the protocol. A draft is shared with the workgroup and comments are incorporated into a final options paper that forms the basis of the draft protocol.

4.2.3 Draft Protocol for Workgroup Review

The Reserve develops a draft protocol based on expert input and insights from an issue paper or the final options paper. The draft protocol is released to the workgroup for review and revision and is also posted on the Reserve's website for review by observers and other interested members of the public. The draft protocol review process usually includes at least one or more in-person workgroup meetings in which members are invited to discuss issues at length. At this point in the process, the Reserve explicitly requests input on possible environmental and social harms associated with project activities and associated operations or facilities, and requests discussion of whether existing legal and regulatory safeguards are appropriate and adequate to mitigate any harms.

Written comments from the workgroup are incorporated into the draft protocol, which may go through multiple iterations of workgroup review before it is ready for public review. Note that observers and the public do not comment on the draft protocol at this stage.

4.2.4 Public Review Period and Public Workshop

The revised draft protocol is posted on the Reserve's website for a 30-day public comment period. The public is notified via the Reserve's listserv database and other venues, and reviewers are asked to submit written comments. During the 30-day public review period, the Reserve also hosts a public workshop to solicit feedback and address concerns regarding the draft protocol in an open forum. After receiving written feedback, all comments are recorded and addressed. A final protocol is produced, taking into account public comments and any further workgroup feedback.

4.2.5 Board Approval

The Reserve's Board of Directors must vote to adopt each project protocol. Protocols are presented at quarterly board meetings, which are open to the public, and issues raised throughout the development process are reviewed, giving workgroup members and interested stakeholders a chance to raise any last concerns or questions. After the Board adopts the protocol, it becomes an official Reserve protocol and is immediately available for use.

4.2.6 Ongoing Public Feedback and Comments

After Board approval, the Reserve continues to solicit, document, and respond to public feedback and comments on the current version of the project protocol. Comments and feedback on adopted protocols can be submitted to the Reserve at policy@climateactionreserve.org. The public is also welcome to contact Reserve staff directly to discuss their comments and concerns.

Public feedback and comments are assessed on an ongoing basis and may initiate a revision to a project protocol.

4.3 Revisions to Project Protocols

After Board approval, the protocols are periodically revised in light of public comments, on-the-ground experience, and technological, scientific, and regulatory developments. In addition, the Reserve may review and update performance standards and standardized baselines to ensure they continue to effectively screen projects for additionality and accurately represent "business as usual" emissions. There are two types of revisions to project protocols: policy revisions and program revisions.

4.3.1 Policy Revisions

Policy revisions are those that affect project definition or eligibility, or that involve significant changes or adjustments to baseline estimation and/or the quantification of emission reductions or removals. A policy revision is generally focused on specific elements of the protocol and is not necessarily an opportunity to revisit all decisions made in the initial protocol development process.

Depending on the extent of the revision, the Reserve may convene an expert stakeholder group or reach out to stakeholders involved in the initial protocol development process. This group may be asked to comment on a revised draft protocol or be convened to discuss key issues prior to changes being circulated for comment. All policy revisions require a 30-day public comment period and adoption by the Reserve's Board. Policy revisions are brought for adoption at the quarterly board meetings or are brought to the executive committee of the Board for adoption if expedited action is required. When adopted, a policy revision creates a new version of the project protocol (e.g., Version 1.0 undergoes a policy revision to become Version 2.0).

4.3.2 Program Revisions

Program revisions are editorial or technical in nature and do not require a public comment period, nor do they require adoption by the Reserve's Board. These revisions do not significantly change the policies or eligibility in the project protocol, but can change or revise quantification methodologies or monitoring requirements. Program revisions create a new sub-version of the protocol (e.g., Version 1.0 undergoes a program revision to become Version 1.1). Program revisions are considered adopted on the date they are posted on the Reserve website. A protocol revision notification is sent to the Reserve's listserv and to Reserve account holders at that time.

4.3.3 Grace Period for Registration under Prior Protocol Versions

Project developers have 90 days from the date on which a revised protocol is adopted to submit a project to the Reserve using the previous version of the protocol. The project must still complete verification within 12 months of the end of its initial reporting period. Otherwise, the project must be resubmitted for registration under the most current version of the protocol.

Projects that have been registered using a previous version of the protocol are not required to have their projects verified under any updated versions. Instead, projects may continue being verified against the original protocol version for the duration of their crediting period. Project developers always have the option, however, of voluntarily choosing to verify against the most current version. Applying the most current protocol to a project does not change the project's crediting period.

4.3.4 Errata and Clarifications

If typographical errors are found in a protocol after it is released, the Reserve may issue an "Errata" document indicating required corrections. Errata are issued to correct typographical errors in text, equations or figures. Similarly, if the Reserve discovers that certain protocol requirements are ambiguous or in need of further guidance, the Reserve may issue a "Clarifications" document. Clarifications are issued to ensure consistent interpretation and application of the protocol.

Errata and Clarifications documents become effective immediately for the version(s) of the protocol to which they apply (applicable versions are identified in each document). Project developers and verification bodies must refer to and follow the corrections and guidance presented in Errata and Clarifications documents once they are issued. Errata and clarifications are considered effective on the date they are first posted on the Reserve website. All listed and registered projects must follow the guidance specified in the Errata and Clarifications document. On a case-by-case basis, in order to ensure that the protocol is consistently applied and that the purpose of the protocol is achieved, the Reserve has sole discretion to apply current errata retroactively to a project for which CRTs have been issued prior to the release of the errata that may affect quantification of its GHG reductions and/or CRTs issued.

All account holders and verification bodies will be notified if an Errata and Clarifications document is released or updated. Errata and Clarifications documents will be appended to all applicable versions of the protocol and will also be available as stand-alone documents on the relevant protocol's webpage. The errata and clarifications identified in these documents will be incorporated into subsequent versions of the relevant protocol.

4.4 Communication with the Public

Current versions of each project protocol and information about protocols in development are available at http://www.climateactionreserve.org/how/protocols/. Each project protocol also has its own dedicated webpage that can be accessed from here.

Interested members of the public can receive protocol development announcements and program updates by joining the Reserve's mailing list at http://www.climateactionreserve.org/news-and-events/newsletter/.

5 Glossary

Business day	Any day except Saturday, Sunday or a Federal Reserve Bank holiday. A business day shall open at 8:00 a.m. and close at 5:00 p.m. Pacific Prevailing Time.
Client	In the Reserve software system, a "client" is an organization or individual who wishes to retire CRTs but does not develop its own projects.
Climate Action Reserve	The national offsets program that establishes standards for quantifying and verifying GHG emission reduction projects, issues carbon credits generated from such projects, and tracks the transfer and retirement of credits in a publicly-accessible online system.
Climate Reserve Tonne or CRT	The unit of offset credits used by the Climate Action Reserve. One Climate Reserve Tonne is equal to one metric ton of CO_2e reduced or sequestered.
Completed	A project is considered "completed" when it is no longer reporting to the Reserve. A project is completed if it reaches the end of its crediting period(s), becomes ineligible, or if the project developer chooses not to continue reporting. The "completed" designation is also used for certain early action projects to indicate that the monitoring, reporting, and verification (MRV) requirements under the Reserve's Early Action Offset Program have been satisfied, and that the project will continue MRV requirements under the Compliance Offset Program. The reason for the completed status is noted in the Reserve's public reports. Once a project is completed, project information remains publicly available indefinitely.
Group Retirement Subaccount	The subaccount for the retirement of CRTs that are held by an account holder on an omnibus basis on behalf of one or more third parties that hold legal title and/or beneficial ownership rights in those CRTs.
Listed	A project is considered "listed" once the Reserve has satisfactorily reviewed all project submittal forms. The project will then appear in the public interface of the Reserve system.
Offset	A reduction or removal of GHG emissions from the atmosphere that is used to compensate for an equivalent amount of emissions from another GHG emitting activity occurring elsewhere. For the purposes of the Reserve program, a CRT becomes an offset when it is retired.
Project developer	An organization or individual that registers projects for the purpose of generating emission reductions or removals. In the Reserve software system, project developers may be issued CRTs for the verified emission reductions or removals that their projects achieve. They can also transfer and manage CRTs.
Project owner (limited)	An organization or individual representing a landowner participating in a cooperative or aggregate according to protocol-specific rules and procedures. In the Reserve software system, project owners may register projects that are formally part of a cooperative or an

	aggregation. This account type may also be used for limited transfers of CRTs under the terms and restrictions imposed by the relevant project protocol and/or aggregation guidance and does not include privileges for retiring CRTs.
Project protocol	A Reserve-developed document that contains the eligibility rules, GHG Assessment Boundary, quantification methodologies, monitoring and reporting parameters, etc. for a specific project type. Project protocols are akin to "methodologies" in other offset programs.
Reduction	A verified decrease in GHG emissions caused by a project, as measured against an appropriate forward-looking estimate of baseline emissions for the project.
Registered	A project is considered "registered" when the project has been verified by an approved third-party verification body, submitted by the project developer to the Reserve for approval, and accepted by the Reserve.
Removal	A verified increase in carbon stocks caused by a forest project, as measured against an appropriate forward-looking estimate of baseline carbon stocks for the project.
Reporting period	A discrete period of time over which a project developer quantifies and reports GHG reductions to the Reserve.
Retired	When CRTs are transferred to a retirement account in the Reserve system, they are considered retired. Retirement accounts are permanent and locked, so that a retired CRT cannot be transferred again. CRTs are retired when they have been used to offset an equivalent tonne of emissions or have been removed from further transactions on behalf of the environment.
Submitted	A project is considered "submitted" when all of the appropriate forms have been completed, uploaded, and submitted to the Reserve software.
Trader/Broker/Retailer	An organization or individual that transfers and manages CRTs in the Reserve system, but does not develop its own projects.
Transitioned	An early action project is considered "transitioned" when the project has been listed and successfully completed a verification under the Compliance Offset Program, but has any number of early action-eligible CRTs remaining active or retired in the Reserve program. The project is no longer reporting or seeking credits under the requirements of the relevant Reserve protocol, but is required to meet the MRV requirements of the California Cap-and-Trade Regulation.
User	An individual or entity that holds an account with the Reserve and has agreed to the Terms of Use and shall include such representative as the entity shall appoint and designate by completing the Designation of Authority form.
Verified	A project is considered "verified" when the project verification body has submitted the project's Verification Statement and the Verification Report in the Reserve system.
Verification body	An organization or company that has been ISO-accredited and

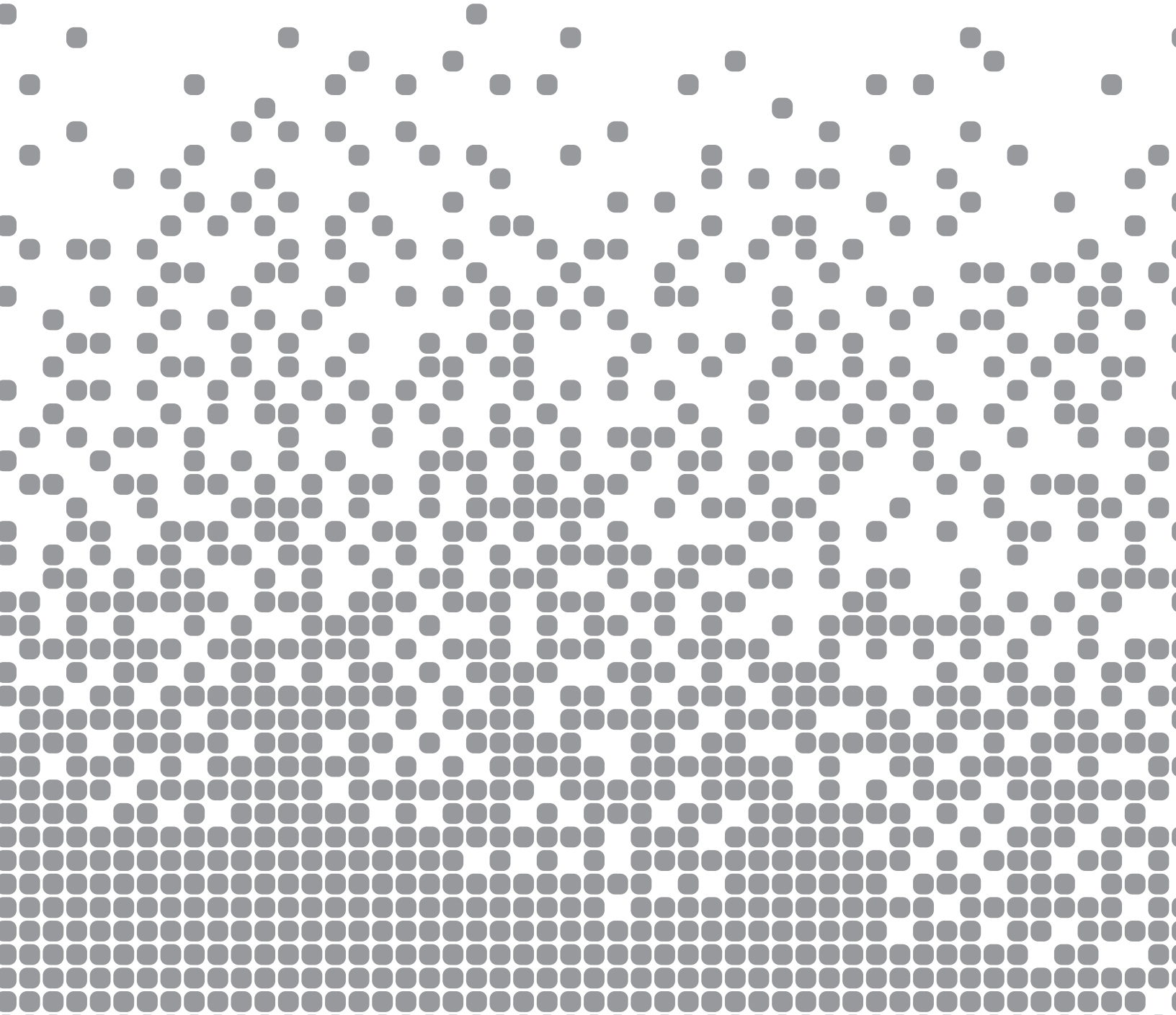
	approved by the Reserve to perform GHG verification activities for specific project protocols.
Verification period	A discrete period of time over which a project's GHG reductions are verified. Under some protocols, a verification period may cover multiple reporting periods. The end date of a verification period must correspond to the end date of a reporting period.
Verifier	An individual that is employed by or subcontracted to an ISO-accredited and Reserve-approved verification body and is qualified to provide verification services for specific project protocols.

CLIMATE ACTION RESERVE

Version 1.1 | October 26, 2012

Coal Mine Methane

Project Protocol



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Released October 26, 2012

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Tim Kidman
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The Reserve would like to thank SAIC, and Chris Minnucci in particular, for their work on the performance standard analysis and ongoing support of Reserve staff throughout the protocol development process.

The Reserve also recognizes the Coal Mine Methane workgroup for their generous contribution of time and expertise, as well as other members of the public who actively participated in the protocol development process.

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Table of Contents

Abbreviations and Acronyms 1

1 Introduction 2
2 The GHG Reduction Project 3
2.1 Background 3
2.2 Project Definition 5
2.2.1 Drainage Projects 6
2.2.2 Ventilation Air Methane Projects 7
2.2.3 Non-Qualifying Devices 7
2.3 The Project Developer 8
3 Eligibility Rules 9
3.1 Location 9
3.2 Project Start Date 9
3.3 Project Crediting Period 9
3.4 Additionality 10
3.4.1 The Legal Requirement Test 10
3.4.2 The Performance Standard Test 11
3.5 Regulatory Compliance 12
4 GHG Assessment Boundary 14
5 Quantifying GHG Emission Reductions 19
5.1 Quantifying Baseline Emissions 21
5.1.1 Calculating Baseline Carbon Dioxide Emissions from Methane Destruction 22
5.1.2 Calculating Baseline Methane Emissions 24
5.2 Quantifying Project Emissions 28
5.2.1 Project Emissions from Energy Required for Methane Collection, Transport, and Combustion 28
5.2.2 Project Emissions from Destruction of Captured Methane 29
5.2.3 Project Emissions from Uncombusted Methane 33
6 Project Monitoring 34
6.1 Monitoring Requirements 34
6.1.1 Arrangement of CMG Metering Equipment 35
6.2 Instrument QA/QC 36
6.3 Missing Data 37
6.4 Monitoring Parameters 38
7 Reporting Parameters 43
7.1 Project Documentation 43
7.1.1 Documentation of Project Expansions 43
7.2 Joint Project Verification 44
7.3 Record Keeping 44
7.4 Reporting Period & Verification Cycle 45
8 Verification Guidance 46
8.1 Verification of Multiple Projects at a Single Mine 46
8.2 Standard of Verification 47
8.3 Monitoring Plan 47
8.4 Verifying Project Eligibility 47
8.5 Core Verification Activities 48
8.6 Coal Mine Methane Verification Items 48
8.6.1 Project Eligibility and CRT Issuance 49

8.6.2 Quantification of GHG Emission Reductions 49
8.6.3 Risk Assessment 51
8.7 Completing Verification 51
9 Glossary of Terms 52
10 References 55

Appendix A Summary of Performance Standard Development 57
Appendix B Emission Factor Tables 68
Appendix C Data Substitution Guidelines 70

List of Tables

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs 16
Table 6.1. Coal Mine Methane Project Monitoring Parameters 38
Table 8.1. Summary of Eligibility Criteria 47
Table 8.2. Eligibility Verification Items 49
Table 8.3. Quantification Verification Items 50
Table 8.4. Risk Assessment Verification Items 51
Table A.1. Historical Trends in Mines Using Methane Drainage and Capture/Utilization 59
Table A.2. Summary of Drainage System Type and Utilization at Longwall Coal Mines 63
Table A.3. Regional Analysis of Methane Utilization among Mines with Drainage Systems 65
Table B.1. CO_2 Emission Factors for Fossil Fuel Use 68
Table B.2. Default Destruction Efficiencies for Combustion Devices 69

List of Figures

Figure 2.1. Schematic of Degasification Types 5
Figure 4.1. Illustration of the GHG Assessment Boundary for VAM Projects 14
Figure 4.2. Illustration of the GHG Assessment Boundary for Drainage Projects 15
Figure 5.1. Organizational Chart for Equations in Section 5 19
Figure A.1. Histogram of Drainage System Usage by Longwall Mines 61
Figure A.2. Ventilation and Drainage System Emissions, 2007 (million cubic feet) 66

List of Equations

Equation 5.1. GHG Emission Reductions 20
Equation 5.2. Converting CMG Volumes to Metric Tons of CMM 21
Equation 5.3. Baseline Emissions 21
Equation 5.4. Baseline CO_2 Emissions from CH_4 Destruction by Non-Qualifying Devices 23
Equation 5.5. Baseline CH_4 Released to the Atmosphere 25
Equation 5.6. Eligible CMM from Surface Pre-mining Boreholes 27
Equation 5.7. Project Emissions 28
Equation 5.8. CO_2 Emissions from Fossil Fuel and Grid Electricity 29
Equation 5.9. CO_2 Emissions from Destruction of Captured CH_4 30
Equation 5.10. CH_4 Destroyed by VAM Oxidation 31
Equation 5.11. CH_4 Destroyed by Other (Non-VAM) Destruction Devices 32
Equation 5.12. Adjusting CMG Flow for Temperature and Pressure 32
Equation 5.13. Uncombusted CH_4 Emissions 33
Equation B.1. Calculating Heat Generation Emission Factor ($EF_{heat,y}$) 69

Abbreviations and Acronyms

ACM	Approved consolidated baseline and monitoring methodology under CDM
CAA	Clean Air Act
CDM	Clean Development Mechanism
CH_4	Methane
CMG	Coal mine gas
CMM	Coal mine methane
CNG	Compressed natural gas
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CRT	Climate Reserve Tonne
EIA	Energy Information Administration
GHG	Greenhouse gas
HMM	Coal mine methane from horizontal pre-mining
ISO	International Organization for Standardization
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquid natural gas
MSHA	Mine Safety and Health Administration
NMHC	Non-methane hydrocarbon
NOV	Notice of Violation
NOVA/COI	Notification of Verification Activities/Conflict of Interest
PMM	Coal mine methane from post-mining (gob wells)
QA/QC	Quality assurance/quality control
SMM	Coal mine methane from surface pre-mining
SSR	Sources, sinks and reservoirs
UNFCCC	United Nations Framework Convention on Climate Change
U.S. EPA	United States Environmental Protection Agency
VAM	Ventilation air methane
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

1 Introduction

The Climate Action Reserve (Reserve) Coal Mine Methane Project Protocol provides guidance to account for, report and verify greenhouse gas (GHG) emission reductions associated with destroying methane from active underground coal mines that would have otherwise been vented to the atmosphere from degasification systems, including drainage systems and ventilation systems. The protocol focuses on quantifying the change in methane emissions, but also accounts for effects on carbon dioxide emissions.

As the premier carbon offset registry for the North American carbon market, the Climate Action Reserve works to ensure environmental benefit, integrity, and transparency in market-based solutions that reduce GHG emissions. It establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, issues carbon credits generated from such projects and tracks the transaction of credits over time in a transparent, publicly-accessible system. By facilitating and encouraging the creation of GHG emission reduction projects, the Climate Action Reserve program promotes immediate environmental and health benefits to local communities, allows project developers access to additional revenues and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501c(3) nonprofit organization based in Los Angeles, California.

Project developers that install coal mine methane destruction technologies use this document to register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve's Verification Program Manual and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a coal mine methane project.[1]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Methane is formed during the same geologic process that converts vegetative matter to coal; coal mining and post-mining processes release this methane from the coal and surrounding rock to the atmosphere. The amount of methane contained in and around a coal seam tends to be correlated with the amount of geologic pressure on the seam, which in turn depends on the seam depth.

When combined with air in concentrations of 5 to 15 percent, methane released by mining activity is explosive within the mine atmosphere. All underground coal mines in the United States are required to establish and maintain ventilation systems meeting detailed specifications set forth in federal regulations; these regulations are enforced by the Mine Safety and Health Administration (MSHA). Under the MSHA regulations, methane concentrations must be kept below 1 percent at the working face. Degasification is therefore an integral and critically important component of the underground mining process. Two primary degasification techniques are available to the operator: ventilation and methane drainage. Methane emissions are vented through mine ventilation shafts or methane drainage wells designed for the express purpose of removing the methane from the mine and venting it to the atmosphere.

Ventilation

The primary purpose of ventilation systems is to (1) dilute the methane in the mine air, and (2) remove the methane from the mine. Clean intake air is drawn into the mine from above ground through intake air shafts and/or horizontal drift entries, where it is channeled through the intake airways to the face, and then through the "returns" to a return air shaft(s) and/or drift entry(ies). The energy needed to move the large quantities of air required under the MSHA regulations through the ventilation system is provided by high-powered exhaust mine fans located on the surface at the return air shaft(s). Upon passing up the return air shaft(s) and through the fan, the mine air, including diluted methane, is vented to the atmosphere.

The ventilation systems emit highly dilute concentrations of the methane; typically the mine air vented from return air shafts is less than 1 percent methane. In this protocol, coal mine methane in mine air emitted through ventilation systems is referred to as ventilation air methane or "VAM."

Methane Drainage

At very gassy mines, ventilation is typically supplemented with methane drainage systems designed to remove methane either in advance of, or behind, the working face. These systems involve drilling boreholes, either from the surface or inside the mine, to drain methane from the coal seam, surrounding strata, or underground workings, thereby reducing the amount of methane that has to be handled by the ventilation system.

There are three main types of drainage systems, which may be employed in isolation or in combination with one another:

- Surface pre-mining boreholes
- Horizontal pre-mining boreholes
- Post-mining (or gob) boreholes

Each of these three system types are described in more detail below. Note that the protocol distinguishes between *coal mine gas* (CMG), which is the gas that comes out of the boreholes before any processing or enrichment and often contains various levels of other compounds (e.g. nitrogen, oxygen, carbon dioxide, hydrogen sulfide, NMHC, etc.) and *coal mine methane* (CMM), which represents only the methane portion of CMG.

Surface Pre-Mining Boreholes

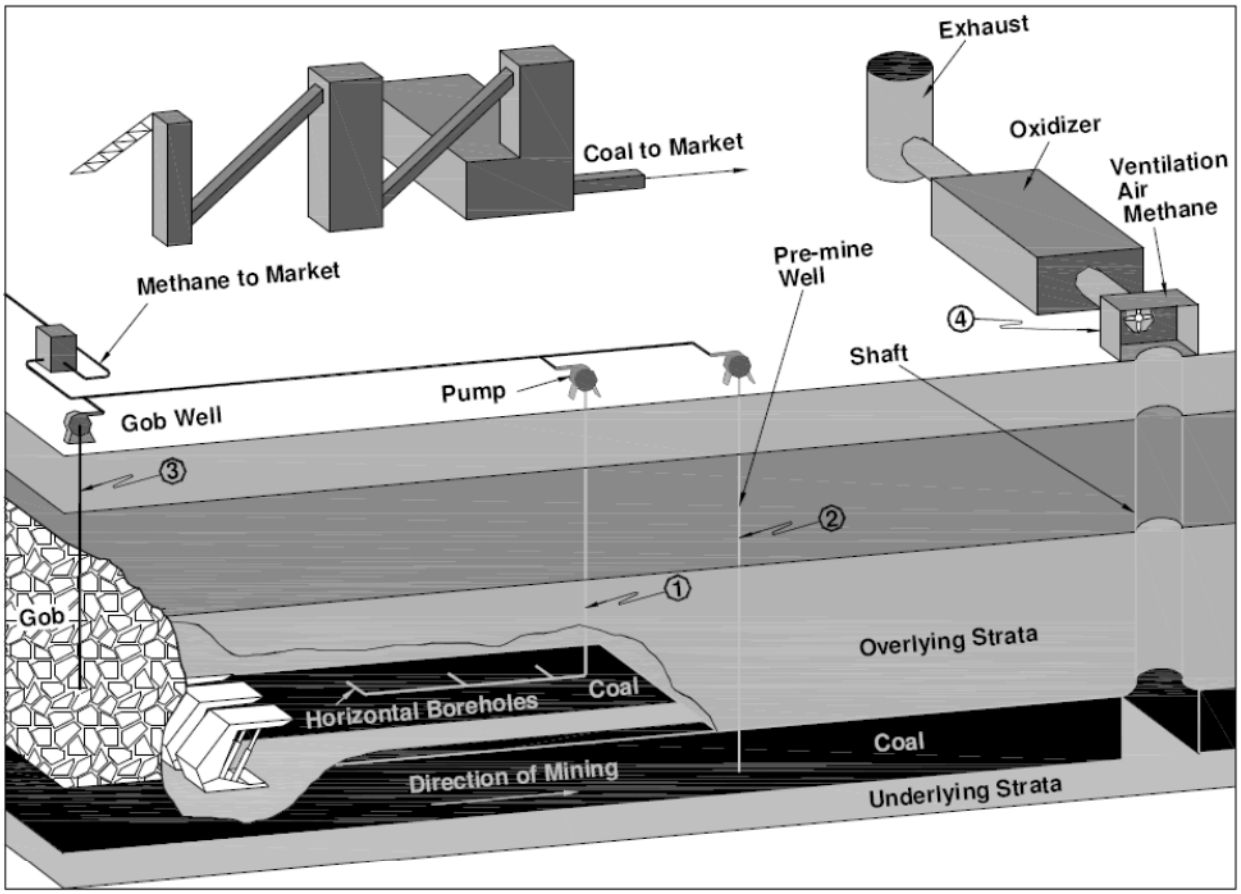
Surface pre-mining boreholes, or wells, are drilled from the surface to unmined portions of the coal seam in advance of mining (see Figure 2.1). They may be vertical, vertical to lateral, or even close to horizontal in their orientation. Surface-to-seam boreholes (otherwise known as surface-drilled directional boreholes) fall into this category. All of these surface pre-mining boreholes collect methane both from the seam itself, as well as from strata lying above the seam. Surface pre-mining wells may be drilled in locations that are not scheduled to be mined through for months or years; sometimes surface pre-mining wells are drilled before the associated mine even opens. Because they are drilled into virgin coal instead of the underground workings, pre-mining surface wells produce a high quality gas that is uncontaminated with mine air. Typically gas from these wells is at least 90 percent pure methane. In this protocol, the acronym “SMM” refers to coal mine methane drained from surface pre-mining boreholes.

Horizontal Pre-Mining Boreholes

Horizontal pre-mining boreholes, also referred to as “in-mine” boreholes, are drilled from within the mine (rather than from the surface) into unmined blocks of coal (see Figure 2.1). They are generally 400 to 800 feet in length, and are drilled shortly (as opposed to years) before mining occurs. Methane is drained from the boreholes by an in-mine vacuum piping system, which transports the methane to the surface where it may be either vented or captured and utilized. Because horizontal boreholes are drilled directly into the coal seam from the mine, drainage is limited to the methane contained within the seam; methane in the surrounding strata is unaffected. Hence recovery rates tend to be low (10 to 18 percent of the methane that would otherwise have been emitted from the ventilation system), although the gas recovered from horizontal boreholes is generally comparable in purity to methane drained from surface pre-mining boreholes. In this protocol, the acronym “HMM” refers to coal mine methane from horizontal pre-mining boreholes.

Post-Mining Boreholes

Post-mining, or gob, boreholes are drilled from the surface to a point 10 to 50 feet above the coal seam in advance of mining (see Figure 2.1). As mining advances under and past the well, the strata above the coal seam fractures and eventually collapses into the mined out area creating a de-pressurized zone extending up to the well; this zone is called the gob. Methane and other gases from the gob are collected via the gob well. The gob is exposed to the mine air, and hence the methane drained by gob wells is typically less pure than gas recovered by pre-mining boreholes, although it can be high quality early on in the life of the well. In many cases vacuum pumps are used in conjunction with gob wells to enhance gas recovery and to prevent methane from entering the mine’s ventilation circuit. However, these pumps may draw in mine air as well as methane, thus exacerbating the contamination of the recovered methane. Gob gas typically has a heating value ranging from 300 to 800 Btus per cubic feet (as compared with approximately 1,000 Btus per cubic foot for pipeline quality natural gas). In this protocol, the acronym “PMM” refers to coal mine methane from post-mining boreholes.



1) Horizontal Pre-Mining 2) Surface Pre-Mining 3) Post-Mining and 4) VAM
Source: U.S. EPA *Identifying Opportunities for Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines 2002 – 2006*, EPA -430-K-04-003, January 2009, p 2-5.

Figure 2.1. Schematic of Degasification Types

2.2 Project Definition

For the purpose of this protocol, a GHG reduction project (project) is defined as the installation and operation of any device, or set of devices, that result in the destruction of methane gas that would otherwise have been vented to the atmosphere from an active underground mine. Eligible mines include coal mines as well as trona mines that are classified by MSHA as Category III gassy underground metal and non-metal mines. While the protocol document refers to "coal mine methane" throughout, it may be applied to methane released through mining at Category III gassy underground trona mines.

A project must consist of either:

1. Installation and operation of a methane destruction device (or multiple devices) that destroys methane from a methane drainage system
2. Installation and operation of a methane destruction device (or multiple devices) that destroys ventilation air methane

A single project may not combine destruction of both drainage system and ventilation air methane, except under limited circumstances.[2] However, both drainage projects and VAM projects may be implemented and registered separately at the same mine. In addition, project developers may register multiple projects of the same type at the same mine, e.g. if separate destruction devices are installed at different times.

The protocol does not apply to projects that:

- Operate in surface mines
- Destroy methane from abandoned mines
- Destroy virgin coal bed methane (e.g. methane of high quality extracted from coal seams independently of any mining activities)
- Use CO_2 or any other fluid/gas to enhance CMM drainage before mining takes place

Under the terms of this protocol, the Reserve will issue CRTs only for the destruction of methane that would otherwise have been emitted to the atmosphere. Some projects may put captured CMM to beneficial use by using it to generate energy. Projects that use CMM for energy production are eligible under this protocol (since they destroy methane in the process). However, such projects will not receive credit for displacing GHG emissions associated with other fossil fuels that might have been used to produce energy. Although the Reserve does not issue CRTs for fossil fuel displacement, it strongly supports using CMM for energy production.

2.2.1 Drainage Projects

A drainage project is one that destroys methane that would otherwise be vented to the atmosphere from a methane drainage system. The methane drainage system may use any of the following extraction activities:

- Surface boreholes, including vertical and surface-to-seam directional drilling, located within the boundary of the mine to capture pre-mining CMM
- In-mine underground horizontal boreholes located within the boundary of the mine to capture pre-mining CMM
- Surface gob wells, underground boreholes, gas drainage galleries or other gob gas capture techniques located within the boundary of the mine, including gas from sealed areas, to capture post mining CMM

The borehole(s) that make up each project's drainage system must be defined by the project developer at the time of project submittal. The project developer must also specify what destruction device(s) is/are part of the drainage project. A single project must be explicitly defined and associated with specific boreholes and destruction devices. Multiple drainage projects may be implemented at a single mine, each with its own start date, crediting period, registration, and verification cycle. Each project's drainage system and destruction devices shall be detailed in the project diagram.

If additional boreholes are drilled and/or connected to an existing qualifying project destruction device, this is considered a project expansion. Similarly, if a new or additional destruction device is added to boreholes that are already connected to an existing project destruction device, this is considered a project expansion. If a new borehole or a borehole that is currently venting CMM

[2] In some cases, CMM from a drainage system is allowed to supplement a VAM project (see Section 3.4.1.1). In this case, a single project can consist of both drainage system and VAM methane destruction, as long as the drainage system contribution is limited to supplemental CMM.

is connected to a new destruction device, this may be considered a new project or a project expansion. If the project developer chooses to define it as a project expansion, the project start date and crediting period remain the same as the original project, and a single verification will cover all activities. If the project developer chooses to define it as a new project, the project will have a new start date and crediting period, and the new project will require separate verification.

2.2.2 Ventilation Air Methane Projects

A ventilation air methane project is one that destroys methane that would otherwise be vented from a ventilation shaft (or multiple shafts). The ventilation shaft(s) and VAM destruction device(s) that make up each VAM project must be defined by the project developer at the time of project submittal. A single project must be explicitly defined and associated with a specific shaft (or multiple shafts that are operating concurrently). Multiple projects may be implemented at a single mine, each with its own start date, crediting period, registration, and verification cycle. Each project's ventilation shaft(s) and VAM destruction device(s) shall be detailed in the project diagram.

If additional VAM destruction equipment is added to a shaft that is part of an existing project, this is considered a project expansion. If VAM destruction equipment is installed at a shaft that is not part of an existing project, this new shaft may be considered a new project or a project expansion. If the project developer chooses to define it as a project expansion, the project start date and crediting period remain the same, and a single verification will cover activities at both shafts. If the project developer chooses to define it as a new project, activities at the new shaft will have a new start date and crediting period, and will require separate verification. For a new VAM project, the VAM destruction equipment does not need to be new; it is only the ventilation shaft that must be new.

2.2.3 Non-Qualifying Devices

Non-qualifying devices are devices that destroy CMM but do not meet one or more of the eligibility rules as described in Section 3 and are located at the same mine where eligible project activities are taking place.[3] If there are any non-qualifying devices in operation at a mine, the project developer must include the non-qualifying device(s) in the project's GHG Assessment Boundary (see Section 0) and in the project diagram (see Section 7.1). Subsequent projects implemented at the same mine may exclude the same non-qualifying device(s) from their GHG assessment boundaries. In other words, if methane destruction at a non-qualifying device is accounted for by one project at a mine, it does not need to be accounted for by other projects at the same mine.

If any new non-qualifying devices become operational at the mine, these devices must be assigned to a specific project. In the case where a project developer has more than one registered project at a mine, the project developer may choose which project will account for the new non-qualifying device.

In the case where there are multiple projects with different crediting periods at a mine, when the crediting period for a project that includes a non-qualifying device expires, the non-qualifying device must be added to the GHG Assessment Boundary of a project that is still active. Thus, all non-qualifying devices must be properly accounted for in the GHG Assessment Boundary of an active project at the mine over time.

[3] Coal mine methane sent off-site through a pipeline is not eligible, but is also outside of the GHG Assessment Boundary. Because CMM sent to a pipeline is outside of the GHG Assessment Boundary, sources of emissions associated with pipelines are not included in the project diagram.

2.3 The Project Developer

The "project developer" is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be mine owners, mine operators, GHG project financiers, utilities, independent energy companies, or other entities. The project developer must have clear ownership of the project's GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership by signing the Reserve's Attestation of Title form.[4]

Under this protocol, the project developer is the only party required to be involved with project implementation.

[4] Attestation of Title form available at http://www.climateactionreserve.org/how/program/documents/.

3 Eligibility Rules

Projects that meet the definition of a GHG reduction project in Section 2.2 must fully satisfy the following eligibility rules in order to register with the Reserve.

Eligibility Rule I:	Location	→	*U.S. and its territories*
Eligibility Rule II:	Project Start Date	→	*No more than six months prior to project submission*
Eligibility Rule III:	Additionality	→	*Exceed legal requirements*
		→	*Meet performance standard*
Eligibility Rule IV:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Under this protocol, only projects located at a single mine in the United States and its territories are eligible to register with the Reserve.[5]

3.2 Project Start Date

The project start date shall be defined by the project developer, but must be no more than three months after coal mine methane is first destroyed by the project, regardless of whether sufficient monitoring data is available to report reductions. The start date is defined in relation to the commencement of methane destruction, not other activities that may be associated with project initiation or development. For projects that involve pre-mine drainage, for example, well-drilling may commence in advance of any methane destruction; in such cases, the start date would be linked to the commencement of methane destruction, not drilling activities.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date.[6] Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Project Crediting Period

The crediting period for coal mine methane projects under this protocol is ten years. At the end of a project's first crediting period, a project developer may apply for eligibility under a second crediting period. However, the Reserve will cease to issue CRTs for GHG reductions if at any point in the future CMM destruction becomes legally required at the project site. Thus, the Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of two ten year crediting periods after the project start date, or until the project activity is required by law, whichever comes first. Section 3.4.1 defines the conditions under which a project is considered legally required, and Section 3.4.1.1 describes the requirements to qualify for a second crediting period. If a project developer wishes to apply for eligibility under a

[5] The Reserve anticipates that this protocol could be applied throughout North America and internationally. To expand its applicability, data and analysis supporting an appropriate performance standard for other countries would have to be conducted accordingly. Refer to Appendix A for information on the performance standard analysis supporting application of this protocol in the United States.

[6] Projects are considered submitted when the project developer has fully completed and filed the appropriate project submittal documentation, available on the Reserve's website.

second crediting period, they must do so within the final six months of the initial crediting period. Deadlines and requirements for reporting and verification, as laid out in this protocol and the Verification Program Manual, will continue to apply without interruption.

The crediting period will also end if the mine where a project is located is declared abandoned; the Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol only up until the date the mine was declared abandoned (i.e. the date when ventilation is discontinued).

3.4 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The Legal Requirement Test
2. The Performance Standard Test

3.4.1 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the destruction of coal mine methane at the project site. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[7] prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

The Reserve did not identify any existing federal, state or local regulations that obligate mines to destroy coal mine methane.[8] If an eligible project begins operation at a mine that later becomes subject to a regulation, ordinance or permitting condition that calls for the destruction of coal mine methane, emission reductions may be reported to the Reserve up until the date that the coal mine methane is legally required to be destroyed. If the mine's methane emissions are included under an emissions cap (e.g. under a state or federal cap-and-trade program), emission reductions may likewise be reported to the Reserve until the date that the emissions cap takes effect.

[7] Attestation of Voluntary Implementation form available at http://www.climateactionreserve.org/how/program/documents/.

[8] To ensure that methane remains well below the concentrations at which it becomes explosive, the Federal Coal Mine Health and Safety Act of 1969 requires that methane levels be kept below 1 percent at the working face of the mine. To ensure that this requirement is met, all underground mines (gassy and non-gassy) are required under the same Act to develop ventilation systems that meet detailed specifications laid out in the federal regulations. The methane concentration limits and ventilation requirements are enforced by MSHA. The Act does not require, however, that CMM be destroyed.

3.4.1.1 U.S. EPA GHG Permitting Requirements under the Clean Air Act

Since January 2, 2011, the United States Environmental Protection Agency (U.S. EPA) has been phasing in[9] regulation of GHG emissions from major stationary sources under the Clean Air Act (CAA).[10]

Under this rule, commonly referred to as the "Tailoring Rule," all existing stationary sources emitting more than 100,000 tons (approximately 90,719 MT) of CO_2e emissions per year are required to obtain Title V operating permits for GHG emissions. Historically, underground mines have not been a source category subject to Title V operating permits. However, the Tailoring Rule also requires Prevention of Significant Deterioration (PSD) permits that address GHG emissions for (1) new source construction with emissions of 100,000 tons CO_2e per year or more and (2) major facility modifications resulting in GHG emission increases of 75,000 tons (approximately 68,000 MT) of CO_2e per year or more.[11] An assessment of "best available control technology" (BACT) for GHGs is required as part of the PSD permitting process; the permitting authority will ultimately mandate installation of a selected BACT. It is possible that future PSD permits may require installation of the same abatement technologies that are currently being voluntarily deployed as part of a carbon offset project at a mine. By legally mandating these technologies, PSD permit requirements may make them ineligible for carbon offsets because implementation of these projects would no longer be voluntary.

According to the Reserve's understanding of the EPA Tailoring Rule requirements, new mines or mines that undertake significant expansion may be subject to the new PSD requirements. If a mine triggers the PSD requirements and an official BACT review results in the mandatory installation of a technology that reduces CMM emissions, this activity will not be eligible for carbon offsets. Verification bodies will need to review these permits to ensure that projects are able to pass the Legal Requirement Test.

The Reserve continues to track these developments under the CAA. BACT determinations made at the state level will inform updates to the protocol's tests for additionality over time.

3.4.2 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all coal mine methane destruction projects, established on an ex-ante basis by this protocol.

There are numerous possible management options and end uses for coal mine methane, ranging from venting, to destruction by flares, to injection of the methane into natural gas pipelines. The Performance Standard Test employed by this protocol is based on a national

[9] All major sources already subject to PSD and/or Title V under the Clean Air Act for other pollutants have been subject to EPA's GHG permitting rules since January 2, 2011. All sources *not* previously subject to the Clean Air Act came under the GHG permitting rules on July 1, 2011, if they triggered the thresholds noted herein.

[10] U.S. EPA published the final rulemaking, "Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule; Final Rule," in the Federal Register on June 3, 2010. The rulemaking is commonly referred to as the "Tailoring Rule," and amended 40 CFR Parts 51, 52, 70, and 71. http://www.gpo.gov/fdsys/pkg/FR-2010-06-03/pdf/2010-11974.pdf#page=1. In the final rulemaking in June 2010, the EPA also committed to undertake another rulemaking to conclude no later than July 1, 2012, which would phase in GHG permitting for smaller sources. However, in July 2012, EPA issued another rulemaking for the Tailoring Rule which continues to focus GHG permitting on the largest emitters, deferring GHG permitting for smaller sources to a later date. http://www.gpo.gov/fdsys/pkg/FR-2012-07-12/pdf/2012-16704.pdf

[11] "PSD and Title V Permitting Guidance for Greenhouse Gases" available at http://www.epa.gov/nsr/ghgdocs/epa-hq-oar-2010-0841-0001.pdf.

assessment of "common practice" for managing coal mine methane. The performance standard defines those end uses that the Reserve has determined will exceed common practice and therefore generates additional GHG reductions.[12]

Drainage projects pass the Performance Standard Test if they destroy CMM through any end-use management option other than injection into a natural gas pipeline for off-site consumption (e.g. flare, power generation, heat generation, producing CNG/LNG for vehicle use, etc.).

All VAM projects pass the Performance Standard Test. Such projects may include, but are not limited to, the following end uses for VAM:

- Thermal flow reversal reactors with or without catalysts
- Volatile organic compound concentrators
- Carbureted gas turbines
- Lean-fueled turbines with catalytic combustors that compress the air/methane mixture and then combust it in a catalytic combustor
- Hybrid coal- and ventilation air-fueled gas turbine technology
- Lean-fueled catalytic microturbine technology
- Combustion air for commercial engine and turbine technologies or a coal-fired steam power plant

In some cases, VAM projects may need to supplement VAM with CMM from drainage boreholes, either to increase the concentration of methane flowing into the combustion/oxidation device or to help balance the concentration of methane flowing into the combustion/oxidation device. This supplemental CMM is also eligible as part of a VAM project, as long as the supplemental CMM would not have been used for energy purposes.

The Performance Standard Test is applied at the time a project applies for registration with the Reserve. Once a project is registered, it does not need to be evaluated against future versions of the protocol or the Performance Standard Test for the duration of its first crediting period.

If a project developer wishes to apply for a second crediting period, the project must meet the requirements of the most current version of this protocol, including any updates to the Performance Standard Test.

3.5 Regulatory Compliance

As a final eligibility requirement, project developers must attest that project activities do not cause material violations of applicable laws (e.g. air, water quality, safety, etc.). To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form prior to the commencement of verification activities each time the project is verified.[13] Project developers are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project or project activities.

A violation should be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the project developer shall disclose the violation to the verifier.

[12] A summary of the study and analysis used to establish the Performance Standard Test is provided in Appendix A.
[13] Attestation of Regulatory Compliance form available at http://www.climateactionreserve.org/how/program/documents/.

If a verifier finds that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurrent administrative violations directly related to project activities may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

4 GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers in order to determine the total net change in GHG emissions caused by a coal mine methane project.

This protocol does not account for carbon dioxide emission reductions associated with displacing grid-delivered electricity or fossil fuel use.

Figure 4.1 provides a general illustration of the GHG Assessment Boundary for VAM projects, indicating which SSRs are included or excluded from the boundary.

Figure 4.2 provides a general illustration of the GHG Assessment Boundary for drainage projects, indicating which SSRs are included or excluded from the boundary.

Table 4.1 provides greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary. The GHG Assessment Boundary diagram and table presented here apply to both drainage and VAM projects; individual SSRs may or may not be relevant depending on the project type.

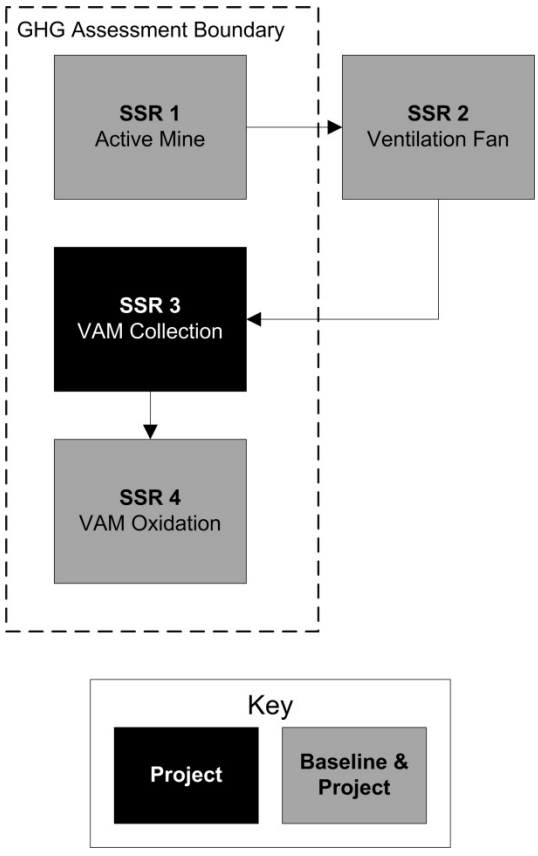


Figure 4.1. Illustration of the GHG Assessment Boundary for VAM Projects

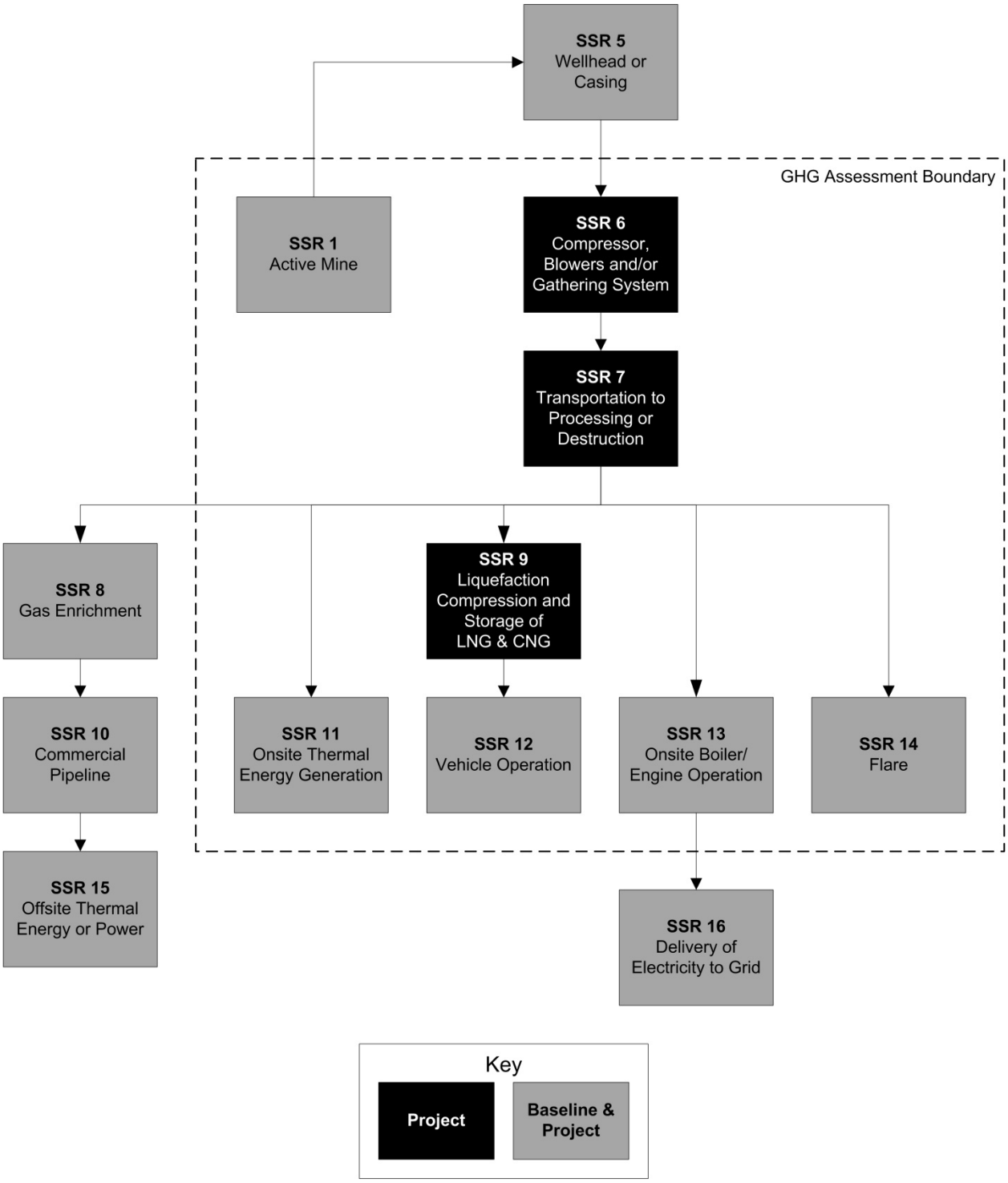


Figure 4.2. Illustration of the GHG Assessment Boundary for Drainage Projects

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
1	Active mine – emissions as a result of venting	CH_4	B, P	Included	Main emission source of methane from active mines. A GHG project will directly affect these emissions. Only the change in CMM emissions release will be taken into account, by monitoring the methane used or destroyed by the project.
2	Ventilation fan	CO_2	n/a	Excluded	Ventilation fan operation will not be affected by the project.
3	VAM collection system	CO_2	P	Included	The VAM collection system will result in increased combustion emissions due to energy consumption from equipment used to drain, compress, blow, and gather VAM.
		CH_4		Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O		Excluded	Excluded for simplification. This emission source is assumed to be very small.
4	VAM oxidation	CO_2	B, P	Included	VAM project will result in increased CO_2 emissions from the oxidation of methane in ventilation air.
		CH_4	P	Included	VAM project will result in CH_4 emissions from non-oxidized CH_4 from the ventilation air stream.
		N_2O	n/a	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from NMHC destruction	CO_2	P	Included if >3,500 mg/m^3	VAM project will result in increased CO_2 emissions from the combustion of NMHC in oxidizer (only included if NMHC accounts for more than 3,500 mg/m^3 (wet basis) of extracted ventilation air).
5	Fugitive emissions resulting from casing or wellhead	CH_4	n/a	Excluded	The project is unlikely to affect quantities of methane from this source.
6	Emissions resulting from energy used by compressors, blowers, and/or gathering system	CO_2	P	Included	If any additional equipment is required by the project beyond what is required in the baseline, energy consumption from additional equipment shall be accounted for. Energy used by equipment installed for the safety of the mine shall be excluded.
		CH_4		Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O		Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Fugitive emissions resulting from compressors, blowers, and/or gathering system	CH_4	n/a	Excluded	Excluded for simplification. This emission source is assumed to be very small.
7	Fuel consumption for transport of CMG to processing or destruction equipment	CO_2	P	Included	If any additional equipment is required by the project beyond what is required in the baseline, energy consumption from additional equipment shall be accounted for.
		CH_4		Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O		Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Fugitive emissions from transport of CMG to processing or destruction equipment	CH_4	n/a	Excluded	Excluded for simplification. This emission source is assumed to be very small.
8	Emissions resulting from gas enrichment	CO_2	n/a	Excluded	The project is unlikely to affect quantities of methane sent to gas enrichment systems, and will
		CH_4		Excluded	

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
	system	N_2O		Excluded	therefore not affect energy consumption or fugitive emissions from gas enrichment systems.
9	Emissions resulting from liquefaction, compression, or storage of methane for vehicle fuel	CO_2	P	Included	If any additional equipment is required by the project beyond what is required in the baseline, energy consumption from additional equipment shall be accounted for.
		CH_4		Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O		Excluded	Excluded for simplification. This emission source is assumed to be very small.
10	Fugitive emissions from commercial pipelines	CH_4	n/a	Excluded	The project is unlikely to affect quantities of methane delivered to commercial pipelines, and will therefore not affect fugitive pipeline emissions.
11	Emissions resulting from combustion during on-site thermal energy generation	CO_2	B, P	Included	If CMM is used for on-site thermal energy generation, project will result in increased CO_2 emissions from the destruction of methane to generate energy. This source is also included where CMM is sent to a non-qualifying device to generate energy.
		N_2O		Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions resulting from incomplete combustion during onsite thermal energy generation	CH_4	P	Included	If CMM is used for on-site thermal energy generation, project will result in increased CH_4 emissions from incomplete combustion. This source is also included where CMM is sent to a non-qualifying device to generate energy.
	Emissions from NMHC destruction	CO_2	P	Included if >35,000 mg/m^3	If CMM is used for on-site thermal energy generation, project will result in increased CO_2 emissions from the combustion of NMHC during energy generation (only included if NMHC accounts for more than 35,000 mg/m^3 of CMG). This source is also included where CMM is sent to a non-qualifying device to generate energy.
12	Emissions resulting from combustion during vehicle operation	CO_2	B, P	Included	If CMM is used to produce CNG/LNG to fuel vehicle operation, project will result in increased CO_2 emissions from the destruction of methane in CNG/LNG vehicles. This source is also included where CMM is used for non-qualifying vehicle operation.
		N_2O		Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions resulting from incomplete combustion during vehicle operation	CH_4	P	Included	If CMM is used to produce CNG/LNG to fuel vehicle operation, project will result in increased CH_4 emissions from incomplete combustion. This source is also included where CMM is used for non-qualifying vehicle operation.
	Emissions from NMHC destruction	CO_2	P	Included if >35,000 mg/m^3	If CMM is to produce CNG/LNG to fuel vehicle operation, project will result in increased CO_2 emissions from the combustion of NMHC during vehicle operation (only included if NMHC accounts for more than 35,000 mg/m^3 of CMG). This source is also included where CMM is used for non-qualifying vehicle operation.
13	Emissions resulting from combustion during on-site electricity generation	CO_2	B, P	Included	If CMM is used for on-site power generation, project will result in increased CO_2 emissions from the destruction of methane to generate power. This source is also included where CMM is sent to a non-qualifying device for electricity generation.

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
		N_2O		Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions resulting from incomplete combustion during on-site electricity generation	CH_4	P	Included	If CMM is used for on-site power generation, project will result in increased CH_4 emissions from incomplete combustion. This source is also included where CMM is sent to a non-qualifying device for electricity generation.
	Emissions from NMHC destruction	CO_2	P	Included if >35,000 mg/m^3	If CMM is used for on-site power generation, project will result in increased CO_2 emissions from the combustion of NMHC during power generation (only included if NMHC accounts for more than 35,000 mg/m^3 of CMG). This source is also included where CMM is sent to a non-qualifying device for electricity generation.
14	Emissions resulting from combustion during flaring	CO_2	B, P	Included	If CMM is sent to a flare, project will result in increased CO_2 emissions from the destruction of methane in flare. This source is also included where CMM is sent to a non-qualifying device for flaring.
		N_2O		Excluded	Excluded for simplification. This emission source is assumed to be very small.
	Emissions resulting from incomplete combustion during flaring	CH_4	P	Included	If CMM is sent to a flare, project will result in increased CH_4 emissions from incomplete combustion. This source is also included where CMM is sent to a non-qualifying device for flaring.
	Emissions from NMHC destruction	CO_2	P	Included if >35,000 mg/m^3	If CMM is sent to a flare, project will result in increased CO_2 emissions from the combustion of NMHC in flare (only included if NMHC accounts for more than 35,000 mg/m^3 of CMG).
15	Emissions resulting from offsite thermal or power generation	CO_2	n/a	Excluded	The project is unlikely to affect quantities of methane delivered through pipelines to offsite thermal or power generation equipment, and will therefore not affect emissions from such equipment.
		N_2O			
	Emissions resulting from incomplete combustion during off-site thermal energy or power generation	CH_4			
16	Delivery of electricity to grid	CO_2	n/a	Excluded	This protocol does not cover displacement of GHG emissions from the use of CMM for grid-connected electricity generation.
		CH_4			
		N_2O			
	Project construction and decommissioning emissions	CO_2	n/a	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		CH_4			
		N_2O			

5 Quantifying GHG Emission Reductions

ER
Equation 5.1 GHG Emission Reductions

Emission Reductions = Baseline Emissions – Project Emissions

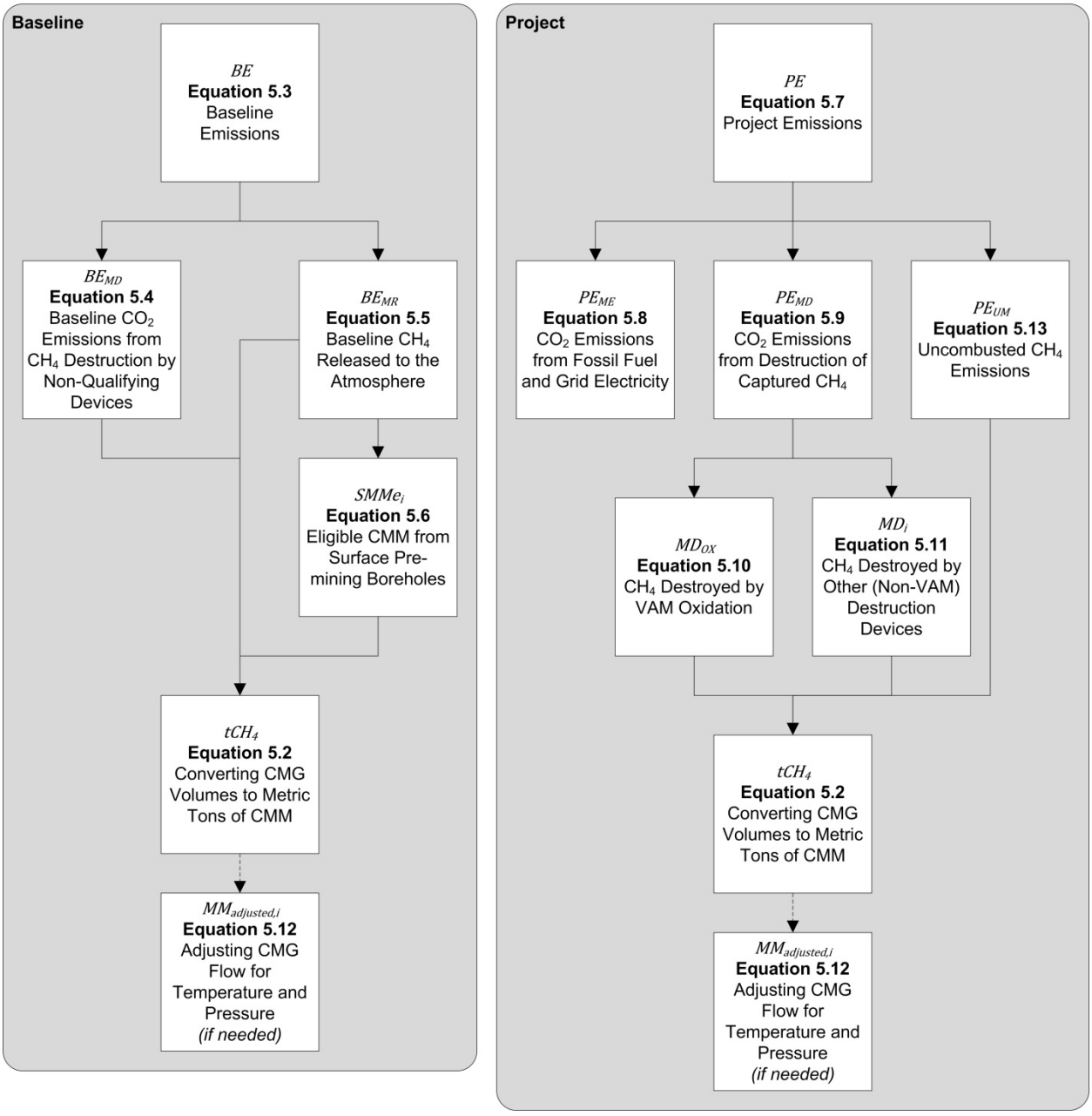


Figure 5.1. Organizational Chart for Equations in Section 5

GHG emission reductions from a coal mine methane project are quantified by comparing actual project emissions to baseline emissions at the mine. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 0) that would have occurred in the absence of the coal mine methane project. Project emissions are actual

GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

GHG emission reductions must be quantified and verified on at least an annual basis. Project developers may choose to quantify and verify GHG emission reductions on a more frequent basis if they desire. The length of time over which GHG emission reductions are quantified and verified is called the "reporting period."

Equation 5.1. GHG Emission Reductions

$$ER = BE - PE$$

Where,			Units
ER	=	GHG emission reductions of the project activity during the reporting period	tCO_2e
BE	=	Baseline emissions during the reporting period	tCO_2e
PE	=	Project emissions during the reporting period	tCO_2e

The calculations provided in this protocol are derived from internationally accepted methodologies.[14] Project developers shall use the calculation methods provided in this protocol to determine baseline and project GHG emissions in order to quantify GHG emission reductions.

Equation 5.2 provides guidance for calculating the mass of methane from the independently measured parameters of gas volume and methane concentration. Note that Equation 5.2 distinguishes between *coal mine gas* (CMG), which is the gas that comes out of the boreholes before any processing or enrichment and often contains various levels of other compounds (e.g. nitrogen, oxygen, carbon dioxide, hydrogen sulfide, NMHC, etc.) and *coal mine methane* (CMM), which represents only the methane portion of CMG.

Throughout the protocol, it is assumed that measured quantities of coal mine gas are converted to metric tons of methane using the following three parameters:

- Measured methane concentration of the coal mine gas
- Volume of gas, corrected to standard conditions (60°F and 1 atm)
- Density of methane at standard conditions (60°F and 1 atm)

[14] The Reserve's GHG reduction calculation method for CMM projects is derived from the UNFCCC approved consolidated methodology under the Kyoto Protocol's Clean Development Mechanism (ACM0008/Version 6), and also draws from Greenhouse Gas Services Methodology for Coal Mine Methane and Abandoned Mine Methane Capture and Destruction Projects (Version 1.1), the U.S. EPA Inventory of U.S. GHG Emissions and Sinks 1990-2007, and the 2006 IPCC Guidelines for National GHG Inventories.

Equation 5.2. Converting CMG Volumes to Metric Tons of CMM

$$tCH_4 = (0.0423 \times 0.000454) \times \sum_t scfCMG_t \times \%CH_{4t}$$

Where,			Units
tCH_4	=	Total quantity of CMM	tCH_4
t	=	Time interval for which flow and concentration measurements are aggregated (daily)	
$\%CH_{4t}$	=	The average methane fraction of the CMG in time interval t as measured	scf CH_4/scf
$scfCMG_t$	=	Total volume of coal mine gas in time interval t, as measured (see Equation 5.12 for additional guidance on adjusting the CMG flow for temperature and pressure)	scf CMG
0.0423	=	Density of methane	lb CH_4/scf CH_4
0.000454	=	tCH_4/lb CH_4	t/lb

5.1 Quantifying Baseline Emissions

Total baseline emissions must be estimated by calculating and summing the expected baseline emissions for all relevant SSRs (as indicated in Table 4.1) using Equation 5.3 and the supporting equations presented below.

Equation 5.3. Baseline Emissions

$$BE = BE_{MD} + BE_{MR}$$

Where,			Units
BE	=	Baseline emissions during the reporting period	tCO_2e
BE_{MD}	=	Baseline emissions from destruction of methane during the reporting period	tCO_2e
BE_{MR}	=	Baseline emissions from release of methane into the atmosphere during the reporting period	tCO_2e

Baseline emissions from CMM release or destruction may be associated with four different stages of mining activity:

1. Surface pre-mining: boreholes are drilled from the surface to unmined portions of the coal seam in advance of mining. CMM drained from surface pre-mining boreholes is represented as SMM in the equations below.

2. Horizontal pre-mining: boreholes are drilled horizontally from within the mine into unmined blocks of coal shortly before mining occurs (also referred to as in-mine boreholes). CMM drained from horizontal pre-mining boreholes is represented as HMM in the equations below.

3. Ventilation during mining through required ventilation systems. CMM collected from ventilation systems is represented as VAM in the equations below.

4. Post-mining: boreholes are drilled from the surface to a point 10 to 50 feet above the coal seam in advance of mining. As mining advances under and past the well, the strata above the coal seam collapses into the mined out area creating a de-pressurized zone extending up to the well; this zone is called the gob. CMM drained from post-mining boreholes is represented as PMM in the equations below.

5.1.1 Calculating Baseline Carbon Dioxide Emissions from Methane Destruction

Depending on the mine, some CMM may be destroyed in the baseline through flaring, oxidation, power generation, heat generation, etc., in non-qualifying destruction devices (see Section 2.2.3). Baseline emissions estimates must include the estimated CO_2 emissions from the destruction of CMM in non-qualifying devices, calculated using Equation 5.4.

The amount of CMM destroyed in the baseline by a non-qualifying destruction device (variables $SMM_{BL,i}$, $HMM_{BL,i}$, $PMM_{BL,i}$ and $VAM_{BL,i}$ in Equation 5.4) is established by calculating and comparing:

1. The actual amount of SMM, HMM, PMM and VAM destroyed by the non-qualifying destruction device during the reporting period; and
2. The amount of SMM, HMM, PMM and VAM destroyed by the non-qualifying destruction device over the three year period prior to the implementation of the project (or however long the non-qualifying destruction device has been operational, whichever is shorter), averaged according to the length of the reporting period. For example, if the reporting period is three months, then the three-year historical amount must be divided by 12 to derive the average amount of destruction in a three-month period.

The higher of either (1) or (2) must be used for $SMM_{BL,i}$, $HMM_{BL,i}$, $PMM_{BL,i}$ and $VAM_{BL,i}$ in Equation 5.4 (and Equation 5.5 in the next section).

Baseline emissions estimates must also include the CO_2 emissions from the destruction of non-methane hydrocarbons (NMHC) in non-qualifying devices, if NMHC comprise more than 35,000 mg/m^3 (measured on a wet basis at standard conditions) of extracted CMG or more than 3,500 mg/m^3 (measured on a wet basis at standard conditions) of extracted ventilation air.

If a non-qualifying destruction device in operation at the mine that was shut down less than one year prior to the project start date – or if a non-qualifying device is shut down at any point during the project's crediting period – the project developer must still account for the device in the baseline calculations, using the historical destruction amount calculated in (2), above. If the device was shut down more than one year before the project start date, it does not need to be accounted for in the baseline calculations.

If there is no destruction of methane in the baseline, then $BE_{MD} = 0$.

5.1.1.1 Treatment of CMM Sent to Pipeline

At some mines, the baseline may involve sending some CMM to a natural gas pipeline for off-site consumption/destruction. The pipeline could therefore be considered a "non-qualifying device." However, because on-site CMM destruction projects are unlikely to affect the quantity of CMM delivered to pipelines (due to the likely physical and temporal separation of these

activities), emissions associated with pipelines are excluded from the GHG Assessment Boundary, and do not need to be accounted for in the baseline or the project emission calculations.

If a mine that has historically sent CMM to a pipeline ceases to do so, CMM from that drainage system (i.e. SMM, HMM or PMM) is not eligible for emission reductions, even if CMM is sent to an otherwise eligible destruction device. Furthermore, if a project mine begins to send CMM to a pipeline while a CMM project is still ongoing, CMM from that drainage system will also be deemed ineligible from that point in time forward.

Equation 5.4. Baseline CO_2 Emissions from CH_4 Destruction by Non-Qualifying Devices

$$BE_{MD} = \left(2.75 + r \times CEF_{NMHC}\right) \times \sum_{i} \left(SMM_{BL,i} + VAM_{BL,i} + HMM_{BL,i} + PMM_{BL,i}\right)$$

Where,			Units
BE_{MD}	=	Baseline emissions from destruction of methane in the reporting period	tCO_2e
i	=	Use of methane (flaring, power generation, heat generation, etc.). Uses must include all non-qualifying devices	
$SMM_{BL,i}$	=	CMM from surface pre-mining that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period	tCH_4
$VAM_{BL,i}$	=	VAM that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period	tCH_4
$HMM_{BL,i}$	=	CMM from horizontal pre-mining that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period	tCH_4
$PMM_{BL,i}$	=	Post-mining CMM that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period	tCH_4
2.75	=	CO_2 emission factor for combusted methane[15]	tCO_2e/tCH_4
CEF_{NMHC}	=	CO_2 emission factor for combusted non methane hydrocarbons	$tCO_2e/tNMHC$
r	=	Relative mass proportion of NMHC compared to methane	

With:

$$r = PC_{NMHC} \Big/ PC_{CH_4}$$

Where,			Units
r	=	Relative mass proportion of NMHC compared to methane	
PC_{NMHC}	=	NMHC concentration (in mass) in extracted CMG or ventilation air, measured on a wet basis	mg/m^3
PC_{CH4}	=	Concentration (in mass) of methane in extracted CMG or ventilation air, measured on wet basis at standard conditions (60°F and 1 atm)	mg/m^3

[15] Use the molar mass of CO_2 and CH_4 to calculate tCO_2e/tCH_4 (44/16 = 2.75).

5.1.2 Calculating Baseline Methane Emissions

Baseline emissions must include the methane that would have been emitted to the atmosphere in the absence of the project activity. Baseline emissions of methane are calculated by summing the total amount of methane *actually destroyed* by all qualifying and non-qualifying devices during the reporting period, and subtracting the amount that would have been destroyed in the baseline, as determined in Section 5.1.1. The difference between the actual amount of methane destroyed and what would have been destroyed determines how much methane would have been released. Baseline methane emissions must be calculated using Equation 5.5.

In Equation 5.5, actual methane destruction at all qualifying devices (those installed as part of the project to destroy methane) and non-qualifying devices must be accounted for. For qualifying devices, baseline values for methane destruction (i.e. $SMM_{BL,i}$, $HMM_{BL,i}$, $PMM_{BL,I}$, and $VAM_{BL,i}$) will be zero.

Baseline methane emissions from surface pre-mining (SMM) are quantified only during reporting periods in which the emissions *would have occurred* (i.e. when the borehole is mined through). Thus, baseline methane emissions from SMM must be determined according to the amount of *eligible* CMM that has been destroyed, as defined in Section 5.1.2.1.

If a qualifying device for a VAM project uses CMM to supplement the flow of VAM, the supplemental CMM must be accounted for in Equation 5.5 according to its source (SMM, HMM or PMM) if VAM flow and supplemental CMM flow are monitored separately, or directly through $VAM_{PJ,i}$ if only the resulting enriched flow is monitored.

Any methane that is still vented in the project scenario is not accounted for in the project emissions or baseline emissions, since it is vented in both scenarios. Similarly, the methane that is injected into natural gas pipeline in the project scenario is not accounted for in the project emissions or baseline emissions, since it is injected in both scenarios.

Equation 5.5. Baseline CH_4 Released to the Atmosphere

$$BE_{MR} = GWP_{CH_4} \times \left[\begin{array}{l} \sum_i \left(SMMe_i - SMM_{BL,i} \right) + \sum_i \left(HMM_{PJ,i} - HMM_{BL,i} \right) \\ + \sum_i \left(PMM_{PJ,i} - PMM_{BL,i} \right) + \sum_i \left(VAM_{PJ,i} - VAM_{BL,i} \right) \end{array} \right]$$

Where,			Units
BE_{MR}	=	Baseline methane emissions avoided by the project activity in the reporting period	tCO_2e
i	=	Use of methane (flaring, power generation, heat generation, etc.). *Uses must include all qualifying and non-qualifying devices*	
$SMMe_i$	=	*Actual* amount of CMM from surface pre-mining captured, sent to and destroyed by use i for the reporting period. For qualifying devices, only the *eligible* amount shall be quantified (see Section 5.1.2.1)	tCH_4
$SMM_{BL,i}$	=	CMM from surface pre-mining that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period, as determined in Section 5.1.1	tCH_4
$HMM_{PJ,i}$	=	*Actual* amount of CMM from horizontal pre-mining captured, sent to and destroyed by use i in the reporting period	tCH_4
$HMM_{BL,i}$	=	CMM from horizontal pre-mining that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period, as determined in Section 5.1.1	tCH_4
$PMM_{PJ,i}$	=	*Actual* amount of post-mining CMM captured, sent to and destroyed by use i in the project activity in the reporting period	tCH_4
$PMM_{BL,i}$	=	Post-mining CMM that would have been captured, sent to and destroyed by use I in the baseline scenario in the reporting period, as determined in Section 5.1.1	tCH_4
$VAM_{PJ,i}$	=	*Actual* amount of VAM sent to and destroyed by use i in the project activity in the reporting period. In the case of oxidation, $VAM_{PJ,i}$ is equivalent to MM_{OX} defined in Section 5.2.2	tCH_4
$VAM_{BL,i}$	=	VAM that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period, as determined in Section 5.1.1	tCH_4
GWP_{CH4}	=	Global warming potential of methane (21)	tCO_2e/tCH_4

5.1.2.1 Determining Eligible SMM

To determine the amount of baseline SMM that is eligible to be quantified in a given reporting period, project developers shall identify what boreholes within the bounds of active coal extraction were "mined through" during the reporting period. The most current mine plan shall be used to identify these boreholes.

Baseline SMM emissions are quantified only when the endpoint of the borehole is mined through. If the mine plan calls for mining past rather than through the borehole, then quantification is allowed once the linear distance between the endpoint of the borehole and the working face that will pass nearest the endpoint of the borehole has reached an absolute minimum.

For the purposes of this protocol, mined through is defined as any of the following:

- The working face intersects the endpoint of the borehole
- The working face passes directly underneath the bottom of the borehole, as long as the endpoint of the borehole is within a -50 meter to +150 meter vertical range of the mined coal seam
- The working face intersects the plane of the borehole
- The working face passes both underneath and to the side of the borehole (which will happen when the bottom of the borehole lies above a block of coal that will be left unmined as a pillar)

Once a borehole is mined through, SMM from that borehole that was captured and destroyed by a qualifying device in previous reporting periods may be reported and quantified for the current reporting period (as a component of $SMMe_i$ in Equation 5.5). $SMMe_i$ is calculated as the sum of SMM captured and destroyed by qualifying devices from wells mined through in the current reporting period ($SMMpre_e$), plus SMM captured and destroyed by qualifying devices from wells that were mined through in previous reporting periods ($SMMpost_e$) – see Equation 5.6.

Equation 5.6. Eligible CMM from Surface Pre-mining Boreholes

$$SMMe_i = SMMpre_e + SMMpost_e$$

Where,			Units
$SMMe_i$	=	Actual amount of CMM from surface pre-mining captured, sent to and destroyed by use i that is *eligible* for quantification in the reporting period	tCH_4
$SMMpre_e$	=	Actual amount of CMM destroyed by qualifying devices from surface pre-mining boreholes that were mined through during the current reporting period	tCH_4
$SMMpost_e$	=	Actual amount of CMM destroyed by qualifying devices in the current reporting period from surface pre-mining boreholes that were previously mined through	tCH_4

And:

$$SMMpre_e = \sum_{w_1} \left(SMM_{w_1} \right)$$

Where,			Units
$SMMw_1$	=	Total actual amount of CMM captured and destroyed from well w_1 from the project start date through the end of the current reporting period	tCH_4
w_1	=	The set of wells mined through during the current reporting period	

And:

$$SMMpost_e = \sum_{w_2} \left(SMM_{w_2} \right)$$

Where,			Units
$SMMw_2$	=	Actual amount of CMM captured and destroyed from well w_2 during the current reporting period	tCH_4
w_2	=	The set of wells mined through prior to the current reporting period	

For example, at a mine in which five surface pre-mining wells had been drilled and whose reporting period is 12 months long, if all five wells are mined through in year 4, then in years 1 to 3 the eligible CMM from surface pre-mining would be zero. In year 4 it would be the cumulative volume for the previous three years plus the volume extracted in year 4. In year 5, it would only be the volume extracted in year 5.

5.2 Quantifying Project Emissions

Project emissions must be quantified at a minimum on an annual, *ex-post* basis. As shown in Equation 5.7, project emissions equal the sum of:

- CO_2 emissions from energy used to collect, process, transport and destroy CMM/VAM
- CO_2 emissions from CMM/VAM destroyed in qualifying and non-qualifying destruction devices
- Uncombusted CH_4 emissions from qualifying and non-qualifying destruction devices

Equation 5.7. Project Emissions

$$PE = PE_{ME} + PE_{MD} + PE_{UM}$$

Where,			Units
PE	=	Project emissions during the reporting period	tCO_2e
PE_{ME}	=	Project emissions from energy required for methane collection, transport, and combustion during the reporting period	tCO_2e
PE_{MD}	=	Project emissions from methane destroyed during the reporting period	tCO_2e
PE_{UM}	=	Project emissions from uncombusted methane during the reporting period	tCO_2e

5.2.1 Project Emissions from Energy Required for Methane Collection, Transport, and Combustion

Included in the GHG Assessment Boundary are carbon dioxide emissions resulting from fossil fuel combustion and/or use of grid-delivered electricity for on-site equipment that is used for:

- VAM collection
- Compressors, blowers and/or CMM gathering systems
- Transporting CMM to on-site combustion
- Liquefaction, compression and storage of liquid natural gas (LNG) or compressed natural gas (CNG) created from CMM
- Transporting CMM to boilers/engines for power generation
- Transporting CMM to a flare

If the project utilizes fossil fuel or grid electricity to power equipment necessary for performing the above processes, the resulting project carbon dioxide emissions shall be calculated per Equation 5.8 below. Note that fossil fuel or grid electricity to power equipment installed for the safety of the mine shall be excluded, as that equipment is not within the GHG Assessment Boundary of the project.

Equation 5.8. CO_2 Emissions from Fossil Fuel and Grid Electricity

$$PE_{ME} = \left(CONS_{ELEC,PJ} \times CEF_{ELEC}\right) + \frac{\left(CONS_{HEAT,PJ} \times CEF_{HEAT} + CONS_{FossFuel,PJ} \times CEF_{FossFuel}\right)}{1000}$$

Where,			Units
PE_{ME}	=	Project emissions from energy required for methane collection, transport, and combustion during the reporting period	tCO_2e
$CONS_{ELEC,PJ}$*	=	Additional electricity consumption for destruction of methane during the reporting period, if any	MWh
CEF_{ELEC}	=	CO_2 emission factor of electricity used by mine during the reporting period [16]	tCO_2/MWh
$CONS_{HEAT,PJ}$	=	Additional heat consumption for destruction of methane during the reporting period, if any	volume
CEF_{HEAT}	=	CO_2 emissions factor of heat used by mine during the reporting period; see Appendix B for guidance on deriving emission factor	kg CO_2/ volume
$CONS_{FossFuel,PJ}$	=	Additional fossil fuel consumption for destruction of methane during the reporting period, if any	volume
$CEF_{FossFuel}$	=	CO_2 emission factor of fossil fuel used by mine during the reporting period; see Appendix B for emission factors by fuel type	kg CO_2/ volume
1/1000	=	Conversion of kg to metric tons	

* If total electricity being generated by project activities is ≥ the additional electricity consumption, then $CONS_{ELEC,PJ}$ shall not be accounted for in the project emissions and shall be omitted from the equation above.

5.2.2 Project Emissions from Destruction of Captured Methane

When CMM/VAM is burned in a flare, heat or power plant, or oxidized in an oxidation unit, carbon dioxide emissions are released and must be accounted for. In addition, if NMHC comprise more than 35,000 mg/m^3 (measured on a wet basis at standard conditions) of extracted CMG or more than 3,500 mg/m^3 (measured on a wet basis at standard conditions) of extracted ventilation air, carbon dioxide emissions from combustion of NMHC must also be accounted for.

Equation 5.9 must be used to calculate carbon dioxide emissions from destruction of captured methane at qualifying and non-qualifying devices.

Note: Although baseline methane emissions from surface pre-mining are accounted for only when they are eligible (i.e. after the borehole is mined through), carbon dioxide emissions

[16] Refer to the version of the U.S. EPA eGRID that most closely corresponds to the time period during which the electricity was used. The project shall use the annual total output emission rates for the subregion where the project is located, not the non-baseload output emission rates. The eGRID tables are available from the U.S. EPA website: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

resulting from the destruction of surface pre-mining CMM must be accounted for in the period during which the destruction occurs, using Equation 5.9.

Equation 5.9. CO_2 Emissions from Destruction of Captured CH_4

$$PE_{MD} = \left(MD_{OX} + MD_i\right) \times \left(2.75 + r \times CEF_{NMHC}\right)$$

With:

$$r = PC_{NMHC} \Big/ PC_{CH_4}$$

Where,			Units
PE_{MD}	=	Project emissions from methane destroyed during the reporting period	tCO_2e
MD_i[17]	=	Methane destroyed by all qualifying and non-qualifying devices during the reporting period	tCH_4
MD_{OX}	=	Methane destroyed through oxidation during the reporting period	tCH_4
2.75	=	CO_2 emission factor for combusted methane	tCO_2/tCH_4
CEF_{NMHC}	=	CO_2 emission factor for combusted NMHC[18]	$tCO_2/tNMHC$
r	=	Relative mass proportion of NMHC compared to methane	
PC_{NMHC}	=	NMHC concentration (in mass) in extracted CMG or ventilation air, measured on a wet basis at standard conditions (60°F and 1 atm)	mg/m^3
PC_{CH4}	=	Concentration (in mass) of methane in extracted CMG or ventilation air, measured on wet basis at standard conditions	mg/m^3

For each end-use destruction device (qualifying and non-qualifying), the amount of gas destroyed depends on the efficiency of combustion for that destruction device. For VAM project destruction devices, Equation 5.10 must be used to quantify the methane destroyed by oxidation, which accounts for the destruction efficiency of the oxidation unit on a continuous basis. For drainage project destruction devices, Equation 5.11 must be used to quantify the methane destroyed for each qualifying and non-qualifying device.

Using Equation 5.11, project developers have the option to use either the default methane destruction efficiencies provided in Appendix B, or site-specific methane destruction efficiencies. Site specific destruction efficiencies for each qualifying or non-qualifying device must be determined by a source-test service provider accredited by a state or local agency. If the project developer chooses to use site-specific destruction efficiencies, the destruction device shall be source tested at least annually and the destruction efficiency updated accordingly.

[17] MD_i includes methane from all SMM sent to qualifying devices, not just eligible SMM.
[18] Because concentrations of different NMHC components may vary over time, the appropriate emission factor shall be obtained through annual analysis of captured gas from each drainage system type.

Equation 5.10. CH_4 Destroyed by VAM Oxidation

$$MD_{OX} = MM_{OX} - PE_{OX}$$

Where,

			Units
MD_{OX}	=	Methane destroyed through oxidation during the reporting period	tCH_4
MM_{OX}	=	Methane measured sent to oxidizer during the reporting period	tCH_4
PE_{OX}	=	Project emissions of non-oxidized CH_4 from oxidation of the VAM stream during the reporting period	tCH_4

And:

$$MM_{OX} = VAM_{flow.rate,y} \times time_y \times PC_{CH_4.VAM} \times D_{CH_4}$$

Where,

			Units
$VAM_{flow.rate,y}$	=	Average flow rate of ventilation air entering the oxidation unit during period y corrected if needed for inlet flow gas pressure and temperature ($P_{VAMinflow}$ and $T_{VAMinflow}$ respectively) per Equation 5.12	scfm
$time_y$	=	Time during which VAM unit is operational during period y	m
$PC_{CH4.VAM}$	=	Concentration of methane in the ventilation air entering the oxidation unit corrected if needed for pressure and temperature in the vicinity of the methane analyzer	scf/scf
D_{CH4}	=	Density of methane under standard conditions	tCH_4/scf

And:

$$PE_{OX} = VAM_{flow.rate,y} \times time_y \times PC_{CH_4.exhaust} \times D_{CH_4}$$

Where,

			Units
$PC_{CH4.exhaust}$	=	Concentration of methane in the ventilation air exhaust corrected if needed for pressure and temperature in the vicinity of the methane analyzer ($P_{VAManalyzerinflow}$, $T_{VAManalyzerinflow}$, $P_{VAMnalyzerexhaust}$, and $T_{VAManalyzerexhaust}$)	scf/scf
D_{CH4}	=	Density of methane under standard conditions	tCH_4/scf

Equation 5.11. CH_4 Destroyed by Other (Non-VAM) Destruction Devices

$$MD_i = \sum_i MM_i \times DE_i$$

Where,			Units
MD_i	=	Methane destroyed by all qualifying and non-qualifying devices i during the reporting period	tCH_4
MM_i	=	Methane measured sent to use i during the reporting period	tCH_4
DE_i	=	Efficiency of methane destruction device i; see Appendix B for default destruction efficiencies by destruction device[19]	%

Equation 5.12. Adjusting CMG Flow for Temperature and Pressure

Important: Apply the following equation only if the CMG flow metering equipment does not internally correct for temperature and pressure.

$$MM_{adjusted,i} = MM_{unadjusted,i} \times \frac{520}{T} \times \frac{P}{1}$$

Where,			Units
$MM_{adjusted,i}$	=	Adjusted volume of CMG collected for the given time interval at utilization type i, adjusted to 60°F and 1 atm	scf/unit time
$MM_{unadjusted,i}$	=	Unadjusted volume of CMG collected for the given time interval at utilization type i	scf/unit time
T	=	Measured temperature of the CMG for the given time period (°R = °F + 460)	°R
P	=	Measured pressure of the CMM for the given time interval	atm

[19] Project developers have the option to use either the default methane destruction efficiencies provided, or site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for each of the combustion devices used in the project.

5.2.3 Project Emissions from Uncombusted Methane

Not all of the methane sent to the flare, to the oxidizer or used to generate heat and power will be combusted; a small amount will escape to the atmosphere. These emissions are calculated using Equation 5.13.

As in Equation 5.11, project developers again have the option to use either the default methane destruction efficiencies provided in Appendix B, or site specific methane destruction efficiencies in Equation 5.13. If the project developer chooses to use site specific destruction efficiencies in Equation 5.11, they must use the same destruction efficiencies in Equation 5.13.

Equation 5.13. Uncombusted CH_4 Emissions

$$PE_{UM} = \left[GWP_{CH_4} \times \sum_i MM_i \times \left(1 - DE_i\right) \right] + PE_{OX} \times GWP_{CH_4}$$

Where,			Units
PE_{UM}	=	Project emissions from uncombusted methane during the reporting period	tCO_2e
GWP_{CH4}	=	Global warming potential of methane (21)	tCO_2e/tCH_4
i	=	The set of all qualifying and non-qualifying devices	
MM_i	=	Methane measured sent to use i during the reporting period	tCH_4
DE_i	=	Efficiency of methane destruction in use i; see Appendix B for default destruction efficiencies by destruction device[20]	%
PE_{OX}	=	Project emissions of non oxidized methane from oxidation of the VAM stream during the reporting period	tCH_4

[20] Project developers have the option to use either the default methane destruction efficiencies provided, or site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for each of the combustion devices used in the project.

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.3 for minimum record keeping requirements); the frequency of instrument cleaning, inspection, field check and calibration activities; and the role of individuals performing each specific monitoring activity. The Monitoring Plan should include QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision. The Monitoring Plan shall also contain a detailed diagram of the coal mine gas collection and destruction system, including the placement of all meters and equipment that affect SSRs within the GHG Assessment Boundary (see Figure 4.1 and Figure 4.2).

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.4.1).

Project developers are responsible for monitoring the performance of the project and ensuring that the operation of CMM destruction devices is consistent with the manufacturer's recommendations for each piece of equipment.

6.1 Monitoring Requirements

For drainage projects, the drainage systems and methane destruction devices must be monitored with measurement equipment that directly meters:

- The total flow of CMG from each drainage system defined as part of a project, measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure

- The flow of CMG delivered to each destruction device (unless otherwise allowed by Section 6.1.1), measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure

- The fraction of methane in the CMG from each drainage system, measured continuously and recorded every 15 minutes and averaged at least daily

For VAM projects, monitoring requirements include:

- The total inlet flow entering the oxidation unit, measured continuously and recorded every two minutes to calculate average flow per hour

- The fraction of methane in the ventilation air entering the oxidation unit and in the exhaust gas, measured continuously and recorded every two minutes to calculate average methane concentration per hour

- If required in order to standardize the flow rate, the temperature and pressure in the vicinity of the flow meter, measured continuously and recorded at least every hour to calculate hourly pressure and temperature.

- If required in order to correct methane concentration readings, the temperature and pressure in the vicinity of the methane analyzer, measured continuously and recorded at least every hour to calculate hourly pressure and temperature.

All flow data collected must be corrected for temperature and pressure at standard conditions (60°F and 1 atm). Equation 5.12 must be applied if flow metering equipment does not make this correction automatically. Depending on the methane analyzer technology used, methane concentration data may or may not need to be corrected for temperature and pressure. If the methane analyzer technology used requires adjustment for temperature and pressure, then concentration data must also be corrected to 60°F and 1 atm.

For both VAM projects and drainage projects, NMHC content of the CMG shall be determined on an annual basis by a full gas analysis using a gas chromatograph at an ISO 17025 accredited lab or a lab that has been certified by an accreditation body conformant with ISO 17025[21] to perform test methods appropriate for NMHC content analysis.[22] Separate gas samples shall be collected by a third-party technician prior to each destruction device within the project definition.

Operational activity of the CMM drainage systems and the destruction devices shall be monitored and documented at least hourly to ensure actual methane destruction. GHG reductions will not be accounted for during periods in which the destruction device is not operational. For flares, operation is defined as thermocouple readings above 500°F. For all other destruction devices, the means of demonstration shall be determined by the project developer and subject to verifier review and professional judgment.

6.1.1 Arrangement of CMG Metering Equipment

For drainage projects, the CMG from each drainage system (i.e. surface pre-mining boreholes, horizontal pre-mining boreholes, or post-mining boreholes) must be monitored separately prior to interconnection with other CMG sources. The volumetric gas flow, methane concentration, temperature, and pressure shall be monitored and recorded separately for each drainage system.

In addition, the flow of gas to each destruction device must be monitored separately for each destruction device, except under certain conditions. Specifically, if all destruction devices are of identical efficiency and verified to be operational throughout the reporting period, a single flow meter may be used to monitor gas flow to all destruction devices. Otherwise, the destruction efficiency of the least efficient destruction device shall be used as the destruction efficiency for all destruction devices monitored by this meter.

If a project using a single meter to monitor gas flow to multiple destruction devices has any periods when not all destruction devices downstream of a single flow meter are operational, methane destruction from the set of downstream devices during these periods will only be

[21] Such as the American Industrial Hygiene Association (AIHA), the American Association for Laboratory Accreditation (A2LA) and the National Environmental Laboratory Accreditation Program (NELAP).
[22] For example, NIOSH method number 1550 for portable gas chromatography.

eligible provided that the verifier can confirm all of the following requirements and conditions are met:

a. The destruction efficiency of the least efficient downstream destruction device in operation shall be used as the destruction efficiency for all destruction devices downstream of the single meter; and
b. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and
c. For any period during which one or more downstream destruction devices are not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period.

6.2 Instrument QA/QC

Monitoring instruments[23] shall be inspected, cleaned, and calibrated according to the following schedule.

All gas flow meters[24] and continuous methane analyzers must be:

- Cleaned and inspected on a regular basis, as specified in the project's Monitoring Plan, with the activities and results documented by site personnel. Cleaning and inspection frequency must, at a minimum, follow the manufacturer's recommendations.

- Field checked for calibration accuracy by an appropriately trained individual or a third-party technician with the percent drift documented, using either a portable instrument or manufacturer specified guidance, at the end of – but no more than two months prior to or after – the end date of the reporting period.[25] If a portable calibration instrument is used for field checks, the portable instrument shall be maintained and calibrated per the manufacturer's specifications, and calibrated at least annually by the manufacturer or at an ISO 17025 accredited laboratory. For portable methane analyzers, the portable instrument must be field calibrated to a known sample gas prior to each use.

- Calibrated by the manufacturer or a third-party calibration service at the frequency recommended by the manufacturer. If the manufacturer does not specify a recommended calibration schedule, then no calibrations are required, unless a field check reveals a difference of +/- 5% or more.

    - Flow meter calibrations shall be documented to show that the meter was calibrated to a range of flow rates corresponding to the flow rates expected at the mine.
    - Methane analyzer calibrations shall be documented to show that the calibration was carried out to the range of conditions (temperature and pressure) corresponding to the range of conditions as measured at the mine.

[23] If separate instruments are used for monitoring temperature and pressure, these instruments must also meet the specified QA/QC guidelines.
[24] Field checks and calibrations of flow meters shall assess the volumetric output of the flow meter.
[25] Instead of performing field checks, the project developer may have equipment calibrated by the manufacturer or a third-party calibration service per manufacturer's guidance, at the end of, but no more than two months prior to or after, the end date of the reporting period to meet this requirement.

If the field check on a piece of equipment reveals a difference of +/- 5% or more between the value measured by the portable calibration instrument and the value measured by the monitoring instrument, calibration by the manufacturer or a third-party calibration service is required for that piece of equipment.

For the interval between the last successful field check/calibration and any field check/calibration event revealing accuracy outside the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure based on the results of the calibration report from the manufacturer or third-party service provider. These adjustments must be made for the entire period from the last successful field check/calibration until such time as the meter is properly calibrated and in place.

1. For calibrations that indicate an underestimation of emission reductions, the metered values must be used without correction.

2. For calibrations that indicate an overestimation of emission reductions, the metered values must be adjusted based on the greatest calibration drift recorded at the time of calibration.

For example, if a project conducts field checks quarterly during a year-long reporting period, then only three months of data will be subject at any one time to the penalties above. However, if the project developer feels confident that the meter does not require field checks or calibration more than annually, then failed events will accordingly require the adjustments above to be applied to the entire year's data. Further, frequent calibration may minimize the total accrued drift (by zeroing out any error identified), and result in smaller overall deductions.

In order to provide flexibility in verification, data monitored up to two months after a field check may be verified. As such, the end date of the reporting period must be no more than two months after the latest successful field check. A field check conducted up to two months after the end date of a reporting period is also acceptable to confirm the accuracy of the equipment during the reporting period. Note that while a field check completed outside of the 12 month reporting period may be used, only the 12 months of data specified as the reporting period can be verified.

Project developers have the option to use either the default methane destruction efficiencies provided in the protocol, or the site-specific methane destruction efficiencies as provided by a state- or local agency-accredited source test service provider, for any of the destruction devices used in the project, performed on an annual basis. Device-specific source testing shall include at least three test runs, with the accepted final value being one standard deviation below the mean of the measured efficiencies.

6.3 Missing Data

In situations where the flow rate or methane concentration monitoring equipment is missing data, the project developer shall apply the data substitution methodology provided in Appendix C. If for any reason the destruction device monitoring equipment is inoperable (for example, the thermocouple on the flare), then no emission reductions can be credited for the period of inoperability.

6.4 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Coal Mine Methane Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
5.4 5.5	$SMM_{BL,i}$	CMM from surface pre-mining that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period	tCH_4	Estimated at start of project and calculated annually, if non-qualifying destruction device is still in place	c, m	The higher of the two calculated values is used
5.4 5.5	$HMM_{BL,i}$	CMM from horizontal pre-mining that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period	tCH_4	Estimated at start of project and calculated annually, if non-qualifying destruction device is still in place	c, m	The higher of the two calculated values is used
5.4 5.5	$PMM_{BL,i}$	Post-mining CMM that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period	tCH_4	Estimated at start of project and calculated annually, if non-qualifying destruction device is still in place	c, m	The higher of the two calculated values is used
5.4 5.5	$VAM_{BL,i}$	VAM that would have been captured, sent to and destroyed by use i in the baseline scenario in the reporting period	tCH_4	Estimated at start of project and calculated annually, if non-qualifying destruction device is still in place	c, m	The higher of the two calculated values is used
5.4 5.9	CEF_{NMHC}	CO_2 emission factor for combusted non methane hydrocarbons (various)	tCO_2e/ tNMHC	Annually	m	To be obtained through analysis of the fractional composition of captured gas
5.4 5.9	PC_{CH4}	Concentration (in mass) of methane in extracted CMG or ventilation air , measured on wet basis	mg/m^3	Continuous	m	To be measured on wet basis
5.4 5.9	PC_{NMHC}	NMHC concentration (in mass) in extracted CMG or ventilation air	mg/m^3	Annually	m	Based on full gas analysis by a certified gas lab using a gas chromatograph
5.5 5.6	$SMMe_i$	CMM from surface pre-mining captured, sent to and destroyed by use i for the reporting period. For qualifying devices, only the *eligible* amount may be quantified	tCH_4	Every reporting period	c, m	Only includes SMM from boreholes that have been "mined through" and SMM destroyed by non-qualifying devices (excluding SMM sent to pipeline)

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
5.5	$HMM_{PJ,i}$	CMM from horizontal pre-mining captured, sent to and destroyed by use i in the reporting period	tCH_4	Continuous	m	Includes metered HMM destroyed by both eligible and non-qualifying devices
5.5	$VAM_{PJ,i}$	VAM sent to and destroyed by use i in the project activity in the reporting period. In the case of oxidation, $VAM_{PJ,i}$ is equivalent to MM_{OX} defined in Section 5.2.2	tCH_4	Continuous	m	Includes metered VAM destroyed by both eligible and non-qualifying devices
5.5	$PMM_{PJ,i}$	CMM from post-mining captured, sent to and destroyed by use i in the project activity in the reporting period	tCH_4	Continuous	m	Includes metered PMM destroyed by both eligible and non-qualifying devices
5.5 5.13	GWP_{CH4}	Global warming potential of methane	tCO_2e/tCH_4		r	21
5.6	$SMMpre_e$	CMM destroyed by qualifying devices in the current reporting period from surface pre-mining boreholes that were mined through during the current reporting period	tCH_4	Every reporting period	m	
5.6	$SMMpost_e$	CMM destroyed by qualifying devices in the current reporting period from surface pre-mining boreholes that were previously mined through	tCH_4	Every reporting period	m	
5.6	$SMMw_1$	CMM captured and destroyed from well w_1 from the project start date through the end of the current reporting period	tCH_4	Every reporting period	m	
5.6	w_1	The set of wells mined through in current reporting period		Every reporting period	o	
5.6	$SMMw_2$	CMM captured from well w_2 during the current reporting period	tCH_4	Every reporting period	m	
5.6	w_2	The set of wells mined through prior to the current reporting period		Every reporting period	o	
5.8	$CONS_{ELEC,PJ}$	Additional electricity consumption for destruction of methane, if any	MWh	Every reporting period	o	From electricity use records
5.8	$CONS_{HEAT,PJ}$	Additional heat consumption destruction of methane	volume	Every reporting period	o	From purchased heat records

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
5.8	$CONS_{FossFuel,PJ}$	Additional fossil fuel consumption for destruction of methane	volume	Every reporting period	o	From fuel use records
5.8	CEF_{ELEC}	CO_2 emissions factor of electricity used by mine	tCO_2/ MWh	Every reporting period	r	See eGRID
5.8	CEF_{HEAT}	CO_2 emissions factor of heat used by mine	kg CO_2/ volume	Every reporting period	c	See Appendix B
5.8	$CEF_{FossFuel}$	CO_2 emissions factor of fossil fuel used by mine	kg CO_2/ volume	Every reporting period	r	See Appendix B
5.9	MD_i	Methane destroyed by all qualifying and non-qualifying devices	tCH_4	Every reporting period	c	
5.10	$VAM_{flow.rate,y}$	Average flow rate of ventilation air entering the oxidation unit during period y	scfm	Continuous	m, c	Readings taken every two minutes to calculate average hourly flow
5.10	$time_y$	Time during which VAM unit is operational during period y	m	Continuous		Readings taken every two minutes to calculate average hourly flow
5.10	D_{CH4}	Density of methane under standard conditions	tCH_4/scf		r	Density of methane under standard conditions (60ºF and 1 atm) = 0.0423 lb/scf
5.10	D_{CH4}	Density of methane under standard conditions	tCH_4/scf		r	Density of methane under standard conditions (60ºF and 1 atm) = 0.0423 lb/scf
5.10	$P_{VAMinflow}$	Pressure of ventilation air entering the oxidation unit	atm	Continuous	m	Readings taken at least every hour to calculate hourly pressure
5.10	$T_{VAMinflow}$	Temperature of ventilation air entering the oxidation unit (ºR = ºF + 460)	ºR	Continuous	m	Readings taken at least every hour to calculate hourly temperature
5.10	$PC_{CH4,VAM}$	Concentration of methane in the ventilation air entering the oxidation unit	scf/scf	Continuous	m	Readings taken at least every two minutes and used to calculate average methane concentration per hour
5.10	$PC_{CH4,exhaust}$	Concentration of methane in the ventilation air exhaust	scf/scf	Continuous	m	Readings taken at least every two minutes (either average over two minutes or instantaneous) and used to calculate average methane concentration per hour

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
5.10	$P_{VAManalyzerinflow}$	Pressure of ventilation air in the vicinity of the VAM methane analyzer at inlet	atm	Continuous	m	If methane analyzer technology requires adjustment for pressure and temperature and the use of $P_{VAMinflow}$ is inappropriate, readings shall be taken in the vicinity of the inlet VAM methane analyzer at least every hour to calculate hourly pressure
5.10	$T_{VAManalyzerinflow}$	Temperature of ventilation air entering the oxidation unit in the vicinity of the VAM methane analyzer	ºR	Continuous	m	If methane analyzer technology requires adjustment for pressure and temperature and the use of $T_{VAMinflow}$ is inappropriate, readings shall be taken in the vicinity of the inlet VAM methane analyzer at least every hour to calculate hourly temperature
5.10	$P_{VAManalyzerexhaust}$	Pressure of exhaust gases in the vicinity of the VAM methane analyzer at inlet	atm	Continuous	m	If methane analyzer technology requires adjustment for pressure and temperature, readings shall be taken in the vicinity of the exhaust VAM methane analyzer at least every hour to calculate hourly pressure
5.10	$T_{VAManalyzerexhaust}$	Temperature of exhaust gases exiting the oxidation unit in the vicinity of the VAM methane analyzer	ºR	Continuous	m	If methane analyzer technology requires adjustment for pressure and temperature, readings shall be taken in the vicinity of the exhaust VAM methane analyzer at least every hour to calculate hourly temperature
5.11 5.13	MM_i	Methane measured sent to use i	tCH_4	Continuous	m	Flow meters will record gas volumes, pressure and temperature
5.11 5.13	Eff_i	Efficiency of methane destruction through use i		Annually	m or r	See Appendix B
5.12	MMadjusted,i	Adjusted volume of CMG collected for the given time interval at use i	scf/unit time	Every reporting period	c	Adjusted to standard conditions (60°F and 1 atm)

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
5.12	MMunadjusted,i	Unadjusted volume of CMG collected for the given time interval at use i	scf/unit time	Continuously	m	If flow meters do not internally correct for temperature and pressure
5.12	T	Measured temperature of CMG for the given time period (ºR = ºF + 460)	ºR	Continuously	m	Measured to adjust the flow of CMG. No separate monitoring of temperature is necessary when using flow meters that automatically adjust flow volumes for temperature and pressure
5.12	P	Measured pressure of the CMG for the given time interval	atm	Continuously	m	Measured to adjust the flow of CMG. No separate monitoring of pressure is necessary when using flow meters that automatically adjust flow volumes for temperature and pressure

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure by project developers. Project developers must submit verified emission reduction reports to the Reserve annually at a minimum.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register a coal mine methane project.

- Project Submittal form
- Project diagram: diagram that illustrates how the project is defined and includes the location, quantity and type of boreholes, ventilation shafts, eligible destruction devices and non-qualifying destruction devices within the project GHG Assessment Boundary, as well as placement of monitoring equipment
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form

At a minimum, the above project documentation (except for the project diagram) will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available by the project developer on a voluntary basis. Project submittal forms can be found at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

7.1.1 Documentation of Project Expansions

If a project expands to include boreholes, ventilation shafts or destruction devices beyond what was included in the project as defined by the project developer at the time of listing (see Section 2.2), the project developer must submit an updated project diagram to the Reserve.

Similarly, if any new non-qualifying device becomes operational at the mine – or if an existing non-qualifying device at a mine is assigned to a different active project (see Section 2.2.3) – the project developer must submit an updated project diagram for the project to which the device is assigned.

7.2 Joint Project Verification

Because the protocol allows for multiple projects at a single mine site, project developers have the option to hire a single verification body to verify multiple projects at a mine through a "joint project verification." This may provide economies of scale for the project verifications and improve the efficiency of the verification process.

Under joint project verification, each project, as defined by the protocol and the project developer, is submitted, listed and registered separately in the Reserve system. Furthermore, each project requires its own separate verification process and Verification Statement (i.e. each project is assessed by the verification body separately as if it were the only project at the mine). However, all projects may be verified together by a single site visit to the mine. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Regardless of whether the project developer chooses to verify multiple projects through a joint project verification or pursue verification of each project separately, the documents and records for each project must be retained according to this section.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of GHG reductions, including all required sampled data
- Copies of mine operating permits, air, water, and land use permits; Notices of Violations (NOVs); and any administrative or legal consent orders related to project activities dating back at least three years prior to the project start date; and for each subsequent year of project operation[26]
- Copies of mine plans and mine ventilation plans submitted to MSHA throughout the crediting period
- Executed Attestation of Regulatory Compliance related to the project
- Flow meter information (model number, serial number, manufacturer's calibration procedures)
- Methane monitor information (model number, serial number, calibration procedures)
- Destruction device monitor information (model number, serial number, calibration procedures)
- Field checks and calibration results for all meters
- Corrective measures taken if meter does not meet performance specifications
- Destruction device monitoring data (for each destruction device)
- Project flow and methane concentration data
- Emission reduction calculations
- Verification records and results from each verification
- All maintenance records relevant to the project monitoring equipment and destruction devices

[26] Note that these documentation requirements are for activities and equipment related to the project and the mine where the project is located.

7.4 Reporting Period & Verification Cycle

Project developers must report GHG reductions resulting from project activities during each reporting period. Although projects must be verified annually at a minimum, the Reserve will accept verified emission reduction reports on a sub-annual basis, should the project developer choose to have a sub-annual reporting period and verification schedule (e.g. quarterly or semi-annually). A reporting period cannot exceed 12 months, and no more than 12 months of emission reductions can be verified at once, except during a project's first verification. A project's initial reporting period must begin on the project's start date. Reporting periods must be contiguous; there can be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced. Project developers may register their project's initial reporting period as a zero-credit reporting period (see Reserve Program Manual, Section 3.3.3 for more details).

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions from coal mine methane projects developed to the standards of this protocol. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities in the context of coal mine methane destruction projects.

Verification bodies trained to verify coal mine methane projects must conduct verifications to the standards of the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Coal Mine Methane Project Protocol
- Any applicable errata and clarifications to the Coal Mine Methane Project Protocol
- Any applicable policy memos issued by the Reserve

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify coal mine methane project reports. Verification bodies approved under other project protocol types are not permitted to verify coal mine methane projects. Information about verification body accreditation and Reserve project verification training can be found in the Verification Program Manual.

8.1 Verification of Multiple Projects at a Single Mine

Because the protocol allows for multiple projects at a single mine site, project developers have the option to hire a single verification body to verify multiple projects under a joint project verification. This may provide economies of scale for the project verifications and improve the efficiency of the verification process. Joint project verification is only available as an option for a single project developer; joint project verification cannot be applied to multiple projects registered by different project developers at the same mine.

Under joint project verification, each project, as defined by the protocol and the project developer, must still be registered separately in the Reserve system and each project requires its own verification process and Verification Statement (i.e. each project is assessed by the verification body separately as if it were the only project at the mine). However, all projects may be verified together by a single site visit to the mine. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Finally, the verification body may submit one Notification of Verification Activities/Conflict of Interest (NOVA/COI) Assessment form that details and applies to all of the projects at a single mine that it intends to verify.

If, during joint project verification, the verification activities of one project are delaying the registration of another project, the project developer can choose to forego joint project

verification. There are no additional administrative requirements of the project developer or the verification body if a joint project verification is terminated.

8.2 Standard of Verification

The Reserve's standard of verification for coal mine methane projects is the Coal Mine Methane Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify a coal mine methane project developer's project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Section 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.3 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.4 Verifying Project Eligibility

Verification bodies must affirm a coal mine methane project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for a coal mine methane project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing no more than 6 months after the project start date	Once during initial verification
Location	United States and its territories	Once during initial verification
Performance Standard	▪ Drainage projects: the project destroys CMM through any end use destruction system other than injection into a natural gas pipeline for off-site consumption ▪ All VAM projects	During initial verification of each crediting period
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures that lay out procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Regulatory Compliance	Project must be in material compliance with all applicable laws, and submit a signed Attestation of Regulatory Compliance form	Every verification
Exclusions	▪ Surface coal mines ▪ Abandoned coal mines ▪ Coal bed methane destruction ▪ Use of CO_2 or other fluid/gas to enhance methane drainage before mining takes place	Every verification

8.5 Core Verification Activities

The Coal Mine Methane Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with the destruction of coal mine methane. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a coal mine methane project, but verification bodies shall also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emissions sources, sinks and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as VAM and CMM destruction system energy use, fuel consumption from transport of the gas, combustion and destruction from various qualifying and non-qualifying destruction devices, and emissions from the incomplete combustion of methane.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the mine operator uses to gather data on methane collected and destroyed and to calculate baseline and project emissions.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.6 Coal Mine Methane Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a coal mine methane project. The tables include references to the section in the protocol where requirements are further described. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to coal mine methane projects that must be addressed during verification.

8.6.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for coal mine methane projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2 - 2.2.2	Verify that the project meets the definition of a CMM project and is properly defined as either drainage project or VAM project	No
2.2.3	Confirm all non-qualifying devices have been properly accounted for within project's GHG Assessment Boundary	No
2.3	Verify ownership of the reductions by reviewing Attestation of Title	No
2.2.1 - 2.2.3, 7.1.1	If there are new destruction devices, boreholes, shafts or a project crediting period expiration at the mine, verify that project expansions have been completed, properly defined and documented to account for these changes	No
3.1	Verify that the project only consists of activities at a single coal mine or Category III gassy underground trona mine operating within the U.S. or its territories	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that project is within its 10-year crediting period	No
3.4.1	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.4.1	Verify that the project monitoring plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
3.4.1.1	Verify that the project meets the appropriate Performance Standard Test for the project type	No
3.4.1.1	If VAM project uses supplemental CMM, verify that supplemental CMM is eligible	No
3.5	Verify that project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes

8.6.2 Quantification of GHG Emission Reductions

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
0	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project diagram for the reporting period	No
5.1	Verify that the project developer correctly accounted for methane destruction in the baseline scenario	No
5.1	Verify that baseline emissions for non-qualifying devices were calculated according to the protocol	No
5.1.2.1	Verify definition of mined through was properly applied to SMM boreholes	No
5.2.2	Verify NMHC concentration of CMG is either below project-specific threshold or, if above, CO_2 emissions from NMHC combustion are accounted for in project emissions	No
5.2.1	Verify that the project developer correctly quantified and aggregated electricity use	Yes
5.2.1	Verify that the project developer correctly quantified and aggregated fossil fuel use	Yes
5.2.1	Verify that the project developer correctly quantified and aggregated heat consumption	Yes
Equation 5.8, Appendix B	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
Equation 5.11, Appendix B	Verify that the project developer applied the correct methane destruction efficiencies	No
Equation 5.11	If the project developer used source test data in place of the default destruction efficiencies (Appendix B), verify accuracy and appropriateness of data and calculations	Yes
6.1	Verify that monitoring meets the requirements of the protocol; if it does not, verify that a variance has been approved for monitoring variations	No
6.1	Verify that NMHC samples were properly collected and analyzed	No
6.1, 6.1.1	Verify that destruction devices were operational during the reporting period, or that guidance in Section 6.1.1 was properly applied	Yes
6.2	Verify that all gas flow meters and continuous methane analyzers adhered to the inspection, cleaning, and calibration schedule specified in the protocol; if they do not, verify that a variance has been approved for monitoring variations or that adjustments have been made to data per the protocol requirements	No
6.2	Verify that any portable calibration instruments were calibrated at least annually by the manufacturer or at an ISO 17025 accredited lab	No
6.2	If any piece of equipment failed a calibration check, verify that data from that equipment was scaled according to the failed calibration procedure for the appropriate time period	No
6.3, Appendix C	If used, verify that data substitution methodology was properly applied	No
n/a	If any variances were granted, verify that variance requirements were met and properly applied	Yes

8.6.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project monitoring plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that the methane destruction equipment was operated and maintained according to manufacturer specifications	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to project-related duties	Yes
6	Verify that all contractors are qualified for project-related duties if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6	If field checks are performed by an individual that is not a third-party technician, verify the competency of the individual to perform the field check and the accuracy of the field check procedure	Yes
7.3	Verify that all required records have been retained by the project developer	No

8.7 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

As stated in Section 8.1, project developers may choose to have a verification body conduct multiple project verifications at a single mine under a joint project verification. The verification body must verify the emission reductions entered into the Reserve system for each project and upload a unique Verification Statement for each project within the joint verification. The verification body can prepare a single Verification Report that contains information on all of the projects, but this must also be uploaded to every project under the joint verification.

9 Glossary of Terms

Active mine	Active mines include mine works that are actively ventilated by the mine operator. For the purposes of this protocol, MSHA designated "intermittent" mines are also considered active mines.
Abandoned mine	A mine where all mining activity including mine development and mineral production have ceased, mine personnel are not present in the mine workings, and mine ventilation fans are no longer operative.[27] In the U.S., mines are declared "abandoned" from the date when ventilation is discontinued.[28] This mine type is not eligible under this protocol.
Baseline emissions	Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that would have occurred in the absence of the GHG reduction project.
Coal bed methane (CBM)	A generic term for methane originating in coal seams that is drained from virgin coal seams and surrounding strata. CBM is unrelated to mining activities.
Coal mine gas (CMG)	Gas from drainage systems before any processing or enrichment that often contains various levels of other components (e.g. nitrogen, oxygen carbon dioxide, hydrogen sulfide, NMHC, etc.).
Coal mine methane (CMM)	Methane contained in coal and surrounding strata that is released because of mining activity. For the purposes of this protocol, CMM also refers to the methane gas that is released because of mining activity at Category III gassy underground trona mines.
Drainage system	A term used to encompass the entirety of the equipment that is used to drain the gas from underground and collect it at a common point, such as a vacuum pumping station. In this protocol, methane drainage systems include surface pre-mining, horizontal pre-mining, and post-mining.
Eligible end use	For the purposes of this protocol, all end uses that result in the destruction/oxidation of methane except for injection into natural gas pipeline.
Gob	Also referred to as goaf, it is the collapsed area of strata produced by the removal of coal and artificial supports behind a working coalface. Strata above and below the gob are de-stressed and fractured by the mining activity.
Intermittent	Mines placed in intermittent status by MSHA, as a result of being seasonally idled for more than 90 days, are not considered abandoned. To maintain intermittent status, facilities and equipment such as the mine office, surface and underground power systems, the main mine

[27] UN Economic and Social Council, Economic Commission for Europe, Committee on Sustainable Energy, Glossary of Coal Mine Methane Terms and Definitions, July 2008.
[28] MSHA Program Policy Manual Volume V, January 2006, p.120.

	fan, and underground coal haulage systems must remain intact.[29] Under this protocol, intermittent mines are considered active mines and are eligible.
Joint project verification	Project verification option where a project developer hires a verification body to verify multiple projects at a mine.
Longwall mine	An underground mining type that uses at least one longwall panel during coal excavation.
Mine Safety and Health Administration (MSHA)	Federal enforcement agency responsible for protecting the health and safety of U.S. miners.
Mined through	When the linear distance between the endpoint of the borehole and the working face that will pass nearest the endpoint of the borehole has reached an absolute minimum. Coal mine methane from surface pre-mining boreholes shall not be quantified in the baseline until the endpoint of the borehole is mined through.
Mine	An area of land and all structures, facilities, machinery tools, equipment, shafts, slopes, tunnels, excavations, and other property, real or personal, placed upon, under, or above the surface of such land by any person, used in, or to be used in, or resulting from, the work of extracting minerals. The mine boundaries are defined by the mine area as permitted by the state in which the mine is located.
Non-qualifying destruction device	A methane destruction device that does not meet one or more of the eligibility rules as described in Section 3 (e.g. operational start date, regulatory requirement, injection into natural gas pipeline) and is located at the same mine where eligible project activities are taking place.
Oxidizer	For the purposes of this protocol, the term oxidizer refers to technology for destruction of ventilation air methane with or without utilization of thermal energy and/or with or without a catalyst.
Project diagram	A diagram of the mine that illustrates the location, quantity, and type of boreholes, ventilations shafts, eligible destruction devices and non-qualifying destruction devices within a project's GHG Assessment Boundary. The project diagram must be updated and submitted to the Reserve whenever a project expansion occurs.
Project emissions	Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of project activities. Project emissions are calculated at a minimum on an annual, *ex-post* basis.
Qualifying destruction device	A methane destruction device that meets the eligibility rules for a CMM project as described in Section 3.
Room and pillar mine	An underground mining type that uses square or rectangular pillars of coal during excavation, laid out in a checkerboard fashion. Pillars typically range in size from 60 feet by 60 feet to 100 feet by 100 feet and rooms are typically 20 feet wide and a few thousand feet long

[29] MSHA Program Policy Manual, p.138.

Reporting period	Specific time period of project operation for which the project developer has calculated and reported emission reductions and is seeking verification and registration. The reporting period must be no longer than 12 months.
Standard conditions	Under this protocol, standard conditions are defined as 60ºF and 1 atm.
Ventilation air methane (VAM)	Coal mine methane that is mixed with the ventilation air in the mine that is circulated in sufficient quantity to dilute methane to low concentrations for safety reasons (typically below 1 percent).
Ventilation system	A system that is used to control the concentration of methane and other deleterious gases within mine working areas. Ventilation systems consist of powerful fans that move large volumes of air through the mine workings to dilute methane concentrations. All underground coal mines in the U.S. are required to develop and maintain ventilation systems.
Verification cycle	The Reserve requires verification of coal mine methane projects annually, but does not require verifications to be completed on specific dates. Project developers select the reporting period to be verified. Thus, each project has a unique verification cycle that begins the first time a project is verified, occurs at least annually, and ends once the crediting period expires or the project is no longer eligible, whichever happens first.
Year	For the purposes of this protocol, year refers to a 12 month period of the project's crediting period, not a calendar year.

10 References

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Appendix A Summary of Performance Standard Development

The analysis to develop the performance standard for the Coal Mine Methane Project Protocol was conducted by Science Applications International Corporation (SAIC) and was completed in May 2009. The analysis culminated in a paper that provided a performance standard recommendation to support the coal mine methane protocol development process, which the Reserve has incorporated into the protocol's eligibility rules (see Section 3).

The purpose of a performance standard is to establish a standard of performance applicable to all coal mine methane management projects that is significantly better than average greenhouse gas production for a specified service, which, if met or exceeded by a project developer, satisfies one of the criterion of "additionality."

The performance standard analysis contained an in-depth study of the following areas:

- Coal mine data trends and regional variations across the U.S.
- Degasification techniques including ventilation, surface pre-mining drainage, horizontal pre-mining drainage, and post-mining gob drainage currently used in coal mines
- Ventilation air methane utilization technologies
- Review of current, pending and anticipated regulations that could affect coal mine methane projects
- Data analysis to establish common practice for coal mine methane management at underground coal mines in the U.S.

A.1 Overview of Data Collection

The primary database used for the SAIC analysis was a coal mine methane emissions database provided by the U.S. EPA.[30] This database provided annual emissions-related data for underground mines classified as gassy by MSHA; the data cover the period 1990 through 2007. For the purposes of this analysis, the annual data for the 2000 to 2007 timeframe was used, covering a total of 295 gassy underground mines. The database provides the following data:

- Company name, mine name, and MSHA ID number
- State and county in which each mine is located
- Daily average and total methane emissions from the ventilation system, as well as the total amount of methane liberated by the mine (equal to the sum of the ventilation emissions and the drainage emissions or capture)
- An indication of whether the mine utilizes a degasification system, and if so, a brief description of the system and the total amount of methane drained through the system
- An indication as to whether the drained methane is captured, and a brief description of how the captured methane is utilized
- Detailed information on the subset of mines using methane capture

To supplement this primary data set, EPA provided a second database containing annual coal production data for the gassy mines for the years 2002 through 2006, along with an indication of

[30] This database is used as the basis for the coal mine methane emissions estimated published in EPA's annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks* reports.

the mine's production status.[31] SAIC also used mine-level production data for 2000, 2001, and 2007, obtained from the Energy Information Administration (EIA).[32] SAIC merged the production data with the emissions database using each mine's MSHA identification number. The final merged dataset included 241 mines for which emissions data for at least one of the eight years in the 2000 to 2007 time frame was available.

EPA also provided a list of longwall mines in the United States that produced in excess of 750,000 tons of coal from January through September 2007, published by CoalUSA magazine. This list was supplemented by SAIC with similar CoalUSA lists for production from 2001 through 2006[33] and a table detailing the production of top non-longwall mines in 2007.[34] SAIC also consulted the mining method information contained in two EPA reports on methane recovery opportunities at gassy mines.[35] They combined the mines on these lists to create a master list of longwall mines in operation during the 2000 to 2007 time period. The master list represents a comprehensive list of longwall mines operating in and around 2007 with the following assumptions:

- The individual lists provide a comprehensive identification of all longwall mines falling above the production cutoff
- Most, if not all, longwall mines would meet the production cutoff when operating at full capacity
- Most, if not all, longwall mines would have operated at full capacity at least in one year during the 2000 to 2007 time period

All remaining mines were assigned to the room and pillar method (the other main underground coal mining method). In keeping with the industry standard definition, a longwall mine is defined as any mine that has at least one longwall face or that opened a longwall face at some point during the 2000 to 2007 period.

In combining and using the data for eight separate years into a single dataset, SAIC characterized each mine according to the furthest development of its drainage system. For example, if a mine used gob boreholes only in some years, but gob boreholes with horizontal pre-mining boreholes in other years, SAIC treated the mine as using both drainage system types during the 2000 to 2007 time frame. Similarly, mines that utilized methane in some years but not in others were treated as having utilization projects in operation in the 2000 to 2007 time frame. The decision to use and combine data for the past eight years into a single dataset was based on a trend analyses which indicated that industry practice with respect to drainage systems and utilization projects has remained fairly stable since 2000 (see Table A.1). Given

[31] EIA was the original source of the production data.
[32] EIA, http://www.eia.doe.gov/cneaf/coal/page/database.html.
[33] Weir International, Inc. 2008. "U.S. Longwall Mines – Production and Productivity: September 2007 Year to Date (Mines Producing in Excess of 750,000 tons through September)." *CoalUSA*, March 2008; Weir International, Inc. 2006. "United States Longwall Mining Statistics: 1996-July 2006." Table 2: 2006 June Year to Date U.S. Longwall Mine Production and Productivity; "Table: U.S. Longwall Production 2005," *International Longwall News*, 27 March, 2006. At: http://www.longwalls.com/sectionstory.asp?SourceID=s50; NIOSH, 2005. "Table: U.S. Longwall production 2004." *International Longwall News*, 23 March 2005; NIOSH, 2004. "Table: U.S. Longwall output 2003 now working." *International Longwall News*, 7 April 2004; NIOSH, 2003. "Table: U.S. Longwall output 2002." *International Longwall News*, 21 July 2003.
[34] Weir International, Inc. 2008. "Top 50 U.S. Underground Mines (non-longwall) – Production and Productivity: September 2007 Year to Date." *CoalUSA*, March 2008. *CoalUSA*, March 2008.
[35] U.S. EPA, *Identifying Opportunities for Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines 1999-2003* and *Identifying Opportunities for Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines 2002-2006*.

this relative stability in coal industry practices, it appeared safe to combine recent data with older data for the purpose of ascertaining current common practice.

Table A.1. Historical Trends in Mines Using Methane Drainage and Capture/Utilization

	Year							
	1990	**1995**	**2000**	**2003**	**2004**	**2005**	**2006**	**2007**
Mines with Drainage Systems	**33**	**25**	**21**	**18**	**21**	**24**	**21**	**20**
Mines with Gob Wells	n/a	n/a	n/a	8	11	15	12	12
Mines with Gob and Horizontal Pre-Mining Wells	n/a	n/a	n/a	3	3	3	3	3
Mines with All Three Drainage System Types	n/a	n/a	n/a	7	7	6	6	5
Mines with Capture/Use Projects	**7**	**12**	**13**	**12**	**12**	**15**	**15**	**15**
Pipeline	6	12	10	11	10	13	13	13
Electricity Generation	0	0	0	1*	1	1	1	1
Vent. Air Heating	0	0	0	1	1	1	1	1
Thermal Coal Drying	0	1*	1*	1*	1*	1*	1*	1*
Unspecified	1	0	3	0	0	0	0	0
*Mine also sells a portion of its recovered methane to a pipeline.								

Source: Developed using data in U.S. EPA, Coal 07 draft.xls file.

Trona Mines

Data on trona mines operating in the United States was also collected and examined.[36] There are four Category III gassy underground trona mines in the United States, of which two are room and pillar and two are longwall mines. The two longwall mines currently have gob wells, but neither is capturing the coal mine methane for destruction.

A.2 Summary of Analysis

Should the Performance Standard Include the Drainage System?

In order to establish the definition of a coal mine methane project, it was necessary to explore if the installation of a drainage system should be tested using a performance standard, or if the performance standard test could be limited to the installation of coal mine methane destruction devices.

The hypothesis was that federal health and safety regulations influence a coal mine operator's decision to install methane drainage systems. As stated in Section 3.4.1, there currently exists no federal, state, or local regulations requiring coal mines to reduce, limit, or control their methane emissions. Hence, based solely on a consideration of emissions regulations, all coal mine methane projects would appear to pass the regulatory test screen.

However, the situation for coal mines is complicated by the existence of federal safety regulations that govern methane concentration levels inside the mine. These safety regulations may effectively necessitate the utilization of methane drainage systems under certain gassy conditions. While there is no requirement to capture the methane emitted from such systems, to the extent that these systems may be necessitated by the safety regulations, they should not be considered a part of an additional coal mine methane project. In other words, the safety

[36] Coal Age *U.S. Longwall Census*, February 2009. MSHA ID numbers and liberation rates provided by Steven Pilling, MSHA Green River, Wyoming Field Office, June 2009. Information on drainage systems provided by Jeff Liebert, Verdeo Group, July 2009.

regulations may have important implications for determining the project definition and eligibility rules. Specifically, the methane drainage system may need to be excluded from the project definition if the system was developed as a response to the safety regulations. If this is the case, the methane drainage system does not pass the regulatory test but the methane destruction system may; the project definition should thus include only the destruction system.

To test this hypothesis, SAIC therefore conducted an analysis to determine the common practices utilized by coal mine operators to dilute methane concentrations as a function of methane liberation rates. As a first step in their data analysis, they computed arithmetic averages of the annual methane liberation data for each mine in the merged emissions dataset. However, a mine's methane emissions depend heavily on its production rate, as it is the process of removing the coal from the seam that relieves the pressure on the nearby unmined coal and surrounding strata, thereby releasing much of the gas. For this reason, the use of arithmetic average emissions data can lead to distorted results, particularly for mines that were underutilized during all or part of the 2000 to 2008 timeframe.

To correct for this possibility, SAIC developed normalized methane liberation rate estimates for the mines in the merged database for which both liberation and production data were available. Specifically, for each mine SAIC divided the sum of the 2000 through 2007 methane liberation data by the sum of the mine's 2000 through 2007 production to derive average methane liberation per ton of coal produced. They then multiplied this methane liberation rate by the largest of the eight annual production data points in the 2000 to 2007 timeframe to obtain their estimate of normalized methane liberation for the period. The year with the largest production value was used in the calculation in order to increase the likelihood that the resulting methane liberation estimate represents the mine's annual liberation rate when it is operating at full capacity. A mine operator will decide on whether or not methane drainage must be used to meet the regulatory requirements based on the expected methane liberation rate under full capacity operations.[37] Hence it is the methane liberation rate at full capacity that governs the mine operator's decision process; by computing a weighted average methane liberation value for the year in which production reaches its maximum they likewise sought to base their analysis on full capacity conditions. They used a production-normalized average rather than the actual methane liberation observed in the selected "maximum production year" because, as previously noted, the amount of methane liberated can fluctuate significantly from year to year depending on the geologic conditions encountered in each year. By using an average rather than an actual methane liberation value they reduced the potential for distortions introduced by abnormally low or high methane liberation rates in any given year.

It should be noted that production data was lacking for seven of the mines in the merged database; these mines were deleted from the database prior to proceeding with further analysis. Six of the deleted mines were room and pillar operations and hence were not a primary focus of the analysis. The single longwall mine lacking production data does not employ a drainage system.

Figure A.1 below presents a histogram of drainage system usage for the longwall mines, based on the production-normalized annual methane liberation rates for the 2000 to 2007 timeframe. This histogram indicates that the use of methane drainage is highly correlated with the quantity

[37] If the operator were to use a methane liberation estimate based on anything less than full capacity production for the purposes of deciding on the need for a drainage system, the mine would run the risk of being unable to meet the regulatory requirements when operating at full capacity.

of methane produced by a longwall mine. From these results, methane drainage can be considered a common practice for gassy longwall mines.

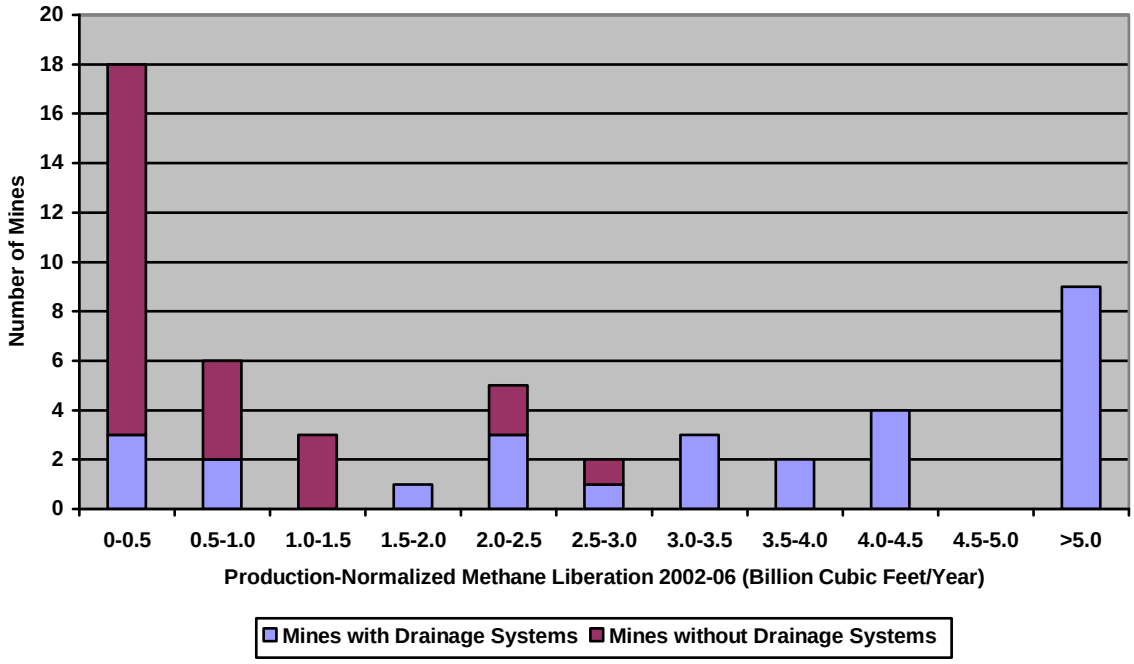


Figure A.1. Histogram of Drainage System Usage by Longwall Mines

There are currently no room and pillar mines with drainage systems in place; there are also no room and pillar mines with either arithmetic average or production-normalized methane liberation quantities in excess of two billion cubic feet.

Conclusion

This analysis strongly supports the hypothesis that the drainage systems currently in place are a response to the regulations. Given these results, we assume that all drainage systems are a response to health and safety regulations. Thus, the installation of a drainage system is not included in the definition of a coal mine methane project and is not tested for by a performance standard.

Recommendation to Use a Common Practice Standard

With the conclusion that the performance standard test must only test the additionality of the installation of a destruction device, it was necessary to determine what type of performance standard test was most suitable for coal mine methane projects.

Coal mine methane projects do not lend themselves to rate- or technology-based comparisons. In general, all coal mine methane projects are characterized by a very high rate of capture, making it difficult to distinguish projects on the basis of a metric such as methane destroyed as a percentage of methane entering the destruction device. Other potential metrics that might be used to establish a performance threshold for coal mine methane projects, such as the total quantity of methane captured on an annual basis, are fraught with difficulties. Specifically, the quantity of methane captured at any given mine is more a measure of the mine's geologic conditions than the performance of the methane capture equipment.

In general, there are no current requirements – federal, state, or local – that should influence a mine operator's choice between venting and utilizing the methane drained from drainage systems. This choice is driven by economic considerations, not regulatory requirements. A common practice standard is well-suited for these projects, in so far as common practice can help us infer whether the decision to install a methane destruction device was influenced by the availability of funding from carbon credits. Specifically, by identifying the conditions under which methane destruction is currently common practice, we can infer that projects operating under those conditions are likely undertaken to use the gas as a valuable byproduct of the mining process, and thus not additional.

Drainage Project Analysis

A strong argument can be made for determining additionality by assessing common practice of coal mine methane destruction by utilization type. As previously noted in Table A.1, only a small number of the mines with known utilization projects use the captured methane for purposes other than for sales to pipelines.

To test this hypothesis, SAIC analyzed a subset of the merged emissions/production database they created. Because the interest here is in mines that already utilize methane drainage systems, they eliminated all mines from the merged dataset that did not employ methane drainage at any time during the 2000 to 2007 timeframe. Following this elimination, they were left with a new data subset covering the 28 mines (all longwall) that employed methane drainage for at least one year during 2000 to 2007. In addition to data on the total annual amount of methane liberated in 2000 to 2007, this new database included 2000 to 2007 data on the annual amount of methane drained and vented at each of the 28 mines. The data set also provided a year-by-year indication as to whether or not all or a portion of the drained methane was captured, and the type of use to which the captured methane was applied (e.g. sales to a pipeline, electricity generation, etc.).

A close review of the database revealed anomalous methane capture indications for five of the 28 mines. Specifically, the data indicated that methane was captured at these five mines in 2002, but not in any of the subsequent years. SAIC reviewed the original EPA data file for these five mines, and found that for 1998 through 2001 the data indicated the mines were not capturing and utilizing methane. Thus the year 2002 was identified as the only year, in a ten-year period, during which methane was being captured at these five mines. In contrast, most of the other mines that practice methane capture are identified as using their capture systems in multiple years. Because of this anomaly, they treated these five mines as *not* utilizing methane capture techniques during the 2000 to 2007 timeframe, since, even if the 2002 data is correct, it appears that the mines' use of methane capture in this one year was atypical and not representative of normal practice at the five mines. In all other cases a mine identified as having employed methane capture at any time during the 2000 to 2007 timeframe was treated as a mine with a utilization project for the purposes of the analysis. See Table A.2 for a summary of this database.

Table A.2. Summary of Drainage System Type and Utilization at Longwall Coal Mines

MSHA ID	State Location	Utilization*	Drainage System Type(s)**
100851	AL	P	GHS
101247	AL	P	GHS
101322	AL	P	GHS
101401	AL	P	GHS
102901	AL	P	GH
503672	CO	H	GH
504452	CO	N	G
504591	CO	N	G
504758	CO	N	G
1514492	KY	N	U
2902170	NM	P	GH
3604281	PA	N	U
3605018	PA	P	G
3605466	PA	P	G
3605466	CO	N	G
3607230	PA	E	G
3607416	PA	N	G
4201890	UT	N	G
4202028	UT	P	G
4403795	VA	P	GHS
4404856	VA	P & TD	GHS
4601318	WV	N	GH
4601433	WV	P	GH
4601436	WV	N	GH
4601437	WV	N	G
4601456	WV	P & E	GH
4601816	WV	P	GHS
4601968	WV	P	GH

*****P = Pipeline injection
E = Electricity generation
TD = Thermal coal drying
H = Mine ventilation air heating
N = None

**G = Gob wells
H = Horizontal pre-mine wells
S = Vertical pre-mine wells
U = Unknown

Results

Analysis of the new database found that:

- Use of methane for pipeline sales is common practice, in so far as it is used at 88 percent (15 of 17) of the mines that capture methane, and 53 percent (15 of 28) of the mines that drain methane
- Use of captured methane for electricity generation is uncommon, in so far as it is limited to 12 percent of the mines that capture methane, and 7 percent of the mines that drain methane
- Use of captured methane for heating ventilation air or fueling thermal coal dryers is uncommon (limited to only 6 percent of the mines that capture methane, and 4 percent of the mines that drain methane)

- Application of captured methane to any use other than the above three is not only uncommon but non-existent

There are two possible explanations for the general lack of end-use projects other than those involving sales to pipelines. First, these projects may be generally uneconomic under current conditions. Alternatively, such projects may be economically viable, but *less so* than pipeline sales projects. Under this second interpretation, on-site projects to generate electricity, heat, etc., would be more numerous than actually observed were it not for the fact that they must compete with a generally more preferable end use—i.e. selling the CMM to a pipeline. In other words, one might hypothesize that pipeline projects are in effect distorting the analysis of common practice with respect to other end use project types, by dominating the competition between the various end use options. If true, this hypothesis would suggest that other end use project types are not generally additional, despite their rarity.

To test this hypothesis, SAIC eliminated all of the mines with pipeline sales projects from the database, and considered whether or not other end use projects are common practice within the remaining group of mines – a group for which competition from pipeline projects is not a barrier to the application of other end uses. However, before performing this analysis, it was necessary to first consider that two of the four non-pipeline projects currently in operation (an electricity generation project and a thermal coal drying project) are located at mines that *also* sell a portion of their CMM to pipelines. It appears that these two projects are not being adversely affected by competition from pipeline projects, as they co-exist with the latter. The existence of these co-located projects suggests that there may be other opportunities for the application of on-site end uses at mines that currently sell their CMM - the fact that such co-located on-site projects are uncommon indicates that these on-site applications may be sub-economic, rather than merely less economic than pipeline sales projects. It was determined that the two co-located on-site projects should be excluded from the analysis, because competition from pipeline sales projects did not prevent these two projects from being undertaken.

Focusing then on the two remaining on-site end use projects – projects which *may* not have been undertaken had pipeline sales projects been feasible at these two mines – and on the mines that are currently venting their CMM, SAIC drew the following conclusions with respect to common practice:

- Only one of the 12 mines (8 percent) that utilize drainage systems *not* connected to natural gas pipelines currently captures methane to generate electricity
- Only one of the 12 mines (8 percent) that utilize drainage systems *not* connected to natural gas pipelines currently captures methane to heat the mine ventilation air

Based on the above analysis SAIC concluded that on-site end use projects are uncommon even at mines that do not sell their CMM to pipelines. In fact, CMM end use project types other than electricity generation, ventilation air heating, and thermal coal drying are non-existent. This finding suggests that such project types are generally uneconomic under current conditions, rather than simply less economic than pipeline sales projects. Thus, even if the current pipeline sales projects did not exist, it is not clear that other project types would take their place.

The Reserve believes it is appropriate to consider the entire population of mines with drainage systems, and not just those mines that do not sell CMM to pipelines, when assessing common practice with respect to non-pipeline end use projects.

Regional Analysis

An additional analysis was conducted to assess whether common practice with respect to utilization varies across regions. Whereas common practice with respect to methane drainage is unlikely to exhibit much regional variation, given that the decision to utilize drainage techniques is often driven by *federal* regulations, the same cannot be presumed for methane utilization. On the contrary, given that the decision to initiate a capture and utilization project will generally be driven by economic criteria rather than regulations, regional variations in common practice, reflecting regional variations in the underlying economic criteria, are a real possibility that must be investigated.

Table A.3. Regional Analysis of Methane Utilization among Mines with Drainage Systems

State/Region	Mines with Normalized Methane Drainage >0.25 Billion ft^3			Mines with Normalized Methane Liberation ≤0.25 Billion ft^3		
	Mines with Drainage Systems	Mines with Utilization	Percent with Utilization	Mines with Drainage Systems	Mines with Utilization	Percent with Utilization
Pennsylvania	3	3	100	1	0	0
W. Virginia	6	4	67	1	0	0
Virginia	2	2	100	0	0	n/a
Kentucky	0	0	n/a	1	0	0
Alabama	5	5	100	0	0	n/a
Eastern U.S.	**16**	**14**	**87**	**3**	**0**	**0**
Colorado	3	1	33	2	0	0
Utah	1	1	100	1	0	0
New Mexico	1	1	100	0	0	n/a
Western U.S.	**5**	**3**	**60**	**3**	**0**	**0**
Total U.S.	**21**	**17**	**81**	**6**	**0**	**0**

Table A.3 presents the results of the regional analysis. It indicates little regional variation in common practice amongst mines with production-normalized methane drainage in excess of 0.25 billion cubic feet per year. Regardless of their regional location, the majority of the mines in this category captures and utilizes methane (87 percent of the eastern mines and 60 percent of the western mines). None of the six mines draining less than 0.25 billion cubic feet per year capture and utilize their CMM, regardless of mine location. Thus SAIC recommended against establishing regional variations in the common practice standards for coal mine methane projects.

Conclusion

Based on the above analysis of current utilization project types, the Reserve concluded that all projects designed to utilize the methane for any purpose other than pipeline sales shall be eligible as additional under the common practice standard. Depending on the specific utilization project type, such non-pipeline projects are rare to non-existent at present. Projects that include both pipeline sales and other uses (e.g. electricity generation) are to be treated as two separate projects for the purposes of applying the common practice standard, and the project involving uses other than pipeline sales are to be eligible under the common practice standard. Because of similarities between the regulatory requirements, operating conditions, mining methods, and methane management of gassy underground trona mines and coal mines, the Reserve concluded the same common practice standard also applies to trona mines categorized as MSHA Category III gassy underground metal and non-metal mines.

Ventilation Air Methane Projects

There is opportunity for achieving significant reductions in coal mine methane emissions from ventilation. In 2007, the methane emissions from ventilation systems were more than 10 times greater than drainage system emissions (78.9 million cubic feet versus 7.3 million cubic feet; see Figure A.2). However, the technology available to tap into this potential market is as yet unproven commercially, at least in the U.S.

The technical barrier to the commercialization of methane destruction or utilization technology capable of being used in conjunction with ventilation systems has been the highly dilute character of the methane emitted by these systems. Typically the mine air vented from return air shafts is less than 1 percent methane. The utilization technologies considered thus far require gas with much higher methane content.

There are at present no commercial projects using ventilation air methane destruction or oxidation technology at active coal or trona mines in the United States.[38] Since commercial VAM projects are non-existent at present, the Reserve concludes that all commercial VAM projects be eligible under a common practice standard.

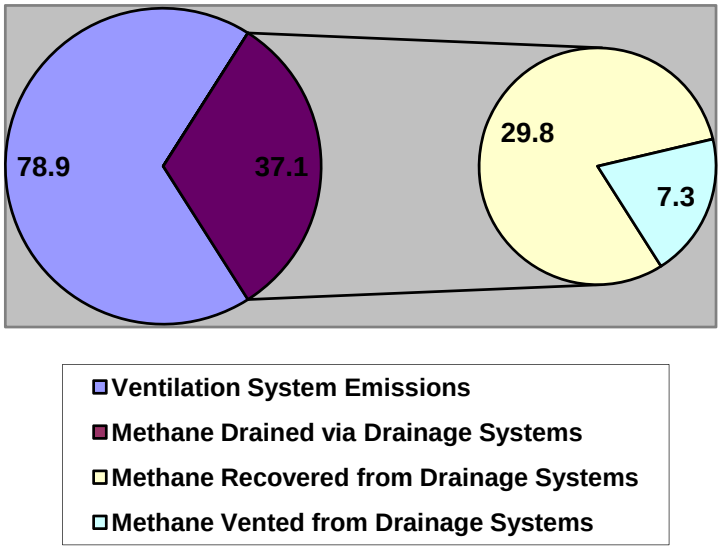


Figure A.2. Ventilation and Drainage System Emissions, 2007 (million cubic feet)

A.3 Evaluation of the Common Practice Standards

The common practice standards summarized above are based on a relatively small number of observations. However, it is important to recognize that this is not a “small sample” problem; rather it is the population of mines that uses drainage, with or without CMM utilization, which is small. With the exception of a very small number of mines with missing data that were deleted from the database, the Reserve believes the analysis covers the entire population of gassy U.S. underground mines. Although we cannot be certain that the original MSHA and EPA databases used as our primary sources provide comprehensive coverage of all gassy mines, all mines with

[38] There is one demonstration project that received approval from the Mine Health and Safety Administration (MSHA) in April 2008.

drainage, and all mines with utilization, this is the intent of these databases and we have no reason to believe that there are significant deficiencies in their coverage.

Thus, while the analysis necessarily rests on a small set of observations, it is nonetheless representative of the population. By pooling the data across eight years (2000 to 2007), SAIC was able to increase the number of mines covered in the analysis, as well as reduce the impact of short-term fluctuations in a mine's methane liberation, drainage and/or production rate on our analysis. Beyond pooling the data, there are few if any viable means of increasing the number of observations used in this analysis. We did consider the possibility of adding data from other countries, but ruled this approach out because we believe that the geologic conditions, mining methods, and economics of mining and CMM recovery are too variable across national borders to enable the application of non-U.S. data to an analysis of common practice within the U.S.

A.4 Updating the Performance Standard

The common practice standards developed for coal mine methane projects reflect operating practices under current economic, regulatory, and technological conditions. SAIC's analysis of sector trends indicated that common practice has been relatively stable or slow to evolve, at least over the past decade. If and when these conditions change in the future, the common practice standard will be affected. Therefore, the performance standard analyses will be updated on a periodic basis to either confirm that common practice has not changed or to develop new standards reflecting changed conditions.

Appendix B Emission Factor Tables

Table B.1. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBtu / short ton**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**Btu / scf**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / scf**
975 to 1,000 Btu / scf	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / scf	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / scf	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / scf	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / scf	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / scf	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBtu / barrel**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Asphalt and Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2, and 4)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 and 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401°F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401°F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable).
Heat content factors are based on higher heating values (HHV).

If available, the official source tested methane destruction efficiency shall be used in place of the default methane destruction efficiency. Project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for each of the combustion devices used in the project, performed on an annual basis.

Table B.2. Default Destruction Efficiencies for Combustion Devices

Destruction Device	Destruction Efficiency
Open Flare	0.96
Enclosed Flare	0.995
Lean-burn Internal Combustion Engine	0.936
Rich-burn Internal Combustion Engine	0.995
Boiler	0.98
Microturbine or Large Gas Turbine	0.995
Upgrade and Use of Gas as CNG/LNG Fuel	0.95
Upgrade and Injection into Natural Gas Pipeline	0.98**

Source: The default destruction efficiencies for enclosed flares and electricity generation devices are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data is made available to the Reserve.

****** The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH_4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH_4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH_4/PJ, which is 0.8%. These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations. [39]

Equation B.1. Calculating Heat Generation Emission Factor ($EF_{heat,y}$)

$$EF_{heat,y} = \frac{EF_{CO_2,i}}{Eff_{heat}} \times \frac{44}{12}$$

Where,			Units
$EF_{heat,y}$	=	Emission factor for heat generation	kg CO_2/volume
$EF_{CO2,i}$	=	CO_2 emission factor of fuel used in heat generation (see Table B.1)	kg C/volume
Eff_{heat}	=	Boiler efficiency of the heat generation (either measured efficiency, manufacturer nameplate data for efficiency, or 100%)	%
44/12	=	Carbon to carbon dioxide conversion factor	

[39] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

Appendix C Data Substitution Guidelines

This appendix provides guidance on calculating emission reductions when data integrity has been compromised due to missing data points. No data substitution is permissible for equipment such as thermocouples which monitor the proper functioning of destruction devices. Rather, the methodologies presented below are to be used only for the methane concentration and flow metering parameters, including temperature and pressure data.

The Reserve expects that projects will have continuous, uninterrupted data for the entire reporting period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously. If data is missing for both parameters, no reductions can be credited. The methodology may also be used for missing temperature and pressure data (which is used to adjust flow rate). However, the methodology must be applied to both parameters simultaneously, regardless of if data is available for one or the other. In other words: if either temperature or pressure data is missing, the project developer must use the following methodology to substitute data for both parameters over the same time interval.

Further, substitution may only occur when two other monitored parameters corroborate proper functioning of the destruction device and system operation within normal ranges. These two parameters must be demonstrated as follows:

1. Proper functioning can be evidenced by thermocouple readings for flares, energy output for engines, etc.
2. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
3. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology maybe applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours of normal operations immediately before and following the outage
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours of normal operations prior to and after the outage, whichever results in greater conservativeness
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours of normal operations prior to and after the outage, whichever results in greater conservativeness
Greater than one week	No data may be substituted and no credits may be generated

The lower confidence limit should be used for both methane concentration and flow readings, as this will provide the greatest conservativeness.

Coal Mine Methane Project Protocol
Version 1.1
ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its Coal Mine Methane (CMM) Project Protocol Version 1.1 in October 2011. While the Reserve intends for the CMM Project Protocol V1.1 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the CMM Project Protocol V1.1.[1]

Per the Reserve's Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered coal mine methane projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the protocol.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact Policy at policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Climate Action Reserve Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications are contained in this single document.

Errata and Clarifications (arranged by protocol section)

Section 5

1. Accounting for Additional Non-Methane Cooling Air Volume in VAM Oxidation Projects (CLARIFICATION – October 22, 2013) 3

Section 6

2. NMHC Sampling Requirements (CLARIFICATION – March 10, 2014)..... 4

Section 5

1. Accounting for Additional Non-Methane Cooling Air Volume in VAM Oxidation Projects (CLARIFICATION – October 22, 2013)

Section: 5.2.2, Equation 5.10

Context: Due to the high temperatures which may result from high methane concentrations of VAM entering destruction devices at a project, additional non-methane fresh air (either occasionally or continuous) may be added to the system to prevent overheating of the destruction device. The protocol assumes a closed system, in which the flow rate of the input and exhaust are the same. However, in the case of destruction devices in which additional non-methane fresh air is added after the point at which VAM input flow is metered, the flow of the exhaust would be greater than the metered flow of the input. Without accounting for this additional flow, the methane destruction will be overestimated due to the dilution of methane in the exhaust gas. It is not clear how projects should account for this situation in the quantification methodology.

Clarification: Destruction devices requiring an additional cooling air intake component are permissible under this protocol. To account for the additional non-methane air, Equation 5.10 shall be replaced with the revised Equation 5.10 below. If destruction devices include a cooling air intake, the flow of additional non-methane air entering the destruction device should be metered and the actual flow data shall be used in the equation. However, if the cooling air intake is not metered, the project developer must instead use the maximum flow rate (e.g. the full capacity) of the cooling air intake system for the full duration of time when it is operating. If the operational status of the cooling air system is not monitored, the project developer shall assume that the system is always operational.

Revised Equation 5.10. CH_4 Destroyed by VAM Oxidation

$$\boldsymbol{MD_{OX} = MM_{OX} - PE_{OX}}$$

Where,

			Units
MD_{OX}	=	Methane destroyed through oxidation during the reporting period	tCH_4
MM_{OX}	=	Methane measured sent to oxidizer during the reporting period	tCH_4
PE_{OX}	=	Project emissions of non-oxidized CH_4 from oxidation of the VAM stream during the reporting period	tCH_4

And,

$$\boldsymbol{MM_{OX} = VAM_{flow\,rate,y} \times time_y \times PC_{CH_4\,VAM} \times D_{CH_4}}$$

Where,

			Units
$VAM_{flow\ rate,y}$	=	Average flow rate of ventilation air entering the oxidation unit during period y corrected if needed for inlet flow gas pressure and temperature ($P_{VAM\ inflow}$ and $T_{VAM\ inflow}$ respectively) per Equation 5.12	scfm
$time_y$	=	Time during which VAM unit is operational during period y	m
$PC_{CH4\ VAM}$	=	Concentration of methane in the ventilation air entering the oxidation unit, corrected if needed for pressure and temperature in the vicinity of the methane analyzer	scf/scf
D_{CH4}	=	Density of methane under standard conditions	tCH_4/scf

And,

$$PE_{OX} = VAM_{exhaust\ volume,y} \times PC_{CH_4\ exhaust} \times D_{CH_4}$$

Where,			Units
$VAM_{exhaust\ volume,y}$	=	Total volume of methane leaving the oxidation unit during period y	scf
$PC_{CH4\ exhaust}$	=	Concentration of methane in the ventilation air exhaust, corrected if needed for pressure and temperature in the vicinity of the methane analyzer ($P_{VAM\ analyzer\ inflow}$, $T_{VAM\ analyzer\ inflow}$, $P_{VAM\ analyzer\ exhaust}$, and $T_{VAM\ analyzer\ exhaust}$)	scf/scf
D_{CH4}	=	Density of methane under standard conditions	tCH_4/scf

And either,

$$VAM_{exhaust\ volume,y} = VAM_{exhaust\ flow\ rate,y} \times time_y$$

Or,

$$VAM_{exhaust\ volume,y} = \left(VAM_{flow\ rate,y} \times time_y\right) + \left(CA_{flow\ rate,z} \times time_z\right)$$

Where,			Units
$VAM_{exhaust\ flow\ rate,y}$	=	Average metered flow rate of the ventilation air exhaust leaving the oxidation unit during period y, corrected if needed for inlet flow gas pressure and temperature ($P_{VAM\ inflow}$ and $T_{VAM\ inflow}$ respectively) per Equation 5.12	scfm
$CA_{flow\ rate,z}$	=	Flow rate[a] of additional cooling air added to VAM destruction system after metering point for $VAM_{flow\ rate}$ (equal to zero, if the project is a closed system in which VAM intake flow is equal to exhaust gas flow)	scfm
$time_z$	=	Subset of time, z, during which the air intake system is operational within the time period y[b]	m

[a] If the project is metering the cooling air intake flow volume, then the average metered data flow rate shall be used. If the flow is not metered, then the maximum capacity of the air intake system shall be used for the flow rate.

[b] If the operational status of the air intake system is not monitored, then the system shall be assumed to be operational at all times (i.e. $time_y = time_z$).

Section 6

2. NMHC Sampling Requirements (CLARIFICATION – March 10, 2014)

Section: 6.1

Context: The protocol requires the non-methane hydrocarbon (NMHC) content of coal mine gas (CMG) to be determined on an annual basis by a full gas analysis using a gas chromatograph for both VAM projects and drainage projects. The protocol goes on to state that these gas samples shall be collected "prior to each destruction device." While the protocol's intent is that the NMHC gas sample be taken upstream of each destruction device, it is not necessary to take multiple NMHC samples of CMG from a single drainage system or ventilation shaft if multiple destruction devices are being used. Rather, the protocol's intent is to require that a separate NMHC sample be taken upstream of the destruction device for each CMG source within the project definition.

Clarification: The last sentence in the relevant paragraph shall be replaced with:

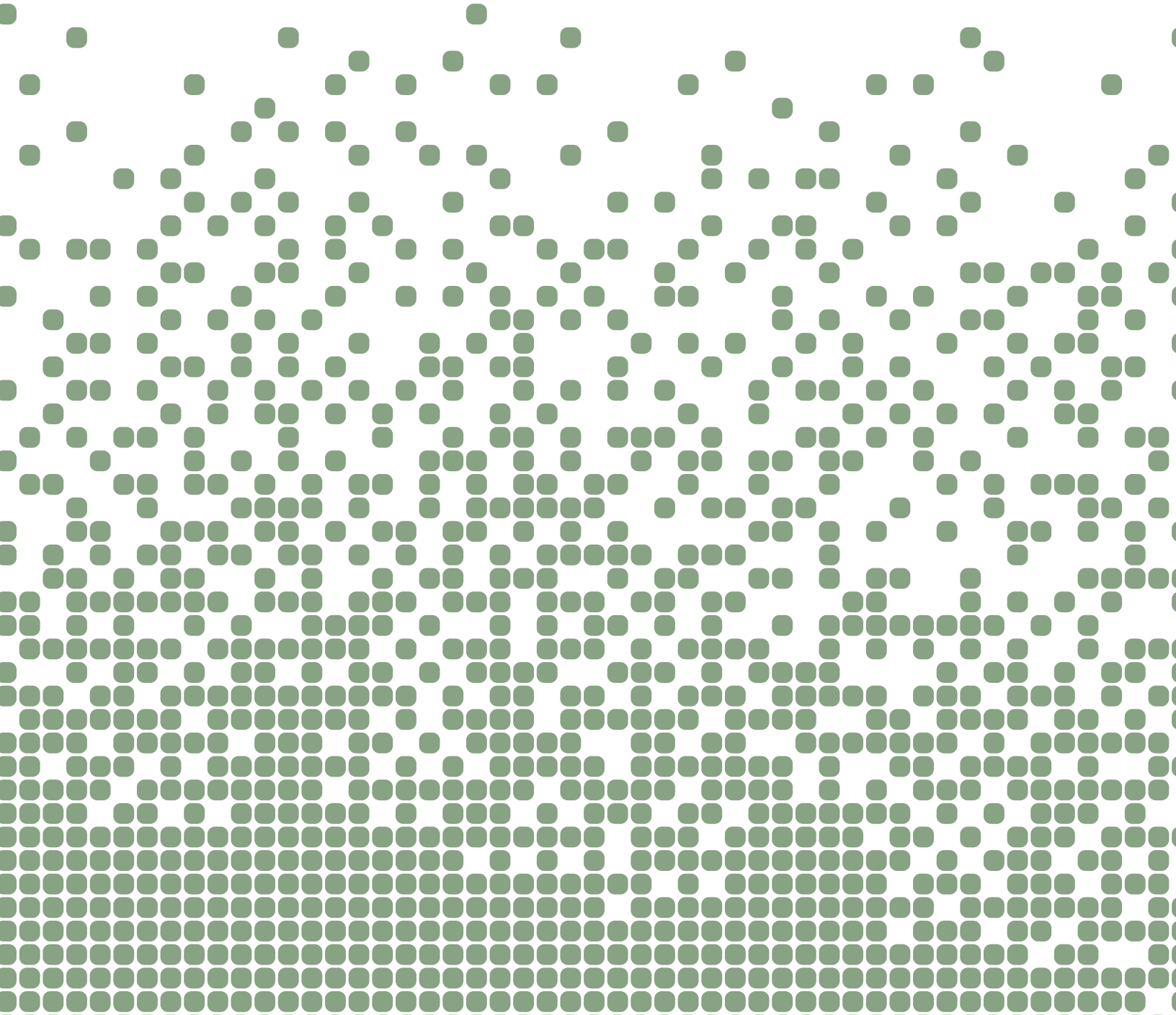
"Separate gas samples shall be collected from each drainage system or ventilation shaft within the project definition by a third-party technician. The sample shall be taken upstream of the destruction device(s)."

CLIMATE ACTION RESERVE

Version 5.0 | October 16, 2019

Forest

Project Protocol



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www.climateactionreserve.org

Released October 16, 2019

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
1.1 About Forests, Carbon Dioxide, and Climate Change 2
2 Forest Project Definitions and Requirements 3
2.1 Project Types 3
2.2 Forest Owners and Project Operators 4
2.3 Forest Project Aggregation 5
3 Eligibility Rules and Other Requirements 6
3.1 Project Location 6
3.2 Project Start Date 7
3.3 Additionality 8
3.4 Project Crediting Period 12
3.5 Permanence 12
3.6 Project Implementation Agreement 14
3.7 Use of Qualified Conservation Easements or Qualified Deed Restrictions 14
3.8 Regulatory Compliance 15
3.9 Sustainable Harvesting and Natural Forest Management Practices 15
4 Identifying the Project Area 23
4.1 Project Configuration and Limitations 23
4.2 Project Area Acreage 24
4.3 Modifying the Project Area 24
5 GHG Assessment Boundary 25
5.1 Improved Forest Management Projects 25
5.2 Avoided Conversion Projects 31
6 Quantifying Net GHG Reductions and Removals 37
6.1 Improved Forest Management Projects 41
6.2 Avoided Conversion Projects 59
7 Ensuring the Permanence of Credited GHG Reductions and Removals 64
7.1 Definition of a Reversal 64
7.2 Insuring Against Reversals 64
7.3 Compensating for Reversals 65
7.4 Disposition of Forest Projects after a Reversal 67
8 Project Monitoring 69
8.1 Project Documentation 69
8.2 Monitoring Report 70
8.3 Reporting and Verification Cycle 72
8.4 Record Keeping 74
8.5 Transparency 74
9 Verification Guidance 75
9.1 Standard of Verification 75
9.2 Emission Sources, Sinks, and Reservoirs 76
9.3 Project Verification Activities 76
9.4 Completing the Verification Process 99
10 Glossary of Terms 100
Appendix A Determination of a Forest Project's Reversal Risk Rating 108
A.1 Financial Risk 109
A.2 Management Risk 109
A.3 Social Risk 110

A.4 Natural Disturbance Risk 111
A.5 Summarizing the Risk Analysis and Contribution to Buffer Pool 112
Appendix B Quantification Guidance for Use with Forest Carbon Projects 114
B.1 Reporting Requirements for Forest Carbon Pools 114
B.2 Guidance for Estimating Carbon in Forest Carbon Pools 115
B.2.1 Inventory Methodologies 115
B.2.2 Updating Forest Inventories 116
B.2.2.1 Updating for Forest Growth 116
B.2.2.2 Updating for Disturbances (Including Harvest) 116
B.2.3 Requirements for Estimating Carbon in Standing Live and Dead Trees 117
B.2.4 Use of Regression Equations 119
B.2.5 Forest Vegetation Stratification 119
B.2.6 Quantification of Carbon in Live Trees from Project Data 119
B.2.7 Adjustments to Standing Live and Standing Dead Trees for Missing Volume and Decay 120
B.2.8 Requirements for Estimating Lying Dead Wood Carbon 123
B.2.9 Requirements for Estimating Soil Carbon Emissions and Soil Carbon Quantification for Avoided Conversion Projects 125
B.2.9.1 Developing an Estimate of Soil CO_2e within the Project Boundaries 125
B.2.10 Total Onsite Carbon Stocks and Calculating the Confidence Deduction 136
B.2.10.1 Applying a Confidence Deduction to Sampled Estimates 138
B.2.10.2 Applying a Confidence Deduction to Non-Aggregated Projects 139
B.2.10.3 Applying a Confidence Deduction for Aggregated Projects 139
B.2.11 Requirements for Calculating Carbon in Harvested Wood Products 140
B.2.12 Improved Forest Management Leakage 141
B.3 Modeling Carbon Stocks 143
B.3.1 Models and their Eligibility for Use with Forest Projects 143
B.3.2 Using Models to Forecast Carbon Stocks 144
B.3.3 Modeling Requirements 144

List of Tables

Table 3.1. Compensation Rate for Terminated Improved Forest Management Projects 13
Table 3.2. Even-Aged Management Retention Guidelines 17
Table 3.3. Evaluation Criteria to Test if a Forest Project Meets the Requirement for the Establishment and Maintenance of Native Species and Natural Forest Management 19
Table 4.1. Project Area Definition for Avoided Conversion Projects 23
Table 5.1. GHG Assessment Boundary – Improved Forest Management Projects 25
Table 5.2. GHG Assessment Boundary – Avoided Conversion Projects 31
Table 6.1. Guidance for Adjusting Other Carbon Pools 53
Table 6.2. Table Rotation Lengths 55
Table 6.3. Default Avoided Conversion Rates for Standing Live and Dead Carbon Stocks 60
Table 8.1. Forest Project Verification Schedule 73
Table 9.1A. Initial Eligibility Verification Items – Improved Forest Management Projects 77
Table 9.2. Site Visit Verification Items 82
Table 9.3. Desk Review Verification Items 83
Table 9.4. Natural Forest Management Verification Items 85
Table 9.5. Inventory Methodology Verification Items 88
Table 9.6. Number of Passing Plots in Sequence, as a Function of Project Size 91

Table 9.7. Additional Verification Items for Inventory Methodology and Implementation.....95
Table 9.8. Modeled Baseline Verification Items.....95
Table 9.9. Default Baseline Verification Items.....97
Table 9.10. Carbon in Harvested Wood Products Verification Items.....97
Table 9.11. Reversal Risk Rating Verification Items.....98
Table A.1. Forest Project Risk Types.....108
Table A.2. Financial Failure Leading to Bankruptcy.....109
Table A.3. PIA Subordination.....109
Table A.4. Risk of Illegal Removals of Forest Biomass.....110
Table A.5. Risk of Conversion to Alternative Land Use.....110
Table A.6. Risk of Over-Harvesting.....110
Table A.7. Social Risk Identification.....111
Table A.8. Natural Disturbance Risk I – Wildfire, Disease, or Insect Outbreak.....111
Table A.9. Vegetation Management Treatments (Y).....111
Table A.10. Natural Disturbance Risk III – Other Episodic Catastrophic Events.....112
Table A.11. Project Contribution to the Buffer Pool Based on Risk.....112
Table B.1. Reserve Requirements for Carbon Pool Categories and Determination of Value for Pool.....114
Table B.2. Requirements for Sampling Standing Live and Standing Dead Trees.....117
Table B.3. Assumed Percentages of Biomass in Each Portion of the Tree.....120
Table B.4. Decay Classes.....121
Table B.5. Average Density Reduction Factors for Standing Dead Wood for Hardwoods and Softwoods by Decay Class.....121
Table B.6. Example: Data Attributes Needed to Calculate CO_2e in Standing Dead Trees.....122
Table B.7. Example: Adjusting Biomass Calculation for Decay Using Density Adjustment Factors.....122
Table B.8. Example: Calculating Net Biomass in a Tree.....122
Table B.9. Decay Class Descriptions of Lying Dead Wood.....124
Table B.10. Average Density Reduction Factors for Lying Dead Wood for Hardwoods and Softwoods by Decay Class.....124
Table B.11. Soil Carbon Quantification Methods by Project Type.....125
Table B.12. Soil Orders.....126
Table B.13. Example: Calculation for Total CO_2 per Acre.....129
Table B.14. Determination of Biomass Removal Index.....130
Table B.15. Determination of Soil Disturbance Index.....131
Table B.16. Harvesting Intensity Classes based on Summing the Biomass Removal and Soil Disturbance Indexes.....131
Table B.17. Site Preparation Classes and Descriptions of Management Activities.....131
Table B.18. Frequency of Disturbance Classification.....132
Table B.19. Estimated Net Carbon Loss.....133
Table B.20. Example: Calculations for Annual Soil Carbon Reporting.....136
Table B.21. Example: Calculations for Avoided Conversion Baseline Soil Carbon Estimates..136
Table B.22. Example: Summing All Onsite Carbon Stocks and Calculating the Confidence Deduction.....138
Table B.23. Forest Carbon Inventory Confidence Deductions Based on Level of Confidence in the Estimate Derived from Field Sampling.....139
Table B.24. Examples: How Secondary Effects Can Be Recouped and Positive Carryover Can Be Applied Over Time.....142

List of Figures

Figure 3.1. Example of Allowable Decrease of Standing Live Carbon Stocks due to Normal Silviculture Cycles 22
Figure 6.1. Example of an *unadjusted averaged baseline* 49
Figure 6.2. Example of an *unadjusted averaged baseline* with an upward trend 50
Figure 6.3. Determining a Project Area's High Stocking Reference 53
Figure 6.4. Example of an Avoided Conversion Project Baseline 61

List of Equations

Equation 6.1. Annual Net GHG Reductions and Removals 40
Equation 6.2. Determining the *Adjusted Initial Baseline* 43
Equation 6.3. Calculate the Baseline Harvest Volume 44
Equation 6.4. Calculate the *Final Baseline* 44
Equation 6.5. Formula for Averaging *Preliminary Unadjusted Baseline* Carbon Stocks 48
Equation 6.6. Formula for Approximating *Preliminary Unadjusted Baseline* Carbon Stocks as a Straight-Line Trend 48
Equation 6.7. Determining the *Adjusted Averaged Baseline* for Aboveground Live and Aboveground Standing Dead Carbon Stocks Where Initial Stocks Are at or Above Common Practice 51
Equation 6.8. Determining the *Adjusted Averaged Baseline* for Aboveground Live and Aboveground Standing Dead Carbon Stocks Where Initial Stocks Are Below Common Practice 52
Equation 6.9. Formula for Determining the *Adjusted Averaged Baseline* Where the *Unadjusted Averaged Baseline* was Approximated using Equation 6.6 52
Equation 6.10. Secondary Effects Emissions 58
Equation 6.11. Conversion Risk Adjustment Factor 62
Equation 6.12. Adjusted Baseline Onsite Carbon Stocks 62
Equation 6.13. Secondary Effects Emissions Risk 63
Equation B.1. California, Oregon, Washington (Temperate Equation) 120
Equation B.2. Alaska (Boreal Equation) 120
Equation B.3. Hawaii (Tropical Equation) 120
Equation B.4. Soil CO_2e per Acre 129

Abbreviations and Acronyms

C	Carbon
CH_4	Methane
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
FIA	USFS Forest Inventory and Analysis[1]
FPP	Forest Project Protocol
GHG	Greenhouse gas
lb	Pound
IFM	Improved Forest Management
N_2O	Nitrous oxide
PF	Professional Forester, in the case of California, a “Registered Professional Forester”
PIA	Project Implementation Agreement
Reserve	Climate Action Reserve
RPF	Registered Professional Forester, a person registered to practice professional forestry in California
USFS	United States Forest Service

[1] http://fia.fs.fed.us/program-features/rpa/

1 Introduction

The Forest Project Protocol (FPP) provides requirements and guidance for quantifying the net climate benefits of activities that sequester carbon on forestland in the United States. The protocol provides project eligibility rules; methods to calculate a project's net effects on greenhouse gas (GHG) emissions and removals of CO_2 from the atmosphere ("removals"); procedures for assessing the risk that carbon sequestered by a project may be reversed (i.e., released back to the atmosphere); and approaches for long term project monitoring and reporting. The goal of this protocol is to ensure that the net GHG reductions and removals caused by a project are accounted for in a complete, consistent, transparent, accurate, and conservative manner and may therefore be reported to the Climate Action Reserve (Reserve) as the basis for issuing carbon offset credits (called Climate Reserve Tonnes, or CRTs).

The Reserve is a national offsets program working to ensure integrity, transparency and financial value in the North American carbon market. It does this by establishing regulatory-quality standards for the development, quantification and verification of GHG emissions reduction projects in North America; issuing carbon offset credits known as CRTs generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emissions reductions associated with projects are real, permanent and additional, thereby instilling confidence in the environmental benefit, credibility and efficiency of the U.S. carbon market.

Only those Forest Projects that are eligible under and comply with the FPP may be registered with the Reserve. Section 9 of this protocol provides requirements and guidance for verifying the performance of project activities and their associated GHG reductions and removals reported to the Reserve.

1.1 About Forests, Carbon Dioxide, and Climate Change

Forests have the capacity to both emit and sequester carbon dioxide (CO_2), a leading greenhouse gas that contributes to climate change. Trees, through the process of photosynthesis, naturally absorb CO_2 from the atmosphere and store the gas as carbon in their biomass, i.e., trunk (bole), leaves, branches, and roots. Carbon is also stored in the soils that support the forest, as well as the understory plants and litter on the forest floor. Wood products that are harvested from forests can also provide long term storage of carbon.

When trees are disturbed, through events like fire, disease, pests or harvest, some of their stored carbon may oxidize or decay over time releasing CO_2 into the atmosphere. The quantity and rate of CO_2 that is emitted may vary, depending on the circumstances of the disturbance. Forests function as reservoirs in storing CO_2.Depending on how forests are managed or impacted by natural events, they can be a net source of emissions, resulting in a decrease to the reservoir, or a net sink, resulting in an increase of CO_2 to the reservoir. In other words, forests may have a net negative or net positive impact on the climate.

Through sustainable management and protection, forests can also play a positive and significant role to help address global climate change. The Reserve's FPP is designed to address the forest sector's unique capacity to sequester, store, and emit CO_2 and to facilitate the positive role that forests can play to address climate change.

2 Forest Project Definitions and Requirements

For the purposes of the FPP, a Forest Project is a planned set of activities designed to increase removals of CO_2 from the atmosphere or reduce or prevent emissions of CO_2 to the atmosphere, through increasing and/or conserving forest carbon stocks.

A glossary of terms related to Forest Projects is provided in Section 10 of this protocol. Throughout the protocol, important defined terms are capitalized (e.g., "Avoided Conversion Project").

2.1 Project Types

The Reserve will register the following types of Forest Project activities.[2]

2.1.1 Improved Forest Management

An Improved Forest Management Project involves management activities that maintain or increase carbon stocks on forested land relative to baseline levels of carbon stocks, as defined in Section 6.1 of this protocol. An Improved Forest Management Project is only eligible if:

1. The project takes place on land that has greater than ten percent tree canopy cover.
2. The project employs natural forest management practices, as defined in Section 3.9.2 of this protocol.
3. The project does *not* employ broadcast fertilization.
4. The project does not take place on land that was part of a previously registered Forest Project, unless the previous Forest Project was terminated due to an Unavoidable Reversal (see Section 7).

Eligible management activities may include, but are not limited to:

- Increasing the overall age of the forest by increasing rotation ages
- Increasing the forest productivity by thinning diseased and suppressed trees
- Managing competing brush and short-lived forest species
- Increasing the stocking of trees on understocked areas
- Maintaining stocks at a high level

Improved Forest Management Projects may be eligible on both private and public lands.

2.1.2 Avoided Conversion

An Avoided Conversion Project involves preventing the conversion of forestland to a non-forest land use by dedicating the land to continuous forest cover at existing or increased stocking levels through conservation easement recordation or transfer to public ownership. An Avoided Conversion Project is only eligible if:

[2] Reforestation Projects were previously included within the FPP. Please refer to the Reserve's website for information about that project type.

1. The Project Operator can demonstrate that there is a significant threat of conversion of project land to a non-forest land use by following the requirements for establishing the project's baseline in Section 6.2 of this protocol.
2. The project does *not* employ broadcast fertilization.
3. The project does not take place on land that was part of a previously registered Forest Project, unless the previous Forest Project was terminated due to an Unavoidable Reversal (see Section 7).

An Avoided Conversion Project may involve tree planting, harvesting, and other silvicultural activities as part of the project activity.

Avoided Conversion Projects are eligible only on lands that are privately owned prior to the project start date.

2.2 Forest Owners and Project Operators

A Forest Owner is an individual or a corporation or other legally constituted entity, city, county, state agency, or a combination thereof that has legal control of any amount of forest carbon[3] within the Project Area. Control of forest carbon means the Forest Owner has the legal authority to effect changes to forest carbon quantities, e.g., through timber rights or other forest management or land-use rights. Control of forest carbon occurs, for purposes of satisfying this protocol, through fee ownership and/or deeded encumbrances, such as conservation easements.

Multiple Forest Owners may exist with respect to a single Forest Project, since control of forest carbon may be associated with fee ownership or through one or more deeded encumbrances that exist within a Project Area, any one of which may convey partial control of the project's forest carbon. However, only one fee owner may exist with respect to a single Forest Project. Any unencumbered forest carbon is assumed to be controlled by the fee owner. Individuals or entities holding mineral, gas, oil, or similar *de minimis*[4] interests in the forest carbon, are precluded from the definition of Forest Owner. Where any Forest Owner chooses to exclude the forest carbon it controls from becoming part of the Forest Project, the project's baseline must demonstrate the exclusion as a legal constraint.

The Project Operator is responsible for undertaking a Forest Project and registering it with the Reserve, and is ultimately responsible for all Forest Project reporting and attestations. The Project Operator has an account with the Reserve and executes the Project Implementation Agreement (see Section 3.6). A Project Operator must be one of the Forest Owners or must have an explicit legal agreement granting the right to operate the project from all other Forest Owners. In the latter case, the Project Operator must at least have fee ownership of the Project Area. The legal agreement granting the right to operate the project on behalf of the Forest Owner(s) will be subject to review and approval by the Reserve.

In all cases, the Project Operator must secure an agreement from all other Forest Owners that (1) assigns authority to the Project Operator to undertake a Forest Project, subject to any conditions imposed by any of the other Forest Owners to include or disallow any carbon they control; and (2) waives any right on the part of the Forest Owners to seek damages, penalties,

[3] See definition of Forest Carbon in glossary.
[4] *de minimis* control includes access right or ways and residential power line right of ways.

costs, losses, expenses, or judgments from the Reserve arising from or in any way connected with the Forest Project, except as explicitly provided for in the PIA.

The Reserve maintains the right to determine which individuals or entities meet the definition of "Forest Owner."

The Project Operator may engage an independent third-party project developer to assist or consult with the Project Operator and to implement the Forest Project. All information submitted to the Reserve on behalf of the Project Operator shall reference the Project Operator, who is responsible for the accuracy and completeness of the information submitted, and for ensuring compliance with this Forest Project Protocol.

2.3 Forest Project Aggregation

Eligible Forest Projects[5] may be aggregated to improve cost-effectiveness while maintaining rigor in overall carbon inventory accounting. Individual Forest Projects can benefit through participation in an aggregate by meeting carbon inventory confidence standards across an aggregate, rather than within each project. This reduces the sampling intensity required within each project to meet statistical confidence requirements. Similarly, verification of aggregated projects is considered across the broader population, which reduces the verification costs to individual Project Operators participating in an aggregate. An aggregate consists of two or more individual Forest Projects enrolled with an Aggregator. For more information, please refer to the Guidelines for Aggregating Forest Projects.

[5] As described in the Guidelines for Aggregating Forest Projects available on the Reserve website.

3 Eligibility Rules and Other Requirements

In addition to the definitions and requirements described in Section 2, Forest Projects must meet several other criteria and conditions to be eligible for registration with the Reserve, and must adhere to certain requirements related to their duration, crediting period, and management activities.

Section 3.1	Project Location	→	*U.S., U.S. Territories (avoided conversion only), and tribal areas*
Section 3.2	Project Start Date	→	*No more than twelve months prior to project submission*
Section 3.3	Additionality	→	*Exceed legal requirements*
		→	*Meet performance standard*
Section 3.4	Project Crediting Period	→	*One hundred year crediting period*
Section 3.5	Permanence	→	*One hundred years following the issuance of CRTs*
Section 3.6	Project Implementation Agreement	→	*Project Operator executes PIA with the Reserve*
Section 3.7	Qualified Conservation Easement	→	*Optional*
Section 3.8	Regulatory Compliance	→	*Compliance with all applicable laws*
Section 3.9	Sustainable Harvesting and Natural Forest Management	→	*Ongoing compliance with the requirements for the project's assessment area(s)*

3.1 Project Location

All Forest Projects located in the United States of America are eligible to register with the Reserve provided they meet all other eligibility requirements described in this protocol. Improved Forest Management Projects may be located on private land or on state or municipal public land. Avoided Conversion Projects must be implemented on private land, unless the land is transferred to public ownership as part of the project. All projects can be transferred from private to public lands, whereby the public entity acquires all terms and conditions described in this protocol.

All Improved Forest Management Projects that are on public lands as of the project's start date must be approved by the government agency or agencies responsible for management activities on the land. This approval must include an explicit approval of the project's baseline, as determined in Section 6, and must involve any public vetting processes necessary to evaluate management and policy decisions concerning the project activity.

Forest Projects on federal lands may be eligible if and when their eligibility is approved through a federal legislative or regulatory/rulemaking process. Forest Projects in tribal areas must demonstrate that the land within the Project Area is owned by a tribe or private entities.

Companion documents to the Forest Project Protocol contain data tables, equations, and benchmark data applicable to projects located in the United States. The Reserve may add approved equations and models as they are developed in future versions of the Forest Project Protocol.

The methods required by this protocol for estimating baseline carbon stocks for Forest Projects cannot currently be applied outside the United States, as they rely on U.S.-specific data sets and models, particularly for Improved Forest Management Projects. Avoided Conversion Projects are eligible in U.S. Territories, as they do not depend on the U.S.-specific data sets mentioned above.

3.2 Project Start Date

The start date of a Forest Project is the date on which an activity is initiated that will lead to increased GHG reductions or removals relative to the Forest Project's baseline. All forest projects must be submitted to the Reserve within 12 months of their project start date.[6]

The following sections detail actions that identify the project start date for each project type.

3.2.1 Improved Forest Management Project Start Date

For an Improved Forest Management Project, the action is initiating forest management activities that increase sequestration and/or decrease emissions relative to the baseline. The start date must be linked to a discrete, verifiable action that delineates a change in practice relative to the project's baseline. Project Operators may choose to identify one of the following actions:

- Recordation of a conservation easement on the Project Area. The project start date is the date the easement was recorded.
- Transferring of property ownership (to a public or private entity). The project start date is the date of property transfer.
- Submitting the project to the Reserve.[7] The project start date is the date of submittal, provided that the project completes verification within 30 months of being submitted. If the project does not meet this deadline, it must be resubmitted under the latest version of the protocol; it will not retain the initial submittal date and will be subject to any new project start date requirements.

Project Operators must affirm the action denoting the project start date by providing documentation. Adequate documentation could include deeds of trust, title reports, conservation easement documentation, dated forest management plans, and/or contracts or agreements.

3.2.2 Avoided Conversion Project Start Date

For an Avoided Conversion Project, the action is committing the Project Area to continued forest management and protection through conservation easement recordation with a provision to maintain the Project Area in forest cover or transferring the Project Area to public ownership where the Project Area will be maintained in forest cover.

[6] See the Reserve's Program Manual for requirements for listing a project with the Reserve, available at http://www.climateactionreserve.org/how-it-works/program/program-manual/.

[7] Submitting a project to the Reserve is considered an initiation of a commitment to employ practices that will maintain or grow net carbon stocks for the duration of the FPP's commitment period, per the requirements of the FPP and signing the Project Implementation Agreement (PIA).

Where recordation of a conservation easement is used to signal the project start date, multiple conservation easements may be used to cover a single Project Area. Where transfer of the Project Area to public ownership is used to signal the project start date, multiple transfers may be used to cover a single Project Area. In either case, the following provisions must be met, as applicable:

- The Project Area being placed under easements has one fee owner, as required by Section 2.2, or the Project Area is being transferred to a single public entity;
- The easements must all have been recorded within the span of 12 months, or the transfers all take place within the span of 12 months;
- The alternative non-forest land use being avoided must be identical for all portions of the project and the default rate of conversion must be used (see Table 6.3); and,
- The Conversion Risk Adjustment Factor must be the same for all portions of the project (see Equation 6.11).

In these cases, the project start date will be the date of the last recorded easement, or the date of the final transfer of land.

3.3 Additionality

The Reserve strives to register only projects that yield surplus GHG emission reductions and removals that are additional to what would have occurred in the absence of a carbon offset market (i.e., under "Business As Usual"). For a general discussion of the Reserve's approach to determining additionality, see the Reserve's Program Manual (available at http://www.climateactionreserve.org/how/program/program-manual/).

The approach to additionality for Forest Projects recognizes increases in the amount of CO_2 removed from the atmosphere relative to Business As Usual management. It also considers the long-term risks to carbon sequestered in the Project Area presented by Business As Usual management and the potential emissions of such carbon into the atmosphere. Under such an approach, it takes into account the following:

- On-site carbon stocks are at risk on a 100-year time scale.
- Land ownership and management direction are not permanent, except in cases where binding commitments limit management options, such as conservation easements.
- Management goals and objectives are likely to change over time, especially as ownership of a forest changes hands, as often happens between generations of family forest owners[8] or between entities owning forests as a financial investment.[9]
- Over the length of a project lifetime and in the absence of a long-term commitment to a Forest Project, emissions may have resulted from the clearing of trees to convert a forest to another land cover type (for avoided conversion projects) or from harvest activities that reduce average on-site carbon stocking (for improved forest management projects).
- Committing a site to a Forest Project for at least 100 years and the long-term requirements specified in this protocol (e.g., monitoring, reporting, and verification; compensation for reversals; buffer pool contributions) removes such risks to emissions.

[8] Butler, B. J., *et al*. 2016. "Family Forest Ownerships of the United States, 2013: Findings from the USDA Forest Service's National Woodland Owner Survey." *Journal of Forestry* 114 (6): 638–47. doi:10.5849/jof.15-099.
[9] Bliss, J. C., *et al*. 2010. "Disintegration of the U. S. Industrial Forest Estate: Dynamics, Trajectories, and Questions." *Small-Scale Forestry* 9 (1): 53–66. doi:10.1007/s11842-009-9101-7.

Furthermore, this protocol acknowledges that the project's baseline, as the way Business As Usual management is represented for quantification purposes, is a counterfactual scenario, i.e., a representation of what may have actually occurred if the project had never happened. Additionality is assured over 100-year crediting period, during which project activities ensure forest carbon stocks are maintained or increase compared to the baseline, since the precise timing of potential outcomes within the counterfactual scenario are impossible to pinpoint. This and other assumptions incorporated into the quantification of a project's baseline and GHG reductions, as described below in Section 6, are used to create more consistency and simplicity in crediting while maintaining conservativeness.

Forest Projects must satisfy the following tests to be considered additional:

1. *Legal Requirement Test*. Forest Projects must achieve GHG reductions or removals above and beyond any GHG reductions or removals that would result from compliance with any federal, state, or local law, statute, rule, regulation, or ordinance. Forest Projects must also achieve GHG reductions and removals above and beyond any GHG reductions or removals that would result from compliance with any court order or other legally binding mandates including management plans (such as Timber Harvest Plans) that are required for government agency approval of harvest activities.

   Deeded encumbrances, such as timber deeds or conservation easements, may effectively control forest carbon, such that there may be multiple Forest Owners within the Project Area. Deeded encumbrances are considered legally binding mandates for the purposes of the legal requirement test, unless they are recorded within a year of the Forest Project's start date with clear agreement from all Forest Owners.

   Deeded encumbrances may contain terms that do not directly refer to forest carbon, but that nevertheless restrict the effect the ability of any one Forest Owner to change forest carbon stocks. These terms must be interpreted with respect to their effect on forest carbon for the purposes of the legal requirement test and baseline determinations. Where the terms of deeded encumbrances are not explicit with regards to forest carbon, the following assumptions shall be made:

   a. Restrictions or references related to canopy cover, basal area, density, volume, carbon or biomass apply to standing live and dead trees of all species.
   b. Carbon in other pools (soil, litter, duff, shrubs, etc.) is assumed to be associated with the other defined terms, such as trees.
   c. Terms related to forest (tree) growth apply to growth in all tree species.

2. *Performance Test*. Forest Projects must achieve GHG reductions or removals above and beyond any GHG reductions or removals that would result from engaging in Business As Usual activities, as defined by the requirements described below (Section 3.3.2).

   Project quantification (Section 6) further ensures that forest projects are additional via checks on financial feasibility.

3.3.1 Legal Requirement Test

The legal requirement test is satisfied if the following requirements are met, depending on the type of Forest Project.

3.3.1.1 Improved Forest Management Projects

At the Forest Project's initial verification, the Project Operator must sign the Reserve's Attestation of Voluntary Implementation form indicating that the Forest Project is not legally required (as defined above) and was not legally required at the time of the project's start date. For the purposes of the attestation, the "Project" is defined as maintaining onsite carbon stocks at or above their current levels (at the time the attestation is signed) for at least 100 years.

A project's final baseline must reflect all legal constraints in effect at the time of the project's start date, as required in Section 6.1 of this protocol.

3.3.1.2 Avoided Conversion Projects

At the Forest Project's initial verification, the Project Operator must sign the Reserve's Attestation of Voluntary Implementation form indicating that the Forest Project's planned forest conservation activities are not legally required (as defined above) and were not legally required at the time of the project's start date.

A project's final baseline must reflect all legal constraints, as required in Section 6.2 of this protocol.

3.3.2 Performance Test

The performance test is satisfied if the following requirements are met, depending on the type of Forest Project.

3.3.2.1 Improved Forest Management Projects

An Improved Forest Management Project automatically satisfies the performance test. Project activities are considered additional to the extent they produce GHG reductions and/or removals in excess of those that would have occurred under a Business As Usual scenario, as defined by the baseline estimation requirements in Section 6.1.

3.3.2.2 Avoided Conversion Projects

An Avoided Conversion Project satisfies the performance test if the Project Operator provides a real estate appraisal (or real estate appraisals) for the Project Area (as defined in Section 4) indicating the following:

1. *The Project Area is suitable for conversion*. The appraisal(s) must clearly identify the highest value alternative land use for the Project Area and indicate how the physical characteristics of the Project Area are suitable for the alternative land use.
2. The appraisal(s) must conform with the following minimum standards[10]:
    a. Appraisal reports shall be prepared and signed by a Licensed or Certified Real Estate Appraiser in good standing.
    b. Appraisal reports shall include descriptive photographs and maps of sufficient quality and detail to depict the subject property and any market data relied upon, including the relationship between the location of the subject property and the market data.

[10] Adapted from Sections 5096.501 and 5096.517, Public Resources Code, State of California.

c. Appraisal reports shall include a complete description of the subject property land, site characteristics and improvements. Valuations based on a property's development potential shall include:

   i. Verifiable data on the development potential of the land (e.g., Certificates of Compliance, Tentative Map, Final Map).
   ii. A description of what would be required for a development project to proceed (e.g., legal entitlements, infrastructure).
   iii. Presentation of evidence that sufficient demand exists, or is likely to exist in the future, to provide market support for the development.
   iv. Where conversion to commercial, residential, or agricultural land uses is identified as the highest value alternative land use, the appraisal(s) must demonstrate that the slope of Project Area land is compatible with the alternative land use by identifying two areas with similar average slope conditions to the Project Area that have been converted within the past ten years in the project's Assessment Area. Alternatively, the Project Area must have an average slope less than 40 percent.
   v. Where conversion to agricultural land use is anticipated, the appraisal(s) must provide:

      1) Evidence of soil suitability for the type of expected agricultural land use.
      2) Evidence of water availability for the type of expected agricultural land use.
      3) Where conversion to mining land use is anticipated, the appraisal(s) must provide evidence of the extent and amount of mineral resources existing in the Project Area.

   vi. Where conversion to residential, commercial, or recreational land uses is anticipated, the appraisal(s) must also describe the following information:

      1) The proximity of the Project Area to metropolitan areas
      2) The proximity of the Project Area to grocery and fuel services and accessibility of those services
      3) Population growth within 180 miles of the Project Area

d. Appraisal reports shall include a statement by the appraiser indicating to what extent land title conditions were investigated and considered in the analysis and value conclusion.
e. Appraisal reports shall include a discussion of implied dedication, prescriptive rights or other unrecorded rights that may affect value, indicating the extent of investigation, knowledge, or observation of conditions that might indicate evidence of public use.
f. Appraisal reports shall include a separate valuation for ongoing forest management prepared and signed by a certified or registered professional qualified in the field of specialty interest. This valuation shall be reviewed and approved by a second qualified, certified or registered professional, considered by the appraiser, and appended to the appraisal report(s). The valuation must identify and incorporate all legal constraints that could affect the valuation of both the ongoing forest management.
g. The appraisal(s) must provide a map that displays specific portions of the Project Area that are suitable for the identified alternative land use. (For example, an appraisal that identified a golf course as an alternative land use must specify the

approximate acres suitable for fairways, greens, clubhouses, and outbuildings.). The smaller of the two areas identified in the appraisals must be used.

3. *The alternative land use for the Project Area has a higher market value than maintaining the Project Area for sustainable forest management.* The appraisal(s) for the property must provide a value for the current forest land use condition of the Project Area and a fair market value of the anticipated alternative land use for the Project Area. The anticipated alternative land use for the Project Area must be at least 40 percent greater than the value of the current forested land use.

The appraisal(s) must be conducted in accordance with the Uniform Standards of Professional Appraisal Practice[11] and the appraiser must meet the qualification standards outlined in the Internal Revenue Code, Section 170 (f)(11)(E)(ii).[12]

3.3.3 Enhancement Payments

Enhancement payments provide financial assistance to landowners in order to implement discrete practices that address natural resource concerns and deliver environmental benefits. Examples of relevant enhancement payments include:

- California Climate Investments (CCI), formerly called Greenhouse Gas Reduction Funds (GGRF)
- USFS grants and agreements

Forest Owner(s) may pursue enhancement payments that support forest carbon project activities. Because every available enhancement payment is not comprehensively addressed by the protocol at this time, the Forest Owner(s) must still disclose any such payments to the verifier and the Reserve on an ongoing basis. The Reserve maintains the right to determine if payment stacking has occurred and whether or not it would impact project eligibility.

3.4 Project Crediting Period

The baseline for any Forest Project registered with the Reserve under this version of the Forest Project Protocol is assumed to be valid for 100 years. This means that a registered Forest Project will be eligible to receive CRTs for GHG reductions and/or removals quantified using this protocol, and verified by Reserve-approved verification bodies, for a period of 100 years following the project's start date. Projects may not end their crediting period early without penalty, as all quantification performed in this protocol assumes reporting and verification will continue for 100 years.

3.5 Permanence

Project Operators must monitor and verify a Forest Project for a period of 100 years following the issuance of any CRT for GHG reductions or removals achieved by the project. For example, if CRTs are issued to a Forest Project in year 99 following its start date, monitoring and

[11] The Uniform Standards of Professional Appraisal Practice may be accessed at: http://commerce.appraisalfoundation.org/html/2006%20USPAP/toc.htm

[12] Section 170 (f)(11)(E) of the Internal Revenue Code defines a qualified appraiser as "an individual who:
(I) has earned an appraisal designation from a recognized professional appraiser organization or has otherwise met minimum education and experience requirements set forth in regulations prescribed by the Secretary,
(II) regularly performs appraisals for which the individual receives compensation, and
(III) meets such other requirements as may be prescribed by the Secretary in regulations or other guidance."

verification activities must be maintained until year 199. All Forest Projects must undergo an initial site visit verification to register with the Reserve. After the initial verification, all Forest Projects must undergo a site visit verification at the interval required in Section 8.3.2.1.

There are three possible exceptions to this minimum time commitment:

1. A Forest Project automatically terminates if a Significant Disturbance occurs,[13] leading to an Unavoidable Reversal that reduces the project's standing live tree carbon stocks below the project's baseline standing live tree carbon stocks. Once a Forest Project terminates in this manner, the Project Operator has no further obligations to the Reserve.
2. A Forest Project may be voluntarily terminated prior to the end of its minimum time commitment if the Project Operator surrenders a quantity of CRTs, as specified under 'Retiring CRTs Following Project Termination' below.
3. A Forest Project may be automatically terminated if there is a breach of certain terms described within the Project Implementation Agreement. Such a termination will require the Project Operator to retire a quantity of CRTs, as specified under 'Retiring CRTs Following Project Termination' below.

Retiring CRTs Following Project Termination

1. For an Avoided Conversion Project, the Project Operator must surrender a quantity of CRTs from its Reserve account equal to the total number of CRTs issued to the project over the preceding 100 years.
2. For an Improved Forest Management Project, the Project Operator must surrender a quantity of CRTs from its Reserve account equal to the total number of CRTs issued to the project over the preceding 100 years, multiplied by the appropriate compensation rate indicated in Table 3.1.
3. For any project seeking to terminate project activities on only a portion of the project area, the change must be treated as a potential Avoidable Reversal. If it is determined that the revision to the project area would lead to an Avoidable Reversal, then credits must be cancelled as described in Section 7.3.2. Improved Forest Management projects must also apply the early termination compensation rate in Table 3.1 below. If the revision to the project area would lower standing live carbon stocks below baseline levels, then this will be considered a complete project termination.
4. In addition:
    a. The cancelled CRTs must be those that were issued to the Forest Project, or that were issued to other Forest Projects registered with the Reserve. If neither of those options is available, CRTs from other land use projects will be given preference. If those are not available, then any other CRT is acceptable.
    b. The cancelled CRTs must be designated in the Reserve's software system as compensating for an Avoidable Reversal.

Table 3.1. Compensation Rate for Terminated Improved Forest Management Projects

[13] The natural disturbance shall not be the result of intentional or grossly negligent acts of any of the Forest Owners.

Number of Years that have Elapsed Between the Start Date and the Date of Termination	Compensation Rate
0-5	1.40
6-10	1.20
11-20	1.15
21-30	1.10
31-50	1.05
>50	1.00

3.6 Project Implementation Agreement

For a Forest Project to be eligible for registration with the Reserve, the Project Operator is required to enter into a Project Implementation Agreement (PIA) with the Reserve. The PIA is an agreement between the Reserve and a Project Operator setting forth: (i) the Project Operator's obligation (and the obligation of its successors and assigns) to comply with the Forest Project Protocol, and (ii) the rights and remedies of the Reserve in the event of any failure of the Project Operator to comply with its obligations. The PIA must be signed by the Project Operator before a project can be registered with the Reserve. It must be signed by all entities that are fee simple owners of the Project Area property. The PIA is recorded and submitted after the Reserve has reviewed the verification documents and is about to register the project.

3.7 Use of Qualified Conservation Easements or Qualified Deed Restrictions

A Qualified Conservation Easement is a conservation easement that explicitly (1) refers to, and incorporates by reference, the terms and conditions of the PIA agreed to by the Project Operator, thereby binding both the grantor and grantee – as well as their subsequent assignees – to the terms of the PIA for the full duration of the Forest Project's minimum time commitment, as defined in Section 3.5 of this protocol; (2) makes all future encumbrances and deeds subject to the PIA; and (3) makes the Reserve a third party beneficiary of the conservation easement.

A Qualified Deed Restriction is a deed restriction that ensures that the Project Implementation Agreement runs with the land and explicitly (1) refers to, and incorporates by reference, the terms and conditions of the PIA agreed to by the Project Operator, thereby Project Operator—as well as their subsequent assignees to the terms of the PIA for the full duration of the Forest Project's minimum time commitment, as defined in Section 3.5 of this protocol; (2) makes all future encumbrances and deeds subject to the PIA; and (3) makes the Reserve a third party beneficiary of the deed restriction. A deed restriction is not "qualified" if it merely consists of a recording of the Project Implementation Agreement or a notice of the Project Implementation Agreement, as such a recording is already required by the Project Implementation Agreement. The Reserve maintains the discretion to determine whether a deed restriction meets the terms to be considered a Qualified Deed Restriction.

Qualified Conservation Easements or Qualified Deed Restrictions may be voluntarily employed with any project type. Projects that choose to employ Qualified Conservation Easements or Qualified Deed Restrictions have reduced obligations to the Reserve's CRT Buffer Pool, as described in Section 7 and Appendix A.

Qualified Conservation Easements and Qualified Deed Restrictions must be recorded no earlier than one year before a project's start date. If a Qualified Conservation Easement or Qualified Deed Restriction was recorded more than one year prior to the start date, the limits imposed by the easement or deed restriction on forest management activities must be considered as a legal mandate for the purpose of satisfying the legal requirement test for additionality (Section 3.3.1) and in determining the project's baseline (Section 6).

3.8 Regulatory Compliance

Each time the Forest Project is verified, the Project Operator must attest that the project is in material compliance with all applicable laws relevant to the project activity. For this protocol, instances of non-compliance are likely to be considered "material" if they directly pertain to the management of project carbon stocks. Project Operators are required to disclose in writing to the verifier all instances of violations of laws that directly protect forests (trees), wildlife, water quality, or other environmental benefits, and which result in criminal or civil penalties. If a verifier finds that a project is in a state of material non-compliance, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance. Non-compliance solely due to administrative or reporting issues, or due to "acts of nature," will not affect CRT crediting.

3.9 Sustainable Harvesting and Natural Forest Management Practices

Forest Projects can create long-term climate benefits as well as provide other environmental benefits, including the sustaining of natural ecosystem processes. To be in conformance with this protocol, Forest Projects must:

1. Employ sustainable long-term harvesting practices, both within their Project Area and on other forest landholdings controlled by the Project Operator and its Affiliate(s) within the project's Assessment Area(s), as described in Section 3.9.1. Forest landholdings are considered "controlled" by the Project Operator if the Project Operator owns the land in fee or has been deeded timber rights on it.
2. Employ Natural Forest Management practices within the Project Area, including meeting species composition, forest structure, and age and habitat distribution requirements, as described in Section 3.9.2.
3. Maintain or increase standing live carbon stocks over the project life, as described in Section 3.9.3.

3.9.1 Sustainable Harvesting Practices

At the time Commercial Rotational Harvesting is initiated on any of the forest landholdings controlled by the Project Operator and its Affiliate(s) within the project's Assessment Area(s), the Project Operator and its Affiliate(s) must employ and demonstrate sustainable long-term harvesting practices on all of its forest landholdings within the project's Supersection(s), including the Project Area, using one of the following options:

1. Certification under the Forest Stewardship Council, Sustainable Forestry Initiative, or Tree Farm System certification programs. Regardless of the program, the terms of certification must require adherence to and verification of harvest levels which can be permanently sustained over time.

2. Adherence to a renewable long-term (50 years minimum) management plan that demonstrates harvest levels which can be permanently sustained over time and that is sanctioned and monitored by a state or federal agency (for federal lands only).
3. The use of silvicultural practices (if harvesting occurs) that maintain canopy cover averaging at least 40 percent, as measured on any 20 acres of the Project Operator's and its Affiliate(s') landholdings within the project's Supersections(s), including the Project Area.[14] Exceptions may be granted by the Reserve where it can be demonstrated that the harvest openings are intended to restore plantations to forest conditions with greater species diversity. The Project Operator is not responsible for harvest openings that preceded their ownership if the previous ownership had no direct business affiliation with the current ownership.
4. Adherence to a deeded conservation easement(s) with terms that ensure growth equals or exceeds harvest over time.

This requirement shall be met always during the project life and is assessed at each site visit verification. Failure to meet this requirement will result in all Reserve account activity being suspended until it is met.

Project Operators and their Affiliate(s) who acquire new forest landholdings within the project's Assessment Area(s) have up to five years to incorporate such acquisitions under their certification or management plan, or otherwise must abide immediately by the terms of the Sustainable Harvesting Practices, whether or not such land is contiguous with the Project Area.

3.9.2 Natural Forest Management

All Forest Projects must promote and maintain a diversity of native species and utilize management practices that promote and maintain native forests comprised of multiple ages and mixed native species within the Project Area and at multiple landscape scales ("Natural Forest Management").

The following key requirements shall apply to all Forest Projects regardless of the silvicultural or regeneration methods that are used to manage or maintain the forest:

1. Forest Projects must show verified progress (verified at scheduled site visit verifications) towards native tree species composition and distribution requirements described below, consistent with the forest type and forest soils native to the Assessment Area.
2. Forest Projects must manage the distribution of habitat/age classes and structural elements, as described below, to support functional habitat for locally native plant and wildlife species naturally occurring in the Project Area.

Forest Projects must incorporate the criteria for Natural Forest Management throughout the project life. The information provided in Table 3.3 shall be used to determine if the Forest Project meets the criteria for engaging in Natural Forest Management. This evaluation must be completed and verified at a Forest Project's initial verification and at all subsequent verifications. Forest Project carbon stock inventories (requirements for which are found in Appendix B) should be used as the basis of these assessments where applicable. Forest Projects that do not initially meet Natural Forest Management criteria but can demonstrate progress towards meeting these criteria at the times identified in Table 3.3 are compliant with the protocol.

[14] Areas impacted by Significant Disturbance may be excluded from this test.

1. Species Composition

All Forest Projects are required to establish and/or maintain forest types that are native to the Project Area. For the purposes of this protocol, native forests are defined as those forests occurring naturally in an area, as neither a direct nor indirect consequence of human activity post-dating European settlement, and are based on reference metrics for each Assessment Area provided in an Assessment Area Data File, a companion document to the FPP available on the Reserve's website. The planting of native species outside of their current distribution is allowed up to 5% of the overall native species requirement as an adaptation strategy due to climate change. Plantings that will result in more than 5% of native species from beyond their current distribution must be done in accordance with a state or federally approved adaptation plan, or a local plan that has gone through a transparent public review process. In all cases, the Project Operator must obtain a written statement from the government agency in charge of forestry regulation in the state where the project is located stipulating that the planting of native trees outside their current range is appropriate as an adaptation to climate change. The specifications for meeting the requirements for species composition are included in Table 3.3.

2. Forest Structure

A variety of silvicultural practices may be employed in the Project Area during the course of a Forest Project, though the protocol does not endorse any particular practice. Any practices employed, however, must meet a minimum set of standards to ensure environmental integrity associated with a balanced distribution of age and habitat classes across the landscape, as well as certain structural elements within the forest.

Harvesting may be conducted within forest projects using a variety of silviculture methods. However, to ensure harvest practices maintain habitat refugia, even-aged rotations are limited to the following guidelines in Table 3.2.

Table 3.2. Even-Aged Management Retention Guidelines

Harvest Retention (Square Feet Basal Area/Acre of All Species)	**Maximum Size of Harvest Block** (Acres)
0	40
>= 15 < 20	60
>=20 < 25	80
>=25 < 30	120
>= 30 < 40	400
>= 40 < 50	600
>=50	Unlimited

Harvest retention is evaluated based on conditions immediately following harvest. Up to 10% of the harvest retention standard may be met with standing dead trees. Where any harvest occurs in harvest blocks where the harvest retention is less than 50 square feet of basal area per acre, additional harvesting may only occur within 300 feet of the harvest area (with less than 50 square feet basal area per acre) if the harvest retention of the additional harvest exceeds 50 square feet of basal area per acre. This requirement shall remain in place until the regeneration within the original harvested area (i.e., with retention less than 50 square feet basal area per acre) achieves a height of five feet or is five years old.

On a watershed scale up to 10,000 acres, all projects must maintain, or make progress toward maintaining, no more than 40 percent of their forested acres in ages less than 20 years. Areas

impacted by a Significant Disturbance are exempt from this test until 20 years after reforestation of such areas.

The protocol does not override a landowner's obligation to abide by applicable laws and regulations, including any governing forest practice rules that may be more stringent. Regardless of the silvicultural practice employed, landowners must fulfill their commitment under the protocol to permanently maintain or increase onsite standing live carbon stocks (i.e., the carbon in live trees within the Project Area) as specified in Section 3.9.3.

Structural elements such as standing dead trees and lying dead wood are features typically found in natural forests. They provide a variety of benefits, including wildlife habitat. Management of Forest Projects must ensure that standing dead trees and lying dead wood are present on the Project Area at certain minimum levels in accordance with the requirements outlined in Table 3.3.

Table 3.3. Evaluation Criteria to Test if a Forest Project Meets the Requirement for the Establishment and Maintenance of Native Species and Natural Forest Management

Criteria	Assessment	Application Rules
Native Species		
Project consists of at least 95% native species, or demonstrates continuous progress over 50 years toward 95% native species. The assessment shall be conducted using basal area per acre from the inventory of standing live trees.	Assessed at initial verification from inventory data. Assessment during site visit verifications must demonstrate continuous compliance with goal (if already met) or continuous progress toward the goal (if not yet met).	Applies to all project types throughout the project life. If criterion is not met within 50 years, all the Forest Project's Reserve account activity will be suspended[15] until the criterion is met.
Composition of Native Species		
No single species' prevalence in a given Assessment Area, measured as the percent of the basal area of all live trees in that Assessment Area, exceeds the percentage value shown under the heading 'Composition of Native Species' in the Assessment Area Data File maintained on the Reserve's website. Where portions of the Project Area falling within a given Assessment Area naturally consists of a single species' dominance, and is inconsistent with the percentage value in the Assessment Area Data File, the Project Operator may obtain a letter from the State Forester or their representative stating that the Project Area's species diversity is reflective of background natural species diversity (despite any inconsistencies with the Assessment Area Data File). Projects must show continuous progress toward criteria. These criteria must be met within 50 years, except in cases where a variance has been granted at the initial verification, a Significant Disturbance has impacted species diversity, or natural mortality takes a project out of compliance	Species composition is assessed at initial verification from inventory data. Species composition is also assessed during the project at each site visit verification.	Applies to all project types throughout the project life. If criterion is not met within 50 years, all the project's Reserve account activity will be suspended until the criterion is met (excluding the aforementioned exceptions).
Distribution of Age Classes		
On a watershed scale up to 10,000 acres (or the Project Area, whichever is smaller), all projects must maintain, or make progress toward maintaining, no more than 40 percent of their forested acres in ages less than 20 years. (Areas impacted by Significant Disturbance may be excluded from this test.) Applies to all project types at first Commercial Rotational Harvest. Project must show continuous progress toward criterion. This criterion must be met within 25 years	Age classes are assessed during project life at each site visit verification.	If criterion is not met within 25 years, all Reserve account activity will be suspended until the criterion is met.

[15] For the purpose of Table 3.3, suspension of Reserve account activity refers to issuance of CRTs and transaction of CRTs. Projects can continue to provide documentation to the Reserve for purposes of completing verification and demonstrating compliance with the Natural Forest Management criteria.

Structural Elements (Standing and Lying Dead Wood)		
Project Operators must ensure that dead wood is recruited and maintained in sufficient quantities, as described below. **Option I**. Monitoring dead wood throughout Project Area. Project Operators may maintain inventories of lying dead wood as part of their normal inventory processes. Where inventory measurements are used to demonstrate compliance with this requirement, monumented plots or line transects must be used so the plot data can be verified. Dead wood measurements must achieve a minimum statistical confidence of +/- 30% at 1 Standard Error. The combination of standing dead and lying dead wood shall be retained at average per acre values at quantity levels identified in the Assessment Area data file. If dead material does not exist at the quantities identified in the Assessment Area data file, dead trees shall be recruited as described below for Option II. **Option II**: Monitoring dead wood on harvested areas. The assessment of sufficient lying and standing dead material shall be made in areas harvested since the last site verification. **For portions of the Project Area that have been harvested under normal circumstances (not salvage harvested):** The combination of standing dead and lying dead wood shall be retained at average per acre values at quantity levels identified in the Assessment Area data file within each harvested unit. If dead material does not exist at the required levels within the harvest units, live trees shall be retained and tagged with aluminum tags at three times the amount identified in the Assessment Area data file minus whatever quantity does exist within each harvest unit. **For portions of the Project Area that have been salvage harvested:** The combination of standing dead and lying dead wood shall be retained at a combined four tonnes per acre on average within each harvest unit. Verification that the requirement has been met shall be conducted using the methodology for verification of dead material transects found in Appendix B **Option III:** No harvesting Projects without any harvesting activities within the project area do not need to monitor specifically for structural elements.	Assessed during project at each site visit verification.	Applies to all project types throughout the project life. If not met within 25 years, all Reserve account activity will be suspended until the areas verified since the previous site-verification meet the requirement.

3.9.3 Promotion of the Onsite Standing Live Carbon Stocks

To promote and maintain the environmental benefits of Forest Projects, the Reserve requires that the standing live carbon stocks within the Project Area be maintained and/or increased during the project life. Therefore, except as specified below, the Reserve will not issue CRTs for quantified GHG reductions and removals achieved by a Forest Project if the Forest Project's monitoring reports – over any ten-year consecutive period – indicate a decrease in the standing live carbon stocks.

Exceptions to this policy are allowed where reductions in standing live carbon stocks are important for maintaining and enhancing forest health, environmental co-benefits, or the long-term security of all carbon stocks; where reductions are due to non-harvest disturbances; or where reductions are required by law. Note that these exceptions in no way change or affect the Reserve's policies and requirements related to compensating for reversals, as detailed in Section 7.3.

Forest Project standing live carbon stocks that have decreased over a ten-year period may continue to receive CRTs issued by the Reserve for verified GHG reductions and removals if, and only if, the decrease in standing live carbon stocks is due to one of the following causes:

1. The decrease is demonstrably necessary to substantially improve the Project Area's resistance to wildfire, insect, or disease risks. The Project Operator must document the risks and the actions that will be taken to reduce the risks. The techniques used to improve resistance must be supported by relevant published peer reviewed research or professionally-accepted standards.
2. The decrease is associated with a planned balancing of age classes (regeneration, sub-merchantable, and merchantable) and is detailed in a long term environmentally responsible management plan. The Project Operator must demonstrate, using documentation submitted to the Reserve at the time of the Forest Project's registration, that the balancing of age classes, resulting in a decrease in the standing live carbon stocks, was planned at the initiation of the Forest Project.

3. The decrease is part of normal silviculture cycles for forest ownerships less than 1,000 acres. Inventory fluctuations are a normal part of silvicultural activities. Periodic harvest may remove more biomass than the biomass growth over the past several years. At no time shall the Forest Project's inventory of carbon in the standing live carbon stocks fall below the Forest Project's baseline carbon stock estimates for the standing live carbon stocks, or 20 percent less than the Forest Project's standing live carbon stocks at the project's initiation, whichever is higher. Documentation submitted to the Reserve at the time the Forest Project is registered must indicate that fluctuations in the Forest Project's standing live carbon stocks are an anticipated silvicultural activity and that the overall trend will be for standing live carbon stocks to increase or stay the same over the life of the project (Figure 3.1).

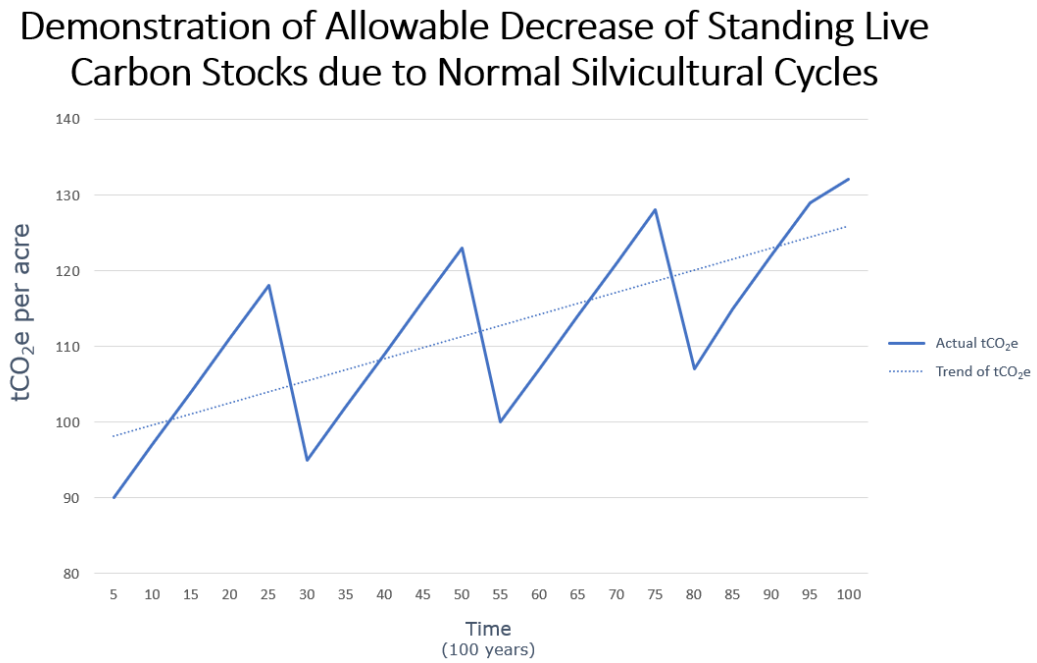


Figure 3.1. Example of Allowable Decrease of Standing Live Carbon Stocks due to Normal Silviculture Cycles

4. The decrease is part of a non-harvest disturbance, including wildfire, disease, flooding, wind-throw, insect infestation, landslides, or as otherwise approved by the Reserve.

4 Identifying the Project Area

The geographic boundaries defining the project area must be described in detail at the time a Forest Project is listed on the Reserve. The boundaries must be defined using a map, or maps that displays public and major private roads, major watercourses (fourth order or greater), topography, towns, and Public Land Survey Townships, Ranges, and Sections or latitude and longitude. The maps must be of adequate resolution to clearly identify the required features.

Once a project's Supersection(s) has been identified, Assessment Area(s) must be determined. A project may do this by comparing dominant species present in the project inventory to the list of native species provided in the Assessment Area Data File. Projects may also utilize Landfire Existing Vegetation Types (EVT) to determine the most appropriate Assessment Areas for the project. EVT descriptions must be used to identify the species descriptions that most closely match the native species provided in the Assessment Area Data File. The Reserve also reserves the right to provide a spatially explicit map of Assessment Areas to be used for identification purposes. The Project Area may also extend across multiple Assessment Areas within a Supersection), and across no more than two adjacent Supersections.

A Geographical Information System (GIS) file depicting the Project Area must be submitted to the Reserve with the project. The file must be submitted in the KML file format. Additionally, the current assessor's parcel identification numbers associated with the project area must be submitted to the Reserve.

For Avoided Conversion Projects, the Project Area is defined through the required appraisal process. The Project Area must be determined following the guidance in Table 4.1 based on the type of anticipated conversion.

Table 4.1. Project Area Definition for Avoided Conversion Projects

Conversion Type	Project Area Definition
Residential	The boundary of the parcel or parcels that have been appraised as having a 'higher and better use' in residential development.
Agricultural Conversion	The boundary of the parcel or parcels that have been appraised as having a 'higher and better use' in agricultural production.
Golf Course	The boundary of the parcel or parcels that have been appraised as having a 'higher and better use' as a golf course. This is to include forested areas within 200 feet of fairways, greens, and buildings.
Commercial Buildings	The boundary of the parcel or parcels that have been appraised as having a 'higher and better use' in commercial buildings. This is to include forested areas with 200 feet of suitable building sites.

4.1 Project Configuration and Limitations

To ensure Project Areas are representative of the Forest Owners' general forest management, Improved Forest Management projects must include all forested areas owned by the Forest Owner(s) within an area no smaller than an area defined by HUC 14-digit hydrological units (HUC 14) where available (or HUC 12-digit hydrological units if HUC 14 is unavailable), or the entire area owned by the Forest Owner, whichever is smaller. HUC 14 or HUC 12 hydrological units must be identified using the USGS National Hydrography Dataset.[16] Exceptions may be

[16] The National Hydrography Dataset can be accessed via the USGS website: http://nhd.usgs.gov/.

provided if approved by the Reserve. Non-forested areas (brush, rocks, range, etc.) may be excluded from all project types. For Improved Forest Management Projects, areas not under forest management may also be excluded from the Project Area. For all project types, the Project Area can be contiguous or separated into tracts or distinct polygons (areas).

4.2 Project Area Acreage

Project acreage shall be based on area calculations derived from GIS analysis, such as ArcGIS or Google Earth. GIS data are generally considered to be improvements over strict adherence to county parcel acreages as they are based on correcting property boundaries to geographic characteristics and/or property corners as described in property deeds or official survey notes. A KML (Google Earth) file depicting the Project Area shall be included with the PDD.

The project must list the county assessor's parcels (APs), the portion of each AP included in the project as a percentage (if GIS parcel data is available from the relevant state, county, or municipality), the sum of acres derived from the county tax records for all included APs, and the sum of acres derived from the GIS analysis. The sum of acres should be compared between the AP and GIS sources, with the lesser of the two used for the project area.

If there is a discrepancy between AP and GIS acres, the Project Operator has the following options:

- Resolve the acres on a per AP basis by using the lesser of the two area references
- Work with the county assessor to resolve acreage disputes on AP acres
- Demonstrate to verifier that GIS acres are based on recorded surveyed corners and correctly referenced with GPS

4.3 Modifying the Project Area

It is possible for project activities to be terminated on a portion of the Project Area. These adjustments must be treated as Avoidable Reversals, as described in Section 3.5. If a project proceeds with terminating the project on a portion of the Project Area, a new KML file must be provided to reflect the new Project Area. An addendum to the Project Design Document (PDD) must also be submitted to reflect this change, and the new legal description of the project will be recorded with the next PIA or PIA Amendment after the change has been verified. The inventory for the modified Project Area will be assessed during the next regularly scheduled site visit verification, unless it is determined that an Avoidable Reversal has taken place, in which case, the guidance in Section 7.3.2 must be followed.

5 GHG Assessment Boundary

The GHG Assessment Boundary defines all the GHG sources, sinks, and reservoirs that must be accounted for in quantifying a Forest Project's GHG reductions and removals (Section 6). The GHG Assessment Boundary encompasses all the GHG sources, sinks, and reservoirs that may be significantly affected by Forest Project activities, including forest carbon stocks, sources of biological CO_2 emissions, and mobile combustion GHG emissions. For accounting purposes, the sources, sinks, and reservoirs included in the GHG Assessment Boundary are organized according to whether they are predominantly associated with a Forest Project's "Primary Effect" (i.e., the Forest Project's intended changes in carbon stocks, GHG emissions, or GHG removals) or its "Secondary Effects" (i.e., unintended changes in carbon stocks, GHG emissions, or GHG removals caused by the Forest Project).[17] Secondary Effects may include increases in mobile combustion CO_2 emissions associated with site preparation, as well as increased CO_2 emissions caused by the shifting of harvesting activities from the Project Area to other forestlands (often referred to as "leakage"). Projects are required to account for Secondary Effects following the methods described in Section 6.

The following tables provide a comprehensive list of the GHG sources, sinks, and reservoirs (SSRs) that may be affected by a Forest Project and indicate which SSRs must be included in the GHG Assessment Boundary for each type of Forest Project. If an SSR is designated as a "reservoir/pool," this means that GHG reductions and removals are accounted for by quantifying changes in carbon stock levels. For SSRs designated as sources or sinks, GHG reductions and removals are accounted for by quantifying changes in GHG emission or removal rates, as described in the tables.

5.1 Improved Forest Management Projects

Table 5.1. GHG Assessment Boundary – Improved Forest Management Projects

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs						
IFM-1	Standing live carbon (carbon in all portions of living trees)	Reservoir / Pool	CO_2	*Included*	**Baseline:** Modeled based on initial field inventory measurements, regulatory environment, and financial feasibility **Project:** Measured by field measurements and updating forest carbon inventory	Increases in standing live carbon stocks are likely to be the largest Primary Effect of Improved Forest Management Projects.
IFM-2	Shrubs and herbaceous understory carbon	Reservoir / Pool	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Shrubs and herbaceous understory constitute a relatively small proportion of carbon stocks in an Improved Forest Management project.

[17] The terms "Primary Effect" and "Secondary Effect" come from WRI/WBCSD, 2005. *The Greenhouse Gas Protocol for Project Accounting*, World Resources Institute, Washington, DC. Available at http://www.ghgprotocol.org.

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
IFM-3	Standing dead carbon (carbon in all portions of dead, standing trees)	Reservoir / Pool	CO_2	*Included*	**Baseline:** Assumed to be static based on initial field inventory measurements **Project:** Measured by updating forest carbon inventory	Improved Forest Management Projects may significantly increase standing dead carbon stocks over time. The protocol requires recruitment and retention of dead material, including standing dead wood as a structural element. Minimum volume thresholds are stated to meet Natural Forest Management criteria. (See Section 3.9.2).
IFM-4	Lying dead wood carbon	Reservoir / Pool	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Lying dead wood is highly variable and it is therefore difficult to achieve accurate estimates. It also constitutes a minor portion of forest carbon. With required retention for Natural Forest Management (see below), it is a conservative programmatic measure not to include it. For Natural Forest Management criteria, the protocol requires recruitment and retention of dead material, including lying dead wood as a structural element. Minimum volume thresholds are stated to meet Natural Forest Management criteria. (See Section 3.9.2).
IFM-5	Litter and duff carbon (carbon in dead plant material)	Reservoir / Pool	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in this reservoir are unlikely to have a significant effect on total quantified GHG reductions/removals. It is a conservative programmatic measure not to include it.
IFM-6	Soil carbon	Reservoir / Pool	CO_2	*Included for emissions estimates*	**Baseline:** Assumed to be static with start date inventory estimates **Project:** Emissions from project activities estimated with standardized guidelines in found in Appendix B	Soil carbon is not anticipated to change significantly as a result of most Improved Forest Management activities. However, all projects must use standardized guidance to account for potential soil carbon emissions associated with management activities.
IFM-7	Carbon in in-use forest products	Reservoir / Pool	CO_2	*Included*	**Baseline:** Estimated from modeled harvesting volumes **Project:** Estimated from measured harvesting volumes	Included because many Improved Forest Management Projects may significantly change carbon storage in in-use forest products relative to baseline levels. Treated as a "source/sink" because forest product carbon is quantified according to the change in harvesting volumes, relative to baseline levels, in each year. Of this change (increase or decrease), only the average amount of carbon expected to remain stored for 100 years is included in the final

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
						quantification of annual net GHG removals/emissions. This approach accounts for CO_2 emissions from decomposition or disposal of wood products (see SSR IFM-17).
IFM-8	Forest product carbon in landfills	Reservoir / Pool	CO_2	*Excluded when project harvesting exceeds baseline* *Included when project harvesting is below baseline*	**Baseline:** Estimated from modeled harvesting volumes **Project:** Estimated from measured harvesting volumes	Because of significant uncertainties associated with forecasting the quantity of forest product carbon that will remain stored in landfills, landfill carbon is excluded from quantification in years when project harvesting volumes exceed baseline volumes. Landfill carbon is included, however, in years when project harvesting volumes are below baseline levels. This case-dependent exclusion or inclusion is necessary to ensure that total GHG reductions and removals caused by the Forest Project are not overestimated.
Secondary Effect Sources, Sinks, and Reservoirs						
IFM-9	Biological emissions from site preparation activities	Source	CO_2	*Included*	**Baseline:** N/A **Project:** Quantified based on measured carbon stock changes in included reservoirs (SSR IFM-6, where applicable)	Biological emissions from site preparation are not quantified separately, but rather are captured by measuring changes in included carbon reservoirs (soil carbon, where applicable). For other carbon reservoirs, changes are unlikely to have a significant effect on total quantified GHG reductions/removals.
IFM-10	Mobile combustion emissions from site preparation activities	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Mobile combustion CO_2 emissions from site preparation are not expected to be significantly different from baseline levels for Improved Forest Management Projects. In addition, this protocol assumes that combustion emissions in the U.S. will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the Forest Project will have no effect on total net emissions.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in CH_4 emissions from mobile combustion associated with site preparation activities are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in N_2O emissions from mobile combustion associated with site preparation activities are not considered significant.

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
IFM-11	Mobile combustion emissions from ongoing project operation and maintenance	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Mobile combustion CO_2 emissions from ongoing project operation and maintenance are unlikely to be significantly different from baseline levels, and are therefore not included in the GHG Assessment Boundary. In addition, this protocol assumes that such emissions will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the Forest Project will have no effect on total net emissions.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in CH_4 emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in N_2O emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
IFM-12	Stationary combustion emissions from ongoing project operation and maintenance	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Stationary combustion CO_2 emissions from ongoing project operation and maintenance could include GHG emissions associated with electricity consumption or heating/cooling at Project Operator facilities, or at facilities owned or controlled by contractors. These emissions are unlikely to be significantly different from baseline levels, and are therefore not included in the GHG Assessment Boundary. In addition, this protocol assumes that such emissions will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the Forest Project will have no effect on total net emissions.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in CH_4 emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in N_2O emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
IFM-13	Biological emissions from clearing of forestland outside the Project Area	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Improved Forest Management Projects are not expected to cause significant shifts in alternative land uses that might lead to clearing of forestland.
IFM-14	Biological emissions/ removals from changes in harvesting on forestland outside the Project Area	Source / Sink	CO_2	*Included / Excluded*	**Baseline:** N/A **Project:** Estimated "leakage" factor applied to the difference in harvested carbon relative to baseline based on the magnitude of that difference relative to baseline harvest amounts	Improved Forest Management Projects may either increase or decrease harvesting relative to baseline levels. If harvesting is reduced in the Project Area, harvesting on other lands may increase to compensate for the lost production. This "leakage" effect is included in the GHG Assessment Boundary. If harvesting is increased in the Project Area, harvesting on other lands may decrease in response to the increased production. The reduction in harvesting may lead to increased carbon stocks on other lands. Carbon stock increases on other lands are excluded from the GHG Assessment Boundary, however, because it is not possible to ensure their permanence.
IFM-15	Combustion emissions from production, transportation, and disposal of forest products	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	This protocol assumes that combustion emissions will be controlled under a regulatory cap-and-trade program in the near future. Thus, for most of a Forest Project's duration, changes in activity due to the project will have no effect on total net emissions due to production, transportation, and disposal of forest products. These emissions are therefore excluded from the GHG Assessment Boundary.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Combustion-related CH_4 emissions related to changes in the production, transportation, and disposal of forest products are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Combustion-related N_2O emissions related to changes in the production, transportation, and disposal of forest products are not considered significant.
IFM-16	Combustion emissions from production, transportation, and disposal of alternative materials to forest products	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in forest-product production may cause consumers of these products to increase or decrease their consumption of substitute materials (such as alternative building materials, including cement or steel). In many cases, alternative materials will have

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
						higher combustion GHG emissions associated with their production, transportation, and/or disposal than wood products. This protocol assumes, however, that combustion emissions will be controlled under a regulatory cap-and-trade program in the near future. Thus, for most of a Forest Project's duration, changes in activity due to the project will have no effect on total net emissions due to production, transportation, and disposal of alternative materials. These emissions are therefore excluded from the GHG Assessment Boundary.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Combustion-related CH_4 emissions related to changes in the production, transportation, and disposal of alternative materials are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Combustion-related N_2O emissions related to changes in the production, transportation, and disposal of alternative materials are not considered significant.
IFM-17	Biological emissions from decomposition of forest products	Source	CO_2	*Included*	**Baseline:** Quantified as a component of calculating carbon stored for 100 years in wood products (SSR IFM-7) and landfills (SSR IFM-8) **Project:** Quantified as a component of calculating carbon stored for 100 years in wood products (SSR IFM-7) and landfills (SSR IFM-8)	CO_2 emissions from the decomposition of forest products are built into calculations of how much forest product carbon will remain in in-use wood products and in landfills, averaged over 100 years (see SSR IFM-7 and Appendix B).
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	In-use wood products will produce little to no CH_4 emissions. CH_4 emissions can result from anaerobic decomposition of forest products in landfills. This protocol assumes that landfill CH_4 emissions will be largely controlled in the near future due to federal and/or state regulations. Thus, changes in forest-product production are assumed to have no significant effect on future CH_4 emissions from anaerobic decomposition of forest products in landfills. These emissions are therefore excluded from the GHG Assessment Boundary.

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Decomposition of forest is not expected to be a significant source of N_2O emissions.

5.2 Avoided Conversion Projects

Table 5.2. GHG Assessment Boundary – Avoided Conversion Projects

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs						
AC-1	Standing live carbon (carbon in all portions of living trees)	Reservoir / Pool	CO_2	*Included*	**Baseline:** Modeled based on initial field inventory measurements and expected land-use conversion rates **Project:** Measured by field measurements and updating forest carbon inventory	Preservation and/or increases of standing live carbon stocks and/or soil carbon stocks relative to baseline levels are likely to be a large Primary Effect of Avoided Conversion Projects.
AC-2	Shrubs and herbaceous understory carbon	Reservoir / Pool	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in this reservoir/reservoir are unlikely to have a significant effect on total quantified GHG reductions/removals. Additionally, it is a conservative programmatic measure to exclude shrubs and herbaceous understory carbon.
AC-3	Standing dead carbon (carbon in all portions of dead, standing trees)	Reservoir / Pool	CO_2	*Included*	**Baseline:** Assumed to be static based on initial field inventory measurements **Project:** Measured by updating forest carbon inventory	Avoided Conversion Projects may significantly increase standing dead carbon stocks over time. The protocol requires recruitment and retention of dead material, including standing dead wood as a structural element. Minimum volume thresholds are stated to meet Natural Forest Management criteria. (See Section 3.9.2).
AC-4	Lying dead wood carbon	Reservoir / Pool	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Exclusion of lying dead wood is programmatically conservative for accounting of total quantified GHG reductions/removals, since project activities most likely will lead to increases in lying dead wood carbon. Lying dead wood is highly variable and is difficult to measure accurately, and therefore challenging to achieve confidence with estimates For Natural Forest Management criteria, the protocol requires recruitment and retention of dead material, including lying dead wood as a structural element. Minimum volume thresholds are stated

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
						to meet Natural Forest Management criteria. (See Section 3.9.2).
AC-5	Litter and duff carbon (carbon in dead plant material)	Reservoir / Pool	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Exclusion of litter and duff carbon is programmatically conservative for accounting of total quantified GHG reductions/removals, since project activities most likely will lead to increases in litter and duff carbon. Litter and duff is highly variable, difficult to measure accurately, and therefore challenging to achieve confidence with estimates.
AC-6	Soil carbon	Reservoir / Pool	CO_2	*Optional for reporting project benefits* *Included for reporting project emissions*	**Baseline:** When included, assumed to have emissions and emission rates according to soil order and baseline conversion activity **Project:** Emissions calculated using standardized guidance in Appendix B. Project Operators may opt to quantify net removals or avoided emissions by updating forest soil carbon inventory	Soil carbon is likely a large primary effect of an Avoided Conversion Project. It is conservative to exclude the conversion effect on soil from the project accounting, which is why it is optional. All projects must use standardized guidance to account for potential soil carbon emissions associated with project management activities. If Project Operators choose to quantify net removals or avoided emissions from soil carbon, they may do so by undertaking and updating a soil carbon inventory.
AC-7	Carbon in in-use forest products	Reservoir / Pool	CO_2	*Included*	**Baseline:** Estimated from modeled harvesting volumes **Project:** Estimated from measured harvesting volumes	Included because many Avoided Conversion Projects may significantly change carbon storage in in-use forest products relative to baseline levels. Treated as a "source/sink" because forest product carbon is quantified according to the change in harvesting volumes, relative to baseline levels, in each year. Of this change (increase or decrease), only the average amount of carbon expected to remain stored for 100 years is included in the final quantification of annual net GHG removals/emissions. This approach accounts for CO_2 emissions from decomposition or disposal of wood products (see SSR AC-17).
AC-8	Forest product carbon in landfills	Reservoir / Pool	CO_2	*Excluded when project harvesting exceeds baseline* *Included when project harvesting is below baseline*	**Baseline:** Estimated from modeled harvesting volumes **Project:** Estimated from measured harvesting volumes	Because of significant uncertainties associated with forecasting the quantity of forest product carbon that will remain stored in landfills, landfill carbon is excluded from quantification in years when project harvesting volumes exceed baseline volumes. Landfill carbon is included, however, in years when project harvesting volumes are below baseline levels. This case-dependent exclusion or inclusion is necessary to ensure that total GHG

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
						reductions and removals caused by the Forest Project are not overestimated.
Secondary Effect Sources, Sinks, and Reservoirs						
AC-9	Biological emissions from site preparation activities	Source	CO_2	*Included*	**Baseline:** N/A **Project:** Quantified based on measured carbon stock changes in included reservoirs (SSR AC-6, where applicable)	Biological emissions from site preparation are not quantified separately, but rather are captured by measuring changes in included carbon reservoirs (soil carbon, where applicable). For other carbon reservoirs, changes are unlikely to have a significant effect on total quantified GHG reductions/removals.
AC-10	Mobile combustion emissions from site preparation activities	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Mobile combustion CO_2 emissions from site preparation (including land-use conversion activities) are likely to be higher in the baseline than under project. These emissions are therefore excluded from the GHG Assessment Boundary in order to be conservative. In addition, this protocol assumes that combustion emissions in the United States will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the Forest Project will have no effect on total net emissions.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Differences in CH_4 emissions from mobile combustion associated with site preparation activities are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Differences in N_2O emissions from mobile combustion associated with site preparation activities are not considered significant.
AC-11	Mobile combustion emissions from ongoing project operation and maintenance	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Mobile combustion CO_2 emissions from ongoing project operation and maintenance are unlikely to be significantly different from baseline levels and are therefore not included in the GHG Assessment Boundary. In addition, this protocol assumes that such emissions will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the Forest Project will have no effect on total net emissions.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in CH_4 emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in N_2O emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
AC-12	Stationary combustion emissions from	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Stationary combustion CO_2 emissions from ongoing project operation and maintenance could include GHG

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
	ongoing project operation and maintenance					emissions associated with electricity consumption or heating/cooling at Project Operator facilities, or at facilities owned or controlled by contractors. These emissions are unlikely to be significantly different from (or will be lower than) baseline levels and are therefore not included in the GHG Assessment Boundary. In addition, this protocol assumes that such emissions will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the Forest Project will have no effect on total net emissions.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in CH_4 emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in N_2O emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
AC-13	Biological emissions from clearing of forestland outside the Project Area	Source	CO_2	*Included*	**Baseline:** N/A **Project:** Estimated using default forestland conversion factors	Avoided Conversion Projects may cause land-use pressures to shift to other forestlands, causing biological emissions that partially negate the benefits of the project.
AC-14	Biological emissions/ removals from changes in harvesting on forestland outside the Project Area	Source / Sink	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Over time, Avoided Conversion Projects will tend to increase harvesting levels relative to the baseline, potentially causing other landowners to reduce harvesting in response to increased wood product supply. The reduction in harvesting may lead to increased carbon stocks on other lands. Carbon stock increases on other lands are excluded from the GHG Assessment Boundary, however, because it is not possible to ensure their permanence. Avoided Conversion Projects are not expected to cause an increase in harvesting on other lands over the long run (except where clearing is involved for other land uses, per SSR AC-13), so this potential effect is also excluded from the GHG Assessment Boundary.
AC-15	Combustion emissions from production, transportation, and disposal of forest products	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	This protocol assumes that combustion emissions will be controlled under a regulatory cap-and-trade program in the near future. Thus, for most of a Forest Project's duration, changes in activity due to the project will have no effect on total net emissions due to production, transportation, and disposal of forest products. These emissions are therefore

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
						excluded from the GHG Assessment Boundary.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Combustion-related CH_4 emissions related to changes in the production, transportation, and disposal of forest products are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Combustion-related N_2O emissions related to changes in the production, transportation, and disposal of forest products are not considered significant.
AC-16	Combustion emissions from production, transportation, and disposal of alternative materials to forest products	Source	CO_2	*Excluded*	**Baseline:** N/A **Project:** N/A	Changes in forest-product production may cause consumers of these products to increase or decrease their consumption of substitute materials (such as alternative building materials, including cement or steel). In many cases, alternative materials will have higher combustion GHG emissions associated with their production, transportation, and/or disposal than wood products. This protocol assumes, however, that combustion emissions will be controlled under a regulatory cap-and-trade program in the near future. Thus, for most of a Forest Project's duration, changes in activity due to the project will have no effect on total net emissions due to production, transportation, and disposal of alternative materials. These emissions are therefore excluded from the GHG Assessment Boundary.
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	Combustion-related CH_4 emissions related to changes in the production, transportation, and disposal of alternative materials are not considered significant.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Combustion-related N_2O emissions related to changes in the production, transportation, and disposal of alternative materials are not considered significant.
AC-17	Biological emissions from decomposition of forest products	Source	CO_2	*Included*	**Baseline:** Quantified as a component of calculating carbon stored for 100 years in wood products (SSR AC-7) and landfills (SSR AC-8) **Project:** Quantified as a component of calculating carbon stored for 100 years in wood products (SSR AC-7) and landfills (SSR AC-8)	CO_2 emissions from the decomposition of forest products are built into calculations of how much forest product carbon will remain in in-use wood products and in landfills, averaged over 100 years (see SSR AC-7 and Appendix B).

SSR	Description	Type	Gas	Included or Excluded	Relevant to Baseline or Project	Justification/Explanation
			CH_4	*Excluded*	**Baseline:** N/A **Project:** N/A	In-use wood products will produce little to no CH_4 emissions. CH_4 emissions can result from anaerobic decomposition of forest products in landfills. This protocol assumes that landfill CH_4 emissions will be largely controlled in the near future due to federal and/or state regulations. Thus, changes in forest-product production are assumed to have no significant effect on future CH_4 emissions from anaerobic decomposition of forest products in landfills. These emissions are therefore excluded from the GHG Assessment Boundary.
			N_2O	*Excluded*	**Baseline:** N/A **Project:** N/A	Decomposition of forest is not expected to be a significant source of N_2O emissions.

6 Quantifying Net GHG Reductions and Removals

This section provides requirements and guidance for quantifying a Forest Project's net GHG reductions and removals. The Reserve will issue Climate Reserve Tonnes (CRTs) to a Forest Project upon confirmation by an ISO-accredited and Reserve-approved verification body that the Forest Project's GHG reductions and removals have been quantified following the applicable requirements of this section (see Section 9 for verification requirements).

For each type of Forest Project, quantification proceeds in seven steps:

1. **Estimating baseline onsite carbon stocks.** The baseline is an estimate of what would have occurred in the absence of a Forest Project. To establish baseline onsite carbon stocks, the Project Operator must estimate 100 years of carbon stock changes in each of the Forest Project's required and selected optional onsite carbon pools (identified in Section 5). The baseline must be based on inventoried carbon stocks at the time of the Forest Project's initiation, following the applicable requirements in this section for modeling or implementing a conservative default baseline. Onsite carbon stocks are inventoried following the requirements described in Appendix B. Modeling of onsite carbon stocks over time must be conducted following the requirements in this section and the guidance in Appendix B. Baseline onsite carbon stocks are estimated over a Forest Project's entire crediting period (100 years) at the time of the project's initiation and are not modified thereafter, except for reconciliation of project baselines to changes in inventory estimates associated with inventory methodology updates.
2. **Estimating baseline carbon in harvested wood products.** In conjunction with estimating baseline onsite carbon stocks, the Project Operator must forecast any harvesting that would have occurred in the baseline and convert this to an average annual harvesting volume. From this, the Project Operator must determine the amount of carbon that would have been transferred each year (on average) to long-term storage in wood products. Baseline harvesting is forecasted following the guidance in this section, depending on the project type - either through a default or modeling approach, and carbon stored in wood products must be calculated following the requirements in Appendix B.
3. **Determining actual onsite carbon stocks.** Each year, the Project Operator must determine the Forest Projects' actual onsite carbon stocks. This must be done by updating the Forest Project's forest carbon inventory for the current year, following the guidance in this section and in Appendix B. The estimate of actual onsite carbon stocks must be adjusted by an appropriate confidence deduction, as described in Appendix B.
4. **Determining actual carbon in harvested wood products.** Each year, the Project Operator must report any harvesting in the Project Area and from this determine the amount of carbon transferred to long-term storage in wood products. Carbon stored in wood products must be calculated following the requirements available in Appendix B
5. **Calculating the project's Primary Effect.** Each year, the Project Operator must quantify the actual change in GHG emissions or removals associated with the Forest Project's intended ("Primary") effect, as defined in Section 5. For any given year, the Primary Effect is calculated by:

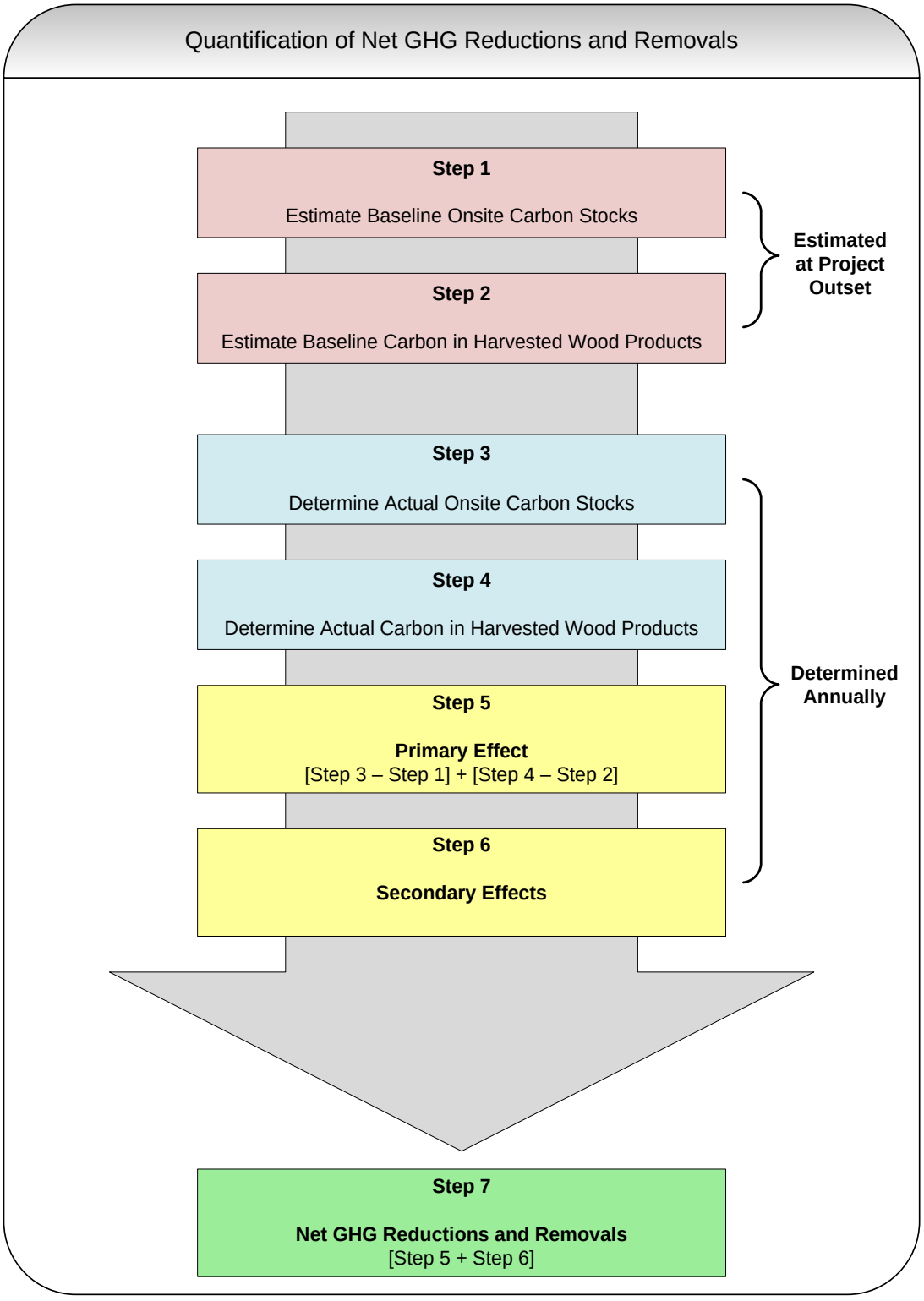
a. Taking the difference between actual onsite carbon stocks for the current year and actual onsite carbon stocks for the prior year[18]
b. Subtracting from (a) the difference between baseline onsite carbon stocks for the current year and baseline onsite carbon stocks for the prior year[19]
c. Adding to (b) the calculated difference between actual and baseline carbon in harvested wood products for the current year (see Equation 6.1)

6. **Quantifying the project's Secondary Effects.** Each year, the Project Operator must quantify the actual change in GHG emissions or removals associated with the Forest Project's unintended ("Secondary") effects, as defined in Section 5. Requirements and guidance for quantifying Secondary Effects are provided below for each type of Forest Project.
7. **Calculating total net GHG reductions and removals.** For each year, total net GHG reductions and removals are calculated by summing a Forest Project's Primary and Secondary Effects. If the result is positive, then the Forest Project has generated GHG reductions and/or removals in the current year. If the result is negative, this may indicate a reversal has occurred (see Section 7).[20]

Requirements and guidance for how to perform quantification steps 1 to 4 for each Forest Project type are presented in the remainder of this section.

The required formula for quantifying annual net GHG reductions and removals is presented in Equation 6.1. Net GHG reductions and removals must be quantified and reported in units of carbon dioxide-equivalent (CO_2e) metric tons.

[18]For the purposes of calculating the project's Primary Effect, actual and baseline carbon stocks prior to the start date of the project are assumed to be zero.
[19] See footnote 18.
[20] A reversal occurs only if: (1) total net GHG reductions and removals for the year are negative; and (2) CRTs have previously been issued to the Forest Project. If calculated GHG reductions and removals are negative and no CRTs have been issued to the project since its start date, then the result should be treated as a "negative carryover" to GHG reduction calculations in subsequent years (variable N_{y-1} in Equation 6.1). This may happen, for example, because the confidence deduction applied to actual onsite carbon stocks can result in actual values being less than baseline values in a Forest Project's initial years.


Quantification of Net GHG Reductions and Removals
Step 1
Estimate Baseline Onsite Carbon Stocks
Step 2
Estimate Baseline Carbon in Harvested Wood Products
Estimated at Project Outset
Step 3
Determine Actual Onsite Carbon Stocks
Step 4
Determine Actual Carbon in Harvested Wood Products
Step 5
Primary Effect
[Step 3 – Step 1] + [Step 4 – Step 2]
Step 6
Secondary Effects
Determined Annually
Step 7
Net GHG Reductions and Removals
[Step 5 + Step 6]

Equation 6.1. Annual Net GHG Reductions and Removals

$$QR_y = \left[(\Delta AC_{onsite} - \Delta BC_{onsite}) + SC_y + (AC_{wp,y} - BC_{wp,y}) \times 0.80 + SE_{as,y}\right] + N_{y-1}$$

Where,			Units
QR_y	=	Quantified GHG reductions and removals for year *y*	CO_2e
SC_y	=	Soil carbon project emissions (if included, and if using the standardized guidance in Appendix B). If an avoided conversion project is reporting avoided emissions from sampled soil carbon, it will be included in AC_{onsite}, in order to apply the confidence deduction as required by Appendix B.	CO_2e
$AC_{wp,\ y}$	=	Actual carbon in wood products produced in year *y* that is projected to remain stored for at least 100 years (i.e., derived for actual harvest volumes following the guidance in Appendix B)	CO_2e
$BC_{wp,y}$	=	Annual baseline carbon in wood products that would have remained stored for at least 100 years (i.e., derived for baseline harvest volumes following the guidance in Appendix B)	CO_2e
0.80	=	The net change in carbon in harvested wood products, ($AC_{wp,y}$ – $BC_{wp,y}$), is multiplied by 80 percent in Equation 6.1 to reflect market responses to changes in wood-product production. The general assumption in this protocol is that for every tonne of reduced harvesting caused by a Forest Project, the market will compensate with an increase in harvesting of 0.2 tonnes on other lands (see Section 6.1.6). Since wood product production is directly related to harvesting levels, the net change in wood products caused by a project is subject to this same market dynamic. Thus, any one-tonne increase in wood product production by a project will result in only a 0.8 tonne increase overall, because it has been assumed other landowners will decrease production by 0.2 tonnes in response. Similarly, any one-tonne decrease in wood product production by a project will result in only a 0.8 tonne decrease overall, because it has been assumed other landowners will increase production by 0.2 tonnes in response	
$SE_{as,y}$	=	Secondary Effect GHG emissions that may result from activity shifting outside the project area, as a result of the project activity in year *y*	CO_2e
N_{y-1}	=	Any negative carryover from the prior year (occurs when total quantified GHG reductions are negative prior to the issuance of any CRTs for the project– see footnote 20, p. 38)	CO_2e

And,

$$\Delta AC_{onsite} = (AC_{onsite,y})(1 - CD_y) - (AC_{onsite,y-1})(1 - CD_{y-1})$$

Where,			
$AC_{onsite,\ y}$	=	Actual onsite carbon as inventoried for year *y* (*y* may be less than a year for the first reporting period following the start date). Includes soil carbon for avoided conversion projects reporting avoided emissions from sampled soil carbon	CO_2e
$AC_{onsite,\ y-1}$	=	Actual onsite carbon as inventoried for year *y-1*. Includes soil carbon for avoided conversion projects reporting avoided emissions from sampled soil carbon	CO_2e
CD_y	=	Appropriate confidence deduction for year *y*, as determined following the Appendix B	%
CD_{y-1}	=	Appropriate confidence deduction for year *y-1*, as determined following the Appendix B	%

And,

$$\Delta BC_{onsite} = \left(BC_{onsite,y}\right) - \left(BC_{onsite,y-1}\right)$$

Where,

$BC_{onsite,\ y}$	=	Baseline onsite carbon as estimated for year *y* (*y* may be less than a year for the first reporting period following the start date)	CO_2e
$BC_{onsite,\ y-1}$	=	Baseline onsite carbon as estimated for year *y-1*	CO_2e

6.1 Improved Forest Management Projects

Improved Forest Management Projects that take place on private land – or on land that is transferred to public ownership at the time the project is initiated – must estimate baseline onsite carbon stocks following the requirements and procedures in Section 6.1.1 (default approach) or Section 6.1.2 (modeling approach). Improved Forest Management Projects that take place on land that was publicly owned prior to the project start date must estimate baseline onsite carbon stocks following the requirements and procedures in Section 6.1.3. Requirements for determining actual onsite carbon stocks, determining actual carbon in harvested wood products, and quantifying Secondary Effects are the same for all Improved Forest Management Projects.

The approach to additionality for all Improved Forest Management Projects relies on an averaged baseline value. The time commitment for a project under this protocol is 100 years, and the baseline is a counterfactual representation of one of a multitude of potential legally compliant and financially feasible management scenarios that could play out in reality in the absence of the project.

6.1.1 Estimating Baseline Onsite Carbon Stocks – Private Lands – Default Approach

The baseline approach for Improved Forest Management Projects on private lands applies a standardized set of assumptions to project-specific conditions. A project must determine a start date inventory and consider how legal and financial constraints affect the baseline carbon stocks. Furthermore, performance standard criteria are applied to Improved Forest Management Projects based on Common Practice statistics, described below in this section.

The first baseline approach option for an Improved Forest Management Project on private lands is to use a conservative default approach, which eliminates the modeling effort required for baseline estimation. The steps are:

1. Determine the start date inventories of aboveground standing live carbon stocks, belowground standing live carbon stocks, aboveground standing dead carbon stocks, and belowground standing dead carbon stocks for the Project Area.
2. Determine Common Practice for the Project Area. Determine the project's initial baseline, based on whether initial carbon stocks are above or below the Common Practice value.
3. Determine the applicable level of legal and financial constraints applicable to the Project Area based on the guidance below and adjust the initial baseline accordingly.
4. Determine the baseline harvest volume based on the guidance below.
5. Combine the results to produce the final baseline for all required carbon stocks.

6.1.1.1 Inventory Carbon Stocks within the Project Area

The start date inventory of standing live carbon stocks, separated into aboveground and belowground portions, and the start date inventory of standing dead carbon stocks, also with aboveground and belowground portions separated, must be determined following the guidance in Appendix B. Projects may choose to use the Standardized Inventory Methodology and/or the Climate Action Reserve Inventory Tool (CARIT),[21] both available on the Reserve's website, but use of the methodology and CARIT is optional.

In the formulas throughout this section, initial carbon stocks are denoted by the variable PUB_0 (i.e., the *preliminary unadjusted baseline* at time zero).

6.1.1.2 Determining Common Practice and the Initial Baseline

Common Practice refers to the average stocks of aboveground standing live and standing dead carbon associated with the Assessment Area(s) covered by the Project Area. This value represents the result of the suite of management activities taking place within the Assessment Area(s) and is used to approximate a Performance Standard for Improved Forest Management Projects. The overall intent of this protocol is for projects to contribute to long-term increases in average carbon stocking in the Assessment Area(s) where they are located. Projects with initial stocking below Common Practice will increase their stocking over time. Projects with initial stocking above Common Practice will also likely increase their stocking over time, but, as or more importantly, will prevent activities that otherwise would have decreased the stocking on the project site to or below Common Practice stocking. In the absence of a forest project, there is no guarantee that a site with stocking above Common Practice will maintain their stocking levels, especially over the 100-year period committed to by projects.

The Common Practice statistic applicable to a project can be found by consulting the Assessment Area Data File on the Reserve's FPP webpage. If the Project Area covers multiple Assessment Areas, Common Practice must be calculated as the average of the values for each Assessment Area, weighted by the percentage of the Project Area that falls within each Assessment Area.

Common Practice statistics are calculated from United States Forest Service Forest Inventory and Analysis (USFS FIA) program. The Reserve will update the Common Practice statistics in the Assessment Area Data File periodically. The frequency of updating Common Practice statistics will be subject to the availability of new USFS FIA data but will be no more frequent than once every five years. The Reserve will announce any forthcoming updates to the Common Practice statistics before they are released, and any updates will not be retroactive.

The performance standard criteria establish minimum aboveground standing live and standing dead carbon stock values for the baseline, regardless of what is legally and financially viable. For projects whose initial aboveground standing live and standing dead carbon stocks are above Common Practice, the *initial baseline* for the project is equal to Common Practice. For projects whose initial aboveground standing live and standing dead carbon stocks are below Common Practice, the *initial baseline* for aboveground standing live and standing dead carbon stocks is either (1) the initial aboveground standing live and standing dead carbon stocks (PUB_0) or (2) the High Stocking Reference, whichever is greater. The High Stocking Reference is a measure of carbon stocks in aboveground standing live and standing dead biomass over

[21] The Standardized Inventory Methodology and Climate Action Reserve Inventory Tool (CARIT) were developed based upon work supported by the Natural Resources Conservation Service, U.S. Department of Agriculture, under number 69-3A75-16-024.

the 10 years preceding the project start date. It governs baseline carbon stocks in certain instances where aboveground standing live and standing dead carbon stocks have declined prior to the start date. Refer to Section 6.1.2.4.1 for guidance around determining High Stocking Reference.

6.1.1.3 Adjust the Initial Baseline for Legal and Financial Constraints

To ensure that projects receive credits for only those GHG removals that are undertaken in addition to existing legal requirements, such legal and financial constraints must be factored into the project's baseline. For the conservative default approach, the Reserve has calculated a multiplier to be applied to the *initial baseline*, which is designed to be a conservative representation of project constraints. Equation 6.2 describes how the *initial baseline* is adjusted. However, if:

1. deeded encumbrances exist that limit forest management beyond existing federal, state, and local laws and regulations that govern forest management, or
2. the project does not pass the Reserve's conservative default baseline screening tool[22], which considers the extent of legal and financial constraints on the Project Area,

then the project may not proceed with the default approach and must instead use the baseline modeling approach described in Section 6.1.2.

Equation 6.2. Determining the *Adjusted Initial Baseline*

$$\boldsymbol{AB = IB \times 1.06}$$

Where,			Units
AB	=	*Adjusted initial baseline* for aboveground standing live and aboveground standing dead carbon stocks value	tCO_2e/acre
IB	=	*Initial baseline* for aboveground standing live and aboveground standing dead carbon stocks (determined according to the guidance in Section 6.1.1.2)	tCO_2e/acre
1.06	=	A conservative multiplier to raise the *initial baseline* by 6%, to account for legal and financial constraints that may prevent harvesting to minimum baseline levels	

6.1.1.4 Estimate the Project's Baseline Harvest Volume

The estimate of baseline harvest volume shall be based on the equation below. The resulting volume shall be used in conjunction with the guidance in Appendix B to determine harvested wood products. The harvest volume shall remain constant for the project life.

[22] The Reserve's default baseline screening tool is available on the FPP website.

Equation 6.3. Calculate the Baseline Harvest Volume

$$HV_{BL} = ((\frac{PUB_0 - IB}{IB}) \times 0.0272) + 0.02$$

Where,			Units
HV_{BL}	=	Baseline harvest volume	tCO_2e/acre
PUB_0	=	Initial aboveground standing live and standing dead carbon stocks	tCO_2e/acre
IB	=	*Initial baseline* for aboveground standing live and aboveground standing dead carbon stocks (determined according to the guidance in Section 6.1.1.2)	tCO_2e/acre
0.0272	=	Regression coefficient derived from analysis to predict baseline harvest volumes based on data reported by existing Improved Forest Management offset projects[23]	
0.02	=	Y-intercept derived from analysis to predict baseline harvest volumes based on data reported by existing Improved Forest Management offset projects[24]	

6.1.1.5 Calculate the Final Baseline for Onsite Carbon Stocks

The final baseline is determined by accounting for belowground biomass and adding the estimated harvested wood products to the *adjusted initial baseline*.

Equation 6.4. Calculate the *Final Baseline*

$$FBL = AB + (\frac{AB \times IBG}{PUB_0}) + HWP_{BL}$$

Where,			Units
FBL	=	*Final baseline* for all required onsite carbon stocks	tCO_2e/acre
AB	=	*Adjusted initial baseline* for aboveground standing live and aboveground standing dead carbon stocks value, from Equation 6.2	tCO_2e/acre
IBG	=	Belowground standing live and standing dead carbon stocks measured in the project's initial inventory	tCO_2e/acre
PUB_0	=	Initial aboveground standing live and dead carbon stocks per acre within the Project Area	tCO_2e/acre
HWP_{BL}	=	Baseline harvested wood products calculated following Appendix B, using HV_{BL}	tCO_2e/acre

6.1.2 Estimating Baseline Onsite Carbon Stocks – Private Lands – Modeling Approach

The following steps must be followed to estimate baseline carbon stocks:

1. Determine the start date inventories of aboveground standing live carbon stocks, belowground standing live carbon stocks, aboveground standing dead carbon stocks, and belowground standing dead carbon stocks for the Project Area.

[23] Includes only those Improved Forest Management offset projects that are participating in the California Air Resources Board's Compliance Offset Program and have completed their initial verification as of 10/02/2018.
[24] See footnote 23.

2. Model a 100-year growth and harvest regime reflecting legal and financial constraints. The result is a *preliminary unadjusted baseline* for aboveground standing live carbon stocks that reasonably reflects the harvesting opportunities present within the Project Area.
3. Standardize the *preliminary unadjusted baseline* for aboveground standing live carbon stocks by averaging the annual values or, if legal constraints require stocks to increase over time, constructing an upward sloping straight line to the apex of the legal constraints and averaging annual values thereafter. Baseline carbon stocks for other carbon pools must be similarly averaged. This results in the *unadjusted averaged baseline* for reported carbon stocks.
4. Apply performance standard criteria to adjust the aboveground standing live and standing dead portions of the *unadjusted averaged baseline*. The result is an *adjusted averaged baseline* for aboveground standing live and standing dead carbon stocks.
5. Proportionally adjust other reported carbon stocks to match the *adjusted averaged baseline*.
6. Combine the results to produce the *final baseline* for all onsite carbon stocks.

For all calculations in this section, all values for "carbon stocks" should be expressed in metric tons of CO_2-equivalent.

6.1.2.1 Inventory Carbon Stocks within the Project Area

The start date inventory of standing live carbon stocks, separated into aboveground and belowground portions, and the start date inventory of standing dead carbon stocks, also with aboveground and belowground portions separated, must be determined following Appendix B. Projects may choose to use the Standardized Inventory Methodology and/or the Climate Action Reserve Inventory Tool (CARIT), both available on the Reserve's website, but use of the methodology and CARIT is optional.

In the formulas throughout this section, initial carbon stocks are denoted by the variable PUB_0 (i.e., the *preliminary unadjusted baseline* at time zero).

6.1.2.2 Model Growth and Harvesting Over 100 Years

The *preliminary unadjusted baseline* for onsite carbon stocks must be estimated through a modeling exercise. The modeling exercise must use the inventories of the carbon from Section 6.1.2 as a starting point for modeling. The *preliminary unadjusted baseline* will consist of each of the following carbon pools that are maintained separately during this stage of baseline development:

- Aboveground standing live
- Belowground standing live
- Aboveground standing dead
- Belowground standing dead
- Harvested aboveground and belowground standing live
- Bole portion of harvested standing live

To determine the *preliminary unadjusted baseline,* model the initial inventory of aboveground standing live carbon stocks through a series of growth and harvesting scenarios over a 100-year timeframe. Modeling must be conducted using an approved growth model, as identified in the

Modeling Carbon Stocks section of Appendix B. Modeling of the growth and harvesting scenarios must reflect all legal requirements that constrain the ability to harvest carbon stocks. In addition, harvesting assumptions must reflect realistic financial constraints, as described in Section 6.1.2.2.2.

Standing dead carbon stocks shall be assumed to remain static throughout the modeling process. Exceptions may be provided, at the Reserve's discretion, if compelling justification can be provided that standing dead carbon stocks are likely to fluctuate substantially as part of the project's baseline.

6.1.2.2.1 Modeling Legal Constraints

All legal constraints that affect the ability to manage carbon stocks must be included in the model design. The *preliminary unadjusted baseline* must represent a growth and harvesting regime that fulfills all legal requirements. Voluntary agreements that can be rescinded, such as rental contracts and forest certifications, are not legal constraints. Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) that are in place more than one year prior to the project's start date shall be modeled as legal constraints. HCPs and SHAs that are approved after the date one year prior to the project's start date are not considered legal constraints for baseline modeling and may be disregarded.

Legal constraints include all laws, regulations, and legally-binding commitments applicable to the Project Area at the time of the project's initiation that could affect carbon stocks. Legal constraints include:

1. Federal, state/provincial, or local government regulations that are required and might reasonably be anticipated to influence carbon stocking over time including, but not limited to:
    a. Zones with harvest restrictions (e.g., buffers, streamside protection zones, wildlife protection zones)
    b. Harvest adjacency restrictions
    c. Minimum stocking standards
2. Forest practice rules, or applicable Best Management Practices established by federal, state, provincial or local government that relate to forest management.
3. Other legally binding requirements affecting carbon stocks including, but not limited to, covenants, conditions and restrictions, and other title restrictions in place prior to or at the time of project initiation, including pre-existing conservation easements, HCPs, SHAs, and deed restrictions, excepting an encumbrance that was put in place and/or recorded less than one year prior to the project start date, as defined in Section 3.7.

For Forest Projects located in California, the *preliminary unadjusted baseline* must be modeled to reflect all silvicultural treatments associated with timber harvest plans (THPs) active within the Project Area at the time of the project's initiation. All legally enforceable silvicultural and operational provisions of a THP – including those operational provisions designed to meet California Forest Practice Rules requirements for achieving Maximum Sustained Production of High Quality Wood Products [14 CCR 913.11 (933.11, 953.11)] – are considered legal constraints and must be reflected in baseline modeling for if the THP will remain active. For portions of the Project Area not subject to THPs (or over time periods for which THPs will not be active), baseline carbon stocks must be modeled by considering any applicable requirements of the California Forest Practice Rules and all other applicable laws, regulations, and legally

binding commitments that could affect onsite carbon stocks. On a case-by-case basis, the California Department of Forestry and Fire Protection (CAL FIRE) may assist Project Operators in identifying minimum carbon stocking levels that would be effectively required under California Forest Practice Rules.

6.1.2.2.2 Modeling Financial Constraints

Harvest assumptions included in the model must be financially viable. The Project Operator must demonstrate that the growth and harvesting regime assumed for the *preliminary unadjusted baseline* is financially feasible through a financial analysis of the anticipated growth and harvesting regime that captures all relevant costs and returns, taking into consideration all legal, physical, and biological constraints. Cost and revenue variables in the financial analysis may be based on regional norms or on documented costs and returns for the Project Area or other properties in the project's Assessment Area.

A financially viable project is defined in this protocol as a project that has a positive net present value using a discount rate of 4%. This would indicate a management regime that does not lose money in the practice of performing long-term forest management activities, including road management, watercourse restoration, fuels management, etc. Inputs to the analysis include the volume of species harvested, logging and hauling costs, delivered log prices, and forest management costs.

6.1.2.3 Generate an Unadjusted Averaged Baseline

The periodic modeled outputs from the *preliminary unadjusted baseline* must be standardized according to the following guidance for each carbon pool. The result will be an *unadjusted averaged baseline* for each carbon pool.

Aboveground standing live carbon stocks: The periodic modeled outputs for aboveground standing live carbon stocks must be either averaged or converted to a straight-line approximation reflective of legal constraints.

If legal constraints do *not* result in an upward trend in aboveground standing live carbon stocks, then the periodic model outputs must be averaged using Equation 6.5. See Figure 6.1 for a simplified example of the resulting *unadjusted averaged baseline*.

If legal constraints do result in an increasing trend of aboveground standing live carbon stocks, beginning at the project start date, then the periodic model outputs may be standardized using a straight-line approximation, as defined in Equation 6.6. The approximation must consist of two line segments. The first of the line segments must initiate at the initial inventory at the project start date and terminate at the point where carbon stocks reach their highest legally required level. The second segment is a straight line with a constant value, defined by the terminus of the first line segment, for the balance of the 100-year modeling timeframe. See Figure 6.2 for a simplified example of the resulting *unadjusted averaged baseline* with an upward slope.

Equation 6.5. Formula for Averaging *Preliminary Unadjusted Baseline* Carbon Stocks

For all years *y*, $UAB_y = \frac{\sum_{y=0}^{100} PUB_y}{100}$

Where,			Units
UAB_y	=	*Unadjusted averaged baseline* value for year *y (*including the start date at *y*=0*)*	tCO_2e/acre
PUB_y	=	*Preliminary unadjusted baseline* value for year *y.*	tCO_2e/acre

Equation 6.6. Formula for Approximating *Preliminary Unadjusted Baseline* Carbon Stocks as a Straight-Line Trend

For years *y* < Y, $UAB_y = PUB_0 + y \times \frac{ES - PUB_0}{Y}$

For years *y* ≥ Y, $UAB_y = ES$

Where,			Units
UAB_y	=	*Unadjusted averaged baseline* value for year *y*	tCO_2e/acre
Y	=	Time in years between the project start date and the year at which the highest legally required stocking level is reached. This is determined by modeling a forest growth and yield simulation that includes legal and financial constraints (in Section 6.1.2.2, above)	years
PUB_0	=	Initial aboveground standing live and dead carbon stocks per acre within the Project Area (as determined in Section 6.1.2)	tCO_2e/acre
ES	=	Ending stocks = The highest legally required stocking level, as determined in Step 2	tCO_2e/acre

Belowground standing live carbon stocks: The belowground portion of the standing live carbon stocks must be standardized in the same way as the aboveground standing live carbon stocks, i.e., either averaged (Equation 6.5), or calculated with an upward-sloping line to a potential terminus (Equation 6.6).

The aboveground and belowground portions of standing dead carbon stocks: Standing dead carbon stocks shall be set at the quantity of carbon stocks present in the standing dead carbon stock pool at the project start date. Exceptions may be provided, at the Reserve's discretion, if compelling justification can be provided that standing dead carbon stocks are likely to fluctuate substantially as part of the project's baseline. Standing dead stocks are not adjusted based on adjustments to the standing live carbon stocks. However, aboveground and belowground portions of standing dead carbon stocks should be maintained as separate values since aboveground standing dead stocks should be combined with the *unadjusted averaged baseline* for aboveground standing live carbon for the purpose of applying the performance standard criteria as described in Section 6.1.2.4 below.

Carbon stocks in the aboveground and belowground portions of standing live trees harvested for wood products: The carbon stocks shall be calculated as the average of the periodic outputs for the entire 100-year modeling if the aboveground live tree carbon stocks do not result in an upward trend.

If the carbon stocks in aboveground standing live carbon stocks results in an upward trend, the carbon stocks shall be calculated as an average from the start date to the highest point of the

aboveground standing live carbon stocks. A separate average of carbon stocks in both the aboveground and belowground portions of standing live trees harvested for wood products between the highest point of the aboveground standing live carbon stocks and the end point of the 100-year modeling shall be calculated, as applicable.

Carbon stocks in the bole portion of trees harvested for wood products: The carbon stocks shall be calculated as the average of periodic outputs for the entire 100-year modeling if the aboveground live tree carbon stocks do not result in an upward trend.

For upward-sloping lines, the values shall be based on the carbon stocks harvested to the legal constraint terminus and be based on the average carbon stocks from the terminus to the balance of the 100-year modeling (if applicable).

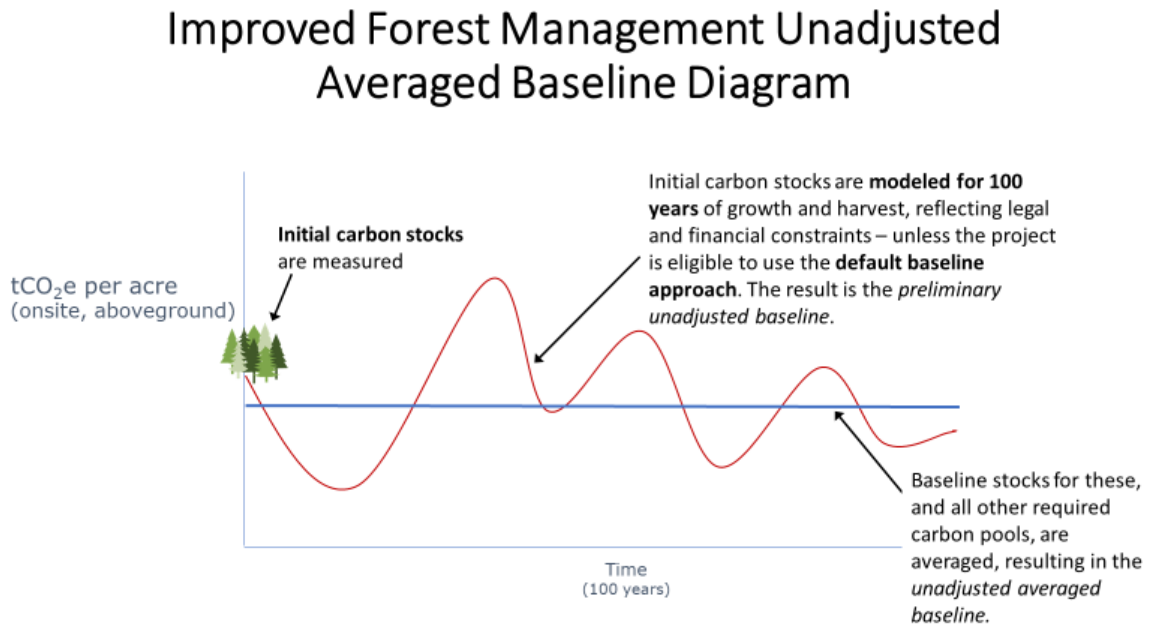


Figure 6.1. Example of an *unadjusted averaged baseline*
(Resulting from Equation 6.5.)

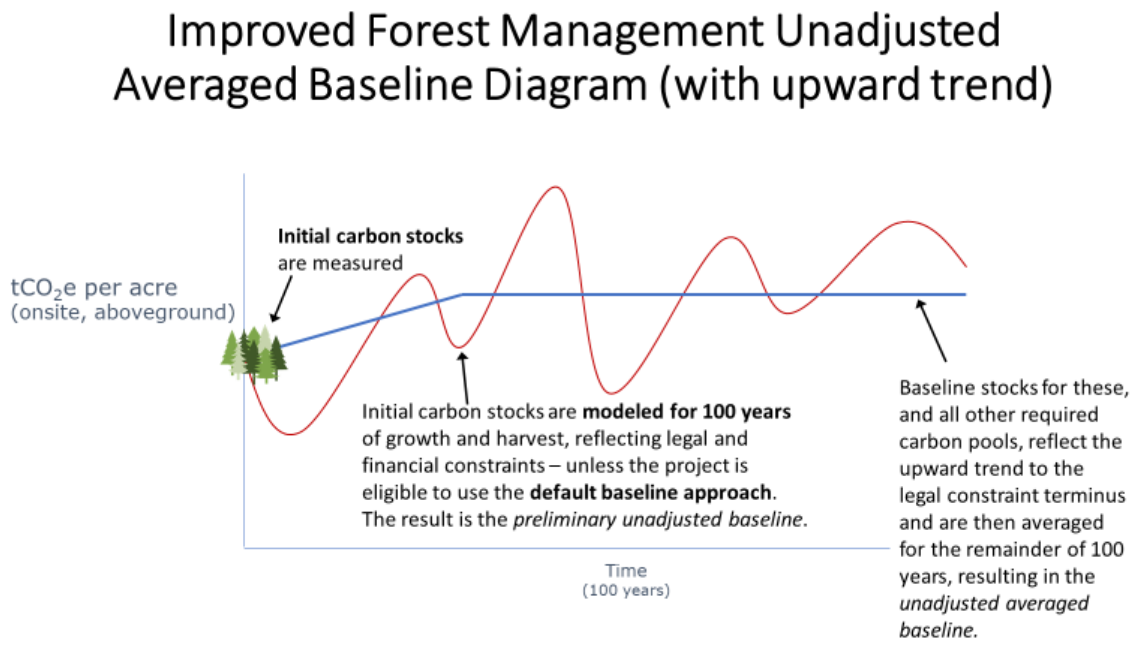


Figure 6.2. Example of an *unadjusted averaged baseline* with an upward trend (Resulting from Equation 6.6.)

6.1.2.4 Apply Performance-Standard Criteria

Once the components of the *unadjusted averaged baseline* are determined in Section 6.1.2.3, the aboveground standing live and standing dead components must be adjusted to conform to a set of performance standard criteria, as described below. The result is an *adjusted averaged baseline* for aboveground standing live and standing dead carbon stocks. Other reported carbon pools are adjusted in Section 6.1.2.5.

The performance standard criteria establish minimum aboveground standing live and standing dead carbon stock values for the baseline, regardless of what is legally and financially viable. The elements of the performance standard are:

- *The High Stocking Reference:* The High Stocking Reference is a measure of carbon stocks in aboveground standing live and standing dead biomass over the 10 years preceding the project start date. It governs baseline carbon stocks in certain instances where aboveground standing live and standing dead carbon stocks have declined prior to the start date. See further guidance below on how to determine the High Stocking Reference.
- *Comparison of initial carbon stocks to Common Practice*: If the *unadjusted averaged baseline* for aboveground standing live carbon stocks was determined according to Equation 6.5, then the *adjusted averaged baseline* may depend on how the initial carbon stocks compare to Common Practice levels (see guidance in Section 6.1.1 for how to determine Common Practice). For projects whose initial aboveground standing live and standing dead carbon stocks are above Common Practice, the *adjusted averaged baseline* for aboveground standing live and standing dead carbon stocks may not be below Common Practice. For projects whose initial aboveground standing live and standing dead carbon stocks are below Common Practice, the *adjusted averaged*

baseline for aboveground standing live and standing dead carbon stocks may not be below either (1) the initial inventory level or (2) the High Stocking Reference, whichever is greater. See Equation 6.7 and Equation 6.8 below.

The procedure for determining the *adjusted averaged baseline* depends on whether the *unadjusted averaged baseline* for aboveground standing live carbon stocks was determined according to Equation 6.5, or as an upward sloping straight-line trend (according to Equation 6.6.

Where the *unadjusted averaged baseline* for aboveground standing live carbon stocks was determined using Equation 6.5:

- If the project's initial aboveground standing live and standing dead carbon stocks (PUB_0) are above Common Practice, use Equation 6.7 to determine the *adjusted averaged baseline*
- If the project's initial aboveground standing live and standing dead carbon stocks (PUB_0) are below Common Practice, use Equation 6.8 to determine the *adjusted averaged baseline*

In both cases, values must be determined for all years, *y*, starting with zero (the start date of the project) and ending with 100.

Equation 6.7. Determining the *Adjusted Averaged Baseline* for Aboveground Live and Aboveground Standing Dead Carbon Stocks Where Initial Stocks Are at or Above Common Practice

$$\boldsymbol{AAB_y = MAX\left(CP, MIN\left(PUB_0, UAB_y\right)\right)}$$

Where,			Units
AAB_y	=	*Adjusted averaged baseline* for aboveground standing live and aboveground standing dead carbon stocks value in year *y*	tCO_2e/acre
CP	=	Common Practice (determined according to the guidance in Section 6.1.1)	tCO_2e/acre
PUB_0	=	Initial aboveground standing live and dead carbon stocks per acre within the Project Area (as determined in Section 6.1.2)	tCO_2e /acre
UAB_y	=	Value of the aboveground standing live and aboveground standing dead portion of the *unadjusted averaged baseline* for year *y,* as determined in Section 6.1.2.3	tCO_2e/acre

Equation 6.8. Determining the *Adjusted Averaged Baseline* for Aboveground Live and Aboveground Standing Dead Carbon Stocks Where Initial Stocks Are Below Common Practice

$$AAB_y = MAX\left(MAX(HSR, PUB_0), MIN(CP, UAB_y)\right)$$

Where,			Units
AAB_y	=	*Adjusted averaged baseline* for aboveground standing live and aboveground standing dead carbon stocks value in year *y*	tCO_2e/acre
HSR	=	"High Stocking Reference" for the Project Area. See guidance below for how the *HSR* is determined	tCO_2e/acre
CP	=	Common Practice (determined according to the guidance in Section 6.1.1)	tCO_2e/acre
PUB_0	=	Initial aboveground standing live and standing dead carbon stocks per acre within the Project Area (as determined in Section 6.1.2)	tCO_2e /acre
UAB_y	=	Value of the *unadjusted averaged baseline* for year *y,* as determined in Section 6.1.3.3, plus the aboveground standing dead carbon stocks for year *y*	tCO_2e/acre

Where the *unadjusted averaged baseline* for aboveground standing live and standing dead carbon stocks was determined using Equation 6.6, the *adjusted averaged baseline* (*AABy*) may be determined according to Equation 6.9.

Equation 6.9. Formula for Determining the *Adjusted Averaged Baseline* Where the *Unadjusted Averaged Baseline* was Approximated using Equation 6.6

For years $y <$ Y, $AAB_y = MAX(PUB_0, HSR) + y \times \frac{ES - PUB_0}{Y}$

For years $y \geq$ Y, $AAB_y = ES$

Where,			Units
AAB_y	=	*Adjusted averaged baseline* value for year *y*	tCO_2e/acre
Y	=	Time in years between the project start date and the year at which the highest legally required stocking level is reached. This is determined by modeling a forest growth and yield simulation that includes legal and financial constraints (in Section 6.1.2.2, above)	years
PUB_0	=	Initial aboveground standing live and dead carbon stocks per acre within the Project Area (as determined in Section 6.1.2)	tCO_2e/acre
HSR	=	"High Stocking Reference" for the Project Area. See guidance below for how the *HSR* is determined.	tCO_2e/acre
ES	=	Ending stocks = The highest legally required stocking level, as determined in Section 6.1.2.2	tCO_2e/acre

6.1.2.4.1 Determining the High Stocking Reference

The High Stocking Reference is defined as 80 percent of the highest value for aboveground standing live and standing dead carbon stocks per acre within the Project Area during the 10-year period preceding the project start date. To determine the High Stocking Reference, the Project Operator must document changes in the Project Area's aboveground standing live and standing dead carbon stocks over the 10 years prior to the initiation of the project, or for as long as the Project Operator has had control of the stocks, whichever is shorter. Figure 6.3. presents a graphical portrayal of a High Stocking Reference determination.

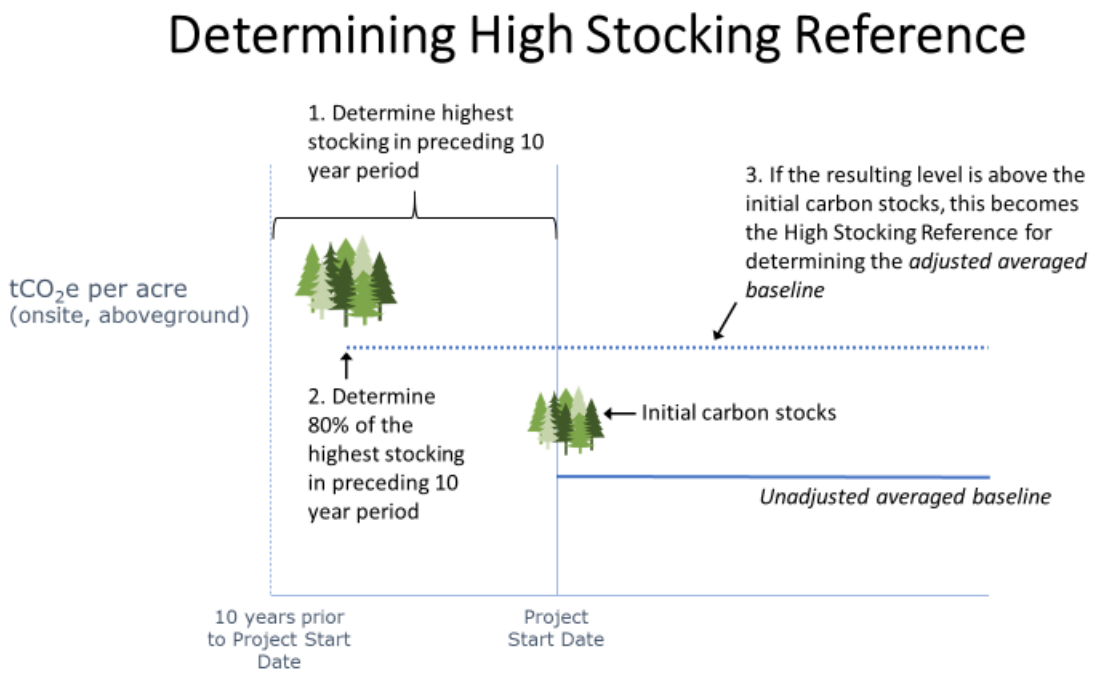


Figure 6.3. Determining a Project Area's High Stocking Reference

Note that it is possible for the High Stocking Reference to be higher than Common Practice, even where initial live and standing dead tree carbon stocks for the project are below Common Practice.

6.1.2.5 Proportionally Adjust Other Reported Carbon Stocks

The *adjusted averaged baseline* for other reported carbon stocks must be determined by adjusting carbon stock values to reflect the *adjusted averaged baseline* for aboveground standing live and standing dead carbon stocks. The guidance for adjusting the other reported carbon stocks is shown in Table 6.1.

Table 6.1. Guidance for Adjusting Other Carbon Pools

Carbon Pool	Relationship to Adjustments of Aboveground Live Carbon Stocks	Adjustment
Belowground Standing Live Carbon Stocks	Directly Proportional	$\boldsymbol{AAB_{bg,y} = \left(AAB_{ag,y}/UAB_{ag,y}\right) \times UAB_{bg,y}}$ *Where,* $AAB_{bg,y}$ = *Adjusted averaged baseline* for belowground standing live carbon stocks in year *y* $AAB_{ag,y}$ = *Adjusted averaged baseline* for aboveground standing live and standing dead carbon stocks in year *y* $UAB_{ag,y}$ = *Unadjusted averaged baseline* for aboveground standing live carbon stocks in year *y*,

Carbon Pool	Relationship to Adjustments of Aboveground Live Carbon Stocks	Adjustment
		plus the aboveground standing dead carbon stocks for year *y* $UAB_{bg,y}$ = *Unadjusted averaged baseline* for belowground standing live carbon stocks in year *y*
Aboveground and Belowground Standing Dead Carbon Stocks	N/A	No adjustment is conducted. Aboveground and belowground standing dead carbon stocks remain constant with inventories of aboveground and belowground standing dead carbon stocks at the project start date. Exceptions may be allowed as described previously. Standing dead carbon stocks are not adjusted based on changes to standing live carbon stocks, but must be used in the comparison to Common Practice.
Harvested Aboveground and Belowground Standing Live Carbon Stocks	Inversely Proportional	$\boldsymbol{AAB_{ht,y}} = \frac{\boldsymbol{UAB_{ht,y}}}{(\boldsymbol{AAB_{ag,y}}/\boldsymbol{UAB_{ag,y}})}$ *Where,* $AAB_{ht,y}$ = *Adjusted averaged baseline* for harvested aboveground and belowground standing live carbon stocks in year *y* $UAB_{ht,y}$ = *Unadjusted averaged baseline* for harvested aboveground and belowground standing live carbon stocks in year *y* $UAB_{ag,y}$ = *Unadjusted averaged baseline* for aboveground standing live carbon stocks in year *y*, plus the aboveground standing dead carbon stocks for year *y* $AAB_{ag,y}$ = *Adjusted averaged baseline* for aboveground standing live and standing dead carbon stocks in year *y*
Harvested Bole Portion of Aboveground and Belowground Standing Live Carbon Stocks	Inversely Proportional	$\boldsymbol{AAB_{htb,y}} = \frac{\boldsymbol{UAB_{htb,y}}}{(\boldsymbol{AAB_{ag,y}}/\boldsymbol{UAB_{ag,y}})}$ *Where,* $AAB_{htb,y}$ = *Adjusted average baseline* for the bole portion of harvested aboveground and belowground standing live carbon stocks in year *y* $UAB_{htb,y}$ = *Unadjusted averaged baseline* for the bole portion of harvested aboveground and belowground standing live carbon stocks in year *y* $UAB_{ag,y}$ = *Unadjusted averaged baseline* for aboveground standing live carbon stocks in year *y*, plus the aboveground standing dead carbon stocks for year *y* $AAB_{ag,y}$ = *Adjusted averaged baseline* for aboveground standing live and standing dead carbon stocks in year *y*

6.1.2.6 Combine All Adjusted Averaged Baseline Components

The *final baseline* is the sum of *adjusted averaged baselines* for all reported *onsite* carbon stocks and must include:

- Aboveground and belowground standing live carbon stocks
- Aboveground and belowground standing dead carbon stocks
- Harvested wood products

The *adjusted averaged baselines* for harvested standing live carbon stocks (aboveground and belowground) and the bole portion of harvested standing live carbon stocks must also be maintained separately from the carbon stocks listed above. The reporting of harvested carbon stocks is conducted separately from other reported carbon stocks.

6.1.3 Estimating Baseline Onsite Carbon Stocks – Public Lands

The baseline is developed for a public forest by determining carbon levels in the Project Area with the assumed condition that the entire forest is at a rotation age common for the forest community (by Assessment Area). The rotation ages are provided as default values and are found with the Assessment Area data. Where forest practice laws, or any other legal encumbrances, require specific management of forest stands at levels that exceed the age criteria mentioned above, the stands must be managed at sufficient stocking levels to ensure compliance with the legal constraints. Project credits are determined by calculating the project's carbon stocks and subtracting the baseline stocks from them.

6.1.3.1 Generate COLE Report

Using the Carbon Online Estimator (COLE),[25] select Forest Inventory and Analysis (FIA) plots using the "plots within this radius" tool. The circle developed must be centered within the Project Area. The radius of the sample area must be at least 100 kilometers. Following the guidance on the website, fetch the data within the circle. Next, filter the data using the 'Filter' tab on the website by selecting species in the 'Forest Type' menu bar that are found in the species list in the Assessment Area Data File for Assessment Area(s) the project is in. Click on the 'Reports' tab and submit the request to produce the 1605(b) report, which will be provided through a web interface. The report must be included as an appendix in the PDD.

Using Table 1 of the COLE 1605(b) report, the baseline for the project, barring any adjustments as part of the legal analysis (below), shall be determined by summing the live tree and dead tree values from the COLE 1605(b) report that correspond with the rotation length value found in Table 6.2. The 1605(b) values are given as metric tons of carbon per hectare and shall be converted into metric tons CO_2e per acre. The determination of rotation length is made using the Assessment Area Data File and identified for rotation length.

Table 6.2. Table Rotation Lengths

Rotation Length	Years
Short	30
Medium	40
Long	60
Extremely Long	70

[25] http://www.ncasi2.org/COLE/. After opening, zoom into project area on map and follow instructions to "get plots within this radius…". Once the data has been retrieved, the report can be obtained following the instructions on the site.

6.1.3.2 Adjust for Legal Constraints

The baseline must exceed all legal constraints. A determination must be made whether the legal constraints that affect forest management within the Project Area require further adjustments to the initial baseline developed above, using the following steps:

1. Identify legal constraints affecting the Project Area.
    a. Identify and describe the legal requirements affecting the Project Area.
    b. Spatially identify (map) the areas to which the legal requirements apply within the Project Area to determine the affected acres.
2. Determine forest structure needed to comply with the legal requirements.
    a. Describe the forest structure needed to ensure compliance with the legal requirements affecting each area.
    b. Explain and justify the forest conditions and associated age class that meets the forest conditions identified for meeting the minimum criteria of the legal requirement. In no case shall the age class be less than the age class associated with the rotation length from Table 6.2.
3. Adjust baseline values
    a. Use the live and dead tree values associated with the age class from the COLE 1605(b) report that is associated with the previous step. The 100-year values for live and dead trees in the COLE 1605(b) report shall be used in cases where determinations of forest structure are not easily justified.
    b. Develop a weighted average by multiplying the acres for each constraint class by the COLE 1605(b) values and dividing by the total acres to determine the adjusted baseline.

6.1.3.3 Estimate the Project's Baseline Harvest Volume

The estimate of baseline harvest volume shall be determined by multiplying the adjusted baseline (above) by 3%. The resulting volume shall be used in conjunction with the guidance in Appendix B to determine harvested wood products. The harvest volume shall remain constant for the project life.

6.1.3.4 Determining the Final Project Baseline

The final baseline is determined by adding the estimated harvested wood products to the adjusted baseline.

6.1.4 Determining Actual Onsite Carbon Stocks

Actual carbon stocks for Improved Forest Management Projects must be determined by updating the Project Area's forest carbon inventory. This is done by:

1. Incorporating any new forest inventory data obtained during the previous year into the inventory estimate. Any plots sampled during the previous year must be incorporated into the inventory estimate.
2. Using an approved model or a stand table projection to "grow" (project forward) prior-year data from existing forest inventory plots to the current reporting year. Guidance for projecting forest inventory data is identified in Appendix B.

3. Updating the forest inventory estimate for harvests and/or disturbances that have occurred during the previous year. To allow some flexibility in updating the forest inventory during onsite verification years, a project may defer updating a small percentage of plots until the following reporting period, as detailed in Appendix B. This will help streamline the sequential sampling process when recent disturbances have taken place.
4. Applying an appropriate confidence deduction for the inventory based on its statistical uncertainty, following the guidance in Appendix B.

6.1.5 Determining Actual Carbon in Harvested Wood Products

Perform the following steps to determine actual carbon in harvested wood products:

1. Determine the actual amount of carbon in standing live carbon stocks (prior to delivery to a mill) harvested in the current year (based on harvest volumes determined in Section 6.1.4).
2. Determine the amount of actual harvested carbon that will remain stored in wood products, averaged over 100 years, following the requirements in Appendix B.

6.1.6 Quantifying Secondary Effects

For Improved Forest Management Projects, significant Secondary Effects can occur if a project reduces harvesting in the Project Area, resulting in an increase in harvesting on other properties. Emission reductions due to substituting wood for materials with higher GHG footprints, such as concrete or steel, are not accounted for as an emission reduction in this protocol because the emission reductions are accounted for by the energy sector.

The risk that Secondary Effects may be occurring is calculated in this protocol. However, the magnitude of risk of Secondary Effects is dependent on how much harvesting occurs on the Project Area relative to the baseline scenario. This protocol considers the impacts of shifting harvest activities over the project life. As discussed above, since the baseline is a representative scenario of legally permissible and financially feasible growth and harvesting regimes in the absence of a project, baseline pools, including those used to quantify the risk of Secondary Effects, are averaged across the baseline period (i.e., 100 years). The risk of Secondary Effects for the project are thus considered in relation to such averaged baseline harvesting. Improved Forest Management Projects, where harvesting is anticipated to be an ongoing activity over the project life, are expected to increase harvest levels over time compared to baseline management due to improved stocking and growth levels and harvesting closer to an optimal age for forest productivity. However, this SSR must be reported annually due to the risk that Secondary Effects may be occurring in any given year.

Equation 6.10 must be used to estimate the Secondary Effects risk for Improved Forest Management Projects. Recognizing that Secondary Effects from projects may be influenced by long term harvesting trends, the evaluation in Equation 6.10 considers how actual cumulative harvest amounts vary from baseline cumulative harvest amounts since project inception.

When baseline cumulative harvested carbon exceeds actual cumulative harvested carbon - *but actual onsite harvested carbon exceeds the baseline amount in a given reporting period* - net GHG reductions are increased (Equation 6.10.B). This allows for prior deductions for Secondary Effects to be recouped, because the risk has been lowered. However, once actual cumulative harvest amounts exceed baseline cumulative harvest amounts, Secondary Effects risk is zero,

and will remain zero for as long as actual cumulative harvest amounts exceed baseline cumulative harvest amounts (Equation 6.10.A). Under no circumstances shall the net balance of Secondary Effects CRTs over the course of a project be positive. However, maintaining actual cumulative harvest above baseline cumulative harvest will allow a project to accrue any uncredited positive carryover that can counteract the amount of future Secondary Effects deductions that would be applied if baseline cumulative harvested carbon were to exceed actual harvested carbon again (Equation 6.10.C). Refer to Appendix B for an example of how Secondary Effects are evaluated over time, and how prior Secondary Effects may be recouped. The Reserve also provides a calculation workbook for quantifying Secondary Effects risk (in addition to the other calculations required by the protocol).

Values used for onsite carbon harvested in the project and baseline scenarios ($AC_{hv,n}$ and $BC_{hv,n}$) shall represent all harvested trees, not just merchantable species.

Equation 6.10. Secondary Effects Emissions

Equation 6.10.A:

$$\boldsymbol{If} \sum_{n=1}^{y} (\boldsymbol{AC_{hv,n}} - \boldsymbol{BC_{hv,n}}) \geq 0, and \sum_{n=1}^{y-1} \boldsymbol{SE_{as,n}} \geq 0,$$

$$then\ \boldsymbol{SE_{as,y}} = \boldsymbol{0}^{\dagger}$$

Equation 6.10.B:

$$\boldsymbol{If} \left(\sum_{n=1}^{y} (\boldsymbol{AC_{hv,n}} - \boldsymbol{BC_{hv,n}}) < 0\ and \sum_{n=1}^{y-1} \boldsymbol{SE_{as,n}} < 0 \right) or \left(\sum_{n=1}^{y} (\boldsymbol{AC_{hv,n}} - \boldsymbol{BC_{hv,n}}) \geq 0\ and \sum_{n=1}^{y-1} \boldsymbol{SE_{as,n}} < 0 \right),$$

$$then\ \boldsymbol{SE_{as,y}} = \boldsymbol{MIN} \left(\left(\boldsymbol{AC_{hv,y}} - \boldsymbol{BC_{hv,y}}\right) \times \boldsymbol{20\%}, \left| \sum_{n=1}^{y-1} \boldsymbol{SE_{as,n}} \right| \right)$$

Equation 6.10.C:

$$\boldsymbol{If} \sum_{n=1}^{y} (\boldsymbol{AC_{hv,n}} - \boldsymbol{BC_{hv,n}}) < 0, and \sum_{n=1}^{y-1} \boldsymbol{SE_{as,n}} \geq 0,$$

$$then\ \boldsymbol{SE_{as,y}} = \boldsymbol{MIN} \left(\sum_{n=1}^{y-1} \boldsymbol{SE_{as,n}} + \left(\left(\boldsymbol{AC_{hv,y}} - \boldsymbol{BC_{hv,y}}\right) \times \boldsymbol{20\%} \right), \boldsymbol{0} \right)^{\dagger}$$

Where,

			Units
$SE_{as,y}$	=	Estimated annual Secondary Effects in current reporting period *y* (used in Equation 6.1)	tCO_2e
$SE_{as,n}$	=	Estimated annual Secondary Effects in reporting period *n*	tCO_2e
$AC_{hv,n}$	=	Actual amount of onsite carbon harvested in reporting period *n* (prior to delivery to a mill)	tCO_2e
$BC_{hv,n}$	=	Estimated average baseline amount of onsite carbon harvested in reporting period *n* (prior to delivery to a mill), as determined above	tCO_2e
$AC_{hv,y}$	=	Actual amount of onsite carbon harvested in current reporting period *y* (prior to delivery to a mill)	tCO_2e

$BC_{hv,y}$	=	Estimated average baseline amount of onsite carbon harvested in current reporting period *y* (prior to delivery to a mill), as determined in Section 6.1.1.4, 6.1.2.5, or 6.1.3.3 as applicable	tCO_2e

† Secondary Effects are not awarded CRTs but may accrue as positive carryover. Annual accruals are calculated in the same way that Secondary Effects are calculated when baseline cumulative harvested carbon exceeds actual harvested carbon. Cumulative Secondary Effects as of the current reporting period are calculated by the following: $\sum_{n=1}^{y} \boldsymbol{SE_{as,n}} = \sum_{n=1}^{y-1} \boldsymbol{SE_{as,n}} + ((\boldsymbol{AC_{hv,y}} - \boldsymbol{BC_{hv,y}}) \times \mathbf{20}\%)$. Positive carryover reduces or negates future Secondary Effects deductions.

6.2 Avoided Conversion Projects

6.2.1 Estimating Baseline Onsite Carbon Stocks

The baseline for Avoided Conversion Projects is a projection of onsite forest carbon stock losses that would have occurred over time due to the conversion of the Project Area to a non-forest land use. Estimating the baseline for Avoided Conversion Projects involves two steps:

1. Characterizing and projecting a baseline
2. Adjusting the baseline based on conversion risk

Step 1 – Characterizing and Projecting the Baseline

Project Operators must characterize and project the baseline by:

1. Clearly specifying an alternative highest-value land use for the Project Area, as identified by an appraisal(s) (required by this protocol). The appraisal(s) must include accompanying documentation that demonstrates the type of anticipated land use conversion is legally permissible. Such documentation must fall into at least one of the following categories:
    a. Documentation indicating that the current land use policies, including zoning and general plan ordinances, and other local and state statutes and regulations, permit the anticipated type of conversion.
    b. Documentation indicating that the Project Operator has obtained all necessary approvals from the governing county to convert the Project Area to the proposed type of non-forest land use (including, for instance, certificates of compliance, subdivision approvals, timber conversion permits, other rezoning, major or minor use permits, etc.).
    c. Documentation indicating that similarly situated forestlands within the project's Assessment Area were recently able to obtain all necessary approvals from the governing county, state, or other governing agency to convert to a non-forest land use (including, for instance, certificates of compliance, subdivision approvals, timber conversion permits, other rezoning, major or minor use permits, etc.).
2. Estimating the rate of conversion and removal of onsite standing live and dead carbon stocks. The rate of conversion and removal of onsite standing live and dead carbon stocks must be estimated by either:
    a. Referencing planning documentation that has been approved and permitted by the appropriate planning department for the Project Area (e.g., construction

documents or plans) that specifies the timeframe of the conversion and intended removal of forest cover on the Project Area; or

b. In the absence of specific documentation, identifying a default annual conversion rate for carbon in standing live and dead carbon stocks from Table 6.3. The default value is subject to any legal constraints, which must be incorporated in modeling the project's baseline.

Table 6.3. Default Avoided Conversion Rates for Standing Live and Dead Carbon Stocks

Type of Conversion Identified in Appraisal	Total Conversion Impact	Annual Rate of Conversion
	This is the assumed total effect over time of the conversion activity on standing live and dead carbon stocks. (The total conversion impact is amortized over a 10-year period to determine the annual rate of conversion in the next column.)	This is the assumed annual rate of the conversion activity on standing live and dead carbon stocks. The percentages below are multiplied by the initial standing and dead carbon stocks for the project on an annual basis for the first 10 years of the project.
Residential	Estimate using the following formula: *TC*% = (min(1,(*P**3) / *PA*)) *Where,* *TC* = % total conversion (*TC* cannot exceed 100%) *PA* = the Project Area (acres) identified in the appraisal *P* = the number of unique parcels that would be formed on the Project Area as identified in the appraisal * Each parcel is assumed to deforest 3 acres of forest vegetation	Estimate using the following formula: *ARC* = *TC* / 10 *Where,* *ARC* = % annual rate of conversion *TC* = % total conversion
Mining and Agricultural Conversion, including Pasture or Crops	90%	9.0%
Golf Course	80%	8.0%
Commercial Buildings	95%	9.5%

A computer simulation, based on 2a or 2b above, must be conducted to project changes in onsite standing live and dead carbon stocks over 100 years. The computer simulation of the onsite standing live and dead carbon stocks must approximate the identified rate of conversion over time to estimate changes in standing live and dead carbon stocks, beginning with the Project Area's initial onsite standing live and dead carbon stocks. If the projected conversion rate does not result in a complete removal of onsite standing live and dead carbon stocks, the baseline projection must account for any residual forest carbon value as a steady condition for the balance of a 100-year projection.

3. Estimating the rate of soil carbon emissions (optional):
   Soil carbon emissions associated with conversion to agriculture (for all soil types) or residential and commercial (for histosols only) may be reported for the baseline. The amount of soil carbon and the rate of soil carbon emissions are dependent upon the soil type ("soil order") and the conversion activity. Emissions from soil carbon are estimated by applying the default emissions estimators from Table B.19 of Appendix B to the estimates of soil carbon in the Project Area. Appendix B provides an estimated

percentage emitted as the result of conversion and presents the rate of emissions associated with each soil order. A weighted estimate of emissions must be conducted where more than one soil order is found in the Project Area.

4. As with standing live and dead carbon, the baseline trend of soil carbon stocks must be graphed to display the soil carbon stocks on an annual basis.

The carbon stock trends for standing live carbon, standing dead carbon, and soil carbon are added together to determine a project baseline for the onsite carbon stocks. Figure 6.4. displays a simplified view of the the baseline trend of onsite carbon stocks, as well as the basis for project crediting over time.

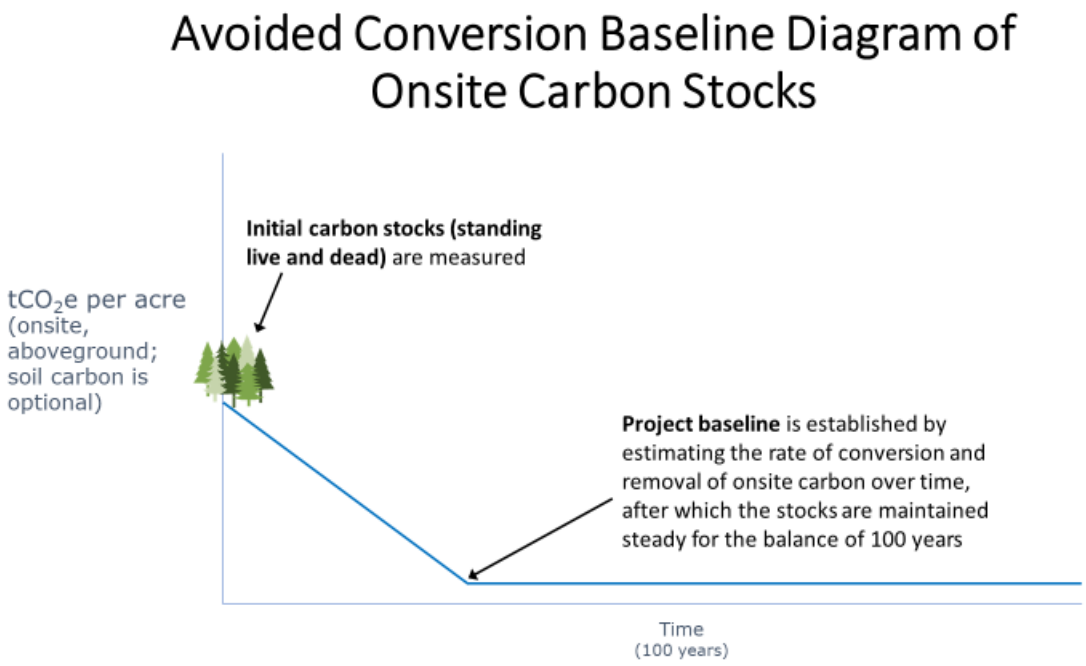


Figure 6.4. Example of an Avoided Conversion Project Baseline

Step 2 – Adjusting the Baseline Based on Conversion Risk

If the fair market value of the anticipated alternative land use for the Project Area (as determined by the required appraisal) is *not more than 80 percent greater* than the value of the current forested land use, then the baseline must be adjusted to reflect uncertainty about the risk of conversion. If the project utilizes multiple appraisals to cover the entire Project Area, the appraisals must all result in the same Conversion Risk Adjustment Factor to be considered for use in the same project.

Equation 6.11. Conversion Risk Adjustment Factor

If 0.4 < ((*VA* / *VP*) – 1) < 0.8, **then** *CRA* = [80% – ((*VA* / *VP*) – 1)] x 2.5
If ((*VA* / *VP*) – 1) ≥ 0.8, **then** *CRA* = 0%
If ((*VA* / *VP*) – 1) ≤ 0.4, **then** *CRA* = 100%

Where,

CRA	=	Conversion Risk Adjustment factor
VA	=	Appraised fair market value of the anticipated alternative land use for the Project Area
VP	=	Appraised fair market value of the current forested land use for the Project Area

The baseline is adjusted by applying the Conversion Risk Adjustment factor to the unadjusted baseline determined in Step 1, using Equation 6.12 below.

Equation 6.12. Adjusted Baseline Onsite Carbon Stocks

$$\boldsymbol{BC_{onsite,y} = BLU_y + \left(IS - BLU_y\right) \times CRA}$$

Where,

			Units
$BC_{onsite,\ y}$	=	Adjusted baseline onsite carbon stocks in year *y*, for each of the 100 years calculated in the project's baseline	tCO_2e
BLU_y	=	Unadjusted baseline onsite carbon stocks in year *y*, for each of the 100 years calculated in the project's baseline (determine in Step 1, above)	tCO_2e
IS	=	Initial onsite carbon stocks at the project start date	tCO_2e
CRA	=	Conversion Risk Adjustment factor, as described above	%

6.2.2 Estimating Baseline Carbon in Harvested Wood Products

Harvesting is assumed to occur in the baseline over time as the Project Area is converted to another land use. To estimate the baseline carbon transferred to long-term storage in harvested wood products each year:

1. Determine the amount of carbon in standing live carbon stocks (prior to delivery to a mill) that would have been harvested in each year, consistent with the rate of reduction in baseline standing live carbon stocks determined in Section 6.2.1. This projection is determined at the project outset, using the same biomass equations used to calculate biomass in live trees, and will not change over the course of the project.
2. On an annual basis, determine the amount of harvested carbon that would have remained stored in wood products, averaged over 100 years, following the requirements in Appendix B.

6.2.3 Determining Actual Onsite Carbon Stocks

Actual carbon stocks for Avoided Conversion Projects must be determined by updating the Project Area's forest carbon inventory. This is done by:

1. Incorporating any new forest inventory data obtained during the previous year into the inventory estimate. Any plots sampled during the previous year must be incorporated into the inventory estimate.
2. Using an approved model to "grow" (project forward) prior-year data from existing forest inventory plots to the current reporting year. Approved growth models are identified in

Appendix B. Guidance for projecting forest inventory plot data using models is also provided in Appendix B.

3. Updating the forest inventory estimate for harvests and/or disturbances that have occurred during the previous year. To allow some flexibility in updating the forest inventory, a project may defer updating a small percentage of plots until the following reporting period, as detailed in Appendix B.
4. Applying an appropriate confidence deduction for the inventory based on its statistical uncertainty, following the guidance in Appendix B.

6.2.4 Determining Actual Carbon in Harvested Wood Products

Perform the following steps to determine actual carbon in harvested wood products:

1. Determine the actual amount of carbon in standing live carbon stocks (prior to delivery to a mill) harvested in the current year (based on harvest volumes determined in Section 6.2.2).
2. Determine the amount of actual harvested carbon that will remain stored in wood products, averaged over 100 years, following the requirements in Appendix B.

6.2.5 Quantifying Secondary Effects

Significant Secondary Effects for Avoided Conversion Projects can arise if the type of land use conversion that would have happened on the Project Area is shifted to other forest land.

To quantify Secondary Effects risk for Avoided Conversion Projects, Project Operators must quantify Secondary Effect emissions risk using Equation 6.13. The value for Secondary Effect emissions will always be negative or zero.

Equation 6.13. Secondary Effects Emissions Risk

$$\boldsymbol{SE_{as,y} = (-1) \times 3.6\% \times (\Delta AC_{onsite} - \Delta BC_{onsite})}$$ **or 0, whichever is lower**

Where,			Units
$SE_{as,y}$	=	Secondary Effect GHG emissions that may result from activity shifting outside the project area, as a result of the project activity in year *y* (Equation 6.1)	tCO_2e
$\Delta\ AC_{onsite}$	=	Annual difference in actual onsite carbon as defined in Equation 6.1	tCO_2e
$\Delta\ BC_{onsite}$	=	Annual difference in baseline onsite carbon as defined in Equation 6.1	tCO_2e

7 Ensuring the Permanence of Credited GHG Reductions and Removals

The Reserve requires that credited GHG reductions and removals be effectively "permanent." For Forest Projects, this requirement is met by ensuring that the carbon associated with credited GHG reductions and removals remains stored for at least 100 years.

The Reserve ensures the permanence of GHG reductions and removals through three mechanisms:

1. The requirement for all Project Operators to monitor onsite carbon stocks, submit regular monitoring reports, and submit to regular third-party verification of those reports along with periodic verification site visits (as detailed in Sections 7 through 9 of this protocol) for the duration of the Project Life.
2. The requirement for all Project Operators to sign a Project Implementation Agreement with the Reserve, as described in Section 3.6, which obligates Project Operators to retire CRTs to compensate for reversals of GHG reductions and removals.
3. The maintenance of a Buffer Pool to provide insurance against reversals of GHG reductions and removals due to unavoidable causes (including natural disturbances such as fires, pest infestations, or disease outbreaks).

GHG reductions and removals can be "reversed" if the stored carbon associated with them is released (back) to the atmosphere. Many biological and non-biological agents, both natural and human-induced, can cause reversals. Some of these agents cannot completely be controlled (and are therefore "unavoidable"), such as natural agents like fire, insects, and wind. Other agents can be controlled, such as the human activities like land conversion and over-harvesting. Under this protocol, reversals due to controllable agents are considered "avoidable". As described in this section, Project Operators are required to identify and quantify the risk of reversals from different agents based on project-specific circumstances. The resulting risk rating determines the quantity of Climate Reserve Tonnes (CRTs) that the project must contribute to the Reserve Buffer Pool to insure against reversals.

7.1 Definition of a Reversal

Project owners must demonstrate, through annual reporting and periodic site visit verification, that stocks associated with credited GHG reductions and removals are maintained for a period of time considered to be permanent (i.e., 100 years). If the quantified GHG reductions and removals (i.e., QR_y in Equation 6.1) in a given year are negative, and CRTs were issued to the Forest Project in any previous year, the Reserve will consider this to be a reversal regardless of the cause of the decrease. Planned thinning or harvesting activities, for example, may cause a reversal if they result in a negative value for QR_y.

7.2 Insuring Against Reversals

The Reserve requires Project Operators to insure against reversals, based on a project-specific risk evaluation. Currently, insurance must take the form of contributing CRTs to the Buffer Pool administered by the Reserve. In the future, the Reserve anticipates that other insurance instruments may be available to insure against reversals.

7.2.1 About the Buffer Pool

The Buffer Pool is a holding account for Forest Project CRTs, which is administered by the Reserve. All Forest Projects must contribute a percentage of CRTs to the Buffer Pool any time they are issued CRTs for verified GHG reductions and removals. Each Forest Project's contribution is determined by a project-specific risk rating, as described in Section 7.2.2. If a Forest Project experiences an unavoidable reversal of GHG reductions and removals (as defined in Section 7.3), the Reserve will retire a number of CRTs from the Buffer Pool equal to the total amount of carbon that was reversed (measured in metric tons of CO_2-equivalent). The Buffer Pool therefore acts as a general insurance mechanism against unavoidable reversals for all Forest Projects registered with the Reserve.

7.2.2 Contributions to the Buffer Pool

Each time the Reserve issues CRTs for verified GHG reductions and removals achieved by a Forest Project, a certain percentage of those CRTs must be contributed to the Buffer Pool. The size of the contribution to the Buffer Pool will depend on the Forest Project's risk rating for reversals. For example, if a Forest Project is issued ten CRTs after annual verification, and the project's reversal risk rating is ten percent, then nine CRTs will be issued to the Project Operator's Reserve account and 1 CRT must be deposited in the Buffer Pool.

Project Operators must determine the reversal risk rating for a project by following the requirements and guidance in Appendix A. The risk rating must be determined prior to registration and recalculated in every year the project undergoes a verification site visit (see Section 9.3.2).

Project Operators who record a Qualified Conservation Easement or Qualified Deed Restriction in conjunction with implementing a Forest Project will receive a lower risk rating (see Appendix A).

Project Operators may be able to reduce the risk rating through actions that lower the risk profile of their project. If a Forest Project's risk rating declines, the Reserve may distribute previously withheld Buffer Pool CRTs to the Project Operator in proportion to the reduced risk. Similarly, however, the Reserve may require additional contributions to the Buffer Pool if the risk rating increases, to ensure that all CRTs (including those issued in prior years) are properly insured.

7.2.3 Other Insurance Options for Reversals

It is the Reserve's expectation that other options to insure against reversals will develop for projects in the future. These options may include direct insurance. Alternative insurance mechanisms could be used to directly reduce the required Buffer Pool contributions for a project. The Reserve must review and approve alternative insurance mechanisms before they may be used.

7.3 Compensating for Reversals

The Reserve requires that all reversals be compensated through the retirement of CRTs. If a reversal associated with a Forest Project was unavoidable (as defined below), then the Reserve will compensate for the reversal on the Project Operator's behalf by retiring CRTs from the Buffer Pool. If a reversal was avoidable (as defined below) then the Project Operator must compensate for the reversal by surrendering CRTs from its Reserve account.

7.3.1 Unavoidable Reversals

An Unavoidable Reversal is any reversal not due to the Project Operator's negligence, gross negligence or willful intent, including wildfires or disease that are not the result of the Project Operator's negligence, gross negligence or willful intent. Requirements for Unavoidable Reversals are as follows:

1. If the Project Operator determines there has been an Unavoidable Reversal, it must notify the Reserve in writing of the Unavoidable Reversal within six months of its occurrence.
2. The Project Operator must explain the nature of the Unavoidable Reversal and provide a verified estimate of onsite carbon stocks so that the reversal can be quantified (in units of CO_2-equivalent metric tons).
    a. Annual monitoring reports submitted for the project must provide observations of ongoing mortality. Based on such observations, an estimate of mortality related to the natural disturbance must be provided. Once mortality has stabilized to background levels, a full verified estimate of the onsite carbon stocks must be submitted to the Reserve, no later than 2 years following the occurrence. Exceptions to this timing may be made if the Reserve agrees that an extension is warranted, for example, if mortality has not stabilized. Observations submitted by the Project Operator are subject to oversight by the Reserve.

If the Reserve determines that there has been an Unavoidable Reversal, it will retire a quantity of CRTs from the Buffer Pool equal to the size of the reversal in CO_2-equivalent metric tons (i.e., QR_y, as specified in Equation 6.1).

7.3.2 Avoidable Reversals

An Avoidable Reversal is any reversal that is due to the Project Operator's negligence, gross negligence, or willful intent, including harvesting, development, and harm to the Project Area due to the Project Operator's negligence, gross-negligence, or willful intent. Avoidable Reversals may also be caused by planned harvest activities or overestimation of the project's growth and yield model.

Requirements for Avoidable Reversals are as follows:

1. If an Avoidable Reversal has been identified during annual monitoring, the Project Operator must give written notice to the Reserve within thirty days of identifying the reversal.
2. Alternatively, if the Reserve determines that an Avoidable Reversal has occurred, it shall deliver written notice to the Project Operator. Within thirty days of receiving the avoidable reversal notice from the Reserve, the Project Operator must provide a written description and explanation of the reversal to the Reserve.
3. Within a year of notifying the Reserve of an Avoidable Reversal or receiving the Avoidable Reversal notice, the Project Operator must provide the Reserve with a verified estimate of current onsite carbon stocks. The verified estimate may be a desk review verification, unless:
    a. a regularly scheduled site visit verification coincides with the year of the reversal, or

b. the loss represents 35% or more of the previous year's onsite carbon stocks or peak carbon stocks in all previous years of the carbon project.

4. Within four months of the Reserve's approval of the verified estimate of onsite carbon stocks, the Project Operator must surrender a quantity of CRTs from its Reserve account equal to the size of the reversal in CO_2-equivalent metric tons (i.e., QR_y, as specified in Equation 6.1). In addition:
    a. The surrendered CRTs must be those that were issued to the Forest Project, unless those CRTs were previously retired for other purposes. Otherwise, the surrendered CRTs must be from other Forest Projects (US or Mexico) registered with the Reserve.
    b. The surrendered CRTs will be cancelled by the Reserve and designated in the Reserve's software system as compensating for the Avoidable Reversal.

7.3.3 Computational Reversals

Computational Reversals include reversals that occur as a result of required protocol calculations. Confidence deductions and accounting for Secondary Effects may cause a computational reversal under certain circumstances. These types of reversals – which are not directly related to on-the-ground activities, but which nonetheless result in a situation in which the project has been overcredited – must be compensated for as described below.

Requirements for Computational Reversals are as follows:

1. If a Computational Reversal has been identified during annual monitoring, the Project Operator must give written notice to the Reserve within thirty days of identifying the reversal.
2. Alternatively, if the Reserve determines that a Computational Reversal has occurred, it shall deliver written notice to the Project Operator.
3. No additional verification requirements will be imposed for a Computational Reversal – the Project Operator may conduct verification at the next regularly scheduled verification period.
4. The Project Operator may true up the Computational Reversal during the next regularly scheduled verification period by deducting the reversed quantity from the to-be-issued CRTs. If growth has not compensated for the amount of the Computational Reversal, then existing CRTs will be cancelled as follows:
    a. The Reserve will cancel CRTs that were issued to the Forest Project, preferably from the relevant vintage, unless those CRTs were previously retired for other purposes or are no longer held by the Project Operator. Otherwise, CRTs must be purchased from other Forest Projects registered with the Reserve and provided for cancellation.
    b. The cancelled CRTs must be designated in the Reserve's software system as compensating for the Computational Reversal.

7.4 Disposition of Forest Projects after a Reversal

If a reversal lowers the Forest Project's actual standing live carbon stocks below its approved baseline standing live carbon stocks, the Forest Project will automatically be terminated, as the original approved baseline for the project would no longer be valid. If the Forest Project is automatically terminated due to an Unavoidable Reversal, another project may be initiated and

submitted to the Reserve for registration on the same Project Area. New projects may not be initiated on the same Project Area if the Forest Project is terminated due to an Avoidable Reversal.

If the Forest Project has experienced a reversal and its actual standing live carbon stocks are still above the approved baseline levels, it may continue without termination as long as the reversal has been compensated. The project must continue contributing to the Buffer Pool in future years based on its verified risk rating.

8 Project Monitoring

This section provides requirements and guidance on project monitoring, reporting rules and procedures.

8.1 Project Documentation

Project Operators must provide the following documentation to the Reserve in order to register a forest project.

- Project Submittal form
- KML file
- Project Design Document
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Verification Report
- Verification Statement
- Project Implementation Agreement
- Project Operator agreement (if Project Operator is not a Forest Owner)

Project Operators must provide the following documentation each time a Forest Project is verified in order for the Reserve to issue CRTs for quantified GHG reductions.

- Monitoring report
- Calculation worksheet
- Verification Report
- Verification Statement
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form (Improved Forest Management projects only)
- Project Implementation Agreement Amendment
- Conservation Easement (if one is employed)

Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

All reports that reference carbon stocks must be submitted with the oversight of a Professional Forester, for jurisdictions with a Professional Forester law or regulation, or a Certified Forester, managed by the Society of American Foresters (see www.certifiedforester.org) so that professional standards and project quality are maintained. Any Professional Forester or Certified Forester preparing a project in an unfamiliar jurisdiction must consult with a Professional Forester or Certified Forester practicing forestry in that jurisdiction to understand all laws and regulations that govern forest practice within the jurisdiction. The Reserve may evaluate and approve alternative certification credentials if requested, but only for jurisdictions where professional forester laws or regulations do not exist. This requirement does not preclude the project's use of technicians or other unlicensed/uncertified persons working under the supervision of the Professional Forester.

All projects shall submit a KML file depicting the Project Area that matches the maps submitted to depict the Project Area. The project's reported acres shall be calculated in accordance with the requirements in Section 4.1. The Reserve will create a file of all verified forest carbon projects on Google Maps for public dissemination.

8.1.1 Forest Project Design Document

The forest Project Design Document (PDD) is a required document for reporting information about a project. The document is submitted at the initial verification. A PDD template has been prepared by the Reserve and is available on the Reserve's website. The template is arranged to assist in ensuring that all requirements of the FPP are addressed. The template is required to be used by all projects. The template is designed to manage the varying requirements based on project type.

Each project must submit a PDD at the project's first verification. The Project Operator must include a general description of the methodology that will be incorporated by the Project Operator to update their inventory estimates on an annual basis per guidance in Appendix B for the reported carbon pools.

PDDs are intended to serve as the main project document that thoroughly describes how the project meets eligibility requirements, discusses the quantification methodologies utilized to generate project estimates, outlines how the project complies with terms for additionality and describes methods for updating inventory estimates and how permanence will be addressed, including how project reversal risks are calculated. All methodologies used by Project Operators and descriptions in the PDD must be clear in a way that facilitates review by verifiers, Reserve staff, and the public. PDDs must be of professional quality and free of incorrect citations, missing pages, incorrect project references, etc.

8.2 Monitoring Report

Monitoring is the process of regularly collecting and reporting data related to a project's performance. Annual monitoring of Forest Projects is required to ensure up-to-date estimates of project carbon stocks and provide assurance that GHG reductions or removals achieved by a project have not been reversed. Project Operators must conduct monitoring activities and submit monitoring reports according to the schedule and requirements presented in Section 8.3. Monitoring is required for a period of 100 years following the final issuance of CRTs to a project for quantified GHG reductions or removals.

For Forest Projects, monitoring activities consist primarily of updating a project's forest carbon inventory, entering the updated inventory into the Forest Project's Calculation Worksheet, and submitting it to the Reserve at frequencies defined in Section 8.3. CRTs are only issued in years that the project data are verified, as described in Section 9.

A monitoring report must be prepared for each Reporting Period. Monitoring reports must be provided to verification bodies whenever a Forest Project undergoes verification. In addition, monitoring reports must be provided to the Reserve upon the completion of any Reporting Period for which verification will be deferred (e.g., if the Project Operator foregoes a desk-review verification). All monitoring reports are due within 12 months of the end of the Reporting Period. Monitoring reports must include an update of the project's calculation worksheet. The project's calculation worksheet includes:

1. An updated estimate of the current year's carbon stocks in the reported carbon pools. Specific methods used to update the forest inventory must follow the inventory methodology approved at the time the project is registered. Modifications to inventory methodologies must be approved in advance by the Reserve. Any changes in inventory estimates associated with the use of the modified inventory methodology will need to be reconciled with previously verified project inventory estimates and baseline projections. The updated estimate of carbon stocks is determined by:
    a. Including any new forest inventory data obtained during the Reporting Period.
    b. *Applying growth estimates to existing inventory.
    c. Updating inventory estimates for harvest and/or disturbances that have occurred during the Reporting Period.
2. The appropriate confidence deduction for the forest carbon inventory, as determined at the last full site visit verification for the project (following Appendix B). The same confidence deduction must be used in interim years between verification site visits.
3. An estimate of current-year harvest volumes and associated carbon in harvested wood products.
4. Estimated mill efficiency, as determined following the guidance in Appendix B.
5. The baseline carbon stock estimates for all required and optional carbon pools for the current year, as determined following the requirements in Section 6 and approved at the time of the project's registration.
6. An estimate of Secondary Effects, following calculation steps and/or factors provided in Section 6 and approved at the time of the project's registration.
7. The uncertainty discount for Avoided Conversion Projects, as determined following the requirements of Section 6.2 and approved at project registration. (Once a project is registered with the Reserve, the uncertainty discount does not change.)
8. A calculation of total net GHG reductions and removals (or reversals) for the year, following the requirements in Section 6.
9. The project's reversal risk rating, as determined following the requirements in Section 7 and Appendix A. The risk rating is updated during each full site visit verification. Between verification site visits, the project's reversal risk rating does not change.
10. A calculation of the project's Buffer Pool contribution.

In addition to data reported using the project calculation worksheet, the following must be submitted to the Reserve as part of a monitoring report.

For each Reporting Period:

1. A description of how the project meets (or will meet) the definition of Natural Forest Management (refer to Section 3.9.2), including progress on criteria that have not been fully met in previous years.
2. An updated estimate of canopy cover across the Project Area. Estimates may be conducted using recent satellite images from within the last year.

Conditional reporting, as pertinent:

1. An explanation for any decrease over any ten-year consecutive period in the standing live carbon pool.
2. Any changes in the status of the Project Operator including, if applicable per Section 3.9.1, the acquisition of new forest landholdings.
3. If a reversal has occurred during the previous year, the report must provide a written description and explanation of the reversal, whether the Reserve classified the reversal as Avoidable or Unavoidable, and the status of compensation for the reversal.

8.3 Reporting and Verification Cycle

A Forest Project is considered automatically terminated (see Section 3.5) if the Project Operator chooses not to report data and undergo verification at required intervals.

8.3.1 Reporting Period Duration and Cycle

A Reporting Period is a discrete period of time for which a Project Operator quantifies and reports GHG reductions and removals, as well as required project data to the Reserve. The initial Reporting Period may cover any length of time, up to one year. Reporting Periods subsequent to the initial Reporting Period must cover 12 months of project activity.

Reporting Periods must be contiguous, i.e., there must be no gaps in reporting during the crediting period of a Forest Project once the project has begun receiving CRTs.

8.3.2 Verification Cycle

All Forest Projects must be initially verified within 30 months of being submitted to the Reserve. The initial verification of all project types must include the initial Reporting Period, confirm the project's eligibility, and confirm that the project's initial inventory and the baseline have been established in conformance with the FPP. Subsequent verification may include multiple Reporting Periods and is referred to as the "Verification Period." The end date of any Verification Period must correspond to the end date of a Reporting Period.

Verification is required at specific intervals to ensure that ongoing monitoring of forest carbon stocks, inventory confidence, and risk ratings are accurate and up to date. Optional verification is at the Project Operator's discretion and may be conducted between required verifications for crediting (non-aggregated projects), to adjust the project's confidence estimate and/or risk ratings, among other rationale, based on changed management circumstances. Submission of annual monitoring reports to the Reserve is required even if the Project Operator chooses to forego an optional verification. The schedule of required verification is dependent upon the project type and whether the project is aggregated or non-aggregated. Details of verification scheduling requirements are provided in Table 8.1.

Verification must be completed within 12 months of the end of the Reporting Period(s) being verified. For required verifications, failure to complete verification within the 12 month time period will result in account activities being suspended until the verification is complete. The project will terminate if the required verification is not completed within 36 months of the end of the Reporting Period(s) being verified. There is no consequence for failure to complete verification activities within 12 months for optional verifications.

8.3.2.1 Site Visit and Desk Review Verification Schedule

Refer to the table below for minimum required site visit schedules, optional desk reviews, and any exceptions to the minimum requirements by project type.

Table 8.1. Forest Project Verification Schedule

Aggregation	Project Type	Verification Type	Required Timing
All	All Forest Projects	Initial verification of the first Reporting Period (with or without site visit, as detailed below)	Must be completed within 30 months of being submitted to the Reserve
All	All Forest Projects	All verifications (full site visit verifications, and desk reviews)	Must be completed within 12 months of the end of the Reporting Period(s) being verified
All	All Forest Projects	Site Visit	Required any time the Project Operator would like to establish new confidence deductions and/or reversal risk ratings, except when confidence deduction changes as a result of a project joining an aggregate
			Required to be completed within one year of notifying the Reserve of an avoidable reversal, when the threshold in section 7.3.2 is met
			Required to be completed within 2 years of notifying the Reserve of an unavoidable reversal
		Desk Review	Required to be completed within one year of notifying the Reserve of an avoidable reversal, unless the threshold in section 7.3.2 is met
Non-aggregated	All Forest Projects	Site Visit	Required for initial verification
			Required for the verification following the end of every 6th Reporting Period thereafter, unless one of the exceptions below are applicable (for under 4,000 CRTs/year, or no CRTs in a given year)
		Desk Review	Optional, between required site visit years
	Any Forest Project receiving under 4,000 CRTs/year[26]	Site Visit	Required for the verification following the end of every 12th Reporting Period after a site visit verification has taken place, or once 48,000 CRTs have been accumulated across the unverified Reporting Periods.[27] If the Reserve has reason to believe that a project proponent has been reporting artificially low numbers to take advantage of this option, the Reserve will require the project to revert to the 6 year site visit cycle.[28]

[26] The 4,000 CRT/year threshold will be assessed as an average of the reported annual gross CRTs (including buffer pool credits) since the last site visit.

[27] When the 48,000 CRT threshold is met, a site visit will be required after the following reporting period. For example, if the threshold is met during reporting period 7, a site visit will be required following reporting period 8.

[28] "Artificially low numbers" will be assessed based on the verifier's review of quantitative materiality. If the project experiences an avoidable reversal, then it will not be eligible for the 12-year verification cycle and will revert to following the 6-year verification cycle until the completion of the next site visit.

Aggregation	Project Type	Verification Type	Required Timing
		Desk Review	Optional, between required site visit years
	Any Forest Project not seeking CRTs by the time a site visit is required	Desk Review	If a forest project opts not to receive additional CRTs during a normal site visit year and has not experienced a reversal, they must undergo a desk review of the monitoring reports submitted since the last verification. If canopy cover has declined on the project area by more than 5%, then the project must be evaluated for a potential reversal and a site visit may be required as described in Section 7.3.. Reporting periods evaluated as part of this type of desk review are considered to be part of the project crediting period, even though credits are not sought. This type of verification cannot be used in the last year of a project's crediting period.[29]
Aggregated	All Forest Projects	Site Visit	Refer to the Reserve's *Guidelines for Aggregating Forest Projects*
		Desk Review	Refer to the Reserve's *Guidelines for Aggregating Forest Projects*

8.3.3 Issuance and Vintage of CRTs

The Reserve will issue Climate Reserve Tonnes (CRTs) for quantified GHG reductions and removals that have been verified through either site visits, desk reviews, or in an aggregate through the aggregated method of site visits and desk reviews described above. A site visit verification may determine that earlier desk reviews overestimated onsite carbon stocks. A net downward adjustment to carbon stock estimates will be treated as a reversal (see Section 7.1). In this case, the Project Operator must retire CRTs in accordance with the requirements for compensating for a reversal (Section 7.3).

Vintages are assigned to CRTs based on the proportion of days in each calendar year within a reporting period.

8.4 Record Keeping

For purposes of independent verification and historical documentation, Project Operators are required to keep all documents and forms related to the project for a minimum of 100 years after the final issuance of CRTs from the Reserve. This information may be requested by the verification body or the Reserve at any time.

8.5 Transparency

The Reserve requires data transparency for all Forest Projects, including data that displays current carbon stocks, reversals, and verified GHG reductions and removals. For this reason, all non-confidential project data reported to the Reserve will be publicly available on the Reserve's website.

[29] This option is not possible in the project's final year because certain aspects of project quantification (like leakage) are assessed over the 100-year time frame of the project. A verification is required in the final year in order to true-up this quantification and ensure the project has not been over-credited.

9 Verification Guidance

This section provides guidance to Reserve-approved verification bodies for verifying GHG emission reductions associated with a planned set of activities to remove, reduce or prevent CO_2 emissions in the atmosphere by conserving and/or increasing forest carbon stocks.

This section supplements the Reserve's Verification Program Manual,[30] which provides verification bodies with the general requirements for a standardized approach for independent and rigorous verification of GHG emission reductions and removals. The Verification Program Manual outlines the verification process, requirements for conducting verification, conflict of interest and confidentiality provisions, core verification activities, content of the verification report, and dispute resolution processes. In addition, the Verification Program Manual explains the basic verification principles of ISO 14064-3:2006 which must be adhered to by the verification body.

Forest Project verification bodies must read and be familiar with the following International Organization for Standardization (ISO) and Reserve documents and reporting tools:

1. Forest Project Protocol (this document)
2. Reserve Program Manual
3. Reserve Verification Program Manual
4. Reserve software
5. ISO 14064-3:2006 Principles and Requirements for Verifying GHG Inventories and Projects

Only Reserve-approved Forest Project verification bodies are eligible to verify Forest Project reports. To become a recognized Forest Project verifier, verification bodies must become accredited under ISO 14065. Information on the accreditation process can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/how-to-become-a-verifier/.

The verification of reports that reference carbon stocks must be conducted with the oversight of a Professional Forester, for jurisdictions with a Professional Forester law or regulation, or a Certified Forester,[31] managed by the Society of American Foresters, so that professional standards and project quality are maintained. Any Professional Forester or Certified Forester verifying a project in an unfamiliar jurisdiction must consult with a Professional Forester or Certified Forester practicing forestry in that jurisdiction to understand all laws and regulations that govern forest practice within the jurisdiction. The Reserve may evaluate and approve alternative certification credentials if requested, but only for jurisdictions where professional forester laws or regulations do not exist.

9.1 Standard of Verification

The Reserve's standard of verification for Forest Projects is the Forest Project Protocol (FPP), the Reserve Program Manual, and the Reserve Verification Program Manual. To verify a land owner's initial Forest Project Design Document and annual monitoring reports, verification

[30] Found on the Reserve website at http://www.climateactionreserve.org/how/program/program-manual/.
[31] See www.certifiedforester.org.

bodies apply the verification guidance in the Reserve's Verification Program Manual and this section of the FPP to the requirements and guidance described in Sections 2 through 8 of the FPP.

This section of the protocol provides requirements and guidance for the verification of projects associated with the two Forest Project types defined in Section 2. Both project types involve planned activities that result in conserving and/or increasing forest carbon stocks. This section describes the core verification activities and criteria for both Forest Project types that are necessary for a verification body to provide a reasonable level of assurance that the GHG removals or reductions quantified and reported by Project Operators are materially correct.

Verification bodies will use the criteria in this section to determine if there exists reasonable assurance that the data submitted on behalf of the Project Operator to the Reserve addresses each requirement in the FPP, Sections 2 through 8. Project reporting is deemed accurate and correct if the Project Operator is in compliance with the Section 2 through 8.

Further information about the Reserve's principles of verification, levels of assurance, and materiality thresholds can be found in the Reserve's Verification Program Manual at http://www.climateactionreserve.org/how/program/program-manual/.

9.2 Emission Sources, Sinks, and Reservoirs

For all verification activities, verification bodies review a project's reported sources, sinks, and reservoirs to ensure that all are identified properly and to confirm their completeness. Table 5.1 and Table 5.2 in Section 5 provide comprehensive lists of all GHG sources, sinks, and reservoirs that must be included in the quantification and reporting of GHG reductions and removals for the two Forest Project types.

It is the Project Operator's responsibility to ensure that verifications are conducted according to the minimum required schedule specified in Section 8.3.2. A Verification Report, List of Findings, and Verification Statement must be submitted within twelve months of the end of any verification period. Site visit verification requirements are described in Section 9.3.2. Desk review verification requirements are described in Section 9.3.3.

9.3 Project Verification Activities

Required verification activities for Forest Projects will depend on whether the verification body is conducting an initial verification for registration on the Reserve, a minimum required verification involving a site visit, or an optional annual verification involving a desk review. Both the initial verification and ongoing verifications must include review of the criteria for Natural Forest Management, inventory of onsite carbon stocks, assessment of carbon in harvested wood products, and review of reversal risk ratings. The following sections contain guidance for all of these verification activities.

9.3.1 Initial Verification

Initial verification includes verification that the Forest Project has met the FPP criteria and requirements for eligibility, Project Area definition, modeling baseline onsite carbon stocks, and calculating baseline carbon in harvested wood products. The initial verification must include a site visit. The verification body must assess and ensure the completeness and accuracy of all required reporting elements for the Forest Project Design Document (Section 8.1.1). Initial verification items are presented in Table 9.1A through 9.1H.

At a Forest Project's initial verification, these items must be verified in addition to all the items required for a standard site visit verification, as detailed in Section 9.3.2.

9.3.1.1 Initial Eligibility

Verification bodies are required to affirm the project's eligibility according to the rules in this protocol. Tables 9.1A and 9.1B provide the initial verification items concerning eligibility for the different Forest Project types and include references to sections of this protocol where requirements are further specified.

Table 9.1A. Initial Eligibility Verification Items – Improved Forest Management Projects

Verification Items		Section of FPP	Apply Professional Judgment?
1. Project Definition	a. Evidence is provided indicating the canopy cover exceeds 10%. b. No evidence exists for use of broadcast fertilization.	2.1.1	Yes (for 1.b)
2. Legal Requirement Test	Proof that a signed Attestation of Voluntary Implementation form is on file with the Reserve.	3.3.1.1	No
3. Start Date	Identification of a discrete, verifiable action that delineates a change in practice relative to the project's baseline.	3.2	No
4. Project Implementation Agreement	Proof that a Project Implementation Agreement (PIA) between the Project Operator and the Reserve has been signed and recorded in the county of interest.	3.6	No
5. Project Location	a. Project is located in the United States of America. b. Project is on private land, or c. If non-federal public lands, provide documentation showing approval by the government agency or agencies responsible, or d. If tribal land, provide documentation that demonstrates that the land within the Project Area is owned by a tribe or private entities.	3.1	No

Table 9.1B. Initial Eligibility Verification Items – Avoided Conversion Projects

Verification Items		Section of FPP	Apply Professional Judgment?
1. Project Definition	a. Proof that the project is/was on private land prior to project initiation. b. Proof that a conservation easement was recorded, or the land was transferred to public ownership. c. Demonstration that conversion out of forest is a significant risk (following the requirements of Section 6.2.1 – see also Table 9.1H). d. No evidence exists for use of broadcast fertilization.	2.1.2, 6.2.1	Yes (for 1.c and 1.d)
2. Legal Requirement Test	a. Proof that a signed Attestation of Voluntary Implementation form is on file with the Reserve. b. Documentation has been provided that demonstrates that the type of land use conversion anticipated by the project is legally permissible; documentation must fall into at least one of the three categories specified in Section 3.3.1.2.	3.3.1.2	No
3. Performance Test	Copy of real estate appraisal(s) for the Project Area indicating conformance to criteria in Section 3.3.2.2.	3.3.2.2	No
4. Start Date	Identification of date on which a conservation easement that dedicates the Project Area to continuous forest cover was recorded or the Project Area was transferred to public ownership.	3.2, 3.7	No
5. Project Implementation Agreement	Proof that a Project Implementation Agreement (PIA) between the Project Operator and the Reserve has been signed and recorded in the county of interest.	3.6	No
6. Project Location	a. Project is located in the United States of America. b. Project is on private land, or c. If non-federal public lands, provide documentation showing approval by the government agency or agencies responsible, or d. If tribal land, provide documentation that demonstrates that the land within the Project Area is owned by a tribe or private entities.	3.1	No

9.3.1.2 Project Area Definition

Verification bodies are required to review the geographic boundaries defining the Project Area and their compliance with the requirements outlined in Section 4 of this protocol. These items are verified only at the project's initiation.

Table 9.1C. Project Area Definition Verification Items

Project Type	Verification Items	Section of FPP	Apply Professional Judgment?
1. All	Proof that a description, shapefile, and maps of the geographic boundaries defining the Project Area are on file at the Reserve.	4, 8.1	No
2. Avoided Conversion	Project Area has been defined following the guidance in Section 4, Table 4.1 for the appropriate conversion type.	4	No

9.3.1.3 Baseline Onsite Carbon Stocks

Verification bodies are required to confirm that the Project Operator has developed a baseline characterization for onsite carbon stocks according to the requirements in this protocol. These items are verified only at the project's initiation.

Table 9.1D. Baseline Estimation Verification Items – Improved Forest Management Projects – Private Lands

Verification Items		Section of FPP	Apply Professional Judgment?
1. Inventory of Onsite Carbon Stocks	An inventory of the Project Area's carbon stocks in required and optional pools has been conducted in accordance with the requirements of the FPP (see Section 9.3.5 for further verification guidance).	6.1.2, Appendix B	Yes
2. Compare Initial Aboveground Standing Live Carbon Stocks with Common Practice	a. Initial aboveground standing live and standing dead carbon stocks have been estimated correctly following the requirements of the FPP. b. The baseline analysis utilizes the correct value for Common Practice c. The project has undertaken the correct baseline analysis, according to whether initial carbon stocks are above or below Common Practice.	6.1.1, 6.1.2, Appendix B	No
3. Estimating Baseline Carbon Stocks	a. The project is qualified to use the conservative default approach, and has correctly implemented the baseline in accordance with the guidance in Section 6.1.1. b. Where using the modeled approach, a 100-year forest management simulation of standing live and dead carbon stocks has been conducted in accordance with the requirements and guidance in Section 6.1.2 and Appendix B (see Section 9.3.6 for further verification guidance).	6.1.1, 6.1.2, Appendix B	Yes
4. Description of Forest Project Activities	A description has been provided of the management activities that will lead to increased carbon stocks in the Project Area compared to the baseline.	2	No

Table 9.1E. Baseline Estimation Verification Items – Improved Forest Management Projects – Public Lands

Verification Items		Section of FPP	Apply Professional Judgment?
1. Initial Forest Carbon Stock Inventory	An inventory of the Project Area's carbon stocks in required and optional pools has been conducted in accordance with the requirements of the FPP (see Section 9.3.5 for further verification guidance).	6.1.3, Appendix B	Yes
2. Estimating Baseline Carbon Stocks	A COLE report and analysis has been conducted per the requirements in Section 6.1.3 and the Appendix B.	6.1.3, Appendix B	Yes
3. Description of Forest Project Activities	A description has been provided of the management activities that will lead to increased carbon stocks in the Project Area compared to the baseline.	2	No

Table 9.1F. Baseline Modeling Verification Items – Avoided Conversion Projects

Verification Items		Section of FPP	Apply Professional Judgment?
1. Initial Forest Carbon Stock Inventory	An inventory of the Project Area's carbon stocks in required and optional pools has been conducted in accordance with the requirements of the FPP (see Section 9.3.5 for further verification guidance).	6.2.1, Appendix B	Yes
2. Baseline Carbon Stock Modeling	a. An alternative highest-value land use for the Project Area has been clearly identified by the required appraisal(s). b. The rate of conversion and removal of onsite forest carbon stocks has been appropriately estimated in accordance with the requirements of Section 6.2.1. c. A 100-year forest management simulation of standing live carbon stocks has been conducted per the requirements in Section 6.2.1, and Appendix B (see Section 9.3.6 for further verification guidance).	3.3.2.2, 6.2.1	Yes
3. Discount for the Uncertainty of Conversion Probability	The Avoided Conversion Discount factor has been correctly calculated per Equation 6.6 in Section 6.2.1.	3.3.2.2, 6.2.1	No
4. Description of Forest Project Activities	A description has been provided of the management activities that will lead to increased carbon stocks in the Project Area compared to the baseline.	2	No

9.3.1.4 Calculating Baseline Carbon in Harvested Wood Products

Verification bodies are required to confirm that the Project Operator has developed a baseline characterization for carbon in harvested wood products according to the requirements of this protocol and requirements and guidance in Section 6.1.1, Section 6.1.2, Section 6.1.3, or Section 6.2.2, and Appendix B.

Table 9.1G. Baseline Carbon in Wood Products Verification Items – Improved Forest Management Projects

Verification Items		Section of FPP	Apply Professional Judgment?
1. Baseline Harvest Volume	The average volume of harvesting in the baseline has been derived from the growth and harvesting regime used to develop the baseline for onsite carbon stocks, following the requirements and guidance in Section 6.1.2, or through the appropriate default approach in Section 6.1.1 or Section 6.1.3, and Appendix B (see Section 9.3.7 for further verification guidance).	6.1.1, 6.1.2, 6.1.3, Appendix B	No
2. Long-Term Storage in Wood Products	The average amount of carbon expected to be transferred to wood products each year and stored over the long-term (100 years) has been calculated following the requirements and guidance in Appendix B (see Section 9.3.7 for further verification guidance).	Appendix B	No

Table 9.1H. Baseline Carbon in Wood Products Verification Items – Avoided Conversion Projects

Verification Items		Section of FPP	Apply Professional Judgment?
1. Baseline Harvest Volume	The volume of harvesting in each year of the baseline over 100 years has been derived from the harvesting regime assumed for the baseline for onsite carbon stocks, following the requirements and guidance in Section 6.2.2, and Appendix B (see Section 9.3.7 for further verification guidance).	6.2.2, Appendix B	No
2. Long-Term Storage in Wood Products	The amount of harvested wood that would be delivered to mills in each year has been determined, and the amount of carbon expected to be transferred to wood products each year and stored over the long-term (100 years) has been calculated following the requirements and guidance of Section 6.2.2 and Appendix B (see Section 9.3.7 for further verification guidance).	6.2.2, Appendix B	No

9.3.2 Site Visit Verification

Site visit verification involves review of the Forest Project's carbon stock inventory estimates, relevant attestations, soil carbon emissions associated with management activities, risk of reversal ratings, and compliance with Natural Forest Management criteria. After a Forest Project's initial verification, subsequent site visits must assess and ensure accuracy in measurement and monitoring techniques and onsite record keeping practices.

Table 9.2. Site Visit Verification Items

Verification Items		Section of FPP	Apply Professional Judgment?
1. Attestation of Title	Proof that a signed Attestation of Title is on file at the Reserve for the dates of the verification period. In addition to reviewing this form, the verification body must conduct a review to confirm ownership and claims to GHG reductions/removals that have occurred over the verification period.	3.7	Yes
2. Attestation of Regulatory Compliance	Proof that a signed Attestation of Regulatory Compliance form is on file with the Reserve for the reporting period. In addition to reviewing this form, the verification body must perform a risk-based assessment to confirm the statements made by the Project Operator in the Attestation of Regulatory Compliance form.	3.8	Yes
3. Attestation of Voluntary Implementation	Proof that a signed Attestation of Voluntary Implementation form is on file with the Reserve for the reporting period. Required for every reporting period for Improved Forest Management projects, and for initial reporting periods only for Avoided Conversion projects.	3.3	No
4. Sustainable Harvesting Practices	a. Commercial Rotational Harvesting has not commenced within the Project Area, or b. At the time Commercial Rotational Harvesting is initiated within the Project Area, the Project Operator meets sustainable harvest practices on all of its landholdings, as described in Section 3.9.1.	3.9.1	No
5. Change in Project Operator Landholdings	If the Project Operator has acquired additional forestlands outside of the Project Area, the Project Operator must incorporate the newly acquired land in their demonstration of sustainable long-term harvesting practices within 5 years of the acquisition.	3.9.1	No
6. Maintenance of Standing Live Carbon Pool	No decrease has occurred in the Project Area's standing live carbon stocks over any ten-year consecutive period not accounted for by allowable exceptions.	3.9.3	No
7. Natural Forest Management	Natural Forest Management eligibility criteria in Section 3.9.2 have been and continue to be met (see Section 9.3.4 for further verification guidance).	3.9.2	Yes
8. Estimates of Actual Onsite Carbon Stocks	An inventory of the Project Area's carbon stocks in required and optional pools has been conducted in accordance with the requirements in Section 6 and the requirements and guidance in Appendix B (see Section 9.3.5 for further verification guidance)	6, Appendix B	Yes
9. Estimates of Actual Carbon	The amount of harvested wood that has been delivered to mills over the reporting period has been determined correctly, and the amount of	6, Appendix B	No

Verification Items		Section of FPP	Apply Professional Judgment?
in Harvested Wood Products	carbon expected to be transferred to wood products and stored over the long-term (100 years) has been calculated correctly, per the requirements in Section 6 and Appendix B (see Section 9.3.7 for further verification guidance).		
10. Quantification of Primary Effect	Calculations for the Primary Effect are complete and accurate for both onsite carbon stocks and harvested wood products.	6	No
11. Quantification of Secondary Effects	Calculations for quantifying Secondary Effects are complete and accurate.	6.1.6, 6.2.5	No
12. Reversal Determination	If a reversal has occurred, the type of reversal (avoidable or unavoidable) has been properly identified.	7.3	Yes
13. Reversal Risk Rating	Project's risk rating has been calculated following the requirements of Appendix A	Appendix A	No

9.3.3 Desk Review Verification

For reporting periods in between required site visits, project verification activities may consist of a desk review. During a desk review, the verification body will review the data in annual monitoring reports to check calculations and information for reasonability, accuracy, and completeness.

Table 9.3. Desk Review Verification Items

Verification Items		Section of FPP	Apply Professional Judgment?
1. Attestation of Title	Proof that a signed Attestation of Title is on file at the Reserve for the dates of the verification period. In addition to reviewing this form, the verification body must conduct a review to confirm ownership and claims to GHG reductions/removals that have occurred over the verification period.	3.7	Yes
2. Attestation of Regulatory Compliance	Proof that a signed Attestation of Regulatory Compliance form is on file with the Reserve for the reporting period. In addition to reviewing this form, the verification body must perform a risk-based assessment to confirm the statements made by the Project Operator in the Attestation of Regulatory Compliance form.	3.8	Yes

Verification Items		Section of FPP	Apply Professional Judgment?
3. Attestation of Voluntary Implementation	Proof that a signed Attestation of Voluntary Implementation form is on file with the Reserve for the reporting period. Required for every reporting period for Improved Forest Management projects, and for initial reporting periods only for Avoided Conversion projects.	3.3	No
4. Maintenance of Standing Live Carbon Pool	No decrease has occurred in the Project Area's standing live carbon stocks over any ten-year consecutive period not accounted for by allowable exceptions.	3.9.3	No
5. Estimates of Actual Onsite Carbon Stocks	Reported onsite carbon stocks are within expected bounds given reported harvest, growth, and disturbance effects since the prior reporting period.	6, Appendix B	Yes
6. Estimates of Actual Carbon in Harvested Wood Products	The reported amount of wood that has been delivered to mills over the reporting period is consistent with reported harvest levels, and the amount of carbon expected to be transferred to wood products and stored over the long-term (100 years) has been calculated correctly, per the requirements in Section 6 and Appendix B (see Section 9.3.7 for further verification guidance).	6, Appendix B	Yes
7. Quantification of Primary Effect	Calculations for the Primary Effect are complete and accurate for both onsite carbon stocks and harvested wood products.	6	No
8. Quantification of Secondary Effects	Calculations for quantifying Secondary Effects are complete and accurate.	6.1.6, 6.2.5	No
9. Reversal Determination	If a reversal has occurred, the type of reversal (avoidable or unavoidable) has been properly identified.	7.3	Yes
10. Reversal Risk Rating	Reversal risk rating is the same used since the previous site visit verification.	Appendix A	No

9.3.4 Natural Forest Management

All Forest Projects must promote and maintain a diversity of native species and utilize management practices that promote and maintain native forests comprised of multiple ages and mixed native species at multiple landscape scales (Natural Forest Management). At a Forest Project's first site visit verification and at all subsequent site visit verifications, the verification body must evaluate the project against the Natural Forest Management criteria described in Section 3.9.2, referencing the most current Assessment Area Data File available on the Forest Project Protocol webpage. Forest project carbon stock inventories (requirements for which are contained in Appendix B) should be used as the basis of these assessments where applicable. Forest projects that do not initially meet Natural Forest Management criteria but can

demonstrate progress towards meeting these criteria within the required timelines are eligible to register and maintain that registration with the Reserve.

Table 9.4. Natural Forest Management Verification Items

Verification Items		Apply Professional Judgment?
1. Native Species	Completed inventory demonstrates that project consists of at least 95% native species. Must demonstrate continuous progress toward goal and criterion must be met within 50 years.	No
2. Composition of Native Species	Completed inventory demonstrates distribution of average basal area of standing live tree species meets composition of native species goal. Project is not eligible unless it is demonstrated that management activities will enable this goal to be achieved over the project life or an exception has been made through a letter from the State Forester as described in Section 3.9.	No
3. Sustainable Harvesting Practices	a. Documentation showing that the forest, including entity lands outside Project Area, is currently under one of the following: i. Third party certification under the Forest Stewardship Council or Sustainable Forestry Initiative/ Tree Farm System, or ii. A renewable long-term management plan sanctioned and monitored by a state or federal agency within a Reserve-approved Assessment Areas, or iii. Silvicultural practices that maintain canopy retention averaging at least 40% across the entire forestland owned by the Project Operator in the same Assessment Areas covered by the Project Area, as measured on any 20 acres within the Project Operator's landholdings found in any of these Assessment Areas, including land within and outside of the Project Area (areas impacted by Significant Disturbance may be excluded from this test), or iv. Possessing a deeded conservation easement(s) that contain terms that ensure growth equals or exceeds harvest over time. Verifiers should make a reasonable attempt to contact the steward of the conservation easement to confirm compliance.	No
4. Forest Structure	a. If the project employs even-aged management, ensure the retention guidelines have been followed. b. Completed inventory demonstrates the project maintains, or makes progress toward maintaining, no more than 40% of forested acres in ages less than 20 years (on a watershed scale up to 10,000 acres, or the Project Area, whichever is smaller). Project must show continuous progress and this criterion must be met within 25 years.	No
5. Structural Elements (Lying and Standing Dead Wood)	Completed inventory work demonstrates that lying and standing dead wood is retained in sufficient quantities and for sufficient duration depending on whether portions of the Project Area have undergone salvage harvesting.	Yes

9.3.5 Verifying Carbon Inventories

Verification bodies are required to verify carbon stock inventory estimates of all sampled carbon pools within the Project Area. Inventories of carbon stocks are used to determine the project baseline and to quantify GHG reductions and removals against the project baseline over time.

Verification of carbon inventories consists of ensuring the Project Operator's sampling methodology conforms to requirements listed in the protocol and that the project's inventory sample plots are within specified tolerances when compared to the verifier's sample plots. Verification is effectively an audit to infer that the inventory estimate is sound. Verification of the project's onsite stocks must occur at each site verification and focus on ensuring that the project's inventory methodology is technically sound and that the methodology has been correctly implemented.

The project must meet the inventory standards in Table 9.5 prior to the verification body initiating field sampling activities. The verifier will re-measure existing monumented sample plots or install sample plots, consistent with the objectives of a random, risk-based, and efficient approach. In doing so, the verifier may weigh the probability of selecting strata and plots based on various criteria – including carbon stocking, access difficulty, and vegetation heterogeneity. Verifiers may choose to sample project plots within a given stratum with a cluster design. The selection of a stratum may use probability proportional to carbon stocks or probability proportional to the risk of errors (as hypothesized by the verifier).

9.3.5.1 Sequential Sampling for Verification

As a policy to ensure a trend of agreement with sampled data is sustained between the verifier and Project Operator, this protocol requires a sequential sampling method for verification of project estimates. Sequential sampling is intended to provide an efficient sampling method for verifiers to determine if randomly selected project measurements are within specified tolerance bounds established by the protocol.

Verification using the sequential sampling methodology requires the verification body to sequentially sample successive plots. Sequential approaches have stopping rules rather than fixed sample sizes. Verification is successful after a minimum number of successive plots in a sequence indicate agreement. Where the stopping rules indicate the potential presence of a bias, additional verification plots may be collected after that time if it is felt that random chance may have caused the test to fail and a convergence towards agreement is expected with additional verification samples. The results of any additional verification plot may also be inconclusive and require additional verification plots for a determination to be made. For effective application of the sequential statistics in the field, the determination of when the stopping rule is met is made as soon as is convenient for the verification team and will include the full set of plots measured in that timeframe.

Worksheets are available on the Reserve's website for use by verifiers to assist in verifying sampled data. The verifier will review the descriptive statistics of the carbon stocks independently for each pool or combination of pools that is being reported for crediting (applicable pool) as shown below:

- Standing live and dead trees
- Soil

To increase efficiency in the verification process, three nested levels of sequential sampling are processed in the sequential sampling worksheets, based on a single sampling exercise performed by the verifier. All tests are performed with the same randomly selected plots and can only be completed by analysis of the plots in the sequential order they were randomly selected. However, inventory data is only considered successfully verified when the stopping rules for the CO_2e/acre test have been met. Passing the diameter and height tests only improves the overall

efficiency of the verification effort. The data identified below used for each test are input into the appropriate sequential sampling tool.

- CO_2e/acre: The testing of inventory data can only be satisfied when the CO_2e/acre comparison between the verifier and Forest Owner is completed. This test is conducted on a plot by plot basis using estimates of CO_2e/acre. The verifier's estimates of CO_2e/acre are derived by measurements of diameter and height (measured by verifier or using Forest Owner's data, as described below), species determinations, defect and decay determinations, and a determination of the appropriate trees to be included in the sample ("in" or "out" trees).
- Diameter Test (paired sequential sampling only): A comparison of diameter data between the verifier and the Forest Owner is conducted on a tree by tree basis until sequential sampling stopping rules have been achieved, indicating that the verifier and Forest Owner measurements of diameter are aligned within acceptable tolerance levels. If the stopping rule for diameter is met before the sequential sampling exercise has ended for CO_2e/acre, verifiers may stop taking their own diameter measurements and may instead use the diameter data provided for each tree from the Forest Owner's database for any additional data inputs needed for the CO_2e/acre comparison. If this happens, the focus of the sampling exercise from that point on will be measuring height (if applicable, see below), making species determinations, defect and decay determinations, and "in" or "out" tree assessments.
- Height Test (paired sequential sampling only): Like the diameter test, a comparison of height data is performed between the verifier and the Forest Owner until sequential sampling stopping rules have been achieved, indicating that the verifier and Forest Owner measurements of height are aligned within acceptable tolerance levels. If the stopping rule for height is met before the sequential sampling exercise has ended for CO_2e/acre, verifiers may stop taking their own height measurements and may instead use the height data provided for each tree from the Forest Owner's database for any additional data inputs needed for the CO_2e/acre comparison. If this happens, the focus of the sampling exercise from that point on will be measuring diameter (if applicable, see above), making species determinations, defect and decay determinations, and "in" or "out" tree assessments.

Separate worksheets have been developed to assess both monumented (paired) and non-monumented (unpaired) plots as well as for DBH, height, and CO_2e/acre. Worksheets are found on the Forest Project Protocol webpage.

The Reserve has established a ten percent allowance as an acceptable level of agreement between the verifier and the Project Operator, without adjusting the project estimates for uncertainty.

9.3.5.2 Inventory Estimates

The items in Table 9.5 are evaluations that should be made before the verifier goes to the field and analyzes the plots. If a project opts to utilize the Reserve's Standardized Inventory Methodology, the methodology need not be assessed beyond correct implementation.

Table 9.5. Inventory Methodology Verification Items

Verification/Evaluation Standards	
1.a	Inventory methodology describes the methodology for plot location in the field. The plot locations are either random or systematic with a random initial point.
1.b	If inventory methodology describes a stratification design: The stratification methodology, including rules for stratification, is clearly defined. The stratification design is relevant for the sampling of biomass. In particular, the stratification design applies to all tree species without a bias for commercial tree species. Verifier shall randomly select 10% of the vegetation units, or strata polygons, by area, or 500 acres (whichever is least) to evaluate that the vegetation (or stratum) label assigned to the polygon is consistent with the stratification rules documented in the inventory methodology. The selection shall be made from a database or spreadsheet list of all vegetation (stratum) polygons within the project that have not experienced a harvest or disturbance that affects carbon stocks by more than 10%, using verifier judgment, within the past 10 years. Evaluation of post-harvest polygons and plots is described in 1.c. Evaluation for consistency shall be conducted through comparison with aerial photos or other remotely sensed data, and/or field observation. During evaluation, a verifier must use professional judgment to determine if a polygon is consistent or inconsistent with the stratification rules. Inconsistent means the existing vegetation (stratum) label is grossly incorrect to an extent that would substantially alter the associated carbon stocks. If more than 10% of the polygons evaluated are determined to be inconsistent with the stratification rules documented in the inventory methodology, the verification shall expand the assessment to an additional 10% of the vegetation units (stratum polygons), or an additional 500 acres (whichever is least) and expand the analysis, or determine that the project has failed to meet the standard.
1.c	Inventory methodology states how the inventory is updated on an annual basis to reflect growth, harvest, and other disturbances. An event is deemed to be a disturbance, whether natural or the result of human activities, if the event results in an estimated loss of more than 10% of the pre-disturbance carbon stocks in the applicable carbon pools. The methodology includes a process to: ▪ Update the inventory for harvest and other disturbances. The immediate updating of an inventory for disturbances will require that a tree list is assigned to the area disturbed, rather than developing a tree list from field measurements, to represent the area disturbed. This may occur by assigning a vegetation label (stratifying) and compiling the inventory so that the area disturbed obtains a tree list representative of the disturbed condition. For stratified inventories, this may be a solution that lasts many years until the forest vegetation is re-stratified due to changes from forest growth. Immediately updating an inventory may also occur by assigning a 'best-fit' tree list that represents the stand conditions to the plots that were affected by disturbance. This solution is a shorter term solution since the plots used to estimate the inventory have been affected. During all site visit verifications (following the initial site visit verification in cases where the project start date is the same year as the initial site visit verification), the Project Operator must provide a map(s) that displays areas where disturbance has occurred. For stratified inventories, a pre-disturbance map must display the vegetation stratum prior to the disturbance and a post-disturbance map must display the vegetation stratum following the disturbance. For non-stratified inventories, the disturbance map must display the underlying plots, if any, affected by the disturbance. For stratified inventories, a summary tree list associated with the updated vegetation strata shall be provided. For non-stratified inventories, tree lists shall be provided for each plot affected by disturbance. During site verification, verifiers shall randomly select a minimum of 10% of the vegetation polygons (strata polygons) or plots updated for disturbance and determine if the assigned tree lists do not obviously overestimate the carbon associated with the forest structure remaining after the disturbance. Where plots are updated through assignment of a tree list (instead of assigning a vegetation stratum) following the disturbance, the verifier shall ensure all plots have been updated and the updated tree list is consistent with

	the forest structure remaining after disturbance. For non-stratified inventories, it is not acceptable for a Project Operator to simply remove disturbed plots from the inventory. The plots must be assigned a tree list to estimate the post-disturbance condition. It is acceptable to remove plots from an inventory that is strata-based upon disturbance that affects the plots. Tree lists resulting from stratification or assignment are determined to be inconsistent if the tree list would result in carbon stocks substantially above what in the verifier's professional judgment would associate with the post-disturbance condition. The determination for consistency can be made through an office review by comparing the assigned tree lists with the disturbance events. A verifier can choose to enhance their review for consistency by visiting disturbed sites in the field. To minimize the risk of inaccuracies to the inventory, no more than 10% of the plots used to characterize the project's inventory can be developed from estimated tree lists without increased scrutiny from verification. The plots assigned an estimated tree list must be appropriately coded in the inventory database so that they can be queried and isolated. Plots assigned with an estimated tree list are not to be used in sequential sampling efforts unless the number of plots with estimated tree lists exceeds 10%, in which case all plots, measured or estimated, must be available for random selection for sequential sampling during verification. ▪ Update the inventory for growth using and approved growth model or a stand table projection, as described in Appendix B. The inventory being verified is determined to be current using the update methodology.
1.d	The inventory methodology has been implemented in a consistent manner since the project's inception. If changes have been made to the inventory methodology, such changes have been discussed and approved in writing by the Reserve.
1.e	The inventory methodology describes the volume and biomass equations used to compute the project's carbon stocks and these equations are consistent with those required by the protocol. Appropriate use of biomass equations is demonstrated.

Each applicable pool/combination of pools must meet the minimum precision threshold of +/- 20 percent at the 90 percent confidence interval. Project Operators can improve the precision of their estimates through additional inventory effort but can only include it in their reporting after the confidence estimate has been verified. Projects must include the uncertainty adjustment associated with their most recent verification effort.

Use of the Standardized Inventory Methodology (available on the Reserve's Forest Project Protocol webpage) will be considered to automatically meet the evaluation standards in Table 9.5 and does not need to be verified beyond ensuring proper implementation. The Reserve has also developed the Climate Action Reserve Inventory Tool (CARIT), an inventory management computer application that Project Operators may also optionally use to manage and update their forest inventories. The use of the Standardized Inventory Methodology does not obligate a Project Operator to use CARIT, nor does the use of CARIT obligate a Project Operator to use the Standardized Inventory Methodology. However, CARIT will only function properly if certain inventory standards are followed. Refer to Appendix B for more information.

9.3.5.3 Measurement Specifics for Verifiers

Verifiers must use the highest standard to conduct measurements during field measurements. Measurements utilized by verifiers during field inspections shall be consistent with the tolerance standards for measurements identified in Appendix B, with the following exceptions:

1. Verifiers shall measure the heights of all trees according to the height measurement used for the species-specific biomass equation on the Reserve's Forest Project Protocol webpage.

2. The use of regressions to estimate heights is allowable for Forest Operators; verifiers should measure each height for comparisons with Forest Operator's estimates.
3. Tools and methods used for distance measurements for plot boundaries should be accurate within 1"/30'.
4. Tools and methods used for distance measurements for height measurements must be able to obtain an accuracy of 6"/100'.
5. Rules for determining 'in'/'out' trees:
    a. All borderline trees should be measured to determine status as an 'in' or 'out' tree.
    b. Verifiers may encounter trees that are 'in' that were not measured by the Project Operator. The cause of the omission(s) may be that the trees were determined to be too small to be included, per sampling methodology criteria, at the time of the Project Operator measurement. Per Appendix B, inventory estimates developed by the Project Operator must include all trees 5 inches DBH and larger.
    c. Additionally, Appendix B permits Project Operators to develop an inventory methodology with varying plot areas that are expanded on a per acre basis depending on the size of the plots and with varying DBH requirements for which trees are included in each plot. In such cases, trees that were determined to be too small to be included in a larger plot by the Project Owner, may have grown and now exceed the minimum threshold for inclusion in the larger plot.
    d. To account for this limited growth, the verifier shall not include trees in the verifier measurements (for sequential sampling purposes) if the tree was omitted by the Forest Owner and the tree diameters, at time of verification audit, are less than 7 inches DBH. Similarly, trees that were included by the Forest Owner in a plot with a certain expansion factor and, at the time of verifier audit, have not exceeded the threshold for being switched to a plot with a different expansion factor by more than 10%, shall continue to be entered in the plot determined by the Project Operator, such that the expansion values are consistent for the Project Operator and the verifier.
        i. This applies a reasonable cushion to Project Operators who apply the sampling methodology correctly, but through no fault of their own would otherwise be penalized due to forest growth changing measurement parameters. It should be noted that the cushion is minimal and will not relieve Project Operators from growth over long periods of time that would exceed these allowances. Hence, Project Operators need to base the re-measurement of the plots on an adequate timeframe to avoid verification problems with their inventory data.
        ii. Any trees that do not meet the criteria of the standards listed above shall be included as part of the verifier's plot estimate for purposes of sequential sampling.
6. Verifiers shall insert their own determination of species for each tree included in the verifier's inventory.
7. For defect and decay, verifiers may first consider the inputs of the Forest Owner and determine whether or not they were reasonable. If considered reasonable, the verifier may insert the same classification as the Forest Owner for each tree included in the verifier's inventory. If, however, not considered reasonable, or not recorded by the Forest Owner, the verifier shall insert their own determination.

9.3.5.4 Verifying a Stratified Inventory

If the Project Operator's inventory is based on a stratified design, verification shall be based on the measurement error that can be assessed at the stratum level, using the sequential sampling tools developed by the Reserve. Individual plots within the strata selected for assessment shall be selected randomly. The verifier shall perform independent assessments on a minimum of three strata, unless the stratification design has less than three strata, in which case the assessment is conducted on two strata. Verifiers shall select the strata used to perform the assessment based on their own professional judgement of where the risks of measurement error are likely to have the biggest effect on the overall inventory estimate. This may be based on criteria related to:

- Carbon stocking levels
- Area of a particular stratum relative to other strata
- Strata that may be found in difficult to access areas due to remoteness or terrain which could lead to a reduced effort by forest inventory personnel

9.3.5.5 Verifying a Non-Stratified Inventory

If the project is not stratified for each applicable pool, the verifier shall select the plots randomly (if plot center can be located) or allocate the plots systematically or in clusters for efficiency. Plots may be measured and assessed one at a time or in reasonable batches that correspond to logistical realities of fieldwork.

9.3.5.6 Verification Within a Strata

Plots must be independently selected using a random or systematic design.

Table 9.6. Number of Passing Plots in Sequence, as a Function of Project Size

Test	Number of Strata Verified	Project Acres				
			<100 – 500	501 - 5,000	5,001 – 10,000	>10,000
Paired/Unpaired	3		3	4	5	6
	2		4	6	8	10
	1		8	10	12	12

The project passes sequential sampling when the minimum number of passing plots in sequence is achieved (as identified in Table 9.6), or the first passing plot after a minimum of 12 plots (paired) or 30 plots (unpaired) have been measured – whichever is achieved first. There are two possible statistical procedures that can be applied to the stratum-level verifications. A paired test can be applied when plot locations can be found and it is statistically appropriate to use a paired test (i.e., plot measurements can be replicated). An unpaired test can be applied when plots cannot be relocated. The range of acceptable error (***δ*, delta**) is fixed at ten percent for both tests.

Paired Plots

The statistical test is based on a comparison of the verifier's measurements of plots within a selected stratum, calculated as CO_2e compared to the Project Operator's measurements of plots, which may include any adjustments for growth.

Use ***α*=0.05** and ***β*=0.20** to control for error.

The null hypothesis (H_0) is that the verification and project plots are equal.

1) Perform verification sampling on at least the minimum number of passing plots required in a sequence from Section 9.3.5.4.

2) If $\boldsymbol{n \geq ((Z_\alpha + Z_\beta)^2 \times S_n^2) / D^2}$ then stop and evaluate. Otherwise take another sample.

   Where,
   n = Number of verification plots measured
   $Z_\alpha = \alpha\%\ N(0,1) = 1.645$
   $Z_\beta = \beta\%\ N(0,1) = 0.8416$
   S_n^2 = sample variance of the differences
   $D = \delta \times$ project average estimate

3) If stopped, then evaluate.

   If $\bar{X}_N \leq K$ then accept H_0,
   If $\bar{X}_N > K$ then reject H_0.

   Where,
   $\bar{X}_N$ = sample mean of the differences
   N = total number of plots measured
   $K = (Z_\alpha \times D) / (Z_\alpha + Z_\beta)$.

4) If H_0 was rejected, then additional samples may be taken as long as the verifier is of the opinion that there is a chance that H_0 may be accepted based on the variability and trend observed.

Unpaired Plots

The statistical test is based on comparing the average CO_2e estimates for each stratum from the verifier plots to the Project Operator plots.

Use $\boldsymbol{\alpha=0.05}$ to control for error; the β is not specified because we are constructing a confidence interval not a test. The null hypothesis (H_0) is that the verification and stratum averages are equal. The following procedure is appropriate for the unpaired test.

1) Perform verification sampling on at least the minimum number of plots required in a sequence from Section 9.3.5.5. Calculate n as the sum of the number of plots from both the stratum (n_p) and the verification (n_v).

2) Calculate the following:

   $T_n = \bar{X}_P - \bar{X}_n$

   Where,
   T_n = the difference between the means
   $\bar{X}_P$ = stratum mean
   $\bar{X}_n$ = verification mean after sample n

3) If $\boldsymbol{n \geq (a^2/D^2) \times (S_n^2 + S_P^2)}$ then stop and evaluate. Otherwise take another sample.

   Where,
   a = the percentile from a standard normal distribution for one half of alpha; 1.96 for α=0.05
   $n = n_p + n_v$
   S_n^2 = sample variance of the verification plots
   S_P^2 = sample variance of the stratum plots
   $D = \delta \times$ stratum average estimate

4) If stopped, then evaluate. Construct a confidence interval $T_n \pm D$.
   If the confidence interval includes zero then accept H_0,
   Otherwise reject H_0.

5) If H_0 was rejected, then additional samples may be taken until as long as the verifier is of the opinion that there is a chance that H_0 may be accepted based on the variability and trend observed.

If the stopping rule in step (3) above cannot be attained within 100 plots, then apply a standard unpaired t-test comparison using $\boldsymbol{\alpha}$**=0.05** and $\boldsymbol{\beta}$**=0.80**.

9.3.5.7 Determining if the Stopping Rules Have Been Met

The verifier must determine if the stopping rules have been met for each stratum as soon as is convenient. The Reserve provides tools to assist verifiers with determining if the stopping rules have been met or not. The tools are Microsoft Excel based and are distinct for paired designs and for unpaired designs.

The verifier must enter their data into the appropriate spreadsheet based upon use of a paired or unpaired test. It is required that the verifier apply the random order selection in the sampling process. The verifier is free to measure the set of plots that were randomly selected in any order that provides the greatest efficiency while sampling in the field, but when the verifier inputs data into the spreadsheet, the verifier must follow the random selection order in order to properly conduct the analysis and maintain the integrity of sequential analysis. This may provide significant efficiencies when selected stands and/or plots are in close geographic proximity and it is hypothesized that the stopping rules will require the full number of plots.

The statistical test is based on a comparison of the verifier's measurements of plots, calculated as CO_2e per acre compared to the Forest Owner's measurements of plots, which may include any adjustments for growth. The inventory verification is complete based on the stopping rules detailed in Section 9.3.5.1. Passing of the plot height and/or diameter stopping rules is not required to pass the inventory verification; however, as discussed above, verifiers may separately compare their measurements for height and diameter with the Forest Owner's measurements in the sequential sampling tool. When those inputs have met the sequential sampling stopping requirements, verifiers may use the height and diameter data provided for each tree from the Forest Owner's database for any additional data inputs needed for the CO_2e/acre comparison.

Finally, in addition to evaluating and verifying adherence to the Project Operator's inventory methodology, the verification body must verify the items in Table 9.7. If the project is using the

Standardized Inventory Methodology and/or CARIT, the verification team need not verify these tools beyond proper implementation.

Table 9.7. Additional Verification Items for Inventory Methodology and Implementation

Verification Items		Apply Professional Judgment?
1. Inventory Update Processes	a. Project Operator's inventory document describes methodology for updating inventory data resulting from growth, harvest, and disturbances. Methodology adheres to acceptable forestry practices* b. Harvest/Disturbance updates in inventory management system are implemented per the specified methodology and are representative of the harvest or disturbance. c. Growth is accounted for using an approved growth model or using a stand table projection, as described in Appendix B.	Yes
2. Biomass Equations and Calculations	a. The carbon tonnes per acre for a representative sample plot, computed using the Project Operator's calculation tools, replicate output computed by the verification body.** b. All conversions and expansions are accurate.	Yes

*A forest biometrician employed by the state in which the project is located, or a consulting forest biometrician may be consulted in the event of a dispute between the verification body and Project Operator. The written opinion of the forest biometrician, submitted to the Reserve as part of the verification report, shall be considered the authoritative word.
**The verification body must provide an (idealized) 'verification plot' consisting of all tree species in Project Area with varying heights and diameters existing within the Project Area. The plot need not correspond to an actual plot within the Project Area.

9.3.6 Baseline Estimation

Forest Project baselines include assumptions about forest growth and harvest, as influenced by legal and financial constraints, and assumptions regarding the extent of harvest operations under Business As Usual conditions. These are based on either modeled assumption, or default assumptions, as described in Section 6.

Verification bodies are required to verify the baseline estimate for the project at the initial site visit verification for Improved Forest Management Projects and Avoided Conversion Projects.

All reports that reference carbon stocks must be submitted by the Project Operator with the oversight of a Professional Forester. If the project is located in a jurisdiction without a Professional Forester law or regulation, then Certified Forester credentials managed by the Society of American Foresters (see http://www.certifiedforester.org) are required so that professional standards and project quality are maintained.

Table 9.8. Modeled Baseline Verification Items
(Improved Forest Management projects using the modeling approach, and Avoided Conversion Projects)

Verification Items		Section of FPP	Apply Professional Judgment?
1. Document	A modeling document exists that contains all the verification items in this table.	9	No

Verification Items		Section of FPP	Apply Professional Judgment?
2. Qualitative Characterization (Avoided Conversion Projects Only)	A sufficiently detailed qualitative characterization has been included in the modeling document that documents the general assumptions of the project's baseline. The qualitative assessment addresses the vegetative conditions and activities that would have occurred.	6.2	Yes
3. Model Choice and Calibration	a. The model used is an approved model. b. The Project Operator has provided a rationale for any model calibrations or a sufficient explanation of why calibrations were not incorporated. c. The Project Operator has provided a description of the site indexes used for each species and a sufficient explanation of the source of the site index values used.	Appendix B	Yes
4. Legal Constraints	A list of legal constraints is provided that includes an accurate description of the type and effect of each constraint on the ability to harvest trees and the area constrained.	3.3.1, 6.1.2, 6.2.1	Yes
5. Financial Constraints	a. A sufficient qualitative description is provided indicating that the harvesting activity modeled in the baseline is a financially viable activity. b. For Improved Forest Management projects, Project Operator has provided either a financial analysis of the anticipated growth and harvesting regime that captures all relevant costs and returns, taking into consideration all legal, physical, and biological constraints.	3.3.2, 6.1.3, 6.2.1	Yes
6. Silviculture Guidelines	The silviculture guidelines incorporated in the model demonstrate all legal constraints are applied in the model. The silviculture guidelines must include: i. A description of the trees retained by species group ii. The level of retention iii. Harvest frequency iv. Regeneration assumptions	Appendix B	No
7. Modeling Guidelines	a. Improved Forest Management: Modeling is conducted per Section 6.1. b. Avoided Conversion: Modeling is conducted per Section 6.2.	6.1, 6.2	No
8. Modeling Outputs	a. The Project Operator has provided reports that display periodic harvest, inventory, and growth estimates for the entire Project Area presented as total carbon tonnes and carbon tonnes per acre. b. Estimates are within the range of expected growth patterns for the Project Area.	9, Appendix B	Yes

Table 9.9. Default Baseline Verification Items
(Improved Forest Management projects using the conservative default approach, and Improved Forest Management projects on public lands)

Verification Items		Section of FPP	Apply Professional Judgment?
1. Document	The PDD explains the baseline quantification steps undertaken.	9	No
2. Default Approach	a. The project is eligible to use the conservative default approach and has followed the steps to establish a default baseline in Section 6.1.1 b. The project has correctly run the COLE report as described in Section 6.1.3	6.1.1, 6.1.3, Appendix B	No
4. Legal Constraints	The project has correctly accounted for baseline legal constraints	6.1.1, 6.1.3	Yes
5. Incorporating Other Carbon Stocks	The final baseline has been adjusted to account for all required SSRs	6.1.1, 6.1.3, Appendix B	No

9.3.7 Verifying Estimates of Carbon in Harvested Wood Products

Verification bodies are required to verify the estimates of carbon that are likely to remain stored in wood products over a 100-year period, as submitted in the Forest Project Design Document (for baseline estimates) and annual monitoring reports (for actual wood product production). Accounting for wood product carbon must be applied only to actual or baseline volumes of wood harvested from within the Project Area. Trees harvested outside of the Project Area are not part of the Forest Project and must be excluded from any calculations.

Table 9.10. Carbon in Harvested Wood Products Verification Items

Verification Items		Section of FPP	Apply Professional Judgment?
1. Carbon in Harvested Wood Delivered to Mills	a. Amount of wood harvested that will be delivered to mills has been estimated and reported. b. The appropriate wood density factor has been applied and/or water weight subtracted to result in pounds of biomass with zero moisture content. c. Total dry weights for all harvested wood have been calculated. d. Total carbon weight has been computed. e. The total has been converted to metric tons of carbon.	Appendix B	No
2. Account for Mill Efficiencies	The correct mill efficiency factors have been used to calculate total carbon transferred into wood products.	Appendix B	No

3. Wood Product Classification	The percentages of harvest by wood product class has been determined correctly with verified reports from the mill(s) where the Project Area's logs are sold; or by looking up default wood product classes for the project's Assessment Area(s); or if not available from either of these sources, by classifying all wood products as "miscellaneous."	Appendix B	No
4. Calculation of In-Use and Landfill Carbon Storage	a. The average amount of carbon stored in in-use wood products over 100 years has been calculated correctly using the worksheets referenced in Appendix B. b. The average amount of carbon stored in landfilled wood products over 100 years has been calculated correctly using the worksheets referenced in Appendix B.	Appendix B	No
5. Total Average Carbon Storage in Wood Products Over 100 Years	Total average carbon storage in wood products over 100 years for a given harvest volume has been calculated and reported.	Appendix B	No

9.3.8 Verifying Calculations of Reversal Risk Ratings and Contributions to the Buffer Pool

At each site visit verification, Project Operators must derive a reversal risk rating for their Forest Project using the worksheets in Appendix A. The worksheets are designed to identify and quantify the specific types of risks that may lead to a reversal, based on project-specific factors.

Table 9.11. Reversal Risk Rating Verification Items

Verification Items		Section of FPP	Apply Professional Judgment?
1. Financial Risk	Use of a Qualified Conservation Easement or Qualified Deed Restriction, occurrence on public lands, or use of a PIA alone.	Appendix A.1	No
2. Management Risk	a. Management Risk I – Illegal removals of forest biomass. b. Management Risk II – Conversion of Project Area to alternative land uses. c. Management Risk III – Over-harvesting.	Appendix A.2	No
3. Social Risk	Social Risk.	Appendix A.3	No
4. Natural Disturbance Risk	a. Natural Disturbance Risk I – Wildfire, Disease or insect outbreak. c. Natural Disturbance Risk II – Other episodic catastrophic events.	Appendix A.4	Yes

Verification Items		Section of FPP	Apply Professional Judgment?
5. Completing the Risk Rating Analysis	Reversal risk rating calculated correctly using the formula in Appendix A.5.	Appendix A.5	No

9.4 Completing the Verification Process

After completing the core project verification activities for a Forest Project, the verification body must do the following to complete the verification process:

1. Complete a detailed List of Findings containing both immaterial and material findings (if any) and deliver it to the Project Operator (private document).
2. Exchange correspondence as necessary to resolve issues detailed in the List of Findings, until all material misstatements and nonconformances have been addressed.
3. If a reasonable level of assurance opinion is successfully obtained, complete a Verification Report to be delivered to the Project Operator (public document).
4. Complete the Verification Statement form, detailing the vintage and the number of GHG reductions and removals verified and deliver it to the Project Operator (public document).
5. Verify that the number of GHG reductions and removals, as well as the reversal risk rating, specified in the Verification Report and Statement match the number entered into the Reserve software.
6. Conduct an exit meeting with the Project Operator to discuss the Verification Report, List of Findings, and Verification Statement.
7. Upload electronic copies of the Verification Report, List of Findings, Verification Statement, and Verification Activity Log into the Reserve.

The recommended content for the Verification Report, List of Findings, and Verification Statement can be found in the Reserve's Verification Program Manual.[32] The Verification Program Manual also provides further guidance on quality assurance, negative verification statements, use of an optional Project Verification Activity Log, goals for exit meetings, dispute resolution, and record keeping.

[32] Available at http://www.climateactionreserve.org/how/program/program-manual/.

10 Glossary of Terms

Aboveground Live Biomass	Live trees including the stem, branches, and leaves or needles, brush, and other woody live plants aboveground.
Activity-Based Funding	The budget line items that are dedicated to agency accomplishments in vegetation management, including pre-commercial thinning, commercial thinning, harvest, hazard tree removal, hazardous fuel reductions, and other management activities designed to achieve forest sustainability health objectives.
Additionality	A criterion for Forest Project eligibility. A Forest Project is "additional" if it would not have been implemented without incentives provided by the carbon offset market, including the incentives created through the Climate Action Reserve program. Under this protocol, Forest Projects meet the additionality criterion by demonstrating that they pass a legal requirement test and a performance test, as described in Section 3.1, and by achieving GHG reductions and removals quantified against an approved baseline, determined according to the requirements in Section 6.
Affiliate	An "affiliate" is defined as any person or entity that, directly or indirectly, through one or more intermediaries, controls or is controlled by or is under common control with the Forest Owner(s) participating in a project, including any general or limited partnership in which the Forest Owner is a partner and any limited liability company in which the Forest Owner is a member. For the purposes of this definition, "control" means the possession, direct or indirect, of the power to direct or cause the direction of the management and policies of a person, whether through the ownership of voting securities, by contract or otherwise, and "person" means an individual or a general partnership, limited partnership, corporation, professional corporation, limited liability company, limited liability partnership, joint venture, trust, business trust, cooperative or association or any other legally-recognized entity.
Allometric Equation	An equation that utilizes the genotypical relationship among tree components to estimate characteristics of one tree component from another. Allometric equations allow the belowground root volume to be estimated using the aboveground bole volume.
Assessment Area	A distinct forest community within geographically identified ecoregions defined by the Reserve that consists of common regulatory and political boundaries that affect forest management. The size of the Assessment Areas is determined by efforts to achieve optimal statistical confidence across multiple scales using U.S. Forest Service Forest Inventory and Analysis Program (FIA) plots

	for biomass. Maps of the Assessment Areas and the associated data may be found on the Reserve's website.
Avoidable Reversal	An avoidable reversal is any reversal that is due to the Project Operator's negligence, gross negligence, or willful intent, including harvesting, development, and harm to the Project Area
Avoided Conversion Project	A type of Forest Project consisting of specific actions that prevent the conversion of forestland to a non-forestland use by dedicating the land to continuous forest cover through conservation easement recordation or transfer to public ownership.
Baseline	The level of GHG emissions, removals, and/or carbon stocks at sources, sinks or reservoirs affected by a Forest Project that would have occurred under a Business As Usual scenario. For the purposes of this protocol, a project's baseline must be estimated following standard procedures in Section 6.
Best Management Practices	Management practices determined by a state or designated planning agency to be the most effective and practicable means (including technological, economic, and institutional considerations) of controlling point and nonpoint source pollutants at levels compatible with environmental quality goals.[33]
Biological Emissions	For the purposes of the Forest Project Protocol, biological emissions are GHG emissions that are released directly from forest biomass, both live and dead, including forest soils. For Forest Projects, biological emissions are deemed to occur when the reported tonnage of onsite carbon stocks, relative to baseline levels, declines from one year to the next.
Biomass	The total mass of living organisms in a given area or volume; recently dead plant material is often included as dead biomass.[34]
Bole	A trunk or main stem of a tree.
Broadcast Fertilization	A fertilizer application technique where fertilizer is spread across the soil surface by tractor or aerial application.
Buffer Pool	The buffer pool is a holding account for Forest Project CRTs administered by the Reserve. It is used as a general insurance mechanism against unavoidable reversals for all Forest Projects registered with the Reserve. If a Forest Project experiences an unavoidable reversal of GHG reductions and removals (as defined in Section 7.3), the Reserve will retire a number of CRTs from the buffer pool

[33] Helms. (1998).
[34] Metz, Davidson, Swart, & Pan. (2001).

	equal to the total amount of carbon that was reversed (measured in metric tons of CO_2-equivalent).
Business As Usual	The activities, and associated GHG reductions and removals that would have occurred in the Project Area in the absence of incentives provided by a carbon offset market. Methodologies for determining these activities – and/or for approximating carbon stock levels that would have resulted from these activities – are provided in Section 6 of this protocol for each type of Forest Project.
Carbon Pool	A reservoir that has the ability to accumulate and store carbon or release carbon. In the case of forests, a carbon pool is the forest biomass, which can be subdivided into smaller pools. These pools may include aboveground or belowground biomass or harvested wood products, among others.
Climate Reserve Tonne (CRT)	The unit of offset credits used by the Climate Action Reserve. Each Climate Reserve Tonne represents one metric ton (2204.6 lbs) of CO_2 reduced or removed from the atmosphere.
Commercial Rotational Harvesting	For the purpose of this protocol, commercial rotational harvesting refers to harvesting activities undertaken by a Forest Owner with the intent to create a new cohort of regenerated trees, where the harvested trees are delivered to a mill.
Common Practice	The average stocks of the aboveground standing live and dead carbon pools from within the Forest Project's Assessment Area, derived from FIA plots on all private lands within the defined Assessment Area.
Computational Reversal	A computational reversal is any reversal that is due to required protocol calculations (including the confidence deduction and secondary effects).
Even-Aged Management	Management where the trees in individual forest stands have only small differences in their ages (a single age class). By convention, the spread of ages does not differ by more than 20 percent of the intended rotation.
FIA	USDA Forest Service Forest Inventory and Analysis program. FIA is managed by the Research and Development organization within the USDA Forest Service in cooperation with State and Private Forestry and National Forest Systems. FIA has been in operation under various names (Forest Survey, Forest Inventory and Analysis) for 70 years.
Forest Carbon	The carbon found in forestland resulting from photosynthesis in trees and associated vegetation, historically and in the present. Forest Carbon is found in soils, litter and duff, plants and trees, both dead and alive.

Forest Management	The commercial or noncommercial growing and harvesting of forests.
Forest Owner	A corporation or other legally constituted entity, city, county, state agency, individual(s), or a combination thereof that has legal control (described in Section 2.2) of any amount of forest carbon within the Project Area
Forest Project	A planned set of activities designed to increase removals of CO_2 from the atmosphere, or reduce or prevent emissions of CO_2 to the atmosphere, through increasing and/or conserving forest carbon stocks.
Forest Project Design Document	A standard document for reporting required information about a Forest Project. The Forest Project Design Document must be submitted for review by a verification body and approved by the Reserve before the Forest Project can be registered with the Reserve.
Forestland	Land that supports, or can support, at least ten percent tree canopy cover and that allows for management of one or more forest resources, including timber, fish and wildlife, biodiversity, water quality, recreation, aesthetics, and other public benefits.
GHG Assessment Boundary	The GHG Assessment Boundary defines all the GHG sources, sinks, and reservoirs that must be accounted for in quantifying a Forest Project's GHG reductions and removals (Section 6). The GHG Assessment Boundary encompasses all the GHG sources, sinks, and reservoirs that may be significantly affected by Forest Project activities, including forest carbon stocks, sources of biological CO_2 emissions, and mobile combustion GHG emissions.
GHG Reductions and Removals	See definitions for Reduction and Removal.
Greenhouse Gas (GHG)	Gas that contributes to global warming and climate change. For the purposes of this Forest Project Protocol, GHGs are the six gases identified in the Kyoto Protocol: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).
Improved Forest Management Project	A type of Forest Project involving management activities that increase carbon stocks on forested land relative to baseline levels of carbon stocks.
Listed	A Forest Project is considered "listed" when the Project Operator has created an account with the Reserve, submitted the required Project Submittal form and other required documents, paid the project submission fee, and the Reserve has approved and accepted the project for listing.

Litter	Any piece(s) of dead woody material from a tree, e.g., dead boles, limbs, and large root masses, on the ground in forest stands that is smaller than material identified as lying dead wood.
Lying Dead Wood	Any piece(s) of dead woody material from a tree, e.g., dead boles, limbs, and large root masses, on the ground in forest stands. Lying dead wood is all dead tree material with a minimum average diameter of five inches and a minimum length of eight feet. Anything not meeting the measurement criteria for lying dead wood will be considered litter. Stumps are not considered lying dead wood.
Metric Ton or "tonne" (t)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Native Forest	For the purposes of this protocol native forests shall be defined as those occurring naturally in an area, as neither a direct nor indirect consequence of human activity post-dating European settlement.
Natural Forest Management	Forest management practices that promote and maintain native forests comprised of multiple ages and mixed native species at multiple landscape scales. The application of this definition, its principles, detailed definition, and implementation are discussed further in Section 3.9.2.
Non-Forest Cover	Land with a tree canopy cover of less than ten percent.
Non-Forest Land Use	An area managed for residential, commercial, or agricultural uses other than for the production of timber and other forest products, or for the maintenance of woody vegetation for such indirect benefits as protection of catchment areas, wildlife habitat, or recreation.
Non-Harvest Disturbance	Reduction in forest cover that is not a direct result of harvest, such as wildfire and insect disturbances.
Onsite Carbon Stocks	Carbon stocks in living biomass, dead biomass, and soils within the Project Area.
Permanence	The requirement that GHGs must be permanently reduced or removed from the atmosphere to be credited as carbon offsets. For Forest Projects, this requirement is met by ensuring that the carbon associated with credited GHG reductions and removals remains stored for at least 100 years.
Primary Effects	The Forest Project's intended changes in carbon stocks, GHG emissions or removals.
Professional Forester	A professional engaged in the science and profession of forestry. A professional forester is credentialed in jurisdictions that have professional forester licensing laws and regulations. Where a jurisdiction does not have a

	professional forester law or regulation then a professional forester is defined as having the Certified Forester credentials managed by the Society of American Foresters (see www.certifiedforester.org).
Project Area	The area inscribed by the geographic boundaries of a Forest Project, as defined following the requirements in Section 4 of this protocol. Also, the property associated with this area.
Project Life	Refers to the duration of a Forest Project and its associated monitoring and verification activities, as defined in Section 3.5.
Public Lands	Lands that are owned by a public governmental body such as a municipality, county, state or country.
Project Operator	A Forest Owner responsible for undertaking a Forest Project and registering it with the Reserve. The Forest Owner who executes the Project Implementation Agreement, as described in Section 2.2.
Qualified Conservation Easement	A qualified conservation easement must explicitly refer to the terms and conditions of the Project Implementation Agreement, apply to current and all subsequent Project Operators for the full duration of the Forest Project's minimum time commitment, as defined in Section 3.5 of this protocol.
Qualified Deed Restriction	A qualified deed restriction shall ensure that the Project Implementation Agreement runs with the land and applies to all current and subsequent Project Operators for the full duration of the Forest Project's minimum time commitment, as defined in Section 3.4 of this protocol, to be determined in the Reserve's reasonable discretion. A deed restriction is not "qualified" if it merely consists of a recording of the Project Implementation Agreement or a notice of the Project Implementation Agreement, as such a recording is already required by the Project Implementation Agreement.
Reduction	The avoidance or prevention of an emission of CO_2 (or other GHG). Reductions are calculated as gains in carbon stocks over time relative to a Forest Project's baseline (also see Removal).
Registered	A Forest Project becomes registered with the Reserve when it has been verified by a Reserve-approved and ISO-accredited verification body, all required documentation (see Section 8) has been submitted by the Project Operator to the Reserve for final approval, and the Reserve approves the project.
Removal	Sequestration ("removal") of CO_2 from the atmosphere caused by a Forest Project. Removals are calculated as gains in carbon stocks over time relative to a Forest Project's baseline (also see Reduction).

Reporting Period	The period of time over which a Project Operator quantifies and reports GHG reductions and removals.
Reservoir	Physical unit or component of the biosphere, geosphere or hydrosphere with the capacity to store or accumulate carbon removed from the atmosphere by a sink, or captured from a source.
Retire	To retire a CRT means to transfer it to a retirement account in the Climate Action Reserve's software system. Retirement accounts are permanent and locked, so that a retired CRT cannot be transferred or retired again.
Reversal	A reversal is a decrease in the stored carbon stocks associated with quantified GHG reductions and removals that occurs before the end of the Project Life. Under this protocol, a reversal is deemed to have occurred if there is a decrease in the difference between project and baseline onsite carbon stocks from one year to the next, regardless of the cause of this decrease (i.e., if the result of (Δ AC_{onsite} - Δ BC_{onsite}) in Equation 6.1 is negative).
Secondary Effects	Unintended changes in carbon stocks, GHG emissions, or GHG removals caused by the Forest Project.
Sequestration	The process of increasing the carbon (or other GHGs) stored in a reservoir. Biological approaches to sequestration include direct removal of CO_2 from the atmosphere through land-use changes[35] and changes in forest management.
Significant Disturbance	Any natural impact that results in a loss of least 20 percent of the aboveground live biomass that is not the result of intentional or grossly negligent acts of the Project Operator.
Sink	Physical unit or process that removes a GHG from the atmosphere.
Source	Physical unit or process that releases a GHG into the atmosphere.
Stand	An individual unit or polygon that is relatively homogeneous in terms of the carbon stocking within its borders. For live and dead trees, the determination of stand boundaries is usually based on forest vegetation attributes, such as species, size (age), and density characteristics. For soils, the determination of soil stand boundaries is made on similar soil orders.
Standing Dead Carbon Stocks	The carbon in standing dead trees. Standing dead trees include the stem, branches, roots, or section thereof, regardless of species, with minimum diameter (breast

[35] Metz, Davidson, Swart, & Pan. (2001).

	height) of five inches and a minimum height of 15 feet. Stumps are not considered standing dead stocks.
Standing Live Carbon Stocks	The carbon in the live tree pool. Live trees include the stem, branches, roots, and leaves or needles of all aboveground live biomass, regardless of species, with a minimum diameter (breast height) of five inches and a minimum height of 15 feet (inventory methodology must include all trees five inches and greater)
Stocks (or Carbon Stocks)	The quantity of carbon contained in identified carbon pools.
Strata	Plural of stratum. The set of different groupings for a specific attribute, such as vegetation or soil.
Stratum	A group of stands that contain a similar attribute, such as vegetation or soils attributes.
Submitted	The Reserve considers a Forest Project to be "submitted" when all of the appropriate forms have been uploaded and submitted to the Reserve's software system, and the Project Operator has paid a project submission fee.
Tree	A woody perennial plant, typically large and with a well-defined stem or stems carrying a more or less definite crown with the capacity to attain a minimum diameter at breast height of five inches and a minimum height of 15 feet with no branches within three feet from the ground at maturity.[36]
Unavoidable Reversal	An unavoidable reversal is any reversal not due to the Project Operator's negligence, gross negligence or willful intent, including wildfires or disease that are not the result of the Project Operator's negligence, gross negligence or willful intent.
Uneven-Aged Management	Management that leads to forest stand conditions where the trees differ markedly in their ages, with trees of three or more distinct age classes either mixed or in small groups.
Verification	The process of reviewing and assessing all of a Forest Project's reported data and information by an ISO-accredited and Reserve-approved verification body, to confirm that the Project Operator has adhered to the requirements of this protocol.
Verification Period	The period of time over which GHG reductions/removals are verified. A verification period may cover multiple reporting periods. The end date of any verification period must correspond to the end date of a reporting period.

[36] Helms. (1998).

Appendix A Determination of a Forest Project's Reversal Risk Rating

Project Operators must derive a reversal risk rating for their Forest Project using the worksheets in this section. The worksheets are designed to identify and quantify the specific types of risks that may lead to a reversal, based on project-specific factors.

This risk assessment must be updated every time the project undergoes a verification site visit. Therefore, a project's risk profile and its assessment are dynamic. Furthermore, estimated risk values and associated mitigation measures will be updated periodically by the Reserve as improvements in quantifying risks or changes in risks are determined. Any adjustments to the risk ratings will affect only current and future year contributions to the Buffer Pool. The Reserve may, from time to time, transfer Climate Reserve Tonnes (CRTs) from the Buffer Pool to the Project Operator's account if the Reserve determines that previously assessed risk ratings were unnecessarily high. Alternatively, the Reserve may waive a Project Operator's future contributions to the Buffer Pool until excess contributions from previous years are recouped. If a Forest Project's risk rating increases, the Project Operator must contribute additional CRTs to the Buffer Pool to ensure that all CRTs (including those issued in prior years) are properly insured.

Risks that may lead to reversals are classified into the categories identified in Table A.1.

Table A.1. Forest Project Risk Types

Risk Category	Risk Type	Description	How Risk is Managed in this Protocol
Financial	Financial Failure Leading to Bankruptcy	Financial failure can lead to bankruptcy and/or alternative management decisions to generate income that result in reversals through over-harvesting or conversion	Default Risk
	Project Implementation Agreement (PIA) Subordination	Subordinating the PIA to mortgages or deeds on or affecting the Project	Default Risk
Management	Illegal Harvesting	Loss of project stocks due to timber theft	Default by Area
	Conversion to Non-Forest Uses	Alternative land uses are exercised at project carbon expense	Default Risk
	Over-Harvesting	Exercising timber value at expense of project carbon	Default Risk
Social	Social Risks	Changing government policies, regulations, and general economic conditions	Default Risk

Risk Category	Risk Type	Description	How Risk is Managed in this Protocol
Natural Disturbance	Wildfire	Loss of project carbon through wildfire	Project-specific Risk
	Disease/Insects	Loss of project carbon through disease and/or insects	
	Other Episodic Catastrophic Events	Loss of project carbon from wind, snow and ice, or flooding events	

A.1 Financial Risk

Financial failure of an organization resulting in bankruptcy can lead to dissolution of agreements and forest management activities to recover losses that result in reversals. Projects that employ a Qualified Conservation Easement or Qualified Deed Restriction, or that occur on public lands, are at a lower risk than projects with a PIA alone.

Table A.2. Financial Failure Leading to Bankruptcy

Applies to all projects		
Identification of Risk	**Contribution to Reversal Risk Rating**	
	PIA only	PIA combined with Qualified Conservation Easement or Qualified Deed Restriction or on public or tribal[37] lands
Default Financial Risk	5%	1%

Table A.3. PIA Subordination

Applies to all projects		
Identification of Risk	**Contribution to Reversal Risk Rating**	
	PIA with "Subordination Clause Type II"	PIA with "Subordination Clause Type I"
Default Financial Risk	10%	2%

A.2 Management Risk

Management failure is the risk of management activities that directly or indirectly could lead to a reversal. Projects that employ a conservation easement or deed restriction, or that occur on public lands, are exempt from this risk category.

Management Risk I – Illegal Removals of Forest Biomass

Illegal logging occurs when biomass is removed either by trespass or outside of a planned set of management activities that are controlled by regulation. Illegal logging is exacerbated by lack of controls and enforcement activities.

[37] For the purposes of this protocol, "tribal lands" includes tribal land, land owned by Alaska Native Corporations, and Hawaiian home land.

Table A.4. Risk of Illegal Removals of Forest Biomass

Applies to all projects	
Identification of Risk	**Contribution to Reversal Risk Rating**
United States Default Harvesting Risk	0%

Management Risk II – Conversion of Project Area to Alternative Land Uses

High values for development of housing and/or agriculture may compete with timber and carbon values and lead to a change in land use that affects carbon stocks. The risk of conversion of any Project Area to other non-forest uses is related to the probability of alternative uses, which are affected by many variables, including population growth, topography, proximity to provisions and metropolitan areas, availability of water and power, and quality of access to the Project Area.

Table A.5. Risk of Conversion to Alternative Land Use

Applies to all projects	
Identification of Risk	**Contribution to Reversal Risk Rating**
With Qualified Conservation Easement or Qualified Deed Restriction that explicitly encumbers all development rights or on public or tribal lands	0%
Without Qualified Conservation Easement or Qualified Deed Restriction	2%

Management Risk III – Over-Harvesting

Favorable timber values, among other reasons, may motivate some project managers to realize timber values at the expense of managing carbon stocks for which CRTs have been credited. Additionally, reversals can occur as the result of harvest associated with fuels treatments.

Table A.6. Risk of Over-Harvesting

Applies to all projects	
Identification of Risk	**Contribution to Reversal Risk Rating**
With Qualified Conservation Easement or Qualified Deed Restriction that explicitly encumbers timber harvesting associated with project stocks or on public or tribal lands	0%
Without Qualified Conservation Easement or Qualified Deed Restriction	2%

A.3 Social Risk

Social risks exist due to changing government policies, regulations, and general economic conditions. The risks of social or political actions leading to reversals are low but could be significant.

Table A.7. Social Risk Identification

Applies to all projects	
Identification of Risk	**Contribution to Reversal Risk Rating**
United States Default Social Risk	2%

A.4 Natural Disturbance Risk

Natural disturbances can pose a significant risk to the permanency GHG reductions and removals. Natural disturbance risks are only partially controllable by management activities. Management activities that improve resiliency to wildfire, insects, and disease can reduce these risks. Management activities that shift harvesting practices from live sequestering trees to trees that have succumbed to natural disturbances reduce or negate the reversal depending on the size and location of the disturbance.

Natural Disturbance Risk I – Wildfire, Disease, or Insect Outbreak

Wildfire, disease, or insect outbreak have the potential to cause significant reversals, especially in certain carbon pools. These risks can be reduced by certain techniques including reducing surface fuel loads, removing ladder fuels, adding fuel breaks, and reducing stand density. However, these techniques cannot reduce emission risk to zero because all landowners will not undertake fuel treatments, nor can they prevent wildfire from occurring. Strategies implemented to reduce fuel loads can also improve resiliency to disease or insect outbreak.

Table A.8. Natural Disturbance Risk I – Wildfire, Disease, or Insect Outbreak

Applies to all projects	
Identification of Risk	**Contribution to Reversal Risk Rating**
Refer to the Assessment Area Data File for the project's Natural Disturbance risk rating	*X*%
If vegetation management treatments have been implemented for the Project Area, reduce the value above by the appropriate percent as indicated below.	*X*% **x** *Y*%

Vegetation treatments must be available in a report and aligned with aa comprehensive vegetation management plan that identifies specific temporal and spatial actions to enhance forest resilience across the Project Area. The vegetation management plan must be approved by a state agency or, if approval by a state agency is not possible, developed under the oversight of a Professional Forester and reviewed by the Reserve. Verifiers must confirm the status of implementation of the management plan.

Table A.9. Vegetation Management Treatments (Y)

Description of Status of Vegetation Management	Y
Approved vegetation management plan exists, and the plan is being implemented across at least 80% of the intended implementation area detailed in the plan	20%
Approved vegetation management plan exists, and the plan is being implemented across at least 50% of the intended implementation area detailed in the plan	70%
Approved vegetation management plan does not exist, or the plan has not yet been implemented across at least 50% of the intended implementation area detailed in the plan	100%

Natural Disturbance Risk II – Other Episodic Catastrophic Events

A major wind-throw event (hurricane, tornado, high wind event) has the potential to cause a reversal, especially in certain carbon pools.

Table A.10. Natural Disturbance Risk III – Other Episodic Catastrophic Events

Applies to all projects	
Identification of Risk	**Contribution to Reversal Risk Rating**
Default Risk Contribution from Other Catastrophic Events	3%

A.5 Summarizing the Risk Analysis and Contribution to Buffer Pool

Use the table below to summarize the Forest Project's reversal risk rating. As indicated above, projects that employ a conservation easement or deed restriction, or that occur on public or tribal lands, are exempt from certain risk categories. Such Qualified Conservation Easements and Qualified Deed Restrictions must clearly identify the goals and objectives of the Forest Project according to the terms of this protocol.

Table A.11. Project Contribution to the Buffer Pool Based on Risk

Risk Category	**Contribution from Risk Descriptions Above**		
	Source	**PIA Only**	**PIA and Qualified Conservation Easement and/or a Qualified Deed Restriction and/or Public or Tribal Ownership**
Financial Failure[38]	Default Risk -Remedies for reversals addressed in PIA	15% or 7%	11% or 3%
Illegal Forest Biomass Removal	Default Risk	0%	0%
Conversion	Default Risk - Remedies for reversals addressed in PIA	2%	0%
Over-Harvesting	Default Risk - Remedies for reversals addressed in PIA	2%	0%
Social	Default Risk	2%	2%
Wildfire, Disease, or Insect Outbreak	Calculated Risk from Table A.8	*X*% or (*X*% x *Y*%)	*X*% or (*X*% x *Y*%)
Other Catastrophic Events	Default Risk	3%	3%

[38] When determining the appropriate risk rating for the Financial Failure Risk Category, use the higher value if intending to use PIA Subordination Clause Type I and the lower value if intending to use PIA Subordination Clause Type II. Please refer to the Project Implementation Agreement on the Reserve website for further information.

Completing the Risk Rating Analysis

The project's reversal risk rating is calculated as follows:

$$100\% - [(1 - FinancialFailure\%) \times (1 - IllegalForestBiomassRemoval\%) \times (1 - Conversion\%) \times (1 - OverHarvesting\%) \times (1 - SocialRisk\%) \times (1 - Wildfire\ /\ Disease/\ InsectOutbreak\%) \times (1 - OtherCatastrophicEvents\%)]$$

Appendix B Quantification Guidance for Use with Forest Carbon Projects

This appendix provides guidance for quantifying a forest project's onsite carbon stocks and carbon in harvested wood products, both for purposes of estimating a project's baseline as well as providing ongoing estimates of onsite project carbon stocks throughout the project life.

B.1 Reporting Requirements for Forest Carbon Pools

Onsite forest carbon pools are broadly grouped into living biomass, dead biomass, and soils. Living biomass includes biomass in live trees and shrubs and herbaceous understory (live non-tree biomass). Onsite dead biomass includes biomass in dead trees, lying dead wood, and litter. Offsite dead biomass includes harvested wood products.

For standardized reporting, all estimates of forest carbon stocks must be provided in terms of metric tons (tonnes) of CO_2-equivalent (CO_2e) on a project and a per acre basis. Unless otherwise required in the referenced biomass equations, the following conversion formulae shall be used:

Base Unit	Conversion		Final Unit
Biomass	0.5 **x** biomass		Carbon
Carbon	3.667 **x** carbon	=	CO_2e
Pounds	lbs **/** 2204.6		Metric tons or tonnes (t)
Acres	0.404686 **x** acres		Hectares

Reporting requirements vary for each of the carbon pools. The estimates for the pools that are derived from sampling must meet the quality standards described later in this document. Table B.1 displays the reporting requirements for each of the carbon pools.

Table B.1. Reserve Requirements for Carbon Pool Categories and Determination of Value for Pool

Category	Carbon Pool	Improved Forest Management	Avoided Conversion
Living Biomass	Live Trees	Required for project reporting	
	Shrubs and Herbaceous Understory	Not allowed for project reporting	
Onsite Dead Biomass	Standing Dead Trees	Required for adherence to Natural Forest Management criteria	
		Required for project reporting	
	Lying Dead Wood	Required for adherence to Natural Forest Management criteria	
		Not allowed for project reporting	
	Litter	Not allowed for project reporting	
Soil	Soil	Required for emissions reporting associated with management activities, if applicable	

		Not allowed for reporting of project benefits	Optional for reporting of project benefits in Avoided Conversion projects only
Offsite Dead Biomass	Harvested Wood Products	Required for project reporting	

B.2 Guidance for Estimating Carbon in Forest Carbon Pools

This section describes requirements for the development of values for the forest carbon pools described in Table B.1. Project Operators must include an inventory methodology in the Project Design Document. The inventory methodology must include the required provisions identified in this section.

B.2.1 Inventory Methodologies

All inventory methodologies must be based on randomized or systematic sampling and include the minimum quality parameters described in this section for each carbon pool. Inventory methodologies must describe the process for locating sample plots. Sample plot locations may be monumented in such a way to assist in relocating them for quantification and verification purposes. Plot monument strategies that incorporate Global Positioning Systems (GPS) along with additional navigational strategies at close range to plot centers (that direct verifiers to the precise plot location) that are resistant to weather, wildlife, and other environmental factors, can substantially reduce verification costs. Project Operators are advised to consider the verification guidance (Section 9) associated with verification of sampled carbon pools (in particular, the sequential sampling guidance) prior to settling on a strategy to monument plot locations.

To increase the efficiency of both project development by Project Operators and verification by verifiers, the Reserve has developed a Standardized Inventory Methodology that Project Operators may optionally use to determine how to collect sample data. The Standardized Inventory Methodology is available on the Forest Project Protocol webpage and draws on observations about the standards and methodologies that have performed well for registered forest carbon projects. Designed in consultation with experienced project developers, verifiers and forest mensuration experts, it was created in consideration of a variety of factors, such as being suitable for use in a variety of forest conditions, achieving consistent results in consecutive plot measurements, and minimizing ambiguity in interpretation of conditions in the field.

Additionally, the Standardized Inventory Methodology was developed to be consistent with the Climate Action Reserve Inventory Tool (CARIT), an inventory management computer application that Project Operators may also optionally use to manage and update their forest inventories. CARIT is available on the Forest Project Protocol webpage at no cost. With CARIT, Project Operators will be able to manage forest inventories, calculate timber and carbon stocking, and update inventories for growth, disturbances (including harvests), and updated sampling data. The volume and biomass equations required by the Forest Project Protocol are already programmed into CARIT, eliminating the need for Project Operators to apply such equations on their own and ensure they are correctly applied. Additionally, CARIT generates reports that are tailored specifically to the reporting requirements of the Forest Project Protocol.

The use of the Standardized Inventory Methodology does not obligate a Project Operator to use CARIT, nor does the use of CARIT obligate a Project Operator to use the Standardized

Inventory Methodology. However, CARIT will only function properly if certain inventory standards are followed. For example, only fixed area plots may be used—variable radius plots are not allowed.

B.2.2 Updating Forest Inventories

Forest inventories are always in flux due to forest growth, harvest, and natural disturbances. Therefore, inventories of carbon pools must either be updated or re-measured at a frequency commensurate with the anticipated or actual changes in the specific carbon pools so that sample plots and forest stratification reflect current conditions. Project Operators must report their estimated carbon stocks on an annual basis. Since it is infeasible to immediately re-measure all plots following forest growth and disturbances that affect plot measurements, acceptable strategies for updating project inventory estimates are described in this section.

B.2.2.1 Updating for Forest Growth

Updating plot data for forest growth can be accomplished through the use of growth models or stand table projections that mimic the diameter and height increment of trees in the inventory database. Any plot data that are updated to reflect current conditions with the use of predicted increments of height and diameter data will be used during site visit verifications to compare against verifier's field measurements using the sequential sampling techniques described in Section 9 of the protocol. This provision ensures that plot measurements and update processes are within accuracy thresholds.

Plot data reported should always coincide with the end of the reporting period. If plot data was taken before the end of the reporting period, it should be grown forward to coincide with the end date. Similarly, if plot data was taken after the end of the reporting period, it should be degrown to the end date. The Project Operator may determine a reasonable method for apportioning growth to the reporting period end date, and should employ the same method whenever new inventory measurements are taken. Projects utilizing CARIT should report plot data for the relevant reporting period year as output by CARIT.

B.2.2.2 Updating for Disturbances (Including Harvest)

Inventory estimates must be updated annually for any disturbance (including harvest disturbance) that results in an estimated reduction to the reported carbon pools of 0.5 percent or more. However, given that it may be infeasible to re-measure all plots following a disturbance, up to 5 percent of the total inventory plots used to derive the inventory estimate can be excluded at any one time. Only plots in disturbed areas may be excluded, and no plot can be excluded for a period of time greater than one reporting period. Plots that are geographically situated in areas that experienced forest cover class-changing harvests and/or natural disturbances in the previous year must be excluded from the inventory analysis until the plots are updated with re-measured data from field visits, subject to the 5 percent limit on excluded plots outlined above.

If the inventory is stratified, the area that has been disturbed can simply be re-stratified with a stratum that reflects the post-disturbance forest condition, following the stratification rules developed for the project. Any plots that existed in the disturbed area must be removed from the set of plots used to estimate the stratum average unless, and until, the affected plots are re-measured. Verification of stratified inventories must ensure that the area disturbed is accurately characterized in the inventory GIS system and that the assigned stratum reflects the forest condition.

For non-stratified inventories, an estimated tree list that represents the post-disturbance condition of the forest must be assigned to any plots affected by the disturbance. The tree list must be carefully selected to not overstate the carbon pools present. Site verification of post-disturbance plots will evaluate whether the tree list assigned is appropriate for the post-disturbance condition. No more than 10 percent of the project's area may be represented through estimated plots without increased verification scrutiny during a site visit. Specifically, where more than 10 percent of the project's area is based on estimated tree lists assigned to plots, verification using sequential sampling techniques shall include all plots (including estimated plots) in the sequential sampling comparison between Project Operator estimates and verifier estimates.

Plots that are estimated shall not be used in the calculations for sampling error. Estimates from sampled pools must meet a minimum confidence standard of +/- 20 percent at the 90 percent confidence interval. It is acceptable to calculate the descriptive statistics, including confidence intervals, using plot data that have been updated to a current date. Discounts for uncertainty are applied to project estimates when confidence standards are below +/- 5 percent at the 90 percent confidence interval. This is described in greater detail below.

B.2.3 Requirements for Estimating Carbon in Standing Live and Dead Trees

It is required that both standing live and standing dead trees be sampled. It is acceptable, but not required, to combine standing live and dead trees during sampling such that descriptive statistics, including confidence statistics, address the combined pools. Whether combined or not, tree data must be coded so that mean estimates can be interpreted independently for standing live and standing dead pools to allow monitoring of standing dead trees with respect to requirements in Section 3.9.2 (Natural Forest Management).

Inventory methodologies must include a description of how the sampled data will be archived and the analytical tools that will be included in the analysis of carbon stocks. The tree lists that are developed from inventory sampling and used to expand inventory estimates to the project level must be available for verification review. It is acceptable for the tree list to be presented and reviewed in an electronic format, such as in a database or spreadsheet application. Table B.2 displays the requirements that all project inventory methodologies must include for standing live and dead trees.

Table B.2. Requirements for Sampling Standing Live and Standing Dead Trees

Species	1. All trees sampled must include a species identifier. The inventory methodology must provide a crosswalk between any codes used to identify a species and the species name the codes represent. 2. Since all trees contain carbon, the inventory methodology must indicate that the sample methodology will include all species present within the project area.
Diameter at Breast Height (DBH) Measurements	1. Inventory estimates must include all trees 5 inches DBH and larger. It is acceptable that inventory methodologies include trees with DBH less than 5 inches. 2. The location of the measurement of DBH must follow U.S. FIA sampling guidelines (can be found on the Forest Project Protocol webpage). 3. Measurement precision must be no greater than the nearest inch.

Height	1. Inventory methodologies must describe whether all trees on sample plots are measured for height or whether a subset of the sample plot heights is measured and regression estimators are developed for unmeasured heights. 2. Inventory methodology must describe whether height measurements describe the tree's total height or some other top height measurement (regression estimators, or published form equations, may also be used to estimate top heights from a partial height or vice versa). Where regression estimators are used for tree heights, the inventory methodology must describe the populations from which the regression estimators were acquired. 3. The sampling precision for tree heights (when measured) must be stated in the inventory methodology. Stated acceptable precision for measured heights not to be greater than +/- 10 feet. 4. The inventory methodology must include a description of the maximum angle accepted for measuring tree heights. The stated maximum acceptable slope to the measured height shall not exceed 120 percent.
Weight (Plot Area and Forest Strata)	1. All methodologies must describe the sample plot areas used to determine which trees are included for measurement. 2. All tree lists must include a field(s) that displays the weighting of each sampled tree in order to expand the sampled tree to a per acre value. 3. Where inventories are stratified, the governing rules for stratification and stratification methodology must be described. The process for updating forest strata must be described. 4. Where inventories are stratified, stratum areas must be provided at verification with maps and tabular outputs.
Status	1. Each sampled tree must be identified as live or dead. 2. Dead trees must be coded with the decay status so density adjustments can be made. Decay class descriptions and density adjustments are provided below.
Biomass Equations	1. All projects must calculate the biomass in each tree using the biomass equations provided by the Reserve (can be found on the Forest Project Protocol webpage). 2. The project's inventory methodology must include a list of the equations and cite the version of the Reserve's equation file from which they were copied. a. The CARIT tool (optional) includes approved biomass equations to reduce the burden of verification.
Deductions for Missing Biomass	1. Both live and dead trees may have cavities, broken tops or other deformities that reduce the biomass in the trees. Therefore, the inventory methodology must include a description of how deductions are estimated to account for missing biomass. The Reserve has provided guidance below that is acceptable. Alternative methods that address deductions for missing biomass are subject to approval by the Reserve.

Sampling methodologies and measurement standards should be consistent throughout the duration of the forest project. If new sampling methodologies are incorporated during the project life, they must be approved by the Reserve. Sampling methodologies and measurement standards will be evaluated for their statistical validity. Additionally, uncertainties in estimates associated with modifications to sampling methodologies may require reconciliation to project data and/or baseline estimates and shall be conducted at the Reserve's sole discretion. The application of a revised sampling methodology can only occur as part of a site visit verification.

B.2.4 Use of Regression Equations

It is acceptable to develop carbon inventories using regression estimators to estimate tree heights. Project Operators must keep in mind that plots or (sub) populations will be randomly selected for verification and that regression estimators should be used where a high level of certainty can be developed from the estimators. Failure to do so will result in increased effort and cost to meet the standards of verification.

B.2.5 Forest Vegetation Stratification

Stratification is not required, but it may simplify verification and possibly lower the costs of verification. Where forest vegetation is stratified, inventory methodologies must describe the guidelines used for stratification. Traditional stratification decisions are usually based on species composition, forest stem size (DBH or height), and density. It is important that the stratification be relevant to sampling forest carbon. The minimum polygon size to which the stratification guidelines apply must be included in the methodology. A map of current forest strata must be included in the Project Design Document. The methodology must also include the process guidelines for updating forest strata for disturbance and growth events.

B.2.6 Quantification of Carbon in Live Trees from Project Data

All projects must use the appropriate biomass equations for the assessment areas the project is located in. The required biomass equations are found on the Reserve's Forest Project Protocol webpage. The calculation of CO_2e for each tree must be conducted in a manner that provides project estimates for:

- Whole tree biomass (roots, stump, bark, bole, top, and branches). Whole tree estimates are used to provide project totals and estimates of emissions associated with harvest activities.
- Bole biomass. The bole must be calculated when the bole portion of harvested trees are delivered to manufacturing facilities for processing. It is used as the basis for determining carbon persisting in long-term wood products.
- Aboveground portion (stump, bark, bole, top, and branches) used to compare project data to Common Practice statistics for Improved Forest Management projects.

Projects outside of California, Oregon, Washington, Alaska, and Hawaii use estimators for non-bole portions of the tree referred to as the Component Ratio Method (CRM). The CRM must be used to compute the various portions of the tree mentioned above. Guidance for the use of the CRM is provided in the biomass equations section of the Reserve's Forest Project Protocol webpage.

Projects in California, Oregon, Washington, Alaska, and Hawaii must use the biomass equations provided on the Reserve's Forest Project Protocol webpage to calculate the aboveground portion of the trees. The Cairn's equations (Cairns, Brown, Helmer, & Baumgardner, 1997) must be used to calculate CO_2e in the below-ground portion of the trees. The Cairn's equations must be used for the appropriate latitude for the project. The Cairn's equations are as follows:

Equation B.1. California, Oregon, Washington (Temperate Equation)

BBD = exp[-0.7747 + 0.8836 x ln(ABD)]

Where,			Units
BBD	=	Belowground biomass density of standing live trees	tonnes/hectare
ABD	=	Aboveground biomass density of standing live trees	tonnes/hectare

Equation B.2. Alaska (Boreal Equation)

BBD = exp[-0.8713 + 0.8836 x ln(ABD)]

Where,			Units
BBD	=	Belowground biomass density of standing live trees	tonnes/hectare
ABD	=	Aboveground biomass density of standing live trees	tonnes/hectare

Equation B.3. Hawaii (Tropical Equation)

BBD = exp[-1.0587 + 0.8836 x ln(ABD)]

Where,			Units
BBD	=	Belowground biomass density of standing live trees	tonnes/hectare
ABD	=	Aboveground biomass density of standing live trees	tonnes/hectare

This estimate must be converted from biomass in tonnes per hectare to CO_2e in tonnes per acre using the conversions identified earlier in this guidance.

B.2.7 Adjustments to Standing Live and Standing Dead Trees for Missing Volume and Decay

Both standing dead trees and standing live trees may be missing portions of the tree as the result of physical and biological disturbances. Tree biomass needs to be adjusted for missing parts to produce an improved estimate of the tree's biomass. Calculating CO_2e in standing dead trees raises additional challenges since they may be in stages of decay such that density equations in standard biomass equations for live trees do not provide an accurate estimate. The guidance in this section provides a standardized method to account for biomass adjustments.

The first step is to estimate the gross biomass in the tree as if it were whole, using the biomass equations (the first step in the biomass and carbon calculations) provided on the Reserve's Forest Project Protocol webpage. The tree's biomass is then adjusted based on the tree's 'net' biomass and adjusted density estimates for standing dead trees. To standardize, the tree is divided into four parts: top, middle, bottom (visually estimating the original disposition of the aboveground portion of the tree when it was alive and vigorous), and the below-ground portion. The below-ground portion must be calculated as it would for a normal, healthy tree, using the Cairn's equation where the regional biomass equations are used instead of the CRM. It is assumed that the below-ground portion is intact and complete. The standardized percentages assumed to be in each portion of the tree are shown in Table B.3.

Table B.3. Assumed Percentages of Biomass in Each Portion of the Tree

Tree Portion	Percent of Tree Biomass
Top 1/3	10%
Middle 1/3	30%
Bottom 1/3	60%

An ocular estimate is made of the portion remaining in each section of the tree during field sampling. Deductions from gross volume are made for anything that reduces the tree's gross biomass, including breakage and cavities. The percentage remaining in each third is then summed to calculate the net biomass remaining in the tree.

The tree's density must be adjusted to account for the varying states of decay in the remaining portion of the tree. Because standing dead wood does not have the same density as a live tree, a density reduction must be applied. Standing dead wood may fall into five decay classes, which must be recorded during the field sampling. The five decay classes, described in Table B.4, are qualitative, based on the physical characteristics of the dead tree (USDA 2007, Woundenberg et al., 2010).

Table B.4. Decay Classes

Decay Class	Description of Condition of Standing Dead Wood
1	All limbs and branches are present; the top of the crown is still present; all bark remains; sapwood is intact with minimal decay; heartwood is sound and hard.
2	There are few limbs and no fine branches; the top may be broken; a variable amount of bark remains; sapwood is sloughing with advanced decay; heartwood is sound at base but beginning to decay in the outer part of the upper bole.
3	Only limb stubs exist; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay in upper bole and is beginning at the base.
4	Few or no limb stubs remain; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay at the base and is sloughing in the upper bole.
5	No evidence of branches remains; the top is broken; less than 20 percent of the bark remains; sapwood is gone; heartwood is sloughing throughout.

The density identified for each species in the biomass equations posted on the Reserve's Forest Project Protocol webpage must be modified for decay classes 2 to 5 using the reduction factors displayed in Table B.5,[39] which are multiplied by the densities provided in the biomass equations.

Table B.5. Average Density Reduction Factors for Standing Dead Wood for Hardwoods and Softwoods by Decay Class

Softwoods		Hardwoods	
Decay Class	**Reduction Factor**	**Decay Class**	**Reduction Factor**
2	1.0	2	0.8
3	0.92	3	0.54
4	0.55	4	0.43
5	0.29	5	0.22

[39] Harmon et al. (2011). Differences between standing and downed dead tree wood density reduction factors: A comparison across decay classes and tree species. Res. Pap. NRS-15. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 40 p.

An example of field data that has all of the required elements for calculating the standing dead tree's CO_2e is shown in Table B.6.

Table B.6. Example: Data Attributes Needed to Calculate CO_2e in Standing Dead Trees

Tree Number	Species (type)	Status	DBH (inches)	Height* (feet)	Percent Remaining			Decay Class
					Top 1/3 of Tree	Middle 1/3 of Tree	Bottom 1/3 of Tree	
1	Hardwood	Dead	16	95	0%	50%	100%	3

*Estimated height prior to death

The density of the tree must be adjusted based on its decay class. The first step is to calculate the tree's biomass as if the tree were a normal tree to determine the tree's gross biomass. Net biomass is determined by multiplying the gross biomass of the tree by the reduction factor displayed in Table B.5. An example is provided in Table B.7.

Table B.7. Example: Adjusting Biomass Calculation for Decay Using Density Adjustment Factors

Tree Gross Biomass	Density Reduction Based on Decay	Net Biomass
(tonnes CO_2e) (Assumed)	(from Table B.5 for a hardwood with a decay class '3')	(tonnes CO_2e) (Assuming tree is whole)
0.100	0.54	0.054

As an example of the application of the biomass deductions for missing sections of the tree, using the data from Table B.6 above, a tree (assuming normal form) with a net biomass of 0.054 CO_2e tonnes would be further adjusted to a net biomass for the missing portions of the tree as shown in Table B.8.

Table B.8. Example: Calculating Net Biomass in a Tree

Tree Portion	Percent of Tree Biomass	Gross Biomass	Percent Remaining in Tree	Net Biomass
	(from Table B.3)	(tonnes CO_2e) Percent of tree biomass **x** tree biomass adjusted for density (Table B.7)	(from example in Table B.6)	(tonnes CO_2e) Percent remaining in tree **x** gross biomass
Top 1/3	10%	10% **x** 0.054 **=** 0.0054	0%	0.00000
Middle 1/3	30%	30% **x** 0.054 **=** 0.0162	50%	0.0081
Bottom 1/3	60%	60% **x** 0.054 **=** 0.0324	100%	0.0324
Total Biomass			200	0.0405

B.2.8 Requirements for Estimating Lying Dead Wood Carbon

All projects must either maintain an inventory of lying dead wood for the project area or monitor harvested areas according to the guidance in this section to ensure the project meets the conditions identified in Section 3.9.2 (Natural Forest Management). Lying dead wood is not eligible for crediting due to the high variability associated with estimating lying dead wood, resulting in estimates with unacceptable levels of uncertainty for crediting. Project Operators are required to include the status of lying dead wood with each monitoring report.

Project Operators that choose to meet the monitoring requirement by maintaining an inventory of lying dead wood must meet the following requirements:

1. Inventory plots or transects used to provide the lying dead wood estimate must be no older than 12 years.
2. Data collected for lying dead wood must include the estimated species, adequate data to estimate volume, and decay class, as defined by Table B.9 below, to estimate the density of the piece of lying dead wood to determine biomass.
3. The sampling methodology must be included in the Project Design Document. The Reserve is not prescriptive with regards to the sampling design, other than adhering to general statistical principles of randomness. Fixed area plots and line transects, among other sampling methodologies, are acceptable.
4. The inventory sampling confidence in the estimate of lying dead wood must be at +/- 30 percent at 1 standard error.

Project Operators that choose to meet the monitoring requirement through monitoring of harvested areas must meet the following requirements:

1. A harvested area is any area where commercial removal of forest vegetation has occurred.
2. A map of all areas harvested during the last reporting period must be submitted with the annual monitoring report and must include the harvest date.
3. All harvested areas must be monitored within one year of the harvest date.
4. Fixed area strips shall be randomly located on compass bearings chosen by the Project Operator (but maintained consistent within each harvest area). A recommended width of the fixed area strip is 66 feet (1 chain), which will require monitoring in each of the 33 foot areas on either side of the center line. Ten square chains equals one acre. Project Operators can determine the width of the strip that best suits the vegetation conditions present in the harvested area.
5. A map shall be produced that displays the location of the fixed area strips on the harvested areas. The width of the strip shall be documented for each strip.
6. The minimum area monitored shall be 5 percent of each harvested area.
7. Data collected within the fixed area strip must include the estimated length of the piece of lying dead wood, the average diameter of the lying dead wood, the estimated species, and the decay class as defined by Table B.9 below.

Lying dead wood density must be adjusted to account for the state of decay. Because lying dead wood does not have the same density as a live tree, a density reduction must be applied. Lying dead wood may fall into five decay classes, which must be recorded during the field sampling. The five decay classes are qualitative based on the physical characteristics of the dead tree (USDA 2007, Woundenberg et al., 2010).

Table B.9. Decay Class Descriptions of Lying Dead Wood

Decay Class	Description of Condition of Lying Dead Wood
1	Sound, freshly fallen, intact logs with no rot; no conks present indicating a lack of decay; original color of wood; no invading roots; fine twigs attached with tight bark.
2	Sound log sapwood partly soft but cannot be pulled apart by hand; original color of wood; no invading roots; many fine twigs are gone and remaining fine twigs have peeling bark.
3	Heartwood is still sound with piece supporting its own weight; sapwood can be pulled apart by hand or is missing; wood color is reddish-brown or original color; roots may be invading sapwood; only branch stubs are remaining which cannot be pulled out of log.
4	Heartwood is rotten with piece unable to support own weight; rotten portions of piece are soft and/or blocky in appearance; a metal pin can be pushed into heartwood; wood color is reddish or light brown; invading roots may be found throughout the log; branch stubs can be pulled out.
5	There is no remaining structural integrity to the piece with a lack of circular shape as rot spreads out across ground; rotten texture is soft and can become powder when dry; wood color is red-brown to dark brown; invading roots are present throughout; branch stubs and pitch pockets have usually rotten down.

The density identified for each species in the biomass equations posted on the Reserve's website must be modified for decay classes 2 to 5 using the reduction factors displayed in Table B.10,[40] which are multiplied by the densities provided in the biomass equations.

Table B.10. Average Density Reduction Factors for Lying Dead Wood for Hardwoods and Softwoods by Decay Class

Softwoods		Hardwoods	
Decay Class	**Reduction Factor**	**Decay Class**	**Reduction Factor**
2	0.87	2	0.74
3	0.70	3	0.51
4	0.40	4	0.29
5	0.29	5	0.22

An adjusted density coefficient for the downed logs is calculated by multiplying the density coefficient provided with the biomass equations on the Reserve's Forest Project Protocol webpage by the reduction value in the table above. The adjusted density value is multiplied by the volume estimate in the lying dead wood to determine the biomass.

[40] Harmon et al. (2011). Differences between standing and downed dead tree wood density reduction factors: A comparison across decay classes and tree species. Res. Pap. NRS-15. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 40 p.

B.2.9 Requirements for Estimating Soil Carbon Emissions and Soil Carbon Quantification for Avoided Conversion Projects

All projects must estimate the soil carbon emissions associated with project management practices. Avoided Conversion projects are eligible (optional) to report the baseline soil carbon emissions the project activity is avoiding. This section provides guidance for estimating soil CO_2e within the project boundaries, and quantifying emissions associated with project activities.

No direct sampling of soil carbon is required for projects that are reporting soil carbon emissions only as part of project management practices. Rather, the estimate of emissions is based on soil carbon estimates from United States Geological Survey (USGS) data for project sites and comparing the data to standardized guidance to assess emissions based on management activities.

For Avoided Conversion projects, the project benefit is determined by comparing the project soil carbon estimate (from sampling) to the standardized estimate of emissions associated with the activity. Currently, only Avoided Conversion projects that demonstrate a risk of conversion to agriculture (all soil orders, grazing not included) and projects that demonstrate a risk of conversion to residential and commercial use (only histosols) are eligible to report soil carbon benefits associated with the avoided conversion activity. Other conversion risks are not currently eligible for this type of reporting.

To summarize, Table B.11 provides the two different approaches to quantifying soil carbon benefits and/or emissions.

Table B.11. Soil Carbon Quantification Methods by Project Type

Project Description	Project Type Identification	Method to Estimate Project Soil Carbon (CO_2e) Stocks	Method to Estimate Project Effects on Soil Carbon (CO_2e)
Project will provide benefits by avoiding soil carbon emissions associated with conversion to agriculture and, in certain cases, residential or commercial (Avoided Conversion)	1	Soil carbon sampling required at project initiation	Initial avoided conversion effects estimated through standardized guidance
			Follow guidance in Step 7
		Follow guidance in Steps 1, 4, 5, and 6	Ongoing project effects estimated through default estimates of soil carbon emissions
			Follow guidance in Steps 1, 4, 5, and 6
Project is reporting management-related emissions	2	Use of USGS data	Project effects estimated through default estimates of soil carbon emissions
		Follow guidance in Steps 1, 2, 3, and 6	Follow guidance in Step 7

B.2.9.1 Developing an Estimate of Soil CO_2e within the Project Boundaries

Step 1: Identify Soil Orders Present Within Project (**Project Types 1 and 2**)

Project Operators must determine the soil orders present in their project area and the area each soil order represents. Where Natural Resource Conservation Service (NRCS) soil data is

available on the NRCS website (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx), projects must use this data. Where NRCS data is either unavailable or believed to be in error at the project site, Project Operators may present the soil orders and area represented by each order with an official letter from a local NRCS representative stating that the portrayal of the soil orders by the Project Operator is accurate. The letter must state why existing data is either absent on the NRCS website or why the data is not accurate.

On the NRCS website mentioned above, users must create an Area of Interest (AOI), using the website tools, that approximates the project boundaries. To determine the soil order, users select the soil reports tab, select land classifications, and select "Taxonomic Classification of Soils". This report provides a taxonomic classification of each of the soils in the AOI. The last four letters of the soil descriptions correspond to the soil order. For example, a soil classified as Xerochrepts is in the Inceptisol order. Table B.12 below displays the soil orders associated with the last four letters in the soil descriptions.

Table B.12. Soil Orders

Soil Order	Last Four Letters in Soil Description
Alfisol	-alfs
Andisol	-ands
Inceptisol	-epts
Mollisol	-olls
Spodosol	-ods
Ultisol	-ults
Histosol	-ists

Step 2: Obtain Soil Organic Matter Values (**Project Type 2**)

Select the tab entitled 'Soil Properties and Qualities', then select 'Soil Organic Matter' and within the advanced options, select 'Weighted Average'. For the aggregation method, select 'Higher' as the tie break rule, and designate '0-30 cm' for the soil depth. Next, click 'View Ratings' to review the organic matter percentage for each soil type in the AOI. Convert the number from the rating to decimal percent by dividing by 100.

Step 3: Obtain the Soil Bulk Density Values (**Project Type 2**)

Soil bulk density estimates are determined by first selecting the 'Soil Properties and Qualities' tab, the 'Bulk Density' tab next, followed by the 'On-third Bar'. Specify the 'Weighted Average' method and soil depth (0-30 cm, unless otherwise noted). Select 'View Ratings. The ratings will provide bulk density values for each soil type in the AOI. If the bulk density values are not available in the database, determine whether the soil orders are qualified as sandy, loamy, or clay using the 'Surface Texture' value in the Soil Properties and Qualities tab and then apply default values of 1.2 g/cm^3 for clay soils, 1.6 g/cm^3 for sand soils, and 1.4 g/cm^3 for loam soils.

Step 4: Sample for Soil Organic Matter (**Project Type 1**)

Soil carbon estimates are based on sampling soil organic matter for the project. Materials needed include:

- Rubber mallet
- Square spade (for removing organic material from core site)
- Soil probe

- Compass
- Trowel and/or sturdy knife (for cleaning soil off outside service of probe)
- Plastic bags (1 bag for each soil core)
- Marking pen
- Measuring tools (meters and centimeters)

Step 4a: Identifying the Plot Locations

Plots must be located randomly or systematically with a random start in each of the soil orders that occur on the project site. An adequate number of plots is needed to ensure the overall estimate of soil carbon meets or exceeds the minimum confidence levels stated in the protocol (+/- 20 percent at 90 percent confidence level). It is acceptable to use the same, or a subset of, plot locations as used for biomass sampling, so long as each soil order is sampled and the overall soil carbon estimate achieves the confidence standards stated above.

Step 4b: Identify Four Random Locations at Each Plot and Extract Soil Organic Matter Samples

4b-i: Select a random number by glancing at a watch's second hand (or digital version). Multiply this number by six to derive a compass bearing to use for the soil sample locations. Following the determined compass bearing, measure 10 meters from the plot center and establish each of the four soil sample locations. Minimal spatial adjustments (less than 2 meters) can be made to avoid rocks and roots from impacting the ability to sample. If obstacles cannot be avoided within 2 meters, an additional sample location must be selected using the method described above.

4b-ii: For each sample location, insert a soil core probe (minimum diameter, ½ inch) into the soil at the sample location to a depth of 30 cm. A rubber mallet may be used to facilitate penetration. If the probe will not penetrate to the required depth, the probe must be removed, wiped free of soil, and inserted in an alternate location with a 2 meter radius from the sample location. If repeated efforts result in difficulties achieving full penetration, an additional sample location must be chosen as described in Step 4b-i. If full penetration is not achieved within two efforts to locate a satisfactory sampling location, the sample must be taken from the initial sample location and the depth recorded.

4b-iii: Soil must be extracted carefully from the probe to avoid losing any of the soil collected. Should any soil be lost, the sample must be rejected and a new sample location selected as described above. The extracted soil is placed in a sealable plastic bag. Label the bag with the plot number followed by the letter "SOM", indicating the sample is a "soil organic matter" sample (not a bulk density sample).

4b-iv: The soil organic matter samples must be sent to a laboratory with expertise in analyzing soil carbon and physical properties within 106 hours of the acquisition of the samples from the plot sites. The laboratory must receive instructions that the samples are to be heated to over 1000 degrees Celsius. This heat will burn off the carbon and a detector is to be used to measure the amount of carbon dioxide produced and reported as a percent of the volume sampled.

Step 5: Sample for Bulk Density (**Project Type 1**)

Sampling for soil bulk density must be conducted on the project site. Materials needed include:

- Rubber mallet
- Piece of wooden 2x4 approximately 1 to 2 feet in length
- Square spade
- Soil core/ring with known volume
- Trowel and/or sturdy knife
- Plastic bags (1 bag for each soil pit)
- Marking pen
- Measuring tools (meters and centimeters)

Step 5a: One random location 4 meters from each plot center must be selected for soil data collection to dig a soil pit to a depth of at least 30 cm^3. The measure of depth must be below the organic layer (branches, leaves, moss, etc.). The sides of the pit can be made straight using the trowel or the study knife. Random selection is achieved through the use of the second-hand method described in Step 4b-i. Adjustments to the location of the pit can be made using the adjustments allowed for difficulties associated with inserting soil probes described in 4b-ii.

Step 5b: Two samples will be taken from the soil pit. The sample is taken by centering the soil ring at a depth of 7.5 cm and the second is taken by centering the ring at a depth of 22.5 cm. The ring is inserted perpendicular to the pit face. The location of each insertion must be into undisturbed soil, as occurs during the process of extracting the soil rings. The soil pit can be expanded to ensure that undisturbed soil is sampled.

5b-i: For each of the samples the sharp end of the ring is pushed in, without twisting, as far as possible with the hands.

5b-ii: The piece of wood is placed over the ring and gently hammered evenly into the soil. If strong resistance is encountered, an alternate location may be found within the pit, or a new pit located using the guidance described above.

5b-iii: Using the trowel or sturdy knife, soil is removed around the outside of the ring to allow for extraction of the ring without losing soil. The surfaces of the ring should be cleaned and cut flush to the surface of the ring. Small losses during extraction and cleaning (up to 2 cm^3) can be restored by filling the void with soil from the pit site and smoothing. Samples must be rejected if soil losses from the ring occurring during extraction and cleaning are greater than 2 cm^3.

5b-iv: The soil from both ring samples is placed in one sealable plastic bag and labeled with BD and the plot number.

5b-v: The bulk density samples must be sent to laboratory with expertise in analyzing soil carbon and physical properties within 106 hours of the acquisition of the samples from the plot sites. Bulk density instructions sent with the samples shall describe that the samples are to be dried at 105 degrees centigrade for at least 48 hours and that all portions of the sample are to be retained (including rocks). The laboratory shall present the results of the analysis of bulk density estimates as g/cm^3, displaying dry weight over total sample volume.

Step 6: Calculate the Total Soil CO_2 per Acre (**Project Types 1 and 2**)

Use Equation B.4 (below) to calculate the soil CO_2 per acre.

Equation B.4. Soil CO_2e per Acre

Soil CO_2e	=	Organic Matter Value (Steps 2 or 4) **x** 0.58 (Conversion of Organic Matter to Carbon) **x** Bulk Density Value (Steps 3 or 5) **x** Soil Depth Sampled (30 cm) **x** 40,468,600 (Conversion of 1 cm^2 to 1 acre) **x** 10^{-6} (Conversion of 1 gram to 1 metric ton) **x** 3.667 (Conversion of Carbon to CO_2)

An example is provided in Table B.13 below.

Table B.13. Example: Calculation for Total CO_2 per Acre

Organic Matter from Steps 2 or 4		0.05
Conversion of Organic Matter to Carbon	x	0.58
Bulk Density (g/cm^3) from Steps 3 or 5	x	1.2
Soil Depth Sampled (30 cm)	x	30
Conversion of 1 cm^2 to 1 acre (1 acre = 40,468,600 cm^2)	x	40,468,600
Conversion of 1 gram to 1 metric ton Carbon	x	0.000001
Conversion of 1 metric ton Carbon to 1 metric ton CO_2	x	3.667
Estimated Metric Tons CO_2 per Acre	=	155.05

Step 7: Quantify the Project Effects on Soil CO_2e (**Project Types 1 and 2**)

Project effects are calculated using the standardized guidance below. Avoided Conversion projects must use the standardized guidance for purposes of estimating project benefits. Soil carbon emissions resulting from management activities are determined where the activity, or set of activities, leads to a net loss of soil carbon across the entire project. Net emissions can occur across the project area in a sustainably managed forest where emissions from management activities are not restored during the rest, or growth, cycle of the stand. The default values provided are derived from scientific literature and address the high-end estimates of net emissions associated with management activities, except in the case of conversion where it is more conservative to underestimate the emissions associated with the avoided activity. The background documentation[41] for the default values is found on the Reserve's Forest Protocol Version 3.3 webpage under References.

Default emission values are provided as percentages for each soil order, based on harvesting intensity, site preparation intensity, and the frequency of disturbance. Project Operators must report their soil carbon emissions by grouping the total acres in each permutation, or class of soil order, harvesting intensity, site preparation intensity, and frequency of disturbance, rather than reporting on an individual stand basis. An example of reporting classes of management activities is provided below, following the descriptions of the management activities.

[41] Gershenson, Alex. Establishing a Standardized Method to Account for Soil Carbon Emissions Associated with Management Activities.

Net carbon emissions are estimated as the difference between carbon stocks (CO_2e) in the soil prior to the management activity and the carbon stocks (CO_2e) in the soil immediately prior to the subsequent harvest event for each harvested stand. Index values are provided for both harvesting intensity and site preparation intensity that, when combined, classify the harvesting intensity for the stand. The index value for harvesting intensity is derived from both the amount of biomass removed during harvest and the soil disturbance associated with the biomass removal. The index value for site preparation is based on the amount of soil disturbance associated with site preparation activities.

For each stand harvested in a given reporting year, Project Operators must determine the harvesting intensity using the guidance below. For Avoided Conversion projects, the guidance is used below to assist in determining baseline conditions and applied to the project rather than individual stands.

Step 7a: Harvesting Intensity

First, the biomass removal index value is determined for the stand based on the amount of biomass removed during harvest. The harvesting intensity value is calculated using a factor for the amount of biomass removed and the amount of soil disturbance that occurs removing the biomass. Both values are added together to calculate the harvesting intensity. The value for disturbance related to biomass removal is determined using Table B.14 below:

Table B.14. Determination of Biomass Removal Index

Biomass Affected by Harvest		
Percentage Pre-Harvest Aboveground Biomass Removed	**Silviculture Activities Generally Associated with Level of Biomass Removed**	**Biomass Removal Index**
< 10%	Sanitation Salvage	0
10 – 50%	Selection, Thinning	0
51 – 80%	Rotation harvest with biomass remaining in tree tops, seed/shelterwood and/or retained trees	1
> 80%	Rotation harvest with whole tree harvesting and little retention	2
Not a Silvicultural Activity – There is no intent to follow up with efforts to regenerate forested conditions		
Based on Table 6.3	Conversion – only relevant to assessment of Avoided Conversion baseline	10

Step 7b: Soil Disturbance from Harvesting Activities

The second value considered for determining the harvest intensity is based on the level of soil disturbance associated with biomass removal. Soil disturbance within the harvested stands boundary may be the result of skidding logs, tree falling, and harvesting equipment. The disturbance may be extensive or minimized, depending on site-specific conditions and care taken during harvesting operations. The soil disturbance index is based on the amount of mineral soil (below the organic layer, including litter and duff) exposed due to harvest activities. The determination of the amount of mineral soil disturbance is from ocular inspection of harvested stands. Table B.15 below is used to determine the soil disturbance index from harvesting.

Table B.15. Determination of Soil Disturbance Index

Percent of Mineral Soil Exposed during Harvest	Soil Disturbance Index
< 5%	0
5 - 20%	2
20 - 40%	3
40 - 60%	4
> 60%	5

Step 7c: Determining the Harvesting Intensity Class

The values for the biomass removal index and the soil disturbance index are summed together to determine the harvesting intensity class, displayed below in Table B.16.

Table B.16. Harvesting Intensity Classes based on Summing the Biomass Removal and Soil Disturbance Indexes

Harvesting Intensity Classes	
Harvesting Intensity Class	**Sum of Biomass Removal and Soil Disturbance Indexes**
Light to Medium	< 3
High	3 - 4
Very High	5 - 7
Conversion	> 7

Step 7d: Determining Site Preparation Classes

For each stand harvested, the Project Operator must determine the site preparation index using the guidance in Table B.17.

Table B.17. Site Preparation Classes and Descriptions of Management Activities

Site Preparation	
Site Preparation Class	**Description**
Very Light	Less than 5% surface area disturbance of soil below litter and duff due to ripping, grading, raking, etc.
Light	5% to 24% surface area disturbance below litter and duff due to ripping, grading, raking, etc.
Medium	25% to 59% surface area disturbance below litter and duff due to ripping, grading, raking, etc.
Heavy	60% to 100% surface area disturbance below litter and duff due to ripping, grading, raking, etc.
Conversion	Soils cleared of trees, stumps and other forest vegetation and prepared for agriculture, grazing, and/or development. No return to forest vegetation.

Step 7e: Determining the Frequency of Disturbance

The frequency of disturbance is determined as the time between harvest activities associated with the specific silviculture event that is being evaluated for soil carbon emissions. The value for frequency of disturbance is assigned to each harvested stand based on the amount of pre-harvest basal area remaining in the post-harvest stand. The standardization of these values is

based on protocol requirements that onsite forest carbon stocks be maintained or increased and the minimum rotation age in even-aged management silviculture effectively set at 50 years.

Table B.18. Frequency of Disturbance Classification

Frequency of Disturbance	Harvest Retention	Assumed Years to Next Harvest
Short	> 75% of pre-harvest basal area	Up to 15 years
Medium	51 – 75% of pre-harvest basal area	16 to 35 years
Long	26 – 50% of pre-harvest basal area	36 to 50 years
Very Long	< 26% or pre-harvest basal area	> 51 years

Step 7f: Determining Emissions Associated with Management Activities

For each class of harvested stands, or stands that have received site treatment, a value is determined for each combination of harvest intensity, frequency of disturbance, site preparation, and soil order. A percent value is derived from Table B.19 below based on the combination of the various classes.

Table B.19. Estimated Net Carbon Loss

Harvesting Intensity	Frequency of Disturbance	Site Treatment	Estimated Net Carbon Loss by Soil Order						
			Alfisol	***Andisol***	***Inceptisol***	***Mollisol***	***Spodosol***	***Ultisol***	***Histosol***
Light to Medium	Short	Very Light	0%	0%	0%	0%	0%	0%	80%
	Medium		0%	0%	0%	0%	0%	0%	80%
	Long		0%	0%	0%	0%	0%	0%	80%
	Very Long		0%	0%	0%	0%	0%	0%	80%
High	Short	Very Light	Conifers 0% Hardwoods 20%	0%	8%	0%	10%	9%	80%
		Light	Conifers 5% Hardwoods 20%	5%	8%	5%	10%	9%	80%
		Medium	Conifers 10% Hardwoods 20%	10%	10%	10%	20%	11%	80%
		Heavy	Conifers and Hardwoods 20%	20%	20%	20%	41%	22%	80%
	Medium	Very Light	Conifers 6% Hardwoods 20%	0%	0%	0%	33%	24%	80%
		Light	Conifers 6% Hardwoods 20%	5%	5%	5%	33%	24%	80%
		Medium	Conifers 10% Hardwoods 20%	10%	10%	10%	33%	24%	80%
		Heavy	Conifers and Hardwoods 20%	20%	20%	20%	41%	24%	80%
	Long	Very Light	Conifers 0% Hardwoods 20%	0%	0%	0%	31%	0%	80%
		Light	Conifers 5% Hardwoods 20%	5%	5%	5%	31%	5%	80%
		Medium	Conifers 10% Hardwoods 20%	10%	10%	10%	31%	11%	80%
		Heavy	Conifers and Hardwoods 20%	20%	20%	20%	41%	22%	80%
	Very Long	Very Light	0%	0%	0%	0%	5%	0%	80%
		Light	0%	0%	0%	0%	10%	5%	80%
		Medium	0%	0%	0%	0%	20%	11%	80%
		Heavy	0%	0%	0%	0%	41%	22%	80%

Harvesting Intensity	Frequency of Disturbance	Site Treatment	Estimated Net Carbon Loss by Soil Order						
			Alfisol	***Andisol***	***Inceptisol***	***Mollisol***	***Spodosol***	***Ultisol***	***Histosol***
Very High	Short	Very Light	Conifers 6% Hardwoods 20%	6%	28%	6%	1%	6%	80%
		Light	Conifers 6% Hardwoods 20%	6%	28%	6%	10%	6%	80%
		Medium	Conifers 10% Hardwoods 20%	10%	28%	10%	20%	11%	80%
		Heavy	Conifers and Hardwoods 20%	20%	53%	20%	41%	22%	80%
	Medium	Very Light	Conifers 6% Hardwoods 20%	6%	6%	6%	0%	5%	80%
		Light	Conifers 6% Hardwoods 20%	6%	6%	6%	10%	6%	80%
		Medium	Conifers 6% Hardwoods 20%	10%	10%	10%	20%	11%	80%
		Heavy	Conifers and Hardwoods 20%	20%	20%	20%	41%	22%	80%
	Long	Very Light	Conifers 6% Hardwoods 20%	5%	6%	6%	0%	6%	80%
		Light	Conifers 6% Hardwoods 20%	6%	6%	6%	10%	6%	80%
		Medium	Conifers 6% Hardwoods 20%	10%	10%	10%	20%	11%	80%
		Heavy	Conifers and Hardwoods 20%	20%	20%	20%	41%	22%	80%
	Very Long	Very Light	Conifers 6% Hardwoods 6%	6%	6%	6%	0%	6%	80%
		Light	Conifers 6% Hardwoods 6%	6%	6%	6%	10%	6%	80%
		Medium	Conifers 6% Hardwoods 6%	6%	6%	6%	20%	6%	80%
		Heavy	Conifers 6% Hardwoods 6%	6%	6%	6%	41%	6%	80%

Harvesting Intensity	Frequency of Disturbance	Site Treatment	Estimated Net Carbon Loss by Soil Order						
			Alfisol	***Andisol***	***Inceptisol***	***Mollisol***	***Spodosol***	***Ultisol***	***Histosol***
Conversion	Conversion	Agriculture	30%	30%	30%	30%	30%	30%	80%
		Residential - Commercial	0%	0%	0%	0%	0%	0%	80%
		Timing of Estimated Emissions	30% in first 10 years	30% in first 10 years	30% in first 10 years	30% in first 10 years	30% in first 10 years	30% in first 10 years	8% every 10 years over 100 years

This percentage is multiplied by the soil carbon (CO_2e) estimate on a per acre basis and multiplied by the stand's acres to determine the emissions to report for each stand. The stand emissions are summed to determine the soil carbon emissions (CO_2e) reported annually. An example of the calculation is provided in Table B.20 below. For avoided conversion projects calculating baseline soil carbon, a weighted average must be used, taking into account the decadal soil carbon emissions, as shown in Table B.21.

Table B.20. Example: Calculations for Annual Soil Carbon Reporting

Reporting Year			**2012**						
A	B	C	D	E	F	G	H	I	J
Stand ID	Soil Order	Soil Carbon (tCO_2e) per Acre	Acres	Stand Soil Carbon (tCO_2e)	Harvesting Intensity	Disturbance Frequency	Site Preparation	Estimated Soil Carbon Loss %	Stand Soil Carbon Loss (tCO_2e)
	From Step 1	From Step 6		C **x** D	From Step 7a	From Step 7e	From Step 7d	Table B.19	I **x** E
1	Alfisol	85	595	50,575	Very High	Very Long	Heavy	6%	3,035
2	Alfisol	85	683	58,055	Light - Medium	Short	Very Light	0%	-
3	Alfisol	85	2,232	189,720	High	Long	Light	5%	9,486
Sum of Soil Carbon Emissions (tonnes CO_2e) for 2012									**12,521**

Table B.21. Example: Calculations for Avoided Conversion Baseline Soil Carbon Estimates

Conversion Type		**Agriculture**							
A	B	C	D	E	F	G	H	…	I
Stand ID	Soil Order	Soil Carbon (tCO_2e) per Acre	Acres	Timing of Estimated Emissions	Project Start Date Soil Carbon (tCO_2e)	Soil Carbon after 10 Years (tCO_2e)	Soil Carbon after 20 Years (tCO_2e)	…	Soil Carbon after 100 Years (tCO_2e)
	From Step 1	From Step 6			C **x** D	E **x** F		Table B.19	
1	Inceptisol	70	150	30% of stand soil carbon in first 10 years	10,500	7,350	7,350	…	7,350
2	Histosol	110	3500	8% of stand soil carbon every 10 years	385,000	354,200	323,400	…	77,000

B.2.10 Total Onsite Carbon Stocks and Calculating the Confidence Deduction

Annual reporting is conducted by summing the carbon stocks present at the end of the reporting period in all of the relevant carbon sources, sinks, and reservoirs for the project. The Reserve has developed a Monitoring Calculation Worksheet to assist in the reporting relevant pools and calculation of CRTs. The worksheet is available on the Reserve's Forest Project Protocol webpage in a bundle with the Harvested Wood Products Calculation Worksheet, and contains instructions for its use. Certain reported pools are sampled and the mean estimate is used for

annual reporting. The number reported for the sampled pools is adjusted based on the confidence in the estimate of the carbon. The sampling error is calculated for each of the sampled pools at the 90 percent confidence level and subsequently calculated as a percentage of the mean, using the following steps:

Step 1: Calculate the mean and the standard error[42] of the inventory estimate (for each pool or combined pools where applicable, such as with standing live and dead wood).

Step 2: Multiply the standard error by 1.645.

Step 3: Divide the result in Step 2 by the total inventory estimate and multiply by 100. This establishes the sampling error (expressed as a percentage of the mean inventory estimate from field sampling) for a 90 percent confidence level.

[42] Under certain circumstances, the finite population correction factor is normally required for the calculation of the standard error. As a conservative measure, Project Operators may opt not to apply the finite population correction factor.

Table B.22. Example: Summing All Onsite Carbon Stocks and Calculating the Confidence Deduction

Carbon Pool	Source of Data	Project Type(s)	Required/ Optional	Mean CO_2e (Tonnes per Acre)	Sampling Error at 90% Confidence Level	Sampling Error as a Percentage of the Mean Carbon Pool Estimate
Data Derived from Sampling						
				Example Data		
Standing Live Trees	Sampled within project boundaries	All project types	Required	95	6	6.32%
Standing Dead Trees	Sampled within project boundaries	All project types	Required	6	2	33.33%
Soil Carbon	Sampled within project boundaries	Avoided Conversion	Optional	65	8	12.31%
				Sum of Reported Pools	Calculation of Combined Sampling Error	Calculation of Combined Sampling Error as a Percentage
Summarizing Sampled Data				All Reported Pools from Sampling	Combined Sampling Error as a Percentage*Sum of All Reported Pools from Sampling Used to Determine the Confidence Deduction	$U_S = \frac{((U_1 \mathbf{x} R_1)^2+(U_2 \mathbf{x} R_2)^2+ \ldots+(U_n \mathbf{x} R_n)^2)^{\wedge}0.5}{\lvert R_1 + R_2 + \ldots + R_n \rvert}$ *Where*, U_S = percentage uncertainty of the sum U_i = percentage uncertainty associated with pool *i* R_i = removal (emission) estimate for pool *i*
Summary of Example Data from Sampled Pools				**166**	**10.20**	**6.14%**
Data Not Derived from Sampling						
Soil Carbon Emissions	Standardized Guidance	All Projects	Required	-5 (Example)	NA Not Subject to Sampling Error	NA Not Subject to Sampling Error
Sum of Onsite CO_2e Tonnes				**156**	**NA**	**NA**

The per-acre unit must be expanded to the project area based on the number of acres in the project. The sum of onsite CO_2e tonnes for the project is input into the calculation worksheet for annual reporting.

B.2.10.1 Applying a Confidence Deduction to Sampled Estimates

Any forest carbon inventory derived from sampling will be subject to statistical uncertainty. Where statistical confidence is low, there is an increased risk of overestimating a project's actual carbon stocks and therefore a higher risk of over-quantifying GHG reductions and removals. To help ensure that estimates of GHG reductions and removals are conservative,

Project Operators are required each year to apply a confidence deduction to the inventory of actual onsite carbon stocks. A confidence deduction is *not* applied to the forest carbon inventory when it is used to model baseline carbon stocks. Confidence deductions are applied, where appropriate, to estimated onsite forest carbon stocks each reporting period.

The confidence deduction must be updated each time the project is subject to a site visit verification but must remain unchanged between verification site visits. If increased sampling over time results in a lower confidence deduction at the time of a site visit verification, the lower deduction may be applied to inventory estimates in all previous years. The Reserve will issue CRTs in the current year for any increase in quantified GHG reductions and removals in prior years associated with the new (lower) confidence deduction. Conversely, if a loss of qualified sampling plots results in a higher confidence deduction, this higher deduction must also be applied to inventory estimates in all previous years. Any resulting decrease in creditable GHG reductions and removals for prior years will be treated as an avoidable reversal and must be compensated for by retiring CRTs in accordance with Section 7.3.2.

B.2.10.2 Applying a Confidence Deduction to Non-Aggregated Projects

The target sampling error for the combined inventory estimates for non-aggregated projects is +/- 5 percent of the mean at the 90 percent confidence level. Projects that cannot meet this target statistic are still eligible but may have to take a "confidence deduction" that reduces their net reported carbon stocks.

The process for calculating the combined sampling error at the 90 percent confidence level is shown above. The combined sampling error must be compared to the table below to determine the confidence deduction for the reporting period in which a site visit verification has occurred. The confidence deduction shall not be modified in the interim years between site visit verifications. The percent deduction from the table below is input into the calculation worksheet which calculates the net reported onsite stocks.

Table B.23. Forest Carbon Inventory Confidence Deductions Based on Level of Confidence in the Estimate Derived from Field Sampling

Sampling Error (Percent of Inventory Estimate)	Confidence Deduction
0 to 5%	0%
5.1 to 19.9%	(Sampling Error – 5%) to the nearest 1/10 percentage
20% or greater	100%

B.2.10.3 Applying a Confidence Deduction for Aggregated Projects

The target sampling error for the combined inventory estimates for aggregated projects is on a sliding scale based on the number of projects participating within the aggregate. Project Operators enrolled in an aggregate may submit project inventories with reduced sampling requirements based on the statistical principle that the targeted standard error (+/- 5 percent of the mean at the 90 percent confidence level) is achieved across the entire aggregate. Refer to the Reserve Guidelines for Aggregating Forest Projects for the targeted sampling error for individual aggregate participants.

B.2.11 Requirements for Calculating Carbon in Harvested Wood Products

A portion of the carbon in harvested trees continues to be sequestered for long periods of time as wood products. Standardized guidance is provided to account for forest carbon that remains sequestered in harvested wood products. The protocol bases the accounting of harvested wood products on the average amount of carbon sequestered over a 100-year period. The 100-year period is consistent with the Forest Project Protocol's definition of permanence. The average amount of carbon remaining sequestered over the 100-year period is determined by calculating the amount of carbon delivered to the mills, the portion of the carbon that is converted to wood products using a coefficient that estimates the mill's efficiency, and determining the wood product classes manufactured by the mill, as different wood products have different decay rates.

An estimate of the average carbon remaining in use over the 100-year term is provided for each wood product class, which is the basis of baseline and annual reporting of harvested wood products. Furthermore, some wood products eventually end up in landfills where anaerobic conditions serve to reduce the rate of further decomposition. Since the amount of harvested wood products that end up in landfills and the actual decay rate of the wood products in landfills are highly uncertain, the accounting of harvested wood products in landfills is included only when it is conservative to do so. Conservative in this case means that if, in a given reporting year, the amount of harvested wood products in the baseline exceeds the amount of harvested wood products in the project activity, the carbon in landfills is reported. If there is more harvesting of wood products in the project case than in the baseline case, harvested wood products are not considered in either the baseline or the project case.

The Reserve has developed a spreadsheet tool to assist in the calculation of harvested wood products, which is available on the Reserve's Forest Project Protocol webpage. The Harvested Wood Products Calculation Worksheet contains step by step instructions for its use. Project reporting of harvested wood products occurs on an annual basis. The volume of logs delivered to the mill in the baseline case remains static throughout the project life. However, the mill efficiencies and the wood product classes identified in a reporting period are applied to the baseline harvested wood products the same way they apply to the project harvested wood products. The intent of this policy is to provide the best comparison of project activity to baseline activity possible.

The spreadsheet is designed with default values for converting volumetric units from logs delivered to mills to cubic feet and the values of mill efficiencies to be used on a geographic basis. The annual reporting of carbon in trees harvested for wood products is based on the relative proportion of volume in trees harvested for wood products and volume delivered to the mill(s) in the baseline case. Therefore, the reporting of volume delivered to mills is essential to calculating the volume in trees harvested for wood products.

Mill efficiency estimates from the actual mills the project logs are delivered to can be used if data exists to support the claim in a form that can be verified. Users must identify the mill(s) the project logs are delivered to and input the volume that is manufactured into lumber, plywood, oriented strand board, non-structural panels, miscellaneous products, and paper/pulp. Where the wood product class is unknown, the Project Operator must classify the product as miscellaneous products. In order to quantify unknown products categorized as miscellaneous conservatively, miscellaneous products are assigned a default storage factor of zero.

Project Operators must provide an affidavit from the mill that the reported wood product classes are reasonable according to production records at the mill, unless they use the default product classes provided in the Assessment Area Data file. Again, the wood product classes reported for a given reporting year apply both to the project and the baseline case which eliminates the calculation of project benefits or detriments based on comparisons of the decay rates of wood products alone.

B.2.12 Improved Forest Management Leakage

Secondary Effects, or leakage, reflect market responses to changes in harvesting levels. The general assumption in this protocol is that modifying harvest in a Forest Project relative to baseline harvesting levels will lead the market to compensate via modifications to harvesting levels by other landowners. The greater the change in harvest by a Forest Project relative to baseline levels, the greater the response by the market to compensate.

Market leakage effects are accounted for under Improved Forest Management Projects by considering the impacts of shifting activities over the life of the project. Recognizing that risk of Secondary Effects from a project may be influenced by long term harvesting trends, the evaluation in Equation 6.10 considers cumulative harvest amounts since project inception. In some years, Secondary Effects may be negative, if project harvesting is below baseline harvesting (on both a cumulative and individual reporting period basis). If project harvesting later increases, deductions for prior negative Secondary Effects can be recouped. However, once all prior negative Secondary Effects are recouped, Secondary Effects when actual harvested carbon exceeds baseline harvested carbon are zero – under no circumstances shall the net balance of the Secondary Effects over the course of a project be positive. However, positive Secondary Effects may accrue as uncredited positive carryover that can counteract the amount of future negative Secondary Effects applied if baseline cumulative harvested carbon were to exceed actual harvested carbon again. Accruals of positive Secondary Effects carryover and their application against future negative Secondary Effects, if they occur, are calculated within the calculation worksheet.

Table B.24. Examples: How Secondary Effects Can Be Recouped and Positive Carryover Can Be Applied Over Time

a. Qualitative example

Reporting Period	Greater of Actual or Baseline		Protocol Equation Reference	Secondary Effect
	Annual	Cumulative		
1	Baseline	Baseline	Equation 6.10.B	Negative Secondary Effect resulting in deduction applied to GHG reductions
2	Actual	Baseline	Equation 6.10.B	Positive Secondary Effect resulting in recouping of previously deducted GHG reductions up until the cumulative Secondary Effect is zero
3	Actual	Actual	Equation 6.10.A	No Secondary Effect, excepting any previous negative Secondary Effect deductions that have not been recouped and including any positive Secondary Effects that are carried over to the following year
4	Baseline	Actual	Equation 6.10.C	No Secondary Effect, though adjusting any positive Secondary Effect carryover and carrying forward any remaining balance to the following year
5	Baseline	Baseline	Equation 6.10.B	Negative Secondary Effect resulting in deduction applied to GHG reductions, with deduction lowered by any positive secondary effects carryover from when actual cumulative harvest carbon exceeded baseline cumulative harvested carbon

b. Quantitative example

Reporting Period	1	2	3	4	5
Annual actual carbon in harvested trees	500	**1,400**	**1,400**	800	800
Annual baseline carbon in harvested trees	**1,000**	1,000	1,000	**1,000**	**1,000**
Cumulative actual carbon in harvested trees	500	1,900	**3,300**	**4,100**	4,900
Cumulative baseline carbon in harvested trees	**1,000**	**2,000**	3,000	4,000	**5,000**
Cumulative difference between actual and baseline C in harvested trees	(500)	(100)	300	100	(100)
Annual difference between actual and baseline C in harvested trees	(500)	400	400	(200)	(200)
Gross annual Secondary Effects	(100)	80	80	(40)	(40)
Adjusted gross annual Secondary Effects, not allowing positive cumulative Secondary Effects but not including positive Secondary Effects carryover	(100)	80	20	0	(40)
Carryover of positive Secondary Effects from prior year	NA	0	0	60	20
Net annual Secondary Effects	**(100)**	**80**	**20**	**-**	**(20)**

B.3 Modeling Carbon Stocks

This protocol requires the use of certain empirical models to estimate the baseline carbon stocks and project stocks of selected carbon pools within the project area for private land IFM projects (with the exception of the IFM default baseline approach). These models may also be used to supplement assessments of actual changes in carbon stocks resulting from the forest project.

B.3.1 Models and their Eligibility for Use with Forest Projects

Empirical models are used for estimating existing values where direct sampling is not possible or cost-effective. They are also used to forecast the estimations derived from direct sampling into the future. Field measurements (standing live and dead trees) provide the base input data for these models. Project Operators should be careful to ensure that all required data inputs for the models are included in the inventory methodology.

The models that simulate growth projections have two basic functions in the development and management of a forest project. Models project the results of direct sampling through simulated forest management activity. These models, often referred to as growth and yield simulation models, may project information regarding tree growth, harvesting, and mortality over time – values that must ultimately be converted into carbon in an additional step. Other models may combine steps and estimate tree growth and mortality, as well as changes in other carbon pools and conversions to carbon, to create estimated projections of carbon stocks over time.

Models are also used to assist in updating inventory plots so that the plots can represent a reporting year subsequent to their actual sample date. The model simulates the diameter and height increment of sampled trees for the length of time between their sampled date and the reporting year. Plot data can be projected for the length of time the projection method is expected to accurately reflect actual forest growth. Inaccurate updating of plot data can lead to the inability of a project to be verified. Verifiers are directed to randomly select plots or stands for verification. If the Project Operator's estimates deviate from the verifier's measurements, the verification will fail. Hence, it is required that plot data be no older than 12 years.

The following growth models have been approved:

- CACTOS: California Conifer Timber Output Simulator
- CRYPTOS: Cooperative Redwood Yield and Timber Output Simulator
- FVS: Forest Vegetation Simulator
- SPS: Stand Projection System
- FPS: Forest Projection System
- FREIGHTS: Forest Resource Inventory, Growth, and Harvest Tracking System
- CRYPTOS Emulator
- FORESEE

A Project Operator may update inventory plot data for estimating diameter and height growth by incorporating data obtained from sample plots, as in a stand table projection. An example of an appropriate method of applying a stand table projection is as follows:

1. The project area is stratified into even-age management and uneven-age management.

2. Diameter increment shall be based on the average annual increment of a minimum of 20 samples of radial growth for diameter increment for each 8 inch diameter-at-breast-height (DBH) class, beginning at 0 to 8 inch DBH for each management type (even-age or uneven-age). The average annual increment shall be added for each year according to the plot's sample date.
3. Height increment is based on regression curves for each management type (even-age or uneven-age) developed from height measurements from the same trees the diameter increment data was obtained. The estimated height shall be determined using the regression estimators for the 'grown' diameters as described above.

The Reserve may include additional models following approval of a state forestry authority (i.e., a state agency responsible for oversight of forests) who will acknowledge in writing that the model:

- Has been peer reviewed in a process that 1) primarily involved reviewers with necessary technical expertise (e.g., modeling specialists and relevant fields of biology, forestry, ecology, etc.), and 2) was open and rigorous
- Is parameterized for the specific conditions of the project area
- Limits use to the scope for which the model was developed and evaluated
- Is clearly documented with respect to the scope of the model, assumptions, known limitations, embedded hypotheses, assessment of uncertainties, and sources for equations, data sets, factors or parameters, etc.
- Underwent a sensitivity analysis to assess model behavior for the range of parameters for which the model is applied
- Is periodically reviewed

B.3.2 Using Models to Forecast Carbon Stocks

The use of simulation models is required for estimating a forest project's baseline carbon stocks (with the exception of projects using the Improved Forest Management default baseline approach). Models may also be required to forecast actual carbon stocks expected under the forest project (e.g., in conjunction with determining expected harvesting volumes or in updating forest carbon inventories).

Standing live tree information must be incorporated into the simulation models to project carbon stocks over time. If a model has the ability to convert biomass to carbon, it must include all the carbon pools required by this protocol. Standing dead trees must be assumed to be static over the baseline modeling. Exceptions to this rule are allowed if approved in writing by the Reserve prior to verification.

Projected baseline carbon stocks must be portrayed in a graph depicting time in the x-axis and carbon tonnes in the y-axis. Baseline carbon stocks must be projected forward from the forest project's start date. The graph should be supported with written characterizations that explain any annual changes in baseline carbon stocks over time. These characterizations must be consistent with the baseline analysis required in Section 6.

B.3.3 Modeling Requirements

A modeling plan must be prepared that addresses all required forecasting of baseline carbon stocks for the forest project (with the exception of projects using the Improved Forest

Management default baseline approach). The modeling plan shall contain the following elements:

1. A description of all silviculture methods modeled. The description of each silviculture method will include:
    a. A description of the trees retained (by species groups if appropriate) at harvest.
    b. The harvest frequency (years between harvests) for each silviculture method modeled.
    c. Regeneration assumptions.
2. A list of all legal constraints that affect management activities on the project area. This list must identify and describe the legal constraint, how the legal constraint affects the project area, and discusses the silviculture methods that will be modeled to ensure the constraint is respected.
3. A description of the site indexes used for each species and an explanation of the source of the site index values used.
4. A description of the model used and an explanation of how the model was calibrated for local use, if applicable.

Modeling outputs must include:

1. Periodic harvest, inventory, and growth estimates for the entire project area presented as total carbon tonnes and carbon tonnes per acre.
2. Harvest yield streams on modeled stands, averaged by silviculture method and constraints, which must include the period over which the harvest occurred and the estimated CO_2e of wood (CO_2e in logs delivered to mills) removed.

CLIMATE ACTION RESERVE

Version 2.1 | February 13, 2020

Grassland

Project Protocol

Climate Action Reserve
www.climateactionreserve.org

Released February, 13 2020

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 3
2 The GHG Reduction Project 5
2.1 Background 5
2.2 Project Definition 5
2.2.1 Defining the Project Area 6
2.2.2 Project Cooperative 7
2.3 Project Ownership Structures and Terminology 7
2.3.1 Qualifications and Role of Grassland Owners 8
2.3.2 Qualifications and Role of Project Owners 9
2.3.3 Qualifications and Role of Cooperative Developers 10
2.3.4 Forming or Entering a Cooperative 10
2.3.5 Leaving a Cooperative 11
2.4 Environmental Best Management Practices 12
3 Eligibility Rules 13
3.1 Location 13
3.2 Project Start Date 14
3.3 Additionality 14
3.3.1 The Performance Standard Test 15
3.3.2 The Legal Requirement Test 19
3.3.3 Ecosystem Services Credit and Payment Stacking 21
3.4 Project Crediting Period 24
3.5 Requirements for Permanence 25
3.5.1 Qualified Conservation Easements 27
3.5.2 Project Implementation Agreement 27
3.6 Regulatory Compliance 28
3.7 Ecosystem Health 29
4 The GHG Assessment Boundary 31
5 Quantifying GHG Emission Reductions 35
5.1 Stratification 36
5.1.1 Geography and Associated Climate 37
5.1.2 Soil Texture 37
5.1.3 Previous Land Use 38
5.1.4 Stratum Identification and Measurement 39
5.2 Quantifying Baseline Emissions 41
5.2.1 Baseline Organic Carbon Emissions 42
5.2.2 Baseline N_2O Emissions 43
5.2.3 Baseline CO_2 Emissions from Fossil Fuels 43
5.2.4 Discount Factors 44
5.3 Quantifying Project Emissions 45
5.3.1 Project Emissions from Burning 45
5.3.2 Project Emissions from Fossil Fuel and Electricity Use 46

5.3.3 Project Emissions from Organic Fertilizer Use 47
5.3.4 Project Emissions from Grazing 49
5.3.5 Project Emissions Due To Leakage 51
5.4 Ensuring Permanence of GHG Emission Reductions 52
5.4.1 Avoidable Reversals 53
5.4.2 Compensating for Unavoidable Reversals 53
5.4.3 Contributing to the Grassland Buffer Pool 53
6 Project Monitoring 56
6.1 Monitoring Ongoing Eligibility 56
6.2 Monitoring Grazing 56
6.3 Monitoring Project Emission Sources 57
6.4 Monitoring Ecosystem Health 58
6.5 Monitoring Project Cooperatives 59
6.6 Monitoring Parameters 59
7 Reporting Parameters 67
7.1 Time Periods for Reporting 67
7.2 Project Documentation 67
7.3 Record Keeping 68
7.4 Reporting Period and Verification Cycle 69
7.5 Reporting and Verification of Permanence 69
7.5.1 Monitoring through Easement Activities 70
7.5.2 Monitoring for Carbon Separately 70
7.6 Joint Reporting of Project Cooperatives 70
7.6.1 Cooperative Verification Cycle 71
8 Verification Guidance 73
8.1 Joint Verification of Project Cooperatives 73
8.2 Standard of Verification 73
8.3 Monitoring Plan 74
8.4 Verifying Project Eligibility 74
8.5 Core Verification Activities 75
8.5.1 Site Visits 75
8.5.2 Desk Review Verification 76
8.6 Grassland Verification Items 76
8.6.1 Project Eligibility and CRT Issuance 76
8.6.2 Quantification 77
8.6.3 Risk Assessment 78
8.6.4 Completing Verification 78
9 Glossary of Terms 79
10 References 82
Appendix A Development of the Performance Standard 85
Appendix B Development of Standardized Parameters and Emission Factors 93
Appendix C Default Parameters and Emission Factors 106
Appendix D Legal Instruments 107

List of Tables

Table 2.1. Guide to Protocol Sections Related to Legal Instruments for Grassland Projects 8
Table 4.1. Description of All Sources, Sinks, and Reservoirs 32
Table 5.1. 100-year Global Warming Potential for Non-CO_2 GHGs 35
Table 5.3. Soil Texture Categorization 41
Table 5.4. Possible Values of $Risk_{rev}$ 55
Table 6.1. Grassland Project Monitoring Parameters 60
Table 7.1. Guide to Relevant Time Periods for Grassland Projects 67
Table 7.2. Document Management for Project Cooperatives 71
Table 7.3. Example Cooperative Verification Scenarios 71
Table 8.1. Summary of Eligibility Criteria for a Grassland Project 74
Table 8.2. Eligibility Verification Items 76
Table 8.3. Quantification Verification Items 77
Table 8.4. Risk Assessment Verification Items 78
Table A.1. Summary of Strata Eligibility Based on Emission Reduction Potential 87
Table B.1. Derivation of Baseline Scenario Input Variables 96
Table B.2. Example Crop Systems and Resulting Probabilities in Baseline 97
Table B.3. Sample Output of Emission Factor Table Format 98
Table B.4. Stratum Availability 99
Table D.1. Legal Instruments Relevant to Grassland Projects 107

List of Figures

Figure 2.1. Grassland Project Ownership Structures and Terminology 8
Figure 3.1. County Eligibility Map for Projects Submitted after December 31, 2019 16
Figure 4.1. General Illustration of the GHG Assessment Boundary 31
Figure 5.1. Organization of Quantification for Grassland Projects 36
Figure 5.2. U.S. Counties Where Nitrogen Leaching is Expected to Occur 48
Figure A.1. Potentially Eligible Strata for Each MLRA 88
Figure A.2. Eligibility of Counties Based on the Financial Threshold for Additionality 90
Figure B.1. Map of 10-30 Year Grassland Data Points on Fine Soils 100
Figure B.2. Map of 30+ Year Grassland Data Points on Fine Soils 100
Figure B.3. Map of 10-30 Year Grassland Data Points on Medium Soils 101
Figure B.4. Map of 30+ Year Grassland Data Points on Medium Soils 101
Figure B.5. Map of 10-30 Year Grassland Data Points on Coarse Soils 102
Figure B.6. Map of 30+ Year Grassland Data Points on Coarse Soils 102

List of Equations

Equation 5.1. GHG Emission Reductions 36
Equation 5.2. Baseline Emissions 42
Equation 5.3. Baseline Organic Carbon Emissions from Soil and Belowground Biomass Loss 43
Equation 5.4. Baseline N_2O Emissions 43
Equation 5.5. Baseline CO_2 Emissions from Fossil Fuel 44
Equation 5.6. Discount Factor for the Uncertainty of Baseline Conversion 44
Equation 5.7. Project Emissions 45
Equation 5.8. Project Emissions from Burning 46
Equation 5.9. Project Emissions from Fossil Fuels and Electricity 47

Equation 5.10. Project Emissions from Fertilizer Use 48
Equation 5.11. Project Emissions from Livestock Grazing 50
Equation 5.12. Project Emissions from Leakage 51
Equation 5.13. Quantifying Reversals 52
Equation 5.14. Buffer Pool Contribution to Insure Against Reversals 55

Abbreviations and Acronyms

AGC	Avoided grassland conversion
AGD	Animal grazing days
AOI	Area of Interest (within the NRCS Web Soil Survey application)
CARB	California Air Resources Board
CDL	Cropland Data Layer
CDM	Clean Development Mechanism
CFR	Code of Federal Regulations
CH_4	Methane
CO_2	Carbon dioxide
CRP	Conservation Reserve Program
CRT	Climate Reserve Tonne
CTIC	Conservation Tillage Information Center
DAYCENT	Daily CENTURY Model
EPA	U.S. Environmental Protection Agency
ERS	USDA Economic Research Service
ESA	Endangered Species Act
ESD	Ecological Site Description
FWS	U.S. Fish and Wildlife Service
GHG	Greenhouse gas
GRP	Grassland Reserve Program
GWP	Global warming potential
HCP	Habitat Conservation Plan
ICC	Irrigated Land Capability Classification
IDB	Inventory Database (from the NRI)
IPCC	United Nations Intergovernmental Panel on Climate Change
IRT	The Army Corps of Engineers-led Interagency Review Team
ISO	International Organization for Standardization
lb	Pound
LCC	Land Capability Classification
MODIS	Moderate Resolution Imaging Spectroradiometer
MLRA	Major Land Resource Area designations
NARR	North American Regional Reanalysis Product

NASA	National Aeronautics and Space Administration
NASS	USDA National Agricultural Statistics Service
NICC	Non-Irrigated Land Capability Classification
NLCD	National Land Cover Database
N_2O	Nitrous oxide
NRCS	USDA Natural Resources Conservation Service
NRI	Natural Resources Inventory
PIA	Project Implementation Agreement
QCE	Qualified Conservation Easement
Reserve	Climate Action Reserve
SHA	Safe Harbor Agreement
SOC	Soil organic carbon
SSR	Source, sink, and reservoir
SSURGO	Soil Survey Geographic database
t	Metric ton (or tonne)
tCO_2e	Metric ton of carbon dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WSS	NRCS Web Soil Survey application

1 Introduction

The Climate Action Reserve (Reserve) Grassland Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with projects that avoid the loss of soil carbon due to conversion of grasslands to cropland, as well as other associated GHG emissions. This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with an avoided grassland conversion project.[1]

The Reserve is an offset registry serving the California cap-and-trade program and the voluntary carbon market. The Reserve encourages actions to reduce GHG emissions and works to ensure environmental benefit, integrity, and transparency in market-based solutions to address global climate change. It operates the largest accredited registry for the California compliance market and has played an integral role in the development and administration of the state's cap-and-trade program. For the voluntary market, the Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, and issues and tracks the transaction of carbon credits (Climate Reserve Tonnes or CRTs) generated from such projects in a transparent, publicly-accessible system.[2] The Climate Action Reserve is a private 501(c)(3) non-profit organization based in Los Angeles, California.

Project Owners and Cooperative Developers that initiate avoided grassland conversion (AGC) projects use this document to quantify and register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol. There are several additional resources which accompany this protocol document. Additional details for all of these resources can be found at the Grassland Protocol page on the Reserve's website: http://www.climateactionreserve.org/how/protocols/grassland/.

Resource	Required or Optional	Description
Grassland Project Parameters (MS Excel spreadsheet)	Required	This spreadsheet file contains parameters and emission factors which are required for the quantification of a grassland project. This includes stratum-level parameters, county-level parameters, and other necessary reference values. The parameters contained in this spreadsheet may be updated when new data becomes available. Stakeholders will be given advanced notice and guidance before updated parameters become effective for projects.
GrassTool v2.1 (MS Excel spreadsheet)	Optional	The GrassTool is built upon the quantification section of this protocol, allowing for Project Owners to conduct project quantification without first developing their own tool. It is updated periodically to enhance usability or correct errors.

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.
[2] The online registry may be accessed from the Reserve homepage at: www.climateactionreserve.org.

Resource	Required or Optional	Description
Project Development Handbook (PDF)	Optional	This document provides additional context and description for the rules and requirements contained in the protocol. It is not considered to be official protocol language, and is not meant to be a standard of verification. It is informal guidance to help understand protocol requirements, and it is updated periodically.

2 The GHG Reduction Project

This section describes the GHG reduction project in terms of defining the project site, the related activities, the parties involved, and the possible project structures.

2.1 Background

Grasslands have the ability to both emit and sequester carbon dioxide (CO_2), the primary GHG responsible for human-caused climate change (1). Grasses and shrubs, through the process of photosynthesis, naturally absorb CO_2 from the atmosphere and store the gas as carbon in their biomass (i.e., plant tissues). As plants die and regrow, some of this carbon is also stored in the soils that support the grassland.

When grasslands are disturbed, such as when the land is tilled for crop cultivation, a portion of the stored carbon oxidizes and decays, releasing CO_2 into the atmosphere. The quantity and rate of CO_2 that is emitted may vary, depending on the particular circumstances of the land and the disturbance. Grasslands function as reservoirs in the global carbon cycle. Depending on how grasslands are managed or impacted by natural and human events, they can be a net source of emissions, resulting in a decrease to the reservoir, or a net sink, resulting in an increase of CO_2 to the reservoir. In other words, grasslands may have a net negative or net positive impact on the climate, depending on their characteristics and management.

Through sustainable management and protection, grasslands can play a positive and significant role to help address global climate change. This protocol is designed to take advantage of grasslands' unique capacity to sequester, store, and emit CO_2 and to facilitate the positive role that grasslands can play to address climate change. The protocol focuses on the avoided conversion of grasslands to cropland. Because conversion is avoided, we can never measure the exact GHG impacts of conversion activities on the project area, and thus cannot know exactly how much carbon would have been released if a particular area of land were converted. To avoid the cost and uncertainty related to site-specific soil sampling and ecosystem modeling, the Reserve has adopted a standardized, probabilistic approach to estimating baseline emissions for AGC projects. This approach is discussed in more detail in Section 5, as well as Appendix B.

2.2 Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the prevention of emissions of GHGs to the atmosphere through conserving grassland belowground carbon stocks and avoiding crop cultivation activities on an eligible project area, as initiated by the recording of a perpetual conservation easement or an eligible transfer of ownership, as described in Section 3.2. The project area must be grassland, as defined below, and it must be suitable for conversion to crop cultivation, as defined in Section 3.3.1.2. The project area must have been in continuous grassland cover for at least 10 years prior to the project start date. The baseline scenario for all AGC projects is conversion to crop cultivation.

For the purposes of this protocol, grassland is defined as an area of land dominated by native or introduced grass species with little to no tree canopy. Other plant species may include woody shrubs, legumes, forbs, and other non-woody vegetation. Tree canopy may not exceed 10% of the land area on a per-acre basis. Areas that exceed this threshold may be eligible to use the

Forest Protocol.[3] For the purposes of this protocol, grassland may include managed rangeland and/or pastureland (as defined in Section 9).

The entire project area must be protected through a single conservation easement, except in cases where there are multiple easements with the same grantor (Grassland Owner) and grantee (Easement Holder). Multiple projects may be managed together as a project cooperative, as described in Section 2.2.2. In addition, the project area must have been privately-owned prior to the project start date, except in the case of non-federal public lands, where:

- The project area is legally able to be converted to cropland without requiring a rulemaking activity; and either
- The public agency in charge of management of the project area must have a legal directive to manage the lands that include the project area for profit; or
- A history of such management for profit,[4] including existing conversion, for similarly-situated lands can be documented during the 10 years prior to the start date.

An AGC project may involve moderate levels of seeding, organic fertilizer application (i.e., manure, compost, etc.), haying, forage harvesting, livestock grazing and/or irrigation as part of the project activity. Projects may not employ synthetic fertilizer additions; CRTs will not be issued for any calendar year during which this occurs. If grazing is employed in the project scenario, the livestock manure must not be managed in liquid form (i.e., containing less than 20% dry matter and subject to active management), and grazing activities must meet the criteria in Section 6.2.

Other recreational or economic activities incidental to the project activities may also occur on the project area (e.g., hunting, bird-watching, light haying), but only to the extent that the incidental activity does not threaten the integrity of the soil carbon stocks and is otherwise compatible with the maintenance of grassland under conservation. The Reserve maintains the right to determine whether an activity is "incidental" to the project or whether the presence of the activity would cause part or all of the project area to be considered an entirely different land use (i.e., not grassland). In those cases, the area used for such activities may not be considered to be part of the project area. For example, the extensive conversion of grasslands to forage crop production may result in that activity no longer being considered incidental to the project, and the subject land no longer eligible to be part of the project area.

The project lifetime for an AGC project is up to 150 years. This includes the crediting period, which may be up to 50 years (Section 3.4) and the permanence period, which is the 100 years following the crediting period (Section 3.5).

2.2.1 Defining the Project Area

An eligible project area consists of grassland that meets the criteria in Section 3 regarding the threat of conversion to cropland and the lack of legal barriers to such conversion. Only areas that are suitable for conversion to cropland, as defined in Section 3.3.1, are eligible to report under this protocol. The entire project area must be protected by the recording of one or more

[3] Information regarding the Reserve's voluntary forest carbon program can be accessed at: http://www.climateactionreserve.org/how/protocols/forest/. Information regarding the California Compliance Offset Protocol for forest projects can be accessed at: http://www.climateactionreserve.org/how/california-compliance-projects/compliance-offset-projects/.

[4] A practice of carrying out all leasing and sales based on fair market value may be considered "management for profit."

conservation easements (see Section 3.5.1). The area bound by the conservation easement(s) does not need to match the project area. However, the entire project area must be included within the area of a conservation easement. A single project may include multiple legal parcels if all of these conditions can be met. The project does not need to include every parcel listed on a deed, and project boundaries do not necessarily need to be coincident with parcel boundaries (i.e., the project area may contain a portion of a parcel without necessarily including the entire parcel).

The geographic boundaries defining the project area must be described in detail at the time a grassland project is listed on the Reserve (see Section 7.2 for details on project documentation). The boundaries must be defined using a georeferenced map, or maps, that displays legal property boundaries, public and private roads, major watercourses (fourth order or greater), topography, towns, and public land survey townships, ranges, and sections or latitude and longitude. The maps should be of adequate resolution to clearly identify the required features. The shapes delineating the project area must contain only areas that meet the eligibility requirements of this protocol. If the project area contains more than one legal parcel, these delineations must also be included. This map is not publicly accessible.

A Geographical Information System file (GIS shapefile) must be submitted with project documentation for the initial verification (see Section 7.2 for a full list of documentation required for each verification). If the project area is changed during a reporting period, the shapefile must be updated and resubmitted for the subsequent verification. The shapefile may be submitted as a KML file. The acres reported for the project must be based on the acres calculated from the shapefile. The project area can be contiguous or separated into tracts, but must share a common Grassland Owner, Project Owner, Easement Holder, and project start date. See Section 5.1 for guidance regarding the stratification of the project area.

After the project has been verified, sections of the project area may be removed (subject to the requirements of Section 5.4). The project area may also be expanded, so long as the new area(s) meets all requirements of this section. Any areas added to a project will share the same start date as the initial project area, but may not be eligible for crediting for the entire period (see Section 3.4). There are also timing requirements in relation to the date the new areas become bound by eligible easements, and the date the new areas are incorporated into the existing project area. The easements covering the new areas must have been put in place within 12 months of the start of the first reporting period for the new or expanded areas, in order to include the expanded project area. Project expansions may not be allowed in cases where a new area would change the eligibility determination of the original project. In such cases, the new area may need to be submitted as a new project. New projects may always be added to a project cooperative (see Section 2.3.4).

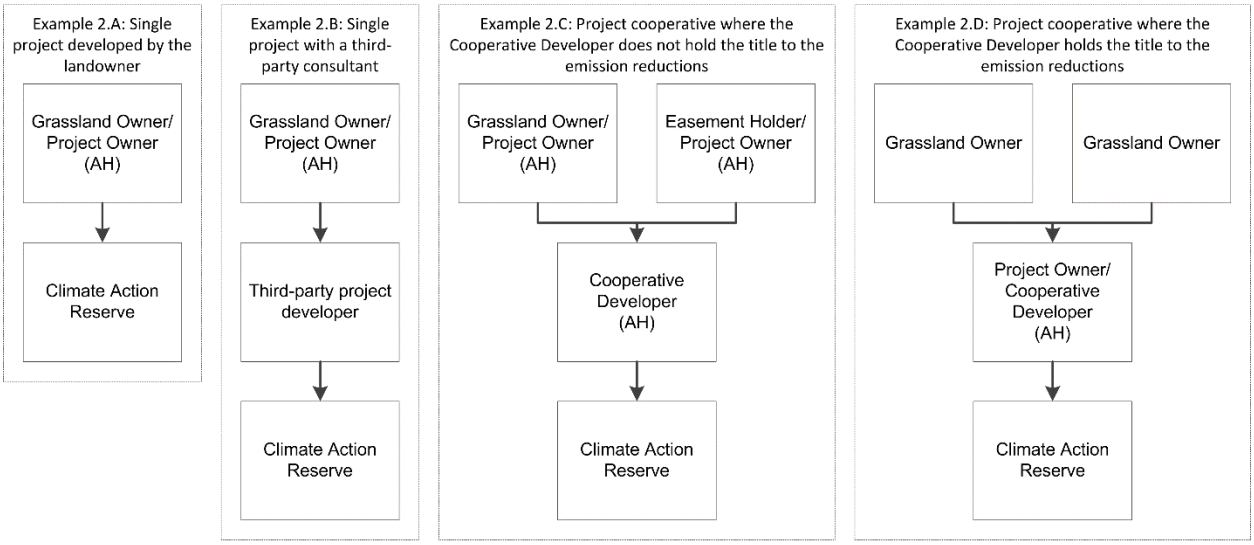
2.2.2 Project Cooperative

A “project cooperative” or “cooperative” is a collection of two or more individual grassland projects managed by a common entity (referred to as the “Cooperative Developer,” Section 2.3) that engage in joint monitoring, reporting, and verification (Sections 6.4, 7.6, and 8.1).

2.3 Project Ownership Structures and Terminology

A grassland project can be implemented using various ownership structures. Figure 2.1 displays possible ownership structures for grassland projects, indicating the flow of information and which entities are required to hold Reserve accounts. These are simplified representations;

actual project and cooperative structures may be more complex, but the relationships follow the same approach.



(AH) denotes an entity which must have an account with the Climate Action Reserve

Figure 2.1. Grassland Project Ownership Structures and Terminology

Depending on the project structure, the existence and/or status of certain legal instruments must be verified in order to successfully register a project. The instruments required are described in general below. For every project, the fee owner of the land on which the project is implemented must demonstrate an understanding of the potential participation in a carbon offset program, either through implementing a project himself, or through clear conveyance of the GHG reduction rights associated with the land through a recorded legal instrument as described below. The sections outlined in Table 2.1 should be referred to for specific requirements for each respective legal instrument required. Additional discussion of these legal instruments can be found in Appendix D.

Table 2.1. Guide to Protocol Sections Related to Legal Instruments for Grassland Projects

Legal Instrument	Protocol Section(s)
GHG reduction rights contract	2.3.2
Indemnification agreement	2.3.2
Conservation easement	2.2, 3.2
Qualified Conservation Easement	3.5.1
Project Implementation Agreement	3.5.2
Reserve attestations (title, voluntary implementation, regulatory compliance)	2.3.2, 3.3.2, 3.6
Instruments associated with concurrently-joined conservation programs	3.3.2.1

2.3.1 Qualifications and Role of Grassland Owners

A Grassland Owner is an individual or a corporation or other legally constituted entity, city, county, state agency, or a combination thereof that has fee ownership and legal control of the land within the project area. A lessee is not a Grassland Owner. Deeded encumbrances that

exist within the project area may prevent a fee owner from satisfying the definition of a Grassland Owner. The Grassland Owner is the entity that has the authority to execute and record a conservation easement on the project area. Any unencumbered soil carbon is presumed to be controlled by the Grassland Owner. Notwithstanding this presumption, the Reserve maintains the right to determine whether an individual or entity meets the definition of Grassland Owner.

2.3.2 Qualifications and Role of Project Owners

A Project Owner is the entity that holds legal title to the emission reductions related to the grassland project, and is responsible for undertaking the grassland project and registering it with the Reserve. The Project Owner may be a Grassland Owner, a holder of a conservation easement on the property, or they may be a third-party entity who has a signed contract with the Grassland Owner conveying title to the emission reductions. Title to the emission reductions may be conveyed through the conservation easement or in a separate contract, but in any case such rights must be legally established. If there are any Grassland Owners who are not party to the GHG reduction rights agreement, the Project Owner must also execute an indemnification stating that they will indemnify the Reserve in connection with any claims brought by other grassland owners or would-be grassland owners against the Reserve.[5] The Project Owner shall execute the Project Implementation Agreement (PIA) (see Section 3.5.2). The Project Owner is also responsible for the accuracy and completeness of all information submitted to the Reserve, and for ensuring compliance with this protocol, even if the Project Owner contracts with an outside entity to carry out these activities. The Project Owner must have a Reserve registry account[6] and must sign all required legal attestations (e.g., Attestation of Title, Attestation of Voluntary Implementation, and Attestation of Regulatory Compliance). Sample language related to ownership of emission reductions is included below, to be amended to fit each project's specific situation:

> *"TITLE TO CARBON OFFSET CREDITS. The [grantor/grantee- i.e., whichever party to the easement or agreement is the Project Owner] hereby retains, owns, and holds legal title to and all beneficial ownership rights to the following (the "Project Reductions"): (i) any removal, limitation, reduction, avoidance, sequestration or mitigation of any greenhouse gas associated with the Property including without limitation Climate Action Reserve Project No. [___] and (ii) any right, interest, credit, entitlement, benefit or allowance to emit (present or future) arising from or associated with any of the foregoing, including without limitation the exclusive right to be issued carbon offset credits or Climate Reserve Tonnes (CRTs) by a third party entity such as the Climate Action Reserve."*

In all cases, the Project Owner must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from the project. Each time a project is verified, the Project Owner must attest that no other entities are reporting or claiming (e.g., for voluntary reporting or regulatory compliance purposes) the GHG reductions caused by the project.[7] The Reserve will not issue CRTs for GHG reductions that are reported or claimed by entities other than the Project Owner (e.g., grassland owners who are not the Project Owner). In the case of project

[5] A sample indemnification agreement is available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[6] Information regarding Reserve accounts and the process for project submittal and registration is available here: http://www.climateactionreserve.org/how/projects/register/.
[7] This is done by signing the Reserve's Attestation of Title form, available at: http://www.climateactionreserve.org/how/program/documents/

cooperatives, each Project Owner must sign an attestation for each individual project. Attestations may be submitted by a third party, but must be signed by the Project Owner.

A Project Owner who will be managing the submittal, reporting, and verification of the grassland project through their own Reserve account will open a Project Developer account. A Project Owner whose project will be managed as part of a cooperative, and who will not be utilizing their Reserve account for any action beyond outgoing transfers of CRTs, will open a Project Owner account.

Project Owners are ultimately responsible for timely submittal of all required forms and complying with the terms of this protocol. Project Owners may designate a technical consultant or Cooperative Developer to manage the flow of documents and information to the Reserve. The scope of services provided by a technical consultant or Cooperative Developer should be determined by the Project Owner and the relevant management entity and reflected in the contracts between the Project Owner and the relevant management entity.

2.3.3 Qualifications and Role of Cooperative Developers

A "Cooperative Developer" is the entity that manages reporting and verification for a project cooperative, i.e., two or more individual grassland projects that report and verify jointly. A cooperative may consist of grassland projects involving multiple Project Owners. A Cooperative Developer must have an account on the Reserve.

A Cooperative Developer must open a Project Developer account on the Reserve and must remain in good standing throughout the duration of the cooperative(s) it manages. Failure to remain in good standing will result in all account activities of the participant projects in the cooperative(s) managed by that Cooperative Developer being suspended until issues are resolved to the satisfaction of the Reserve. In order for a Cooperative Developer to remain in good standing, Cooperative Developers must perform as follows:

- Complete cooperative contracts with Project Owners (see following section on Joining a Cooperative)
- Engage the services of a single verification body for all grassland projects enrolled in the cooperative in any given verification period
- Coordinate the submittal, monitoring, and reporting activities required by this protocol for all projects in the cooperative(s), observing all cooperative deadlines
- Coordinate a verification schedule that maintains appropriate verification status for the cooperative. Document the verification work and report to the Reserve on an annual basis how completed verifications demonstrate compliance (see Sections 6.4, 7.6, and 8.1)
- Maintain a Reserve account in good standing

As discussed in Section 2.3.2, Project Owners are ultimately responsible for timely submittal of all required forms and complying with the terms of this protocol.

2.3.4 Forming or Entering a Cooperative

Individual grassland projects may join a cooperative by being included in the cooperative's Cooperative Submittal Form[8] (if joining a cooperative at initiation) or by being added through the

[8] All forms referenced in this section are available at: http://www.climateactionreserve.org/how/program/documents/.

submission of a New Grassland Project Enrollment Form (if joining once the cooperative is underway).

The Cooperative Developer will initiate the creation of the cooperative by submitting a Cooperative Submittal Form. The Cooperative Submittal Form includes the submittal information for all of the individual projects to be initially included in the cooperative. If the Cooperative Developer is not the Project Owner for one or more projects within the cooperative, the appropriate Project Owner account will be confirmed at the time of project submittal. All documentation related to the cooperative and its participant projects is submitted by the Cooperative Developer. After successful verification, CRTs are issued to the accounts of the Project Owners for each project.

Individual grassland projects that have already been submitted to the Reserve may choose to join an existing cooperative by submitting a Cooperative Transfer Form to the Reserve. The Cooperative Developer must also submit a New Project Enrollment Form, listing that project area, if the cooperative is already underway. Emission reductions occurring on individual projects or new projects entering a cooperative are reported as part of the cooperative during the reporting period in which the transfer occurred.[9] The project will begin reporting with the cooperative no earlier than the beginning of the cooperative's current verification period. If the project has already been registered, either as an individual project or as part of another cooperative, reporting under the new cooperative may not include any period of time that has already been reported and verified.

The crediting periods of the individual projects within a cooperative are derived from their individual project start dates, and are not affected by the crediting periods of other projects within the cooperative. All projects within a cooperative must follow the same version of this protocol. If a project that is subject to a more recent version of the protocol wishes to enter an existing cooperative, the rest of the projects in that cooperative must elect to upgrade to the newer version of the protocol.

2.3.5 Leaving a Cooperative

Individual grassland projects must meet the requirements in this section in order to leave or change cooperatives and continue reporting emission reductions to the Reserve. Reporting must be continuous.

Individual Project Owners may elect to leave a cooperative and participate as an individual grassland project for the duration of their crediting period, effective as of the day after the end date of the project's most recently registered reporting period. To leave a cooperative and become an individual grassland project, the Project Owner must submit a Project Submittal Form to the Reserve, noting that it is a "transfer project" and identifying the cooperative from which it is transferring. For projects which leave a cooperative to become an individual project, the deadline for submittal of the subsequent monitoring or verification report (whichever is sooner) is extended by 12 months beyond the deadline specified in Section 7.4. The Project Owner must submit either a monitoring report or verification report (whichever is due) by this new deadline in order to keep the project active in the Reserve. If the Project Owner has a Project Owner account in the Reserve at the time they leave the cooperative, they must contact the Reserve Administrator to set up a Project Developer account.

[9] The transfer is considered to have occurred once the Reserve has approved the Cooperative Transfer Form and the New Project Enrollment Form.

To leave one cooperative and enter another cooperative, the Project Owner must submit a Cooperative Transfer Form to the Reserve prior to enrolling in the new cooperative. Reporting under the destination cooperative shall continue according to the guidance in Section 7.6.1.

2.4 Environmental Best Management Practices

The Grassland Protocol is intended to generate GHG reductions through the avoided conversion of grassland to cultivated cropland. The protocol also seeks to limit potential environmental harms caused by project activities through the requirements for regulatory compliance specified in Section 3.6. Environmental enhancements in addition to GHG reductions are beyond the scope of this document. However, the Reserve does strongly encourage Project Owners and Grassland Owners to adopt practices that provide additional benefits to the grassland ecosystem beyond the GHG reductions. Project Owners and Grassland Owners are encouraged to review and implement the appropriate recommendations for rangeland management developed by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Conservation Effects Assessment Project (2). It is furthermore recommended that best management practices relevant to the project area be included as terms of the conservation easement(s) and/or the GHG reduction rights contract.

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to register with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project (Section 2.2).

Eligibility Rule I:	Location	→	*Conterminous U.S. and tribal areas*
Eligibility Rule II:	Project Start Date	→	*No more than 12 months prior to project submission*
		→	*Record a conservation easement or eligible transfer of ownership*
Eligibility Rule III:	Additionality	→	*Meet performance standard*
		→	*Exceed legal requirements*
		→	*Satisfy credit and payment stacking requirements*
Eligibility Rule IV:	Project Crediting Period	→	*Emission reductions may only be reported during the crediting period, up to a maximum of 50 years*
Eligibility Rule V:	Permanence	→	*Maintain stored carbon for at least 100 years following issuance of CRTs*
		→	*Employ a Qualified Conservation Easement and Project Implementation Agreement*
Eligibility Rule VI:	Regulatory Compliance	→	*Compliance with all applicable laws*
Eligibility Rule VII:	Rangeland Health	→	*Periodic monitoring and adaptive management*

3.1 Location

Only projects located in the conterminous United States and on U.S. tribal lands are eligible to register reductions with the Reserve under this protocol. All sources within the project boundary (Figure 4.1) must be located within the conterminous United States. Under this protocol, reductions from international projects are not eligible to register with the Reserve. Grassland projects in tribal areas must demonstrate that the land within the project area is owned by a tribe or private entities. Projects are not eligible on organic soils (histosols),[10] including areas identified as wetlands or peatlands.

In addition, the project area must be located on land whose particular combination(s) of Major Land Resource Area (MLRA), soil texture, and prior land use history would result in emissions of soil carbon in the baseline scenario. To be eligible, the grassland project must be able to generate emission reductions through project activities. This is determined by identifying the project strata following the guidance in Section 5.1. The project location is ineligible if there are no baseline emission reductions from soil organic carbon in the first 10-year emission factor period.[11]

[10] Wherever soil types or characteristics are referenced in this protocol, they shall be assumed to describe the upper 20 cm soil layer, unless otherwise specified.

[11] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

3.2 Project Start Date

The project start date is defined as the date on which the project area is committed to the long-term management and protection of grassland and therefore avoids conversion to cropland.

Commitment to long-term management and protection of grassland must be demonstrated by one of the following:

1. Submitting the project to the Reserve.[12] Note that the project must meet the tests for additionality as of the project start date. Thus, this option is not applicable if the project is submitted after the recordation of a conservation easement covering the project area.
2. Recordation of a conservation easement on the project area, with a provision to maintain the project area as grassland for the protection of soil carbon. The project start date is the date the easement was recorded. If an easement is amended to meet the requirements of a Qualified Conservation Easement (Section 3.5.1), the recordation date of the unamended easement may be used for purposes of determining the project start date. If the Project Owner intends to use the date of recordation of the amended easement as the project start date, they must be able to show that, prior to amendment, the original conservation easement would not have violated any provisions of the legal requirement test (Section 3.3.2). If the project area is protected through multiple easements, the date of recordation of the earliest easement will establish the project start date under this option.
3. Transferring of property ownership to a public or private entity. The project start date is the date of property transfer. Projects are still required to record a conservation easement, as described above, prior to the initial registration.

To be eligible, the project must be submitted to the Reserve no more than 12 months after the project start date.[12]

Projects that have previously been submitted to and accepted by another offset project registry (transfer projects) may be eligible with a historical start date. Start date requirements for those projects are described in the Reserve Offset Program Manual.[13] Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following criteria to be considered additional:

1. The performance standard test
2. The legal requirement test
3. Limits on payment and credit stacking

[12] Projects are considered submitted when the Project Developer has fully completed and filed the appropriate Project Submittal Form, available at: http://www.climateactionreserve.org/how/program/documents/.
[13] Please refer to the most current version of the Reserve Offset Program Manual, available at: http://www.climateactionreserve.org/how/program/program-manual/.

3.3.1 The Performance Standard Test

Projects pass the performance standard test by meeting a performance threshold, i.e,. a standard of performance applicable to all grassland projects, established by this protocol. The performance standard test is applied at the time a project applies for registration with the Reserve. The performance standard test for a grassland project has two parts:

1. Financial threshold
2. Suitability threshold

3.3.1.1 Financial Threshold

The Reserve has determined that there is a financial barrier to project activities due to the economic incentives to convert grassland to cropland. Rather than have each project demonstrate the existence of this barrier individually, the Reserve has developed a standardized threshold for financial additionality, referred to as the cropland premium. The cropland premium is determined as the percentage difference in the value (represented by land rental rates in $/acre) of cropland over pastureland in the county where the project is located. Project eligibility is based on the cropland premium for the county where the project is located, based on the conditions below:

1. Projects in counties with a cropland premium greater than 100% are eligible without any discount for uncertainty
2. Projects in counties with a cropland premium greater than 40% but less than 100% are eligible, but must apply a discount to their baseline emissions (see Section 5.2.4 for a description of DF_{conv}), unless the county can meet the requirements of step 4
3. Projects in counties with a cropland premium less than 40% are not eligible, unless the project meets the requirements of step 4
4. Projects in counties that meet the description of step 2 or step 3, or which are identified in the tables as having "No Data," have the option to obtain a certified appraisal to determine a site-specific cropland premium, following the guidelines below for the appraisal process.

If more than 10% of the project area is located in a particular county, then eligibility must be assessed separately for that county.[14] If the county is not eligible, then that portion must be removed from the project area. If less than 10% of the project area is located in an ineligible county, that area may be included in the project area as long as it is physically contiguous with a portion of the project area which is located in an eligible county. A document and a spreadsheet with the eligibility status of each county are available from the Reserve website.[15] A paper copy of this list will be provided upon request. The standardized financial threshold will be updated whenever new rental rate data are published by the NASS. The new table of county-specific parameters will be published prior to the date on which the new values become effective.[16] When new tables are published, guidance will be given regarding the effective date. Figure 3.1 displays the county eligibility for projects submitted after December 31, 2019 (until such time as a new table and guidance are published by the Reserve). For counties that are identified as

[14] If this 10% threshold is exceeded only after an expansion of the project area per Section 2.2.1, the Project Owner must consult with the Reserve to determine whether the new project area is subject to an eligibility assessment separate from the existing project area.

[15] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

[16] Typically, rental rate data are released in September, in which case the Reserve will publish a new table in October with an effective date of January 1 of the following year. However, this could change if the NASS adopts a different schedule for data release.

having no data, a Project Owner may request that the Reserve examine the data for surrounding counties and determine whether the county may be considered eligible (and the appropriate value for DF_{conv}, if applicable). Additional information regarding the development of this threshold can be found in Appendix A.

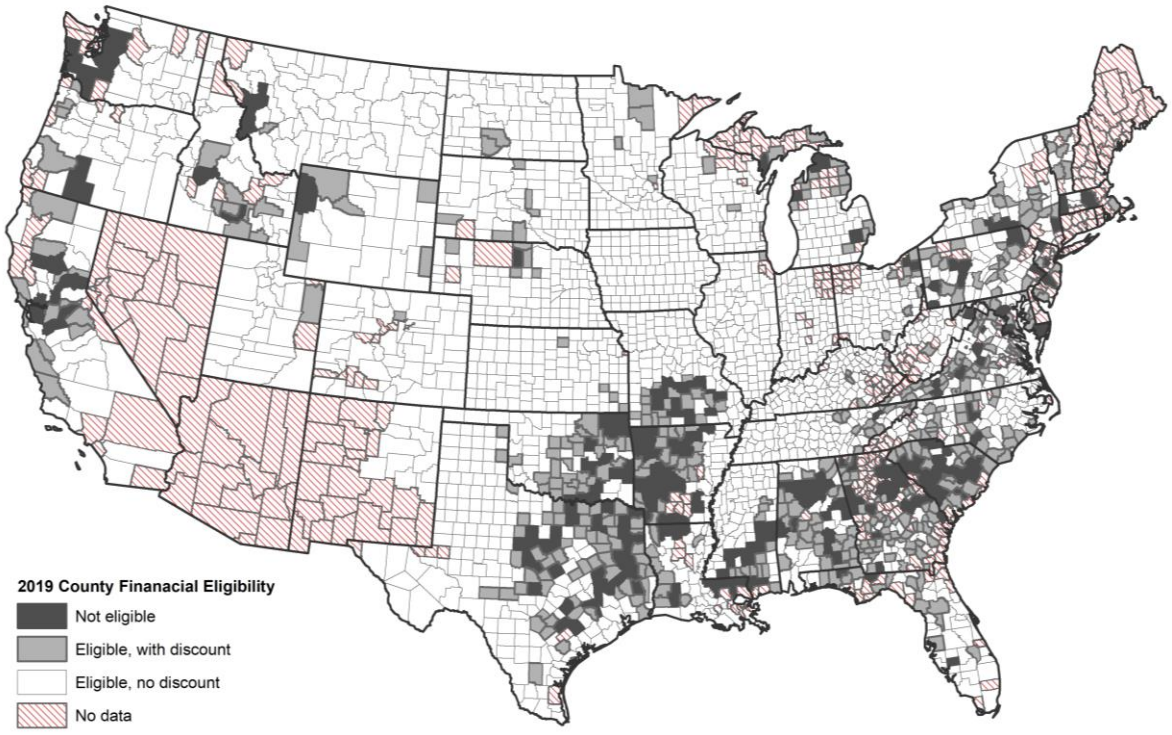


Figure 3.1. County Eligibility Map for Projects Submitted after December 31, 2019

Appraisal Option

If using step 4 above, a project may satisfy the financial threshold if the Project Owner provides an up-to-date[17] real estate appraisal for the project area (as defined in Section 2.2.1) indicating the following:

1. *The project area is suitable for conversion to cropland*. The appraisal must clearly indicate how the physical characteristics of the project area are suitable for crop cultivation, including the particular crops expected to be grown.
2. The appraisal must conform with the following minimum standards[18]:
    a. Appraisal reports shall be prepared and signed by a third-party, Licensed or Certified Real Estate Appraiser in good standing.
    b. Appraisal reports shall include descriptive photographs and maps of sufficient quality and detail to depict the subject property and any market data relied upon, including the relationship between the location of the subject property and the

[17] An appraisal will be considered "up-to-date" if it is finalized no more than12 months before or after the project start date.
[18] Adapted from Sections 5096.501 and 5096.517, Public Resources Code, State of California.

market data. The appraisal must provide a map that displays specific portions of the project area that are suitable for crop production. (For example, an appraisal that identified corn production as an alternative land use must specify the approximate acres suitable for both the crops and any related roads, buildings, or other infrastructure.)

c. Appraisal reports shall include a complete description of the subject property land, site characteristics and improvements. Valuations based on a property's development potential shall include:
    i. Verifiable data on the conversion potential of the land (e.g., Certificates of Compliance, Tentative Map, Final Map, approval for crop insurance, new breakings request form).
    ii. A description of what would be required for a conversion to cropland to proceed (e.g., legal entitlements, infrastructure).
    iii. Presentation of evidence that sufficient demand exists, or is likely to exist in the future, to provide market support for the conversion to cropland.
    iv. The appraisal must demonstrate that the slope of project area land is compatible with crop production by identifying two areas with similar average slope conditions to the project area within the project's MLRA that are currently in crop cultivation.
    v. The appraisal must also provide:
        1. Evidence of soil suitability for the type of expected agricultural land use.
        2. Evidence of water availability for the type of expected agricultural land use.
d. Appraisal reports shall include a statement by the appraiser indicating to what extent land title conditions were investigated and considered in the analysis and value conclusion.
e. Appraisal reports shall include a discussion of implied dedication, prescriptive rights or other unrecorded rights that may affect value, indicating the extent of investigation, knowledge, or observation of conditions that might indicate evidence of public use.
f. Appraisal reports shall include a separate valuation for ongoing grassland management prepared and signed by a certified or registered professional qualified in the field of specialty interest. This valuation shall be reviewed and approved by a second qualified, certified or registered professional, considered by the appraiser, and appended to the appraisal report. The valuation must identify and incorporate all legal constraints that could affect the valuation of the ongoing grassland management.
g. The appraisal must be conducted in accordance with the Uniform Standards of Professional Appraisal Practice[19] and the appraiser must meet the qualification standards outlined in the Internal Revenue Code, Section 170 (f)(11)(E)(ii).[20]

[19] The Uniform Standards of Professional Appraisal Practice may be accessed at: http://commerce.appraisalfoundation.org/html/2006%20USPAP/toc.htm

[20] Section 170 (f)(11)(E) of the Internal Revenue Code defines a qualified appraiser as "an individual who:
(I) has earned an appraisal designation from a recognized professional appraiser organization or has otherwise met minimum education and experience requirements set forth in regulations prescribed by the Secretary,
(II) regularly performs appraisals for which the individual receives compensation, and
(III) meets such other requirements as may be prescribed by the Secretary in regulations or other guidance."

3. *The alternative land use for the project area has a higher market value than maintaining the project area for sustainable grassland management, such that it meets the financial additionality threshold.* The appraisal for the property must provide an estimated fair market value for the rental rate (in US$ per acre per month) for the current grassland use condition of the project area (considering the land to be encumbered and thus unable to be converted to cropland) and an estimated fair market value of the rental rate for the anticipated use the project area as cropland. The appraisal must identify whether or not irrigation is considered in the valuation (or, alternatively, may provide estimations both with and without irrigation). The difference between the rental rate for cropland and the rental rate for grassland, divided by the rental rate for grassland, is the cropland premium for the project area. Eligibility is then determined according to the thresholds as outlined in the beginning of Section 3.3.1.1.

If a project that has been registered using the appraisal option later applies to expand the project area, they must first consult with Reserve staff to determine if a new appraisal is needed for the expanded project area.

3.3.1.2 Suitability Threshold

The project area must be suitable for conversion to cropland. Suitability is demonstrated by determining the Land Capability Classification (LCC) for the soil map units that are contained within or intersect the project area. Soil map units and their corresponding characteristics, such as LCC, are defined in the Soil Survey Geographic Database (SSURGO).[21] The LCC is divided into eight classes of decreasing value as cropland, with LCC I-IV being considered generally suitable for cultivation (3). SSURGO contains LCC for both irrigated and non-irrigated land uses. The Project Owner shall refer to the non-irrigated LCC (NICC) to determine eligibility for the project area. If a Project Owner would like to use the irrigated LCC (ICC) for a project, they must provide evidence that the project area would have access (both legal and physical) to irrigation in the baseline scenario. The entire project area must be assessed using a single version of the LCC and a single suitability threshold. This can be demonstrated by one or more of the following methods, subject to the verifier's professional judgment:

- Comprehensive assessment of the existence of available groundwater,[22] and the legal and economic feasibility of the Grassland Owner to access it from within the project area
- Documentation of the current availability of water rights and/or permits for the project area on or around the project start date
- Documentation of installation of new irrigation on lands within the project county within the 24 months prior to the project start date
- Evidence of ongoing irrigation practice on other parcels within the county

Grassland projects are generally only eligible on LCC I-IV soils, with allowances for a limited amount of LCC V-VI soils. LCC VII-VIII soils are not eligible for crediting. This protocol offers two options for determining the allowable amount of LCC V-VI soils in the project area: a default MLRA-specific threshold or an assessment of the LCC of local cropland. Project Owners may select either of the two options below.

[21] Additional background and details regarding SSURGO may be found at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627 (accessed 10/27/16).
[22] The groundwater assessment should be completed by an appropriately-trained professional, such as a Professional Geologist, Professional Engineer, or Certified Hydrogeologist.

If the project area is expanded at a later date, the suitability threshold is applied to the new, expanded project area as a whole. If the original suitability threshold was based on the ICC the project developer must demonstrate that the added land would have access to irrigation in the baseline scenario by either proving that the evidence for the initial project area applies to the expanded area or by providing additional evidence for the expanded area.

Option 1: Default Land Capability Classification Threshold Based on Major Land Resource Area

The Reserve has developed a table of default, MLRA-specific LCC thresholds. The specific default value for each MLRA is contained in the *Grassland Project Parameters* spreadsheet.[23] The percentage of cultivated land that is classified as NICC I-IV (rounded to the nearest whole number) represents the minimum allowable percentage of the project area for those land classes. For example, if the default value is 80%, the threshold for eligibility for that MLRA is 80% NICC I-IV, allowing for up to 20% NICC V-VI. Please see Appendix A for a description of how these thresholds were derived.

The default MLRA-specific thresholds are calculated using the NICC. Certain MLRAs with high levels of irrigation also have a default threshold provided based on the ICC. Project Owners have the option of applying the default NICC threshold, using the NICC values for their project area, or the default ICC threshold, using the ICC values for their project area. Use of the ICC values is subject to the requirements above to demonstrate access to irrigation in the baseline scenario.

If the project area includes more than one MLRA, the appropriate threshold for Class I-IV soils shall be an area-weighted average of the MLRA-specific thresholds (e.g., if half of the project area is in a MLRA with a threshold of 80%, and the other half is in a MLRA with a threshold of 70%, the overall threshold for the project area will be 75%).

Option 2: Local Cropland Assessment

In areas where the Project Owner believes that the option above does not accurately reflect the LCC of local cropland, a local assessment may be carried out. The assessment must include at least three actively-cultivated farms within 30 miles of the project area, with the total acreage of each farm being no less than the total acreage of the project area, and must include the entire area under cultivation for each property, excluding areas that are not used for crop cultivation. For each property the Project Owner shall identify the NICC of the soil map units, add up the acreage for each NICC across all properties in the assessment, and determine the percentage by area for NICC I-IV land. The fraction of cultivated land that is classified as NICC I-IV (rounded to the nearest whole number) represents the minimum allowable fraction of the project area for those land classes. This analysis may be conducted using the ICC values, in which case the Project Owner must follow the requirements above to demonstrate access to irrigation in the baseline scenario. Project Owners are strongly encouraged to consult with Reserve staff when conducting an assessment under this option.

3.3.2 The Legal Requirement Test

All projects are subject to a legal requirement test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or

[23] Certain parameters required for project eligibility and quantification are contained in a separate resource, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

other legally binding mandates. The legal requirement test for grassland projects involves three parts to ensure the project activity is allowed but not compelled:

1. There must be no federal, state, or local regulation for the project area to be maintained as grassland, either pre-existing or subsequent, or other pre-existing legally binding mandate, agreement, contract[24], deed restriction or deeded encumbrance[25] for the project area to be maintained as grassland (other than the easement that is enacted for the project); and,
2. There must be no zoning, permitting, ownership, or other legal obstacle to the conversion of the project area to cropland; and,
3. There must be no federal, state, or local regulation that would prohibit ongoing management of the project area as cropland.

Parts 1 and 2 are assessed as of the project start date. Part 3 is assessed on an ongoing basis following the project start date. Voluntary agreements that can be rescinded, such as rental contracts, are not considered legal requirements. Temporary or emergency restrictions or regulations shall be assessed with regard to the legal requirement test so long as they constitute a legally binding mandate, as described in this section. If a temporary legal restriction would violate parts 1 and/or 2 above, the project may delay implementation until such time that the project may pass the legal requirement test. If a temporary legal restriction violates part 3 above, the project is ineligible to receive CRTs for the period of time during which the regulation is effective.

Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) are voluntary agreements that shield landowners from certain liabilities under the Endangered Species Act. Agreements of this nature that were approved more than 6 months prior to the project's start date are considered to be pre-existing legally binding agreements.[26] Agreements of this nature that are approved no more than 6 months prior to the project's start date and that satisfy Section 3.3.2.1 are not considered pre-existing legally binding agreements for the purpose of the legal requirement test.[27]

Any agreement that serves to generate credits or payments for ecosystem services derived from the land is subject to the eligibility requirements in Section 3.3.3.

[24] An agreement that can be enforced specifically, that is, where a party to the agreement (who is not participating as a "Grassland Owner") can prevent the physical breaking of the grassland, is considered a binding legal requirement.
[25] Unless all parties with a potential claim to soil carbon ownership participate in the project as Grassland Owners, per Section 3.2, any pre-existing encumbrance or restriction or any other recorded agreement, must expressly and unequivocally assign soil carbon ownership and control to the participating Grassland Owner(s) and/or expressly permit the participating Grassland Owner(s) and Project Developer(s) to undertake a soil carbon offset project on the project area. Any subsequent legally binding agreement must be made subordinate to the PIA (if applicable) and project-related conservation easement; the terms of a subsequent legally binding agreement must not be incompatible with an AGC project. See Sections 2.3.2 and 3.5.1 for more information on eligibility requirements regarding title recordings and encumbrances.
[26] While voluntary in nature, the penalties for terminating HCPs or SHAs are such that they are effectively legally-binding in the opinion of the Reserve. The allowance for agreements approved within 6 months of the project start date is based on the opinion that this represents a "concurrent" activity.
[27] While an agreement may not violate the legal requirement test, an easement or other deed restriction associated with the performance of that agreement may be a pre-existing legal requirement, and therefore disqualify certain portions, if not all, of the agreement area. See Section 3.3.2.1.

Deeded encumbrances, such as conservation easements, may effectively control soil carbon. Deeded encumbrances that are enacted prior to the project start date are considered legally binding mandates for the purposes of the legal requirement test.

To satisfy the legal requirement test, the Project Owner must submit a signed Attestation of Voluntary Implementation form[28] as part of the verification activities for the initial verification (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the Project Owner follows to ascertain and demonstrate that the project at all times passes the legal requirement test.

3.3.2.1 Requirements for Concurrent Legally Binding Agreements

A Grassland Owner may concurrently enter into a legally binding agreement related to ecosystem services or protection on the project area, subject to Sections 3.3.2 for liability shielding agreements and/or Section 3.3.3 for ecosystem services or protection credit and payment stacking, under the following conditions. For liability shielding programs, i.e., HCPs and SHAs, an agreement is considered concurrently entered into if the legal agreement is approved no more than 6 months prior to the project start date. For credit and payment stacking programs, the agreement is considered concurrently entered into if the easement required by the ecosystem program serves both the ecosystem services program and the start date requirement of the Grassland Protocol.

The Grassland Owner must ensure that the agreement, and/or the program under which the agreement is authorized, provides sufficiently clear language to demonstrate the legal additionality of the grassland project. Specifically, the agreement must make explicit that the Grassland Owner has the right to use the land covered by the agreement for the purposes of participating in a carbon offset market. The Reserve maintains the right to determine whether this issue is clear.

For agreements that require land to be put under perpetual conservation easement, the easement may also serve the requirements of a grassland project so long as the easement conforms to the requirements of Section 3.2. For agreements that require at least one perpetual conservation easement but allow for multiple subsequent easements, each easement should be evaluated individually. If any easement does not conform to Section 3.2, the portion of the land covered by that easement is ineligible as a project area.

3.3.3 Ecosystem Services Credit and Payment Stacking

When multiple ecosystem services credits or payments are sought for a single activity on a single piece of land, with some temporal overlap between the different credits or payments, it is referred to as "credit stacking" or "payment stacking," respectively (4). Under this protocol, credit stacking is defined as receiving both offset credits and other types of mitigation credits for the same activity on spatially overlapping areas (i.e., in the same acre). Mitigation credits are any instruments issued for the purpose of offsetting the environmental impacts of another entity, such as emissions of GHGs, removal of wetlands or discharge of pollutants into waterways, to name a few. Payment stacking is defined as issuing mitigation credits for a best management or conservation practice that is also funded by the government or other parties via grants, subsidies, payment, etc., on the same land.

[28] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

Any type of conservation or ecosystem service payment or credit received for activities on the project area must be disclosed by the Project Owner to the verification body and the Reserve on an ongoing basis.

3.3.3.1 Credit Stacking

The Reserve identified two mitigation credit market opportunities that need to be assessed as part of the eligibility of a grassland project. These markets credit the same activity on the same acreage as a grassland project: permanently conserving grassland.

Endangered Species Habitat Credits

Endangered species habitat credits can be generated through habitat conservation banks. These conservation banks are authorized under Section 10 of the Endangered Species Act (ESA) to restore, create or otherwise protect endangered species habitat (5). Section 10 allows landowner-developers to perform certain actions that would otherwise result in an illegal taking of an endangered species or its habitat under Section 9 of the ESA, provided that they receive and comply with an incidental take permit from the U.S. Fish and Wildlife Services (FWS)[29]. The permit requires the landowner-developer to mitigate the negative impacts of the activity on the habitat, and may allow the landowner-developer to achieve this mitigation by purchasing – or generating – endangered species habitat credits from habitat conservation banks.

In order to establish a conservation bank and generate endangered species credits, FWS requires landowner-bankers to enter into a conservation bank agreement with the FWS and other relevant government agencies, and to record a perpetual conservation easement on the land covered by the conservation bank. A Grassland Owner can concurrently seek the establishment of a conservation bank on the project area, but the Grassland Owner must ensure that both the conservation bank agreement and the perpetual easement provide sufficiently clear language to demonstrate the additionality of the grassland project, i.e., that potential revenues from the grassland project were considered at the time of the negotiation of both of these agreements.

The date of the easement recordation is subject to the start date requirements in Section 3.2 and the easement itself is subject to the easement requirements in Section 3.2. The conservation bank agreement is not considered to be a pre-existing legal requirement for the purposes of the legal requirement test so long as it satisfies Section 3.3.2.1.

Furthermore, FWS specifies that land used to establish conservation banks must not be previously designated for conservation purposes.[30] It is thus reasonable to assume that FWS would not approve a conservation bank and issue endangered species habitat credits to lands already engaged in a grassland project. However, it is ultimately the decision of FWS if such subsequent credit stacking is allowed.

Wetland Credits

Under the guidelines established for Section 404 of the Clean Water Act, developers may impact a wetland if those impacts are offset through the restoration, creation, enhancement or preservation of another wetland elsewhere. The Army Corps of Engineers-led Interagency

[29] U.S. Code Title 16, Chapter 35, §1539 - Exceptions (2009).
[30] *Ibid*.

Review Team (IRT)[31] may issue a Department of Army permit to authorize such actions subject to the creation of a wetland mitigation bank.[32] In some cases, wetland mitigation banks may include and credit the preservation of upland habitat that could be eligible under this protocol.

Similar to conservation banks, the acreage covered by mitigation banks is required to be protected in perpetuity.[33] A Grassland Owner can concurrently seek the establishment of a mitigation bank on the project area, but the Grassland Owner must ensure that both the mitigation bank agreement and the perpetual easement provide sufficiently clear language to demonstrate the additionality of the grassland project, i.e., that potential revenues from the grassland project were considered at the time of the negotiation of both of these agreements.

The date of the easement recordation is subject to the start date requirements in Section 3.2 and the easement itself is subject to the easement requirements in Section 3.2. The mitigation bank agreement is not considered to be a pre-existing legal requirement for the purposes of the legal requirement test so long as it satisfies Section 3.3.2.1.

Furthermore, federal law states that under no circumstances may the same credits be used to provide mitigation for more than one permitted activity but that, where appropriate, mitigation banks may be designed to holistically address requirements under multiple programs and authorities for the same activity.[34] It is then reasonable to assume that the IRT would not approve a mitigation bank and issue wetland credits to lands already engaged in a grassland project. However, it is ultimately the decision of the IRT if such subsequent credit stacking is allowed.

3.3.3.2 Payment Stacking

The Reserve has identified two general types of payments that support the grassland activities being credited under this protocol: “landscape-scale” payments and “enhancement” payments. The majority of these payments are available via programs implemented by the USDA NRCS. NRCS expressly allows the sale of environmental credits from enrolled lands,[35] but does not provide any further guidance on ensuring the additional environmental benefit of any payment for ecosystem service stacked with an NRCS payment.

Landscape-Scale Payments

Landscape-scale payments generally come from land conservation programs that prevent grazing and pasture land from being converted into cropland, used for urban development, or developed for other non-grazing uses. Participants in these programs voluntarily limit future development of their land through the use of long-term contracts or easements, and payments are generally made based on the value of the land being protected. Thus, these payments are incentivizing the same project activity as this protocol. Examples of landscape-scale payments include:

- NRCS Grasslands Reserve Program (2008 Farm Bill)
- NRCS Conservation Reserve Program (2008 Farm Bill)
- NRCS Farm and Ranch Lands Protection Program (2008 Farm Bill)

[31] The Army Corps of Engineers is the chair; other members can be EPA, FWs, NRCS, NOAA and other federal, state, tribal, and local agency representatives.
[32] Code of Federal Regulations, Title 33, Part 332 (33 CFR 332).
[33] 33 CFR 332.3(h)(1)(v).
[34] 33 CFR 332.3 (j)(1)(ii).
[35] Environmental Quality Incentives Program: 7 CFR §1466.36; CSP, 7 CFR §1470.37.

- NRCS Agricultural Conservation Easement Program (2014 Farm Bill)
- Conservation easement support offered by non-governmental organizations such as Ducks Unlimited, The Nature Conservancy and the Trust for Public Land (which are often themselves funded by government programs)

If a Grassland Owner concurrently seeks a landscape-scale payment on the project area, any easement or agreement on the project area is subject to the start date requirements in Section 3.2 and the legal requirement test in Section 3.3.2.

Furthermore, under the current rules of government funded programs the recordation of a new permanent conservation easement in order to initiate a grassland project would disqualify the lands from continued participation in any NRCS payment program.[36] Therefore, the Reserve does not expect lands participating in such programs will have the opportunity to stack payments once the project easement has been recorded, or subsequently stack such payments.

Because every available landscape-scale payment is not comprehensively addressed by the protocol at this time, the Project Owner must disclose any such payments to the verifier and the Reserve on an ongoing basis. The Reserve maintains the right to determine if payment stacking has occurred and whether or not it would impact project eligibility.

Enhancement Payments

Enhancement payments provide financial assistance to landowners in order to implement discrete conservation practices that address natural resource concerns and deliver environmental benefits. For government-funded enhancement payments, participants sign short-term contracts and receive annual cost-share payments specific to the conservation practice they have implemented. Examples of relevant enhancement payments include:

- NRCS Environmental Quality Incentives Program (2014 Farm Bill)
- NRCS Conservation Stewardship Program (2014 Farm Bill)
- NRCS Continuous Conservation Reserve Program (2008 Farm Bill)
- NRCS Wildlife Habitat Incentive Program (2008 Farm Bill)

The practices that are compensated for by the programs above can only occur on land that is being maintained as grassland; however the payment contracts do not purport to pay for the preservation of the grassland, only its enhancement. Furthermore, the programs do not, in practice, sufficiently incentivize the preservation of grassland, much less compensate for the permanent conservation of grassland. Because of this, Grassland Owners may pursue enhancement payments without restriction.

Because every available enhancement payment is not comprehensively addressed by the protocol at this time, the Project Owner must still disclose any such payments to the verifier and the Reserve on an ongoing basis.

3.4 Project Crediting Period

The baseline for any grassland project registered under this protocol is valid for up to 50 years. This means that a registered grassland project is eligible to receive CRTs for GHG reductions

[36] Guidance on eligibility criteria for the CRP program, for both new enrollments and re-enrollments can be found here, respectively:
http://www.fsa.usda.gov/Internet/FSA_File/gs43factsheet.pdf
http://www.fsa.usda.gov/programs-and-services/conservation-programs/current-participants-general-public/index

quantified using this protocol, and verified by Reserve-approved verification bodies, for a period of up to 50 years following the project's start date. Certain strata may not generate baseline emissions for the full 50 years (as evidenced by a baseline emission factor for organic carbon loss equal to zero for a particular emission factor period), in which case the maximum crediting period is less than 50 years.

In the case of project cooperatives, project crediting periods are tied to each individual grassland project within the cooperative and their respective start dates. Thus, unless all of the projects in the cooperative share the same start date, there is not a single crediting period applicable to the entire cooperative.

In the case of project expansions, the entire project area will be bound to the existing project start date. However, the newly added project areas will only be eligible to receive credits beginning on the date the new portion of the project area became bound by the conservation easement or was transferred to the Grassland Owner, provided that this does not predate the reporting period during which the project area is expanded. In the latter case, the newly added project areas will be eligible to receive credits beginning with the reporting period start date during which the expansion took place.

Projects may elect to end their crediting period at any time. Any CRTs that have been issued are subject to the permanence requirements described in Section 3.5. Any project that wishes to end its crediting period must notify the Reserve prior to the next monitoring or reporting deadline, as determined in Section 7.4. If a project chooses to end its crediting period, no future emission reductions may be reported. If a project would like to forgo credits for a period of time in order to delay verification, this is considered a zero-credit reporting period.[37]

3.5 Requirements for Permanence

To validly offset GHG emissions, the reversible emission reductions credited under this protocol must be permanent. An emission reduction is considered reversible if it is related to carbon which remains stored in a carbon pool, such as soil organic carbon. An example of a non-reversible emission reduction on a grassland project would be the avoided N_2O emissions related to baseline fertilizer use. For the purposes of this protocol, an emission reduction is considered "permanent" if the quantity of carbon associated with that reduction is stored for at least 100 years following the issuance of a credit for that reduction. Once an emission reduction is considered permanent, it is no longer considered reversible. For example, if CRTs are issued to a grassland project in year 24 following its start date, soil carbon in the project area must be maintained through at least year 124. To meet this requirement, Project Owners must monitor and verify a grassland project for a minimum period of 100 years following the issuance of any CRT for GHG reductions achieved by the project, unless the project is terminated. Failure to maintain ongoing monitoring and verification may result in the automatic termination of the project. Note that this means that monitoring and verification for a project must continue even after the end of the project's crediting period. The period of time after the project crediting period has ended and before the minimum time commitment has been met is referred to as the "permanence period".

If carbon is released before the end of the 100-year period after a CRT is issued, the release is termed a "reversal". A reversal occurs if stored carbon is actually released through a disturbance of the project area, or is deemed to be released through termination of the project

[37] See the Reserve Offset Program Manual, available at: http://www.climateactionreserve.org/how/program/program-manual/.

or a portion of the project. Reversals may impact only a portion of the project area or the entire project area.

This protocol distinguishes between two categories of reversals, avoidable and unavoidable, and specifies separate remedies for each. Many biological and non-biological agents, both natural and human-induced, can cause reversals. Some of these agents cannot completely be controlled (and are therefore "unavoidable"), such as natural agents like fire, insects, and wind. This protocol also takes into consideration the extent to which a Project Owner has contributed towards the reversal through negligence, gross negligence or willful intent. Thus reversals caused by biological agents, where the Project Owner has not contributed to the reversal through negligence, gross negligence or willful intent, are considered unavoidable.

An avoidable reversal occurs if:

1. The Project Owner voluntarily terminates the project prior to the end of the 100-year time commitment. A Project Owner may voluntarily terminate the entire project, or a portion of the project area. If only a portion is terminated, then the reversal is considered to affect only the terminated area.
2. There is a breach of certain terms described within the Project Implementation Agreement (see Section 3.5.2, below). Such a breach results in the entire project being automatically terminated.
3. The Project Owner prematurely ceases ongoing monitoring and verification activities. Monitoring, reporting, and verification requirements are described in Sections 6, 7, and 8. Cessation of monitoring and verification results in the entire project being automatically terminated.
4. Any activity occurs on the project area that leads to a significant disruption of soil carbon. Examples include, but are not limited to, cropping activities (conversion to cropland), eminent domain, mining or drilling activities, or installation of wind turbines. In most cases, such disturbances would not constitute a reversal on the entire project area.
5. A natural disturbance occurs to the soil carbon in the project area, and the Reserve determines that the disturbance is attributable to the Grassland Owner's or Project Owner's negligence, gross negligence, or intentional mismanagement of the project area as grassland.

Avoidable reversals must be communicated to the Reserve and compensated for by the Project Owner, as prescribed in Section 5.4.

To ensure that the permanence obligations are guaranteed for the duration of the minimum time commitment, projects are required to employ a Qualified Conservation Easement (QCE) (Section 3.5.1) and a Project Implementation Agreement (Section 3.5.2).

For the purposes of this protocol, both QCEs and the PIA must be effective for 100 years following the issuance of CRTs. However, it may be the case that state law for the project area places limitations on the term length for contracts of this sort. For example, in North Dakota, property easements and restrictions are subject to a maximum limit of 99 years.[38] CRTs will only be issued for periods of time for which the required easement(s) are effective for at least 100 years following the year in which the emission reduction was generated. For projects where

[38] North Dakota Century Code §47-05-02.1, *Requirements of easements, servitudes, or nonappurtenant restrictions on the use of real property*. Accessible at: http://www.legis.nd.gov/cencode/t47.html.

length of property restrictions is limited by state law, CRTs issued for any given reporting period shall be held by the Reserve for a period of time based on the contract length. These CRTs shall be released following a subsequent renewal of the property restrictions such that the restrictions are effective through a date that is at least 100 years after the end of the relevant reporting period.

For example, if a verification period covers two 12-month reporting periods, and a 99-year easement is recorded at the end of the verification period, CRTs will only be issued for the first reporting period. CRTs for the second reporting period shall be withheld until such time as the easement is rerecorded, thus ensuring permanence for at least 100 years from the end of the second reporting period.

3.5.1 Qualified Conservation Easements

A conservation easement is required for all grassland projects. The area bound by the conservation easement does not need to match the project area. However, the entire project area must be included in the area of the conservation easement. A Qualified Conservation Easement (QCE) is one whose terms prevent the conversion of the project area from grassland to another land use, such that avoidable reversals are sufficiently precluded as long as the easement is enforced. For example, whereas a basic conservation easement may only restrict the subdivision and/or development of the project area, a QCE would also restrict activities such as plowing and farming, which could release carbon stored in the soil. The QCE may allow for other activities, such as road or building construction, on the land bound by the easement. However, insofar as these activities would result in a land use other than grassland, the areas where they are allowed should be specified in the QCE and subsequently excluded from the project area in order to avoid the occurrence of a reversal due to such activities. Additionally, the QCE may make reference to the carbon project and simply specify that any non-grassland land use must occur outside of the specified project area. The language of the QCE should be sufficiently clear to reasonably prevent cultivation on the entire project area.

All QCEs must include a statement indicating that the easement is granted pursuant to the state enabling statute for conservation easements for the state in which the project is located (e.g., California Civil Code Section 815). There are additional provisions for project conservation easements that the Reserve strongly encourages, but does not require. For enhanced transparency and legal clarity, the conservation easement should explicitly 1) refer to, and incorporate by reference, the terms and conditions of the PIA and the GHG reduction rights agreement, thereby binding both the grantor and grantee – as well as their subsequent assignees – to the terms of the agreements for the full duration of the grassland project's minimum time commitment, as defined in Section 3.5 of this protocol; and 2) make all future encumbrances and deeds subject to the PIA.[39] It is also recommended that the QCE incorporate and require environmental best management practices for rangeland management (Section 2.4).

3.5.2 Project Implementation Agreement

Permanence obligations must be guaranteed through a legal agreement that obligates the Project Owner to conduct monitoring activities on the project area for the required period of 100 years following CRT issuance, and to compensate for avoidable reversals that occur during that period. For grassland projects this agreement is known as the Project Implementation

[39] The approach to subordination of the PIA will impact the project's contribution to the risk buffer pool, as described in Section 5.4.3.

Agreement.[40] Requirements for monitoring and reporting activities during the permanence period are detailed in Section 7.5.

The PIA is an agreement between the Reserve and a Project Owner setting forth: (i) the Project Owner's obligation (and the obligation of its successors and assigns) to comply with the Grassland Protocol, and (ii) the rights and remedies of the Reserve in the event of any failure of the Project Owner to comply with its obligations. The PIA must be signed by the Project Owner before a project can be registered with the Reserve. The PIA is executed and submitted after the Reserve has reviewed the verification documents and is otherwise ready to register the project. It is not possible to terminate the PIA for only a portion of the project area; however an amended PIA may be executed that reflects a change to the project area as provided for by the exceptions to the minimum time commitment at the beginning of this section. The PIA is also amended at each subsequent verification in order to extend the term of applicability.

There are two types of PIAs available to a grassland Project Owner:

Contract PIA

A Contract PIA is a contract between the Project Owner and Reserve whereby the Project Owner agrees to the requirements of the protocol, including but not limited to monitoring, verification, and compensating for reversals. The PIA does not restrict the transferability of the specific CRTs issued, but does hold the Project Owner to the compensation requirements of Section 5.4. By the terms of the PIA, the contract is satisfied upon the Project Owner's full performance of the requirements of this protocol (i.e., monitoring and verifying permanence for 100 years following CRT issuance). The PIA is executed at the completion of the initial project verification, and then amended at the completion of each subsequent verification (prior to or at the time of CRT issuance). The Contract PIA is not a public document.

Recorded PIA

In the case where the Project Owner is the Grassland Owner, or where the Grassland Owner is willing to record the PIA on the deed to the property, the Project Owner may employ a Recorded PIA. This is a contract between the Project Owner and the Reserve that is recorded on the deed to the property and binds the Project Owner and Grassland Owner to the terms of the protocol. This version of the PIA does not grant the Reserve a security interest, but rather grants the Reserve the ability to enforce the protocol requirements on the project area. The Recorded PIA is publicly available from the records office of the county in which the project is located.

3.6 Regulatory Compliance

As a final eligibility requirement, Project Owners must attest that project activities do not cause material violations of applicable laws (e.g., air, water quality, safety, etc.). To satisfy this requirement, Project Owners must submit a signed Attestation of Regulatory Compliance form[41] prior to the commencement of verification activities each time the project is verified. Project Owners are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project activities. Where a temporary or

[40] The template PIA is available on the Grassland Protocol webpage: http://www.climateactionreserve.org/how/protocols/grassland/.
[41] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

emergency restriction or regulation is in force during the reporting period, it shall be included in the assessment of the project's regulatory compliance.

A violation should be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the Project Owner shall disclose the violation to the verifier.

If a verifier finds that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and do not affect CRT crediting. However, recurrent administrative or reporting violations directly related to project activities may affect crediting, especially if related to negligence or intent on the part of the Project Owner or Grassland Owner. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

3.7 Ecosystem Health

Grassland project areas, regardless of location or management, are subject to forces that could degrade the grassland ecosystem and potentially cause the land to transition to a different landscape type, even in the absence of a single disturbance event. Such degradation or landscape transition not only has the potential to negatively impact the belowground carbon stocks (thus jeopardizing the integrity of the project quantification), but may also lead to eventual conversion of the project area to a land use other than grassland (e.g., dense shrubland, forest, bare soil, etc.). Project activities such as livestock grazing or recreation could also lead to impaired rangeland health, if not properly managed. Projects that are located adjacent to land that has already been converted to cropland or development may also be subject to a higher risk of rangeland health impairment due to encroachment of invasive species or increased grazing/foraging by wild animals whose habitat has been constrained by land conversion. The Reserve does not seek to prescribe specific land management activities. Rather, the intent of this section is to encourage thoughtful and proactive land management to maintain and/or improve rangeland health.

In order to protect against long term degradation of the project area, periodic assessments of rangeland health[42] must be conducted according to the guidance contained in Section 6.4. If a project area is expanded to include land with an Ecological Site Description that differs from the original project area, the rangeland health assessment must be updated to incorporate the initial health condition metrics of the new project area. For any metrics that are determined to display "moderate" departure from the reference condition, the Project Owner must document how the land management will be adapted to address these deficiencies. If the assessment determines that the project area exhibits greater than "moderate" departure from the defined reference condition for any metric, the Project Owner must not only show a plan for management adaptation, but must also show improvement in that metric at the subsequent rangeland health assessment.

If projects that are required to improve rangeland health fail to do so at the subsequent assessment, the Reserve will determine whether the degradation was avoidable or unavoidable. Avoidable degradation could lead to ineligibility for the current reporting period, resulting in no CRTs being issued for that period. If the continued degradation is determined to be

[42] Additional details regarding the U.S. Federal Government's multi-agency program for assessing Rangeland Health can be found at: http://jornada.nmsu.edu/monit-assess/manuals/assessment (accessed 10/14/16).

unavoidable, the project may still receive CRTs for the reporting period, but must abide by the requirements of the previous paragraph to implement new management approaches to improve rangeland health.

In cases where there is a rangeland health assessment showing greater than moderate departure from the reference condition for one or more metrics, the Reserve will consult with rangeland health experts to determine whether the degradation is sufficiently significant to warrant the determination that a reversal has occurred. In cases where is the Reserve determines that a reversal has occurred, the requirements of Section 5.4 regarding avoidable and unavoidable reversals shall apply.

The requirements of this section may be satisfied through alternative assessment methods with written approval from the Reserve (See section 6.4 for alternatives).

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed in order to determine the net change in emissions caused by an avoided conversion of grasslands project.[43] The GHG Assessment Boundary encompasses all of the GHG SSRs that may be significantly affected by project activities, including biological CO_2 emissions and soil carbon sinks and sources of N_2O.

Figure 4.1 illustrates all relevant GHG SSRs associated with grassland project activities and delineates the GHG Assessment Boundary.

Table 4.1 provides greater detail on each SSR and justification for the inclusion or exclusion of certain SSRs and gases from the GHG Assessment Boundary. The SSRs that are marked with "(R)" represent those for which baseline emissions are reversible, and thus subject to the requirements for permanence in Section 3.5.

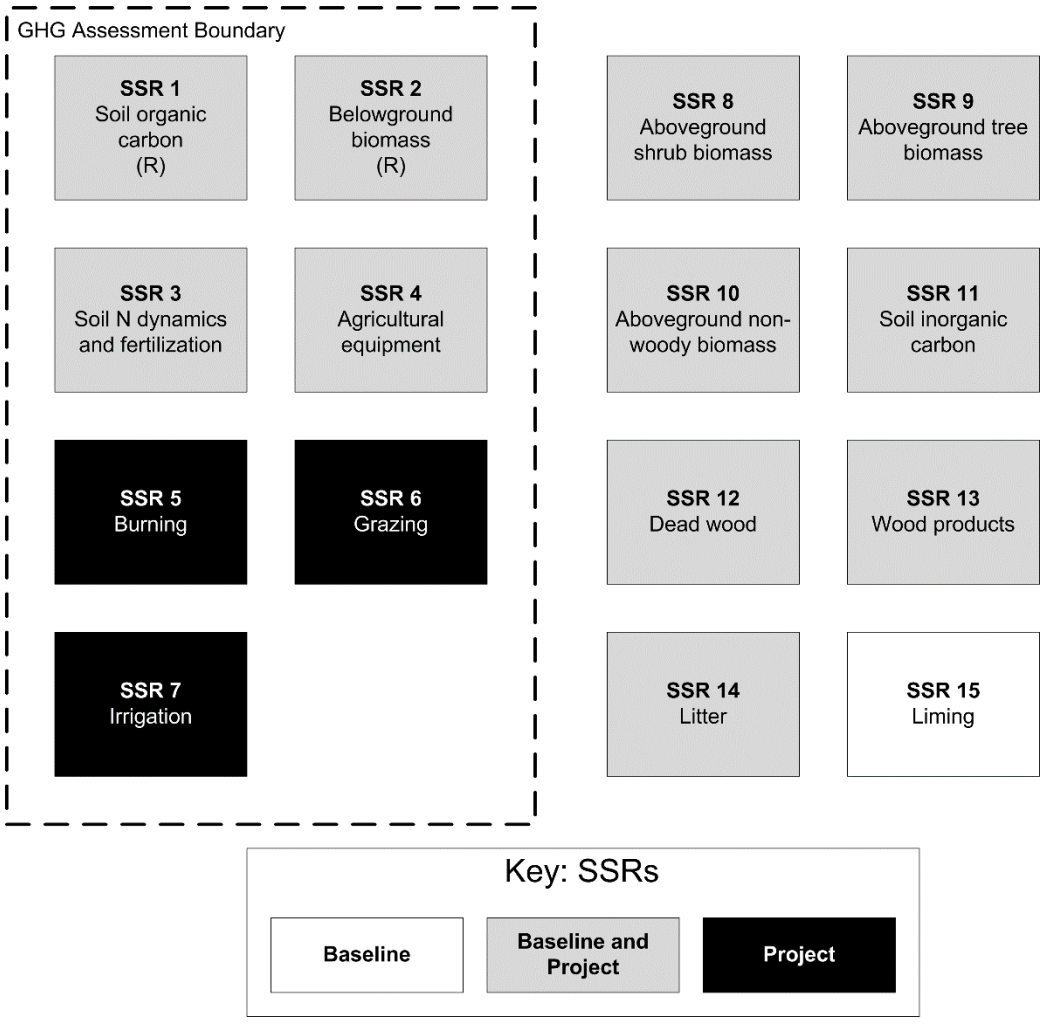


Figure 4.1. General Illustration of the GHG Assessment Boundary

[43] The definition and assessment of sources, sinks, and reservoirs is consistent with ISO 14064-2 guidance.

Table 4.1. Description of All Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I), Optional (O), or Excluded (E)	Quantification Method	Justification/Explanation
1	Soil organic carbon	CO_2	I	Default emission factor modeled using DAYCENT	Emissions from the loss of soil organic carbon are a primary effect and major emission source in the baseline. Reversible.
2	Belowground biomass	CO_2	I	Default factor modeled using DAYCENT	Emissions from the loss of below-ground biomass are a primary effect and major emission source in the baseline. Reversible.
3	Soil nitrogen dynamics and fertilization	N_2O	I	**Baseline:** Default emission factors modeled using DAYCENT **Project:** Calculated based on monitored data	Direct and indirect N_2O emissions from conversion activities, soil processes and fertilization can be significant in the baseline. Direct and indirect N_2O emissions from fertilization can be significant in the project scenario, if applicable.
4	Agricultural equipment from site preparation and ongoing operations	CO_2	I*	**Baseline:** Default emission factor **Project:** Calculated based on monitored data	Fossil fuel emissions from equipment used for conversion site preparation and ongoing field operations (tillage, fertilization, etc.) may be significant in the baseline. * Associated emission reductions excluded in jurisdictions where these emissions are subject to a binding cap (e.g., California). Fossil fuel and electricity emissions from equipment used for grassland management may be significant in the project scenario.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
5	Burning	CO_2	E	N/A	CO_2 emissions due to grass biomass burning are considered biogenic and thus are excluded from the project boundary.

SSR	Source Description	Gas	Included (I), Optional (O), or Excluded (E)	Quantification Method	Justification/Explanation
		CH_4	I	Calculated based on monitored data	When grass biomass is burned, a portion of the carbon is released as CH_4. Depending on the area burned, this could be a significant source of project emissions.
		N_2O	I	Calculated based on monitored data	When grass biomass is burned, a portion of the carbon is released as N_2O. Depending on the area burned, this could be a significant source of project emissions.
6	Grazing	CO_2	E	N/A	Excluded, as this is not a significant source of emissions. Additionally, any CO_2 emissions from grazing would be considered biogenic.
		CH_4	I	Calculated based on monitored data	Grazing livestock in the project scenario produces potentially significant quantities of CH_4 through the decomposition of manure, as well as enteric fermentation.
		N_2O	I	Calculated based on monitored data	Grazing livestock in the project scenario produces potentially significant quantities of N_2O through the decomposition of manure.
7	Irrigation	CO_2	I	Calculated based on monitored data	Emissions from equipment used for grassland management may be significant in the project scenario.
		CH_4	E	N/A	No significant CH_4 emissions related to irrigation of the project area are expected.
		N_2O	I	Calculated based on monitored data	Indirect N_2O emissions from irrigation can be significant in the project scenario, where livestock grazing and/or fertilizer application occurs.
8	Aboveground shrub biomass	CO_2	E	N/A	Emissions from the loss of above-ground shrub biomass can be a significant emission source in the baseline for certain projects. Exclusion is conservative.

SSR	Source Description	Gas	Included (I), Optional (O), or Excluded (E)	Quantification Method	Justification/Explanation
9	Aboveground tree biomass	CO_2	E	N/A	Trees may hold a significant amount of biomass, but the fate of that carbon after conversion is uncertain, depending upon the volume of wood, the species, and the accessibility of mills. This protocol conservatively excludes tree biomass from the baseline emissions calculations.
10	Aboveground non-woody biomass	CO_2	E	N/A	Excluded, as the permanent pool is assumed to be very small, despite seasonal fluxes. The exclusion is conservative.
11	Soil inorganic carbon	CO_2	E	N/A	Excluded, as this source is not included in the baseline modeling. The exclusion is conservative.
12	Dead wood	CO_2	E	N/A	Excluded, as this emission source is assumed to be very small. The exclusion is conservative.
13	Wood products	CO_2	E	N/A	Excluded, as this emission source is assumed to be very small. The exclusion is conservative.
14	Litter	CO_2	E	N/A	Excluded, as this emission source is assumed to be very small. The exclusion is conservative.
15	Liming	CO_2	E	N/A	Excluded, as the direction and magnitude of this emission source is uncertain. Current IPCC emission factors treat liming as an emission source, whereas current USDA quantification methodologies treat it as a net sink (6) (7).

5 Quantifying GHG Emission Reductions

GHG emission reductions from an avoided grassland conversion project are quantified by comparing actual project emissions to the calculated baseline emissions. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the project. In the case of grassland projects, the baseline emissions include the loss of belowground organic carbon through conversion to cropland, as well as the GHG emissions from crop production. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions include GHG emissions from grassland maintenance and grazing, as well as any leakage of baseline conversion activities. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

Quantification of baseline emissions is done through the use of default emission factors developed through a probabilistic composite modeling approach. This approach greatly simplifies the quantification and monitoring of grassland projects, as compared to an approach based on site-specific sampling and modeling. Additional discussion of this approach can be found in Appendix B.

Timelines for quantifying and reporting GHG emission reductions are detailed in Section 7.4. Project Owners may choose to quantify and verify GHG emission reductions on a more frequent basis if they desire. The length of time over which GHG emission reductions are periodically quantified is called the "reporting period." The length of time over which GHG emission reductions are verified is called the "verification period." Under this protocol, a verification period may cover multiple reporting periods (see Section 7.4).

As of this writing, the Reserve relies on values for global warming potential (GWP) of non-CO_2 GHGs published in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007).[44] The values relevant for this protocol are provided in Table 5.1, below. These values are to be used for all grassland projects unless and until the Reserve issues written guidance to the contrary.

Table 5.1. 100-year Global Warming Potential for Non-CO_2 GHGs

Non-CO_2 GHG	100-Year GWP (CO_2e)
Methane (CH_4)	25
Nitrous Oxide (N_2O)	298

For project cooperatives, the quantification of emission reductions is carried out separately for each individual project. The cooperative structure does not change the quantification methodology contained within this section. To report the total results for the cooperative, the Cooperative Developer shall sum the results of Equation 5.1 for each project in the cooperative. However, it should be noted that CRTs are serialized and issued to individual projects, rather than the cooperative.

[44] Available here: https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml.

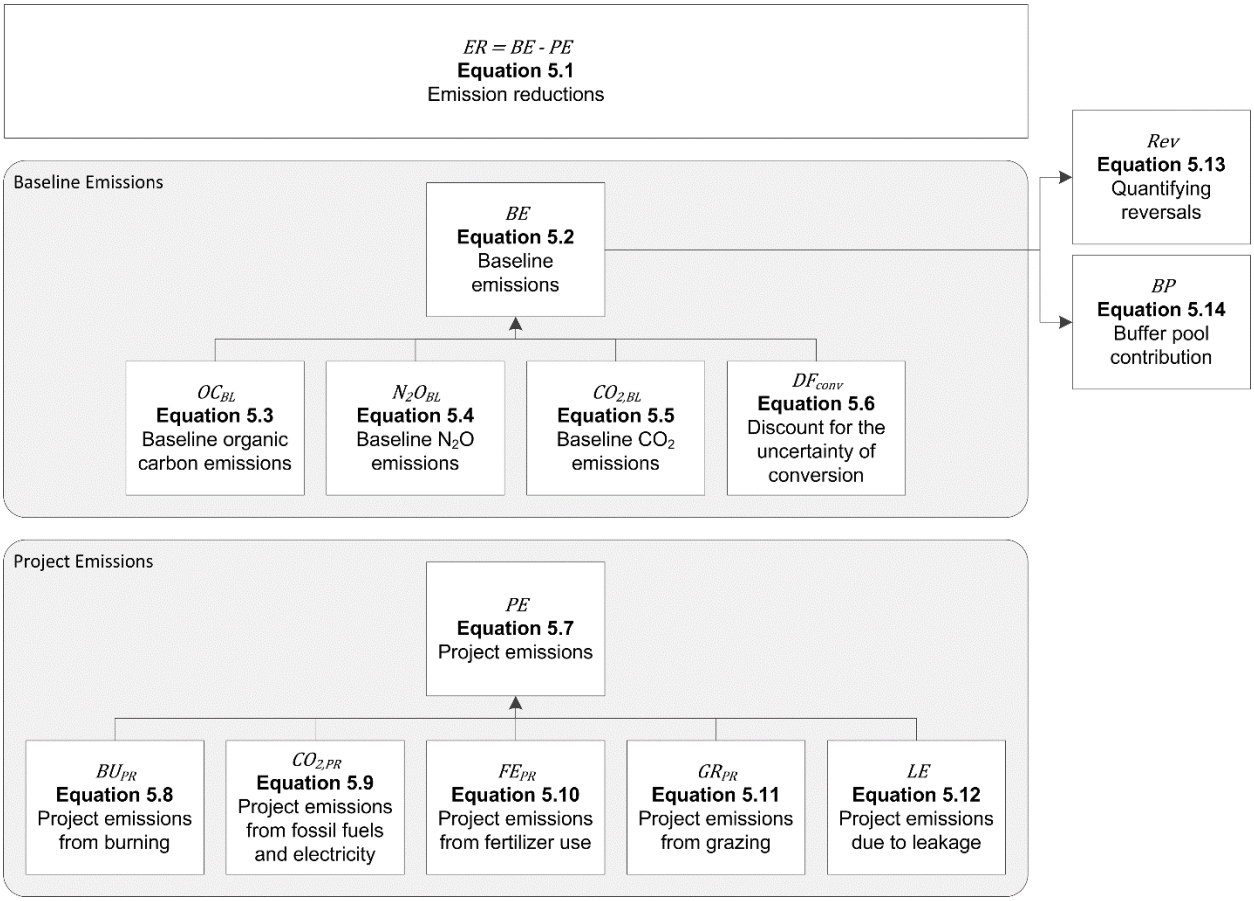


Figure 5.1. Organization of Quantification for Grassland Projects

Equation 5.1. GHG Emission Reductions

$$\boldsymbol{ER = BE - PE}$$

Where,

			Units
ER	=	Total emission reductions for the reporting period	tCO_2e
BE	=	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.1)	tCO_2e
PE	=	Total project emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.3)	tCO_2e

5.1 Stratification

For the purposes of this protocol, the U.S. has been stratified in order to enable the development of baseline and project emissions estimates that correspond to local soil conditions, climatic conditions, starting condition, and agricultural practices. A stratum represents a unique combination of these variables. All baseline and project modeling has been performed at the stratum level, enabling the resulting emissions estimates to represent relatively fine distinctions in the primary drivers of variation in emissions. In total, this protocol establishes emissions estimates for 1,002 total strata within the U.S. By stratifying the country in this manner, the emissions estimates used in this protocol provide greater local accuracy and

representation than would emission estimates generated at a national scale or with fewer variables. These variables act as filters that bring greater specificity to the emissions estimates by more precisely estimating the conditions of the project. Land is first broken down by climate and geography, then further delineated by the major soil type and texture, and finally evaluated based on the previous land use.

For large projects, the project area may cover more than one stratum. In these instances, the project itself shall be divided up on an acreage basis into all appropriate strata. Instructions for identifying and calculating acreage in each stratum are provided in Section 5.1.4. All calculations shall be performed at the stratum level and summed to the project level where indicated.

The following variables are used to stratify the U.S., and shall be used to determine the appropriate stratum for a project or project area:

- Geography and associated climate
- Soil texture
- Previous land use

Each project shall be evaluated on the basis of each of these variables to determine its appropriate stratum, or strata, should its area contain multiple strata. The following sections provide guidance on determining the appropriate stratum for any parcel or portion of the project area.

5.1.1 Geography and Associated Climate

The first level of stratification used in this protocol delineates land based on its geography and associated climate, due to these factors' important influence over carbon pools and sources in both natural and managed ecosystems (6). Regional climate and geographic conditions are determined through the use of Major Land Resource Area designations, as defined by the USDA NRCS (9). These designations are used for a variety of policy and planning decisions, as they represent information about land suitability for farming and other purposes. As such, they constitute a land area that has similar physical and climatic characteristics. In total, there are approximately 280 MLRAs in the U.S. However, some of these MLRAs contain very little cropland or grassland feasible for conversion. Appendix B provides an overview of the methodology used to screen out certain MLRAs based on the absence of significant areas of grassland or cropland, and constraints on data availability and modeling confidence.

The USDA NRCS makes available tools for the geographic identification of MLRAs.[45]

5.1.2 Soil Texture

Soil texture has a significant impact on land productivity and carbon dynamics through influences on soil fertility and water balance and on soil organic matter stabilization processes (8). Accordingly, the second level of stratification requires differentiating by soil texture. While successively finer delineations of soil type and texture would yield greater precision, this protocol limits the stratification of soils into three major classes of surface soil texture as defined by USDA. These are:

[45] MLRA geographic data are available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053624.

- Coarse
- Medium
- Fine

Table 5.2 explains how these three categories can be mapped to the various soil surface textures as they are listed in the soil database.

5.1.3 Previous Land Use

Initial carbon pools at project commencement are significantly influenced by previous land uses. Additionally, soil quality at project initiation influences nutrient inputs and farming practices in the baseline scenario. Because this protocol allows for the avoided conversion of grasslands with somewhat varied histories, the third level of stratification requires grasslands to be delimited by the duration of time the project area has been in a grassland state. This protocol defines the following two categories for grasslands:

- Greater than 10, but less than 30 years continuous grassland
- Greater than 30 years continuous, long-term permanent grassland

Per Section 3.1, all lands enrolled under this protocol must have been in a documented grassland or pastureland state for at least 10 years prior to project commencement. This requirement is necessary to ensure the validity of the baseline soil carbon emission factors. Areas that have exceeded 30 years of pre-project grassland cover are classified in a different stratum.

The Project Owner must document that the project site meets the definition of grassland as of the project start date. This may be done through a site visit by the verifier, or through other sources of evidence. Project Owners can use a wide variety of types of evidence, subject to review by the verifier. Evidence must cover every year that the land is asserted to have been grassland. It is easier for a verifier to confirm that the project area was in grasslands when the Project Owner provides evidence that is as specific and objective as possible. The list below contains examples of evidence that may be employed to document land use of the project area for a given period of time.

Each piece of evidence must be corroborated by another piece of evidence of a different type. For example, if a Project Owner provides satellite data indicating grassland as the land cover on the project area for a given year, at least one additional form of documentation (such as a contract or an affidavit) is required for corroboration. Evidence cannot be corroborated by other evidence of the same type (e.g., satellite evidence cannot be corroborated by other satellite evidence). All land use evidence shall be subject to review and approval by the verifier.

<u>Examples of evidence demonstrating land use history:</u>

- Site visit by the verifier (applies only to the relevant reporting period)
- Time-referenced photos of the project area taken during the relevant year(s) (applies to the areas that can reasonably be assessed with these photos)
- Time-referenced aerial photos taken during the relevant year(s)

- Satellite data products, such as the Cropland Data Layer (CDL)[46], National Land Cover Database,[47] or MODIS Enhanced Vegetative Index[48]
- Continuous Vegetation Cover Report developed by the Rangeland Analysis Platform demonstrating the permanence of annual and perennial forb & grass cover[49]
- Contract(s) covering the relevant year(s) whose terms would require that the project area be grassland, but that would not cause the project to fail the legal requirement test (e.g., grazing leases or haying contracts)
- Tax records that indicate the land use during the relevant year(s)
- Notarized affidavit(s) from unrelated and unaffiliated parties attesting to the land use in the relevant year(s)
- Notarized affidavit from the Grassland Owner(s) attesting to the land use in the relevant year(s)
- Other official records submitted to or generated by a government agency that would indicate the land use or management during the relevant year(s)
- Easement monitoring reports applicable to the totality of the relevant reporting period(s)[50] and developed by the Grantee

This list is not meant to be comprehensive. The Project Owner may employ alternative approaches to monitoring land use on the project area, subject to review by the verifier. The evidence provided to satisfy this requirement must be sufficient to provide reasonable assurance as to the nature of the land use during the relevant time period. The Reserve has developed a companion document to this protocol, the Grassland Project Handbook, that provides further detail and discussion of the various options for satisfying the requirements of this section.[51]

5.1.4 Stratum Identification and Measurement

In total, this protocol stratifies the U.S. into 1,674 unique strata based on the three variables previously discussed (although emission factors were only able to be generated for 1,002 strata; see Appendix B for further details). Box 5.1 describes the method for naming each individual stratum. These names are then used in the companion tables for default parameters provided for each stratum.[52]

[46] The Cropland Data Layer is a free remote sensing product developed and provided by the USDA National Agricultural Statistics Service. The data are available online at: http://nassgeodata.gmu.edu/CropScape/.
[47] The NLCD is a free remote sensing product provided by the Multi-Resolution Land Characteristics Consortium. The data are released every 5 years and is available online at: http://www.mrlc.gov/.
[48] MODIS data are provided by NASA and the USGS. Information regarding MOD13Q1 (the 16-day 250m global vegetation indices) is online at: https://lpdaac.usgs.gov/products/modis_products_table/mod13q1.
[49] The Continuous Vegetation Cover report can be generated by accessing https://rangelands.app and uploading a zip file of the project area to the service. These reports are only available for the Western United States.
[50] See this example for clarification: if a reporting period covers from January 1 to December 31 of one year and the easement monitoring report was issued on March of that year, the monitoring report cannot justify grassland permanence after March.
[51] The Grassland Project Handbook is available for download from the Reserve website at: http://www.climateactionreserve.org/how/protocols/grassland/. This handbook will be updated periodically.
[52] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Box 5.1. Stratum Naming Convention

Name format: **X_Y_Z**

Where,		Range of Values
X =	Numbered designation of the MLRA in which the stratum is found	1 – 278
Y =	Soil texture classification	coarse, medium, or fine
Z =	Minimum year threshold for the previous land use	10 or 30

EXAMPLES:

Stratum	MLRA	Soil Texture	Previous Land Use
1_Medium_10	1 - Northern Pacific Coast Range, Foothills, and Valleys	Medium	Greater than 10, but less than 30 years continuous grassland or pastureland
150A_Fine_30	150A - Gulf Coast Prairies	Fine	Greater than 30 years continuous, long-term permanent grassland or pastureland

Most quantification in this protocol is conducted at the stratum level. Equations require inputs in the form of total acreage within each stratum, and use of stratum-specific emission factors for various carbon pools and emissions sources. Project Owners must prepare a georeferenced map file that contains the entire project area, excluding any portion of the project parcels not legally permitted to be converted due to buffer restrictions[53] or other requirements.

Data from the Soil Survey Geographic Database must be used to identify the acres of the stratum for each soil texture class. It is recommended that Project Owners utilize the NRCS Web Soil Survey application (WSS),[54] which is a user-friendly tool for accessing data from SSURGO. SSURGO data are also available for direct download from the USDA NRCS Geospatial Data Gateway.[55] If an alternate source of data from the SSURGO is available, use of the WSS as described here is not required. At a minimum, Project Owners must be able to identify the acreage of each soil texture group based on the dominant condition[56] of each SSURGO map unit within the project area.

Through the WSS application, the user may locate the general area of the project and then draw a detailed polygon around the project area. This identifies the Area of Interest (AOI) for which the data are generated (it is preferable to use a previously-created shapefile to define the AOI, which ensures that the project boundaries are consistently defined). After identifying the correct AOI, select the "Soil Data Explorer" tab, then the "Soil Properties" subtab below it. Using the

[53] For example, a landowner may be subject to regulations which limit how close crops may be grown to property boundaries or watercourses, or may require the maintenance of forested areas around watercourses or as windbreaks. In these cases, those restrictions would be represented by creating buffers around those features and excluding the buffered region from the project area.

[54] This web application is available at: http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx.

[55] The USDA NRCS Geospatial Data Gateway may be accessed at: https://gdg.sc.egov.usda.gov/GDGOrder.aspx (last accessed 12/14/16).

[56] Soil map units are comprised of multiple components, which are not represented on the map. In order to assign a single value to the map unit based on the values of the components, some aggregation method must be selected. This protocol applies the "dominant condition" method, whereby the value which applies to the greatest total area of the map unit is used to represent the value of the entire map unit.

menu to the left, select “Soil Physical Properties” and then “Surface Texture.” Within the options for Surface Texture, select the Aggregation Method as “Dominant Condition,” then click “View Rating.” This generates a table with the surface texture rating for each map unit within the AOI, identifying the acres for each. Then click “Printable Version” at the top right of the page to generate a PDF containing the AOI map and the table. This PDF aids with both stratification and verification. The texture ratings used in the soil data tables shall be aggregated into the three soil texture groups used in this protocol using the relationships described in Table 5.2.

Table 5.2. Soil Texture Categorization

SSURGO Texture Class	Grassland Protocol Texture Group
Sand	Coarse
Coarse sand	
Fine sand	
Very fine sand	
Loamy very fine sand	
Loamy fine sand	
Loamy sand	
Loamy coarse sand	
Coarse sandy loam	
Sandy loam	
Fine sandy loam	
Very fine sandy loam	
Loam	Medium
Silt loam	
Silt	
Sandy clay	Fine
Sandy clay loam	
Silty clay loam	
Clay loam	
Silty clay	
Clay	

5.2 Quantifying Baseline Emissions

Total baseline emissions for the reporting period are estimated by calculating and summing the emissions from all relevant baseline SSRs that are included in the GHG Assessment Boundary (as indicated in Table 4.1).

The baseline emission equations rely on emission factors that model the emissions of a full year. If this quantification methodology is being applied to a reporting period of less than one full year, Project Owners must refer to Box 5.2 in order to correctly pro-rate the annual baseline emission factors. Baseline emission factors for soil organic carbon, nitrous oxide, and fossil fuel emissions are organized in ten year groups. Those ten years are counted as calendar years from the year of the project start date, inclusive. The emission factor group to be used for a given reporting period is based on the beginning date of that reporting period, and applies throughout the reporting period. For example, if the project start date is May 9, 2015, the “Year

1-10" emission factor group shall be used for all reporting periods that begin during the years 2015-2024. For reporting periods beginning during 2025-2034, the "Year 11-20" emission factor group shall be applied.

Equation 5.2. Baseline Emissions

$$\boldsymbol{BE = \left[\left(OC_{BL} + N_2O_{BL} + CO_{2,BL}\right) \times (1 - DF_{\sigma})\right] \times (1 - DF_{conv}) \times Pro}$$

Where,			Units
BE	=	Total baseline emissions for the reporting period, rounded down to the nearest whole number	tCO_2e
OC_{BL}	=	Baseline emissions due to loss of organic carbon in soil and biomass (Equation 5.3)	tCO_2e
N_2O_{BL}	=	Baseline emissions of nitrous oxide (Equation 5.4)	tCO_2e
$CO_{2,BL}$	=	Baseline CO_2 emissions due to fossil fuel combustion (Equation 5.5)	tCO_2e
DF_{conv}	=	Discount factor for the uncertainty of baseline conversion (Equation 5.6)	%
DF_{σ}	=	Discount factor for the uncertainty of modeling future management practices and climatic conditions[57]	%
Pro	=	Pro-rating factor for reporting periods of less than one year (see Box 5.2)	%

Box 5.2. Pro-Rating for Reporting Periods of Less than One Year

Projects may report GHG reductions more frequently than on an annual basis. If a project reports on a sub-annual basis, then annual emission factors and quantities used in this section must be prorated. The following equation shall be used to determine the pro-rating factor for a sub-annual reporting period:

$$\boldsymbol{Pro = \frac{rd}{365.25}}$$

Where,			Units
Pro	=	Pro-rating factor	%
rd	=	Number of reporting days in the sub-annual reporting period (i.e., days for which the project is claiming credit for emission reductions)	Days
365.25	=	Average number of days in a calendar year	Days

5.2.1 Baseline Organic Carbon Emissions

The baseline assumption for grassland projects is that the project area would be converted to cropland absent the project activities. When grassland is converted to cropland, carbon emissions occur through the loss of stored soil organic carbon over time. There is an immediate loss of soil carbon when the soil is tilled (9), followed by potentially decades of loss until a new equilibrium is reached. Determining the exact nature of the converted land use (crop rotation, tillage practices, fertilization, ongoing management) is complex, uncertain, and subjective. The Reserve has adopted a modeled, composite approach to determining organic carbon emissions from the baseline scenario for grassland projects. Refer to Appendix B for the development of

[57] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

the emission factors used in this quantification and the companion tables for the baseline emission factors.

Equation 5.3. Baseline Organic Carbon Emissions from Soil and Belowground Biomass Loss

$$OC_{BL} = \sum_{S} \left(\frac{BEF_{OC,s} \times Area_s}{1000} \right)$$

Where,			Units
OC_{BL}	=	Baseline quantity of organic carbon emissions from soil and belowground biomass	tCO_2e
S	=	Total number of strata	
S	=	Individual stratum	
$BEF_{OC,S}$	=	Annual baseline emission factor for organic carbon in stratum *s* (refer to companion tables,[58] selecting the appropriate stratum and time category)	kg CO_2e/ac/yr
$Area_s$	=	Area of project in stratum *s*	acres
1000	=	Conversion factor	kg/t

5.2.2 Baseline N_2O Emissions

The use of fertilizer for crop cultivation results in emissions of nitrogen in the form of N_2O, which is a potent GHG.[59] Using emission factors developed with the composite modeling approach described in Appendix B, baseline emissions of N_2O are estimated for each stratum.

Equation 5.4. Baseline N_2O Emissions

$$N_2O_{BL} = \sum_{s}^{S} \left(\frac{BEF_{N_2O,s} \times Area_s \times GWP_{N_2O}}{1000} \right)$$

Where,			Units
N_2O_{BL}	=	Baseline emissions of N_2O	tCO_2e
$BEF_{N2O,S}$	=	Annual baseline emission factor for N_2O emissions in stratum *s* (refer to companion tables,[58] selecting the appropriate stratum and time category)	kg N_2O/ac/yr
$Area_s$	=	Area of the project in stratum *s*	acres
GWP_{N2O}	=	100-year global warming potential of N_2O (refer to Table 5.1).	CO_2e/N_2O
1000	=	Conversion factor	kg/t

5.2.3 Baseline CO_2 Emissions from Fossil Fuels

The conversion of grassland to cropland, as well as the ongoing cropland management activities, involves the use of fossil fuels for vehicles and equipment. This usage results in direct emissions of CO_2. Using emission factors developed with the composite modeling approach described in Appendix B, baseline emissions of CO_2 for fossil fuel usage are estimated for each

[58] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[59] For additional details regarding the pathways of N_2O emissions due to fertilizer use, refer to the Reserve's Nitrogen Management Protocol, available online: http://www.climateactionreserve.org/how/protocols/nitrogen-management/.

stratum. If the project is located in a jurisdiction where GHG emissions from mobile sources are subject to a binding emissions cap (such as California[60]), then those projects may not claim emission reductions for this source, and must use a value of zero for $CO_{2,BL}$.

Equation 5.5. Baseline CO_2 Emissions from Fossil Fuel

$$CO_{2,BL} = \sum_{s}^{S} \left(BRC_{CO_2,s} \times \frac{10.15}{1000} \times Area_s \right)$$

Where,			Units
$CO_{2,BL}$	=	Baseline emissions due to fossil fuel combustion	tCO_2e
$BRC_{CO2,s}$	=	Annual baseline rate of fossil fuel consumption for stratum *s* (refer to companion tables,[61] selecting the appropriate stratum and time category)	gal/ac/yr
10.15	=	Emission factor for diesel (distillate fuel #2)[62]	kg CO_2/gal
1000	=	Conversion factor	kg/t

5.2.4 Discount Factors

There are two discount factors that are applicable to the quantification of baseline emissions, DF_{conv} and DF_σ. DF_{conv} represents the uncertainty of using a standardized financial additionality threshold to represent the likelihood of the baseline conversion scenario. As the cropland premium decreases, uncertainty around the likelihood of baseline conversion increases. Equation 5.6 explains how to determine the value of this discount based on the value of the cropland premium for the county in which the project area is located (found in the companion tables[63]). In Equation 5.2, this discount is applied to the entire estimate of baseline emissions. As stated in Section 3.3.1.1, if more than 10% of the project acres are in a different county, eligibility (including the value of DF_{conv}) must be assessed separately for that county.

Equation 5.6. Discount Factor for the Uncertainty of Baseline Conversion

$$DF_{conv} = \left(1 - \frac{CP - FT_l}{FT_u - FT_l} \right) \times 50\%$$

Where,			Units
DF_{conv}	=	Discount factor for the uncertainty of baseline conversion	%
CP	=	Cropland premium for the county where the project is located	%
FT_l	=	Lower threshold for financial additionality (Section 3.3.1.1)	%
FT_u	=	Upper threshold for financial additionality (Section 3.3.1.1)	%
50%	=	Maximum value of DF_{conv}	

DF_σ is meant to embody the uncertainty contained within the modeling of the baseline emission factors. The baseline emissions quantified in this protocol are discounted to account for increasing uncertainty about input assumptions and model outputs into the future. Uncertainty

[60] Additional information regarding the California cap-and-trade program is available at: http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm.
[61] See the Reserve's Grassland Protocol webpage at: http://www.climateactionreserve.org/how/protocols/grassland/
[62] 40 CFR Part 98 Subpart C Table C-1.
[63] See the Reserve's Grassland Protocol webpage at: http://www.climateactionreserve.org/how/protocols/grassland/.

arises due to anticipated but unknown shifts in practices in, among other things, tillage, cropping, and nitrogen management, and the interaction of agricultural systems with a changing climate. Model inputs and outputs are expected to accurately reflect baseline conditions in early years, but have greater uncertainty in future years. Accordingly, the quantification of baseline emissions is discounted , with the discount increasing through time in accordance with increasing uncertainty. The value of DF_σ for a given year is found in the separate file containing the companion tables.[64] If the modeling exercise is updated in the future, it is likely that this discount schedule would reset back to 1% for new projects that would use the updated emission factors. The discount factor is assigned based on the year of the beginning date of the reporting period (i.e., a reporting period which begins on May 9, 2019 would apply the discount listed for 2019 for an entire 12-month reporting period, even though a portion of the period is in the calendar year 2020).

5.3 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of the project activity. Project emissions must be quantified every reporting period on an *ex post* basis. In certain cases where these emissions are determined to be *de minimis*,[65] this protocol specifically allows for the Project Owner to use an alternative estimation methodology. Unless otherwise specified, project emission equations cover the entire reporting period, regardless of whether it covers a full year.

Equation 5.7. Project Emissions

$$\boldsymbol{PE = BU_{PR} + FF_{PR} + FE_{PR} + GR_{PR} + LE}$$

Where,			Units
PE	=	Project emissions, rounded to the nearest whole number	tCO_2e
BU_{PR}	=	Emissions from burning in the project scenario (Equation 5.8)	tCO_2e
FF_{PR}	=	Emissions from fossil fuel and electricity use in the project scenario (Equation 5.9)	tCO_2e
FE_{PR}	=	Emissions from organic fertilizer use in the project scenario (Equation 5.10)	tCO_2e
GR_{PR}	=	Emissions from livestock grazing in the project scenario (Equation 5.11)	tCO_2e
LE	=	Leakage emissions (Equation 5.12)	tCO_2e

5.3.1 Project Emissions from Burning

The project scenario for a grassland project may involve periodic burning, either prescribed or accidental. Regardless of the reason for the fire, the combustion of aboveground biomass results in emissions of CO_2, CH_4, and N_2O. The CO_2 emissions from grass burning are considered biogenic and are excluded from this quantification. The project emissions of CH_4 and N_2O must be estimated using Equation 5.8.

[64] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[65] For the purposes of this protocol, emissions are *de minimis* if they are less than the relevant materiality threshold when applied to the overall calculation of emission reductions. The materiality threshold for projects is defined in the Verification Program Manual, available online at: http://www.climateactionreserve.org/how/verification/verification-program-manual/.

Equation 5.8. Project Emissions from Burning

$$BU_{PR} = \sum_{S} \left[\left(Area_{burn,s} \times DM_s \times \frac{2.3}{1000000} \times GWP_{CH_4} \right) + \left(Area_{burn,s} \times DM_s \times \frac{0.21}{1000000} \times GWP_{N_2O} \right) \right]$$

Where,			Units
BU_{PR}	=	Emissions from burning in the project scenario	tCO_2e
S	=	Total number of strata	
s	=	Individual stratum	
$Area_{burn,s}$	=	Area of stratum *s* that was burned	acres
DM_s	=	Amount of aboveground dry matter in stratum *s* (refer to companion tables,[66] selecting the appropriate stratum and time period)	kg/acre
2.3	=	Emission factor for methane from biomass burning (6)	g/kg dry matter
0.21	=	Emission factor for nitrous oxide from biomass burning (6)	g/kg dry matter
GWP_{CH4}	=	100-year global warming potential for methane (Table 5.1).	tCO_2e/tCH_4
GWP_{N2O}	=	100-year global warming potential for nitrous oxide (Table 5.1)	tCO_2e/tN_2O
1000000	=	Conversion factor	g/t

5.3.2 Project Emissions from Fossil Fuel and Electricity Use

In the case that the project activities include the use of mobile or stationary equipment or vehicles that consume fossil fuels or electricity, these project emissions are estimated using Equation 5.9. However, if the project can demonstrate that the total value of FF_{PR} is reasonably expected to be *de minimis* (i.e., less than the relevant materiality threshold[67]), these emissions may be estimated through a conservative method proposed by the Project Owner and deemed acceptable by the verifier.

[66] See the Reserve's Grassland Protocol webpage at: http://www.climateactionreserve.org/how/protocols/grassland/.
[67] Materiality thresholds for Reserve projects are specified in the Reserve Verification Program Manual, available at: http://www.climateactionreserve.org/how/verification/verification-program-manual/.

Equation 5.9. Project Emissions from Fossil Fuels and Electricity

$$FF_{PR} = \frac{\sum_f (QF_f \times PEF_{FF,f})}{1000} + \frac{(QE \times PEF_{EL})}{1000}$$

Where,			Units
FF_{PR}	=	Carbon dioxide emissions due to fossil fuel combustion and electricity use in the project scenario	tCO_2e
QF_f	=	Quantity of fossil fuel type *f* consumed	volume
$PEF_{FF,f}$	=	Project emission factor for fossil fuel type *f* (refer to companion tables)[68]	$kgCO_2$/volume fossil fuel
1000	=	Conversion factor	kg/t
QE	=	Quantity of electricity consumed during the reporting period	MWh
PEF_{EL}	=	Carbon emission factor for electricity used, referenced from the most recent U.S. EPA eGRID emission factor publication.[69] Projects shall use the annual total output emission rates for the subregion where the project is located	kg CO_2/MWh

5.3.3 Project Emissions from Organic Fertilizer Use

Certain grasslands may see ecosystem improvements or possibly even enhanced carbon sequestration (not credited under this protocol) following the addition of organic soil amendments (10). In the case that the project activities include the application of organic fertilizer (such as compost or manure), the project emissions of N_2O are estimated using Equation 5.10. This equation quantifies the total direct and indirect emissions of N_2O related to the application of organic fertilizers through the use of project-specific activity data and default emission factors. Additional information regarding the default emission factors used in the next two equations can be found in Appendix C.

Accounting for leaching is required for counties where, on average, the annual precipitation exceeds 80% of annual potential evapotranspiration. This protocol assigns the leaching factor based on an analysis carried out for the annual U.S. GHG Inventory which identifies the probability of leaching on non-irrigated land for every county (13). The results of this analysis are displayed in Figure 5.2 and are contained within the county-level companion tables.[70] Project Owners should refer to Figure 5.2 and the companion tables to determine if their project must account for leaching.[71] Accounting for leaching is also required for any projects which employ irrigation on the project area during the reporting period.

[68] This information can be found in the *Grassland Project Parameters*, document available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[69] Available online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/
[70] Ibid.
[71] Ibid.

Figure 5.2. U.S. Counties Where Nitrogen Leaching is Expected to Occur

Equation 5.10. Project Emissions from Fertilizer Use

$$FE_{PR} = \left(\sum_{C} QF_{PR,c} \times NC_c\right) \times (0.012 + Leach) \times \frac{44}{28} \times \frac{GWP_{N_2O}}{1000}$$

Where,			Units
FE_{PR}	=	Direct and indirect nitrous oxide emissions from organic fertilizer use in the project scenario	tCO_2e
C	=	Total number of types of organic fertilizer applied, other than manure from grazing livestock	
$QF_{PR,c}$	=	Quantity of fertilizer type *c* applied	kg
NC_c	=	Nitrogen content of fertilizer type *c*	kg N/kg
0.012	=	Default factor representing the direct emission factor of N_2O from organic fertilizer, the fraction of N which is volatilized, and the indirect emission factor for N volatilization and deposition	
Leach	=	Default factor for the fraction and emission factor for N_2O emissions due to leaching. Equal to **0.00225** for projects that are required to use this factor, and **0** for all other projects. Refer to the companion tables[72] to determine whether leaching must be quantified for the county where the project is located.[73] The 0.00225 factor must also be used when irrigation is employed.	
44/28	=	Molar mass ratio of N_2O to N	kg N_2O/kg N_2O-N
GWP_{N2O}	=	100-year global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O
1000	=	Conversion factor	kg/t

[72] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[73] If the project area includes land in more than one county, and the companion tables specify that leaching must be accounted for in any of the given counties, then leaching must be accounted for across the entire project area.

5.3.4 Project Emissions from Grazing

It is likely that grasslands projects include livestock grazing on the project area in the project scenario, leading to enteric methane and manure (methane and nitrous oxide) emissions that would not exist in the baseline scenario. These emissions are quantified using Equation 5.11 and the guidance in Box 5.3. For the purposes of this equation, the "grazing season" is defined as the period of time between the first and last grazing days of the reporting period.

Equation 5.11. Project Emissions from Livestock Grazing

$$GR_{PR} = N_2O_{MN} + CH_{4,MN} + CH_{4,ENT}$$

Where,			Units
GR_{PR}	=	Project emissions from grazing activities in the project area	tCO_2e
N_2O_{MN}	=	N_2O emissions from manure deposited by grazing animals	tCO_2e
$CH_{4,MN}$	=	CH_4 emissions from manure deposited by grazing animals	tCO_2e
$CH_{4,ENT}$	=	CH_4 emissions from enteric fermentation in grazing animals	tCO_2e

$$N_2O_{MN} = \sum_{L} \left(AGD_l \times Nex_l \times (0.022 + Leach)\right) \times \frac{44}{28} \times \frac{GWP_{N_2O}}{1000}$$

Where,			Units
L	=	Total number of livestock categories in the project scenario	
AGD_l	=	Animal grazing days for livestock category *l* (see Box 5.3)	animal days
Nex_l	=	Nitrogen excreted by grazing animals in livestock category *l*	kg N/head/day
0.22	=	Default factor representing the emission factor of nitrogen from manure, the fraction of N which is volatilized, and the emission factor for N volatilization. Additional details can be found in Appendix C.	
Leach	=	Default factor for the fraction and emission factor for N_2O emissions due to leaching. Equal to **0.00225** for projects which are required to use this factor, and **0** for all other projects. Refer to the companion tables to determine whether leaching must be quantified for the county where the project is located.[74, 74] The 0.00225 factor must also be used when irrigation is employed.	
44/28	=	Molar mass ratio of N_2O to N	N_2O/N
GWP_{N2O}	=	100-year global warming potential for N_2O (Table 5.1)	CO_2e/N_2O
1000	=	Conversion factor	kg/t

$$CH_{4,MN} = \sum_{L} \left(AGD_l \times VS_l \times B_{0,l}\right) \times \frac{MCF_{PRP} \times \rho_{CH_4} \times GWP_{CH_4}}{1000}$$

Where,			Units
VS_l	=	Volatile solids excreted by grazing animals in category *l*	kg VS/animal/day
$B_{0,l}$	=	Maximum methane potential for manure from category *l*	m^3 CH_4/kg VS
MCF_{PRP}	=	Methane conversion factor for pasture/range/paddock manure management, dependent on average temperature during grazing season	%
ρ_{CH4}	=	Density of methane at 1 atm and the average temperature during the grazing season	kg/m^3
GWP_{CH4}	=	100-year global warming potential for CH_4 (Table 5.1)	CO_2e/CH_4

$$CH_{4,ENT} = \sum_{L} \left(AGD_l \times PEF_{ENT,l}\right) \times \frac{GWP_{CH_4}}{1000}$$

Where,			Units
$PEF_{ENT,l}$	=	Project emission factor for enteric methane emissions from livestock category *l* in the project State[74]	kg CH_4/head/day

[74] Default emission factors and parameters can be found in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Box 5.3. Determining Animal Grazing Days (AGD_l)

Equation 5.11 requires the use of parameter AGD_l, which represents the total number of days that were grazed by a single category of animals. This is the sum of the number of days each animal category was grazed during the relevant time period. A simplified example is below:

Animal Category	Population	Grazing Days	Animal Grazing Days
Bulls	100	240	24,000
Beef Cows	200	240	48,000
Beef Replacements	40	240	9,600

Note: the numbers in this table are fictional used only for illustrative purposes

If the population of each category is not stable over the grazing period, a reasonable approach shall be applied to estimate AGD_l for each category over the relevant time period.

5.3.5 Project Emissions Due To Leakage

Avoided grassland conversion projects would result in leakage if the project activities result in the conversion of other grassland outside of the project area. This would cause the "avoided" baseline emissions to simply shift and occur elsewhere, thus never actually being avoided. The extent to which this occurs depends on the economics of crop production. The project emissions due to leakage represent the probability that the avoided baseline emissions will occur outside of the project area due to the project activities. Calculating a precise value for this probability is both complex and uncertain. As this protocol relies on default baseline assumptions which are composites of multiple baseline scenarios, it is not possible to determine a precise leakage value for each specific project.

Estimates of the leakage effects of grassland conservation are variable. Several studies have examined the Federal Conservation Reserve Program (CRP) to assess "slippage" (leakage) caused by conservation of arable land. One study determined the slippage effect of CRP enrollment to be 20% (i.e., for every 100 acres that are conserved, 20 acres are converted elsewhere) (12). A later study found no slippage effect from CRP enrollment (13). A third study determined that there is a range from 17.5% to 20.6%, depending upon the number of acres enrolled (higher enrollment led to higher slippage), as well as the elasticity of supply of nitrogen fertilizer (inelastic fertilizer supply led to higher slippage) (14). Lastly, another study, attempting to address the disagreement between the first two, used satellite imagery to attempt to estimate the magnitude of this effect, and came up with estimates that ranged from 3% to 11% (15). This is all to say that estimates of leakage from CRP enrollment, a reasonable proxy for avoided grassland conversion, range from 0% to 20%, with evidence to support various values in the middle of that range. Thus, the Reserve has taken a conservative approach, assuming a 20% leakage effect from grassland projects.

Equation 5.12. Project Emissions from Leakage

$$\boldsymbol{LE = 0.2 \times BE}$$

Where,			Units
LE	=	Leakage emissions during the reporting period	tCO_2e
0.2	=	Leakage discount factor	
BE	=	Baseline emissions during the reporting period	tCO_2e

5.4 Ensuring Permanence of GHG Emission Reductions

If a reversal occurs during a reporting period (see Section 3.5), the reversal must be compensated for by retiring CRTs. Specific requirements depend on the whether the reversal was avoidable or unavoidable, as described below. Reversal compensation requirements do not apply to emission reductions unrelated to carbon stored in the project area soils (e.g., CH_4 and N_2O).

Identification of a reversal is a binary decision based on area; either an area is subject to a reversal or not. For example, if the Grassland Owner decides to plow and cultivate a 10-acre portion of the project area, that entire 10-acre portion shall be considered to have experienced a complete and avoidable reversal. If an area is subject to a reversal, then the quantity of soil carbon reversed is considered to be equal to total number of CRTs issued for reversible emission reductions on that specific portion of the project area. For the purposes of this protocol, reversible emission reductions are those related to the avoided loss of organic carbon in soil and belowground biomass (Equation 5.3) for which CRTs were issued for reporting periods during the 100 years prior to the date of the reversal. The quantity of CRTs that must be retired is determined using Equation 5.13.

Equation 5.13. Quantifying Reversals

$$\boldsymbol{Rev} = \left(\boldsymbol{OC_{BL,rev,RP}}\right) \times \left(\mathbf{1} - \boldsymbol{DF_{conv}}\right)$$

Where,			Units
Rev	=	Quantity of emissions due to the reversal	tCO_2e
$\boldsymbol{OC_{BL,rev,RP}}$	=	Baseline emissions due to the loss of organic carbon in soil and biomass for all reporting periods	tCO_2e
DF_{conv}	=	Discount factor for the uncertainty of baseline conversion	

$$\boldsymbol{OC_{BL,rev,RP}} = \sum_{\boldsymbol{s,rp}}^{\boldsymbol{RP}} \left(\left(\boldsymbol{OC_{BL,s,rp}} \times \frac{\boldsymbol{Area_{rev,s}}}{\boldsymbol{Area_s}} \right) \times \left(\mathbf{1} - \boldsymbol{DF_{\rho,rp}}\right) \times \left[\mathbf{1} - \left(\boldsymbol{Y_{s,rp}} \times \mathbf{0.01}\right)\right] \right)$$

Where,			Units
RP	=	Total number of reporting periods for which CRTs have already been issued to the project	years
s	=	Individual stratum	
rp	=	Specific project reporting periods	
$OC_{BL,s,rp}$	=	Baseline emissions due to the loss of organic carbon and biomass in stratum *s* during reporting period *rp*	tCO_2e
$Area_{rev,s}$	=	Area of stratum *s* affected by the reversal	acres
$Area_s$	=	Total project area in stratum *s*	acres
$DF_{\rho,rp}$	=	Discount factor for the uncertainty of modeling future management practices and climatic conditions for reporting period *rp*	
$Y_{s,rp}$	=	Total number of years that have elapsed since the first day of the reporting period *rp* until the first day of the reporting period when the reversal occurred and, for which CRTs were previously issued for stratum *s*	years
0.01	=	Simplified annual atmospheric impact of avoided GHG emissions in a given year	tCO_2e/tCO_2e

5.4.1 Avoidable Reversals

Requirements for avoidable reversals are as follows:

1. If an avoidable reversal is identified during annual monitoring, the Project Owner must give written notice to the Reserve within thirty days of identifying the reversal. Additionally, if the Reserve determines that an avoidable reversal has occurred, it shall deliver written notice to the Project Owner.
2. Within thirty days of receiving the avoidable reversal notice from the Reserve, the Project Owner must provide a written description and explanation of the reversal to the Reserve, including a map of the specific area that is affected.
3. Within four months of receiving the avoidable reversal notice, the Project Owner must transfer to the Reserve a quantity of CRTs from its Reserve account equal to the size of the reversal as calculated in Equation 5.13.
    a. The surrendered CRTs must be those that were issued to the grassland project, or that were issued to other grassland projects registered with the Reserve. If there is not a sufficient quantity of grassland CRTs available for compensation, as determined by the Reserve, CRTs issued to a forest project registered with the Reserve are acceptable.
    b. The surrendered CRTs shall be retired by the Reserve and designated in the Reserve software as compensating for an avoidable reversal.

5.4.2 Compensating for Unavoidable Reversals

Requirements for unavoidable reversals are as follows:

1. If the Project Owner determines there has been an unavoidable reversal, it must notify the Reserve in writing of the unavoidable reversal within 30 days of identifying the reversal.
2. The Project Owner must explain the nature of the unavoidable reversal, including a map of the specific area affected, and provide an estimate of the size of the reversal using Equation 5.13.

If the Reserve determines that there has been an unavoidable reversal, it shall retire a quantity of CRTs from the Reserve Grassland Buffer Pool equal to the size of the reversal in metric tons of CO_2.

5.4.3 Contributing to the Grassland Buffer Pool

For each reporting period, the Project Owner must transfer a quantity of credits (determined by Equation 5.14) to the Reserve Grassland Buffer Pool at the time of credit issuance. Credits that enter the buffer pool are never returned to the project directly (except as specified for credits related to $Risk_{SV}$), but instead are held in trust for the benefit of all registered grassland projects, to be used as compensation for unavoidable reversals, as described in Section 5.4.2. Equation 5.14 shall be used to calculate the buffer pool contribution for the project during the reporting period.

The risk of an unavoidable reversal to a grassland project is extremely low. Fires would not typically release the carbon that is stored underground. Catastrophic floods would typically only occur in areas that have already been screened out by the eligibility criteria. Volcanic activity is exceedingly rare in the conterminous U.S., and does not occur in the areas where grassland

projects typically occur. Due to the fact that the risk of unavoidable reversals is not significantly differentiated by location or land management, the Reserve has decided to adopt a default buffer pool contribution for all projects that is intended to insure against all types of unavoidable reversals.

In addition to the default contribution, projects may be obligated to make additional contributions to the buffer pool in certain situations. Where the Project Owner has elected to employ a Contract PIA, an additional contribution is required to reflect risks from financial failure; the value of $Risk_{FF}$ in Equation 5.14 shall be 0.1. Where the Grassland Owner has elected to employ a Recorded PIA, and has elected to allow the PIA to be subordinated to subsequent deed restrictions (such as a mortgage), an additional contribution is required to reflect risks from financial failure. If the property owner has employed Recorded PIA Subordination Clause Type 1, the value of this risk is 0. If the property owner has employed Recorded PIA Subordination Clause Type 2, the value of this risk is 0.1.[75] An exception to these rules is made for cases where the Project Owner is a land trust with accreditation through the Land Trust Accreditation Commission,[76] in which case the value of $Risk_{FF}$ shall be 0, regardless of the particular format of the PIA.

Site visits during verification are not mandatory for grassland projects. However, there is risk associated with a project that has never been visited for the purposes of a third-party verification. The Reserve believes that this risk is low enough that the site visit during verification has been made optional. However, an additional buffer pool contribution must be made to account for the increased risk (designated as "$Risk_{SV}$" in Equation 5.14). For each project that has never had a site visit during verification, the value of $Risk_{SV}$ shall be 0.05 until such time that a site visit verification occurs.[77] At that time, the CRTs contributed to the buffer pool due to this requirement shall be returned to the project in the form of either a reduced buffer pool contribution in future reporting periods or a lump sum refund of CRTs from the buffer pool, subject to agreement between the Project Owner and the Reserve. The amount of CRTs to be returned shall be determined by calculating what the buffer pool contributions would have been had the value of $Risk_{SV}$ been 0 for the previous reporting periods. If a site visit occurs during the initial verification, the value of $Risk_{SV}$ shall be 0 for the entire crediting period. This applies equally to individual projects as well as projects participating in a cooperative. For example, if a cooperative contains 10 projects and site visits occur on only 2 of them during the initial verification, the remaining 8 projects are subject to the increased buffer pool contribution, until such time that a site visit is carried out for those projects. If a project is expanded after a site visit has occurred, the value of $Risk_{SV}$ shall return to 0.05 for subsequent verifications until such time that either:

a) The project developer can demonstrate to the satisfaction of the subsequent verification body that the previous site visit was sufficiently thorough to be applied to the new project area, in whole; or,
b) Another site visit occurs at the new portion(s) of the expanded project area.

[75] The Project Implementation Agreements are available at: http://www.climateactionreserve.org/how/protocols/grassland/. Details on the buffer pool contribution related to subordination of the Recorded PIA are found in Exhibit E.
[76] Information regarding the Land Trust Accreditation Commission and the requirements for accreditation can be found at: http://www.landtrustaccreditation.org/.
[77] The reporting period during which the site visit occurs shall be the first reporting period not subject to the additional buffer pool contribution.

Equation 5.14. Buffer Pool Contribution to Insure Against Reversals

$$\boldsymbol{BP = Risk_{rev} \times OC_{BL}}$$

Where,			Units
BP	=	Project contribution to the buffer pool	tCO_2e
$Risk_{rev}$	=	Risk of reversals, as determined below	%
OC_{BL}	=	Baseline quantity of organic carbon emissions from soil and biomass (Equation 5.3)	tCO_2e

$$\boldsymbol{Risk_{rev} = 1 - [(1 - 0.02) \times (1 - Risk_{FF}) \times (1 - Risk_{SV})]}$$

Where,			Units
0.02	=	Default risk of unavoidable reversals, applicable to all projects[78]	fraction
$Risk_{FF}$	=	Additional risk related to financial failure, the value is either 0 or 0.1, as described above.	fraction
$Risk_{SV}$	=	Risk of misstatement by projects which have not had a site visit by a third-party verifier. The value is either 0 or 0.05.	fraction

As there are only three risk categories that contribute to $Risk_{rev}$, one of which is mandatory, there are ten possible project scenarios, leading to four possible values for this parameter. The potential project scenarios and the resulting value of $Risk_{rev}$ are listed in Table 5.3.

Table 5.3. Possible Values of $Risk_{rev}$

Default Risk	PIA	Project Owner	$Risk_{FF}$	Site Visit	$Risk_{SV}$	$Risk_{rev}$
0.02	Contract PIA	Accredited land trust	0	Yes	0	**0.020**
0.02	Contract PIA	Accredited land trust	0	No	0.05	**0.069**
0.02	Contract PIA	Other	0.1	Yes	0	**0.118**
0.02	Contract PIA	Other	0.1	No	0.05	**0.162**
0.02	Recorded PIA, Type 1 Subordination Clause	Any	0	Yes	0	**0.020**
0.02	Recorded PIA, Type 1 Subordination Clause	Any	0	No	0.05	**0.069**
0.02	Recorded PIA, Type 2 Subordination Clause	Accredited land trust	0	Yes	0	**0.020**
0.02	Recorded PIA, Type 2 Subordination Clause	Accredited land trust	0	No	0.05	**0.069**
0.02	Recorded PIA, Type 2 Subordination Clause	Other	0.1	Yes	0	**0.118**
0.02	Recorded PIA, Type 2 Subordination Clause	Other	0.1	No	0.05	**0.162**

[78] Based on discussion between and among Reserve staff and external stakeholders regarding the risks of unavoidable reversals to grassland projects. Such risks were determined to be low, but also not zero.

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan serves as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and continue to be met, and that consistent, rigorous monitoring and record keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 are collected and recorded.

At a minimum, the Monitoring Plan shall include a description of ownership of both the property and the emission reductions; the methods and frequency of data acquisition; a record keeping plan (see Section 7.3 for minimum record keeping requirements), and the role of individuals performing each specific monitoring activity. The Monitoring Plan should include QA/QC provisions to ensure that data acquisition and recordkeeping are carried out consistently and with precision.

Finally, the Monitoring Plan must include procedures that the Project Owner follows to ascertain and demonstrate that the project at all times passes the legal requirement test and the Regulatory Compliance Test (Section 3.3.2 and 3.6, respectively).

Project Owners are responsible for monitoring the performance of the project.

6.1 Monitoring Ongoing Eligibility

To maintain eligibility on an ongoing basis, grassland projects must demonstrate that the project area has not been converted into another land use during the reporting period. If the project verification includes a physical site visit, that satisfies the requirements of this section. Otherwise, Project Owners shall refer to the guidance in Section 5.1.3 for guidance on documenting land use in the project area.

6.2 Monitoring Grazing

Livestock grazing is allowed in the project scenario. While low to moderate levels of grazing intensity may have a beneficial effect on the grassland ecosystem and net soil carbon storage (16), overgrazing can be detrimental to both the storage of soil carbon (17) and the health of the grassland ecosystem (18). Project grazing must be limited to moderate levels of intensity, balancing stocking rates with forage production and accounting for site characteristics, including climate variability (especially periods of drought), range condition, slope, distance from water, and the needs of the particular animals (19) (20).

Grassland projects must employ a mechanism to detect and prevent overgrazing on project lands, which is tailored to the specific conditions of their project and its ecosystem. It is up to each project developer to determine the appropriate means to safeguard the project against overgrazing. The project developer must obtain Reserve approval for the particular administrative means they will use to ensure project land is not overgrazed. Such approval must be obtained prior to listing of the project, and any changes to the mechanism must be approved by the Reserve prior to the completion of verification activities in a given reporting period.

The mechanism in question should include requirements for monitoring and enforcement, as well as identify the entity or entities that are responsible for such enforcement. The entity

empowered to enforce this mechanism must be an entity (or entities) other than the Reserve or project verifier, and can be a third-party to the offset project (e.g., the easement holder, in certain cases). Project developers shall include in their monitoring plan full details of the administrative mechanism they are employing to safeguard against over-grazing.

For each reporting period, Project Owners must provide both a quantitative and qualitative accounting of grazing activities for the reporting period. In terms of quantitative data, projects must document the type of livestock being grazed and the total animal grazing days for each type (see Box 5.2). The livestock shall be categorized according to the categories in the *Grassland Project Parameters* spreadsheet.[79] These data are used for the parameter AGD_l in Equation 5.11. The frequency of monitoring and the form of the documentation is not prescribed by this protocol. In terms of qualitative reporting, project developers shall include in their monitoring report a description of grazing activity for the reporting period and whether this conforms to the administrative mechanism in place to guard against overgrazing. Written confirmation from the entity or entities providing oversight with respect to this administrative mechanism should be provided to the verifier, that no overgrazing has occurred during the verification period. The verifier shall use professional judgment to confirm with reasonable assurance that the quantification of project emissions from grazing is conservative, that effective monitoring of grazing has been maintained in accordance with this administrative overgrazing mechanism, and that no overgrazing has been detected using this administrative mechanism.

Examples of documentation that may suffice to demonstrate the quantitative grazing monitoring requirements may include (this list is not comprehensive nor is it intended to define sufficiency of documentation):

- Grazing logs (kept daily, weekly, or monthly) that specify the animal categories, populations, and grazing locations
- Animal purchase and sale records, assuming all animals are grazed on the project area
- Grazing management plan, assuming maximum allowable grazing activity

CRTs will not be issued for any reporting period during which it is determined that there has been a violation of the administrative mechanism to prevent overgrazing. In addition, the Reserve may conduct additional review to confirm that a reversal has not occurred due to overgrazing.

6.3 Monitoring Project Emission Sources

For fossil fuels and electricity emissions (Equation 5.9), if the Project Owner can demonstrate that the total value of $CO_{2,PR}$ is reasonably expected to be *de minimis* (i.e., less than the relevant materiality threshold), these emissions may be estimated through a conservative method proposed by the Project Owner and deemed acceptable by the verifier. If not required for the alternative method, the monitoring of fossil fuels and electricity as described in this section is not required.

Otherwise, for each reporting period, the Project Owner must provide documentation for the following parameters used for the quantification of project emissions:

- Total acres burned and cause(s) of fire(s)
- Animal grazing days by livestock category

[79] Available at: http://www.climateactionreserve.org/how/protocols/grassland/.

- Mass of organic fertilizer applied (other than manure from grazing), by type
- Nitrogen content of organic fertilizer applied, by type
- Purpose, type, and quantity of fossil fuels used (e.g., tractor, diesel, 100 gallons)
- Purpose, source, and quantity of electricity (e.g., electric fence, MROW grid, 100 kWh)

For projects that employ additions of organic fertilizer (beyond the manure from on-site grazing of livestock), it is strongly encouraged that the project develop a nutrient management plan. Nutrient management plans should consider the principles contained in NRCS Conservation Practice Standard 590 for Nutrient Management.[80] Where a project also incorporates irrigation and/or grazing, such activities should be taken into account in developing any nutrient management plan for the project. Development of and adherence to a nutrient management plan is not required, but is strongly recommended.

6.4 Monitoring Ecosystem Health

As described in Section 3.7, grassland projects are subject to forces, both natural and cultural, active and passive, that could impair the long-term health and functioning of the rangeland system. Thus, it is required that projects undergo a periodic assessment of rangeland health according to the assessment protocol described in the Bureau of Land Management's Technical Reference 1734-6, "Interpreting Indicators of Rangeland Health" (21).[81] A rangeland health assessment must be submitted for review during one of the first two project verifications. Subsequent assessments may occur as frequently as desired by the Project Owner, with a minimum frequency of once every six years.[82] These assessments are only required during the crediting period, and are not required during the permanence period, although it is strongly recommended that the practice be continued on a voluntary basis. If the project area is already subject to periodic rangeland health assessments according to TR 1734-6, then the most recent assessment may be submitted during the initial project verification, provided that it is dated no more than six years prior to the end of the initial reporting period.

The reference conditions for the project area may be determined using the appropriate Ecological Site Description (ESD).[83] If the ESD does not contain specified reference conditions for the project area, they may be developed following the guidance in TR 1734-6. The rangeland health assessment must be conducted by an appropriately-trained individual. The result of the assessment is the rating of 17 different metrics by the severity of their departure from the expected reference condition, categorized into five levels:

1. None to Slight
2. Slight to Moderate
3. Moderate
4. Moderate to Extreme
5. Extreme to Total

The Reserve understands that heterogeneity of ecosystems, land use history, and land management practices mean that it is likely that the project area exhibits at least slight deviation

[80] Available at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046896.pdf.
[81] The assessment protocol, associated documents, and information regarding training opportunities are available online at: http://jornada.nmsu.edu/monit-assess/manuals/assessment (accessed 10/14/16).
[82] The result of this schedule is that if a project elects to follow the most relaxed verification schedule (once every six years), there will be at least one rangeland health assessment during every verification period.
[83] An ESD may be obtained from the USDA NRCS at: https://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx (accessed 10/14/16).

from the reference condition for at least one, if not several, rangeland health metrics. Projects are not required to meet reference conditions for rangeland health metrics.

For any metric that is assessed to be at the third level ("Moderate"), the Project Monitoring Plan must be updated prior to the next verification to reflect planned management changes to address that metric, with a minimum goal of preventing further departure from the reference condition. A preferred goal would be a return to reference condition.

For any metric that is assessed to be at the fourth or fifth levels ("Moderate to Extreme" or "Extreme to Total") of departure from the reference condition, the Project Monitoring Plan must be updated prior to the next verification to reflect planned management changes to address that metric, with a goal of improving that metric toward reference condition. The subsequent rangeland health assessment must show improvement in these metrics. If a project does not improve (or declines) in these metrics at the next assessment, the Project Owner must notify the Reserve, which shall determine whether the project is eligible for crediting for the current reporting period. Projects that can demonstrate rangeland health impairment occurred despite reasonable, good-faith efforts in land management may not need to forfeit credits. However, significant degradation in rangeland health could be considered a reversal, despite the lack of a specific disturbance event. Refer to Section 3.7 for additional information regarding the consequences of significantly degraded rangeland health.

Management planning for rangeland health should explicitly include management of livestock grazing.

The requirements of this section may be satisfied through alternative assessment methods with written approval from the Reserve. Potential alternatives for complying with this requirement include (this list is not comprehensive nor is it intended to define sufficiency):

1. Use of an alternative assessment protocol which employs a robust sampling design which avoids or reduces bias in the selection of sample plots, assesses widely recognized metrics for ecosystem health, is/was developed with input from relevant experts, and is applied consistently over time; or,
2. Use of advanced remote sensing techniques, coupled with a clear, scientific evidence to support their use for this purpose. Such remote sensing must be of a sufficiently high resolution to detect ecosystem degradation at a scale which would be obvious from direct observation.

6.5 Monitoring Project Cooperatives

There can be gains in efficiency through centralized monitoring for project cooperatives. A Cooperative Developer may organize their monitoring plan such that information from individual projects is collected and processed together. However, all information and documentation must be organized in such a manner that the verifier can assess that the requirements of this protocol have been met for each individual project. For example, it is acceptable to submit a single spreadsheet of grazing data for the cooperative, but the grazing data for each individual project must still be clearly defined within that spreadsheet.

6.6 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Grassland Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
General Project Parameters						
	Project Definition	Must confirm project land use has not changed		R, O	Each reporting period	Information used to asses that the project area remains as grassland.
	Eligibility	Must satisfy all requirements of the Eligibility section		N/A	Each reporting period	Information used to assess satisfaction of the requirements of Section 3.
	Regulations	Project Owner attestation of compliance with regulatory requirements relating to the project	All applicable regulations	N/A	Each reporting period	Information used to: 1) Demonstrate ability to meet the legal requirement test – where regulation would prevent conversion of project area. 2) Demonstrate compliance with associated environmental rules, e.g., criteria pollutant limits.
Equation 5.3, Equation 5.4	S	Total number of strata relevant to the project area	strata	R	Once[84]	Information used to determine acres assigned to each relevant stratum.
Equation 5.1	ER	Emission reductions	tCO_2e	C	Per reporting period	Emission reductions are quantified once per reporting period per project. May be summed for reporting of a project cooperative.
Equation 5.5	Area	Area of the entire project	acres	M	Once[84]	The project area is measured using GIS.
Equation 5.3, Equation 5.4	$Area_s$	Area of project in stratum *s*	acres	M	Once[84]	The area of each stratum is measured using GIS.

[84] This parameter would only change if a portion of the project area was subsequently removed from the project and excluded from future quantification or if the project area was expanded.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Baseline Emission Calculation Parameters						
Equation 5.1, Equation 5.2, Equation 5.12	BE	Baseline emissions	tCO_2e	C	Per reporting period	Calculated based on default factors.
Equation 5.2, Equation 5.3, Equation 5.14	OC_{BL}	Baseline emissions due to loss of organic carbon from soil and belowground biomass	tCO_2e	C	Per reporting period	Calculated for each stratum using default emission factors.
Equation 5.2, Equation 5.4	N_2O_{BL}	Baseline emissions of nitrous oxide	tCO_2e	C	Per reporting period	Calculated for each stratum using default emission factors.
Equation 5.2, Equation 5.5	$CO_{2,BL}$	Baseline emissions of carbon dioxide	tCO_2e	C	Per reporting period	Calculated for each stratum using default consumption rates.
Equation 5.2, Equation 5.6, Equation 5.13	DF_{conv}	Discount factor for the uncertainty of conversion	%	R	Once	The value of this uncertainty is based on the performance standard test.
Equation 5.2, Equation 5.13	DF_{σ}	Discount factor for the uncertainty of modeling future management practices and climatic conditions	%	R	Per reporting period	The value of this uncertainty is related to the amount of time that has passed since the baseline modeling was completed.
Equation 5.2	Pro	Pro-rating factor	%	C	Per reporting period	For reporting periods which do not cover an entire year
Equation 5.3	CP	Cropland premium for the project site county	%	R	Once[85]	The cropland premium for the project site county may be referenced from the companion tables.[86]

[85] If a new county is added due to project expansion, then this value needs to be updated.
[86] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.3	$BEF_{OC,s,y}$	Annual baseline emission factor for organic carbon	kg CO_2e/ac/yr	R	Per reporting period	Default factor based on stratum.
Equation 5.4	$BEF_{N2O,s}$	Annual baseline emission factor for N_2O emissions in stratum *s*	kg N_2O/ac/yr	R	Per reporting period	Default factor based on stratum.
Equation 5.5	BRC_{CO2}	Annual baseline rate of consumption of diesel fuel due to cultivation activities	gal/ac/yr	R	Per reporting period	Default consumption rate based on stratum.
Equation 5.5	EF_{FF}	Emission factor for diesel fuel	kg CO_2/gal	R	Per reporting period	Default value for all projects.
Project Emission Calculation Parameters						
Equation 5.7	PE	Project emissions	tCO_2e	C	Per reporting period	Actual emissions in the project area during the reporting period.
Equation 5.7, Equation 5.8	BU_{PR}	Emissions from burning in the project scenario	tCO_2e	C	Per reporting period	Calculated only in the case of a fire during the reporting period.
Equation 5.7, Equation 5.9	FF_{PR}	Emissions from fossil fuels and electricity in the project scenario	tCO_2e	C	Per reporting period	Calculated only if fossil fuels or electricity are used for the project during the reporting period.
Equation 5.7, Equation 5.10	FE_{PR}	Emissions from fertilizer use in the project scenario	tCO_2e	C	Per reporting period	Calculated only if fertilizer is applied on the project area during the reporting period.
Equation 5.7, Equation 5.11	GR_{PR}	Emissions from livestock grazing in the project scenario	tCO_2e	C	Per reporting period	Calculated only if livestock grazing occurs on the project area during the reporting period.
Equation 5.7, Equation 5.12	LE	Emissions from leakage in the project scenario	tCO_2e	C	Per reporting period	Based on a default factor for leakage.
Equation 5.8	$Area_{burn,s}$	Area of stratum *s* that was burned	acres	O	Per fire event	Estimated through either remote sensing or on-site measurement.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.8	DM_s	Amount of aboveground dry matter in stratum *s*	kg/ac	R	Per reporting period	Default factor based on stratum.
Equation 5.9	QF_f	Quantity of fossil fuel type *f* consumed	volume	O	Per reporting period	Includes fossil fuels consumed for any activities on the project area.
Equation 5.9	$PEF_{FF,f}$	Project emission factor for fossil fuel type *f*	kg CO_2/volume fuel	R	Per reporting period	Default emission factors provided.
Equation 5.9	QE	Quantity of electricity consumed during the reporting period	MWh	O	Per reporting period	Includes any electricity consumed on the project area.
Equation 5.9	PEF_{EL}	Emission factor for electricity consumed	kg CO_2/MWh	R	Per reporting period	Referenced from the most recent U.S. EPA eGRID emission factor publication.[87] Projects shall use the annual total output emission rates for the subregion where the project is located.
Equation 5.10	C	Total number of types of organic fertilizer applied, other than manure from grazing livestock	Categories	O	Per reporting period	Must be documented if fertilizer is applied on the project area during the reporting period.
Equation 5.10	QF_{PR}	Quantity of organic fertilizer type *c* applied	kg	O	Per reporting period	Must be documented if fertilizer is applied on the project area during the reporting period.
Equation 5.10	NC_c	Nitrogen content of fertilizer type *c*	kg N/kg fertilizer	O	Per reporting period	Must be documented if fertilizer is applied on the project area during the reporting period.

[87] Available online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.10, Equation 5.11	Leach	Default factor for the fraction and emission factor for N_2O emissions due to leaching	N/A	R	Once[88]	Default factor based on the county where the project area is located. Default factor also be used when irrigation employed in project reporting period.
Equation 5.11	N_2O_{MN}	N_2O emissions from livestock grazing	tCO_2e	C	Per reporting period	Based on AGD for each livestock category using default emission factors.
Equation 5.11	$CH_{4,MN}$	CH_4 emissions from manure	tCO_2e	C	Per reporting period	Based on AGD for each livestock category using default emission factors.
Equation 5.11	$CH_{4,ENT}$	CH_4 emissions from enteric fermentation	tCO_2e	C	Per reporting period	Based on AGD for each livestock category using default emission factors.
Equation 5.11	L	Total number of livestock categories	Categories	O	Per reporting period	Documented for every reporting period where livestock are grazed on the project area.
Equation 5.11	AGD_l	Animal grazing days for livestock category *l*	Animal days	O	Per reporting period	Documented for every reporting period where livestock are grazed on the project area.
Equation 5.11	Nex_l	Nitrogen excreted by animals in livestock category *l*	kg N/animal grazing day	R	Per reporting period	Default factors based on livestock category and project state.
Equation 5.11	VS_l	Volatile solids excreted by animals in livestock category *l*	kg VS/animal grazing day	R	Per reporting period	Default factors based on livestock category and project state.
Equation 5.11	$B_{0,l}$	Maximum CH_4 potential for manure from animal category *l*	m^3 CH_4/kg VS	R	Per reporting period	Default factors based on livestock category.

[88] If a new county is added due to project expansion, then this value needs to be updated.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.11	MCF_{PRP}	CH_4 conversion factor for pasture/range/paddock manure management	%	R	Per reporting period	Default value based on average ambient temperature during the grazing season.
Equation 5.11	ρ_{CH4}	Density of CH_4 at 1 atm pressure and the average ambient temperature during the grazing season	kg/m^3	R	Per reporting period	Based on average ambient temperature during the grazing season.
Equation 5.11	$PEF_{ENT,l}$	Project emission factor for enteric methane emissions from livestock category *l*	kg CH_4/animal grazing day	R	Per reporting period	Default factors based on livestock category and project state.
Equation 5.13	Rev	Quantity of emissions due to a reversal	tCO_2e	C	Per reversal event	Any event, avoidable or unavoidable, which causes a loss of belowground organic carbon results in a reversal of CRTs which have been issued. Reversals must be quantified and compensated for.
Equation 5.13	Y	Number of years for which CRTs have already been issued	years	O	Per reversal event	The magnitude of a reversal is related to the affected area and the number of CRTs which have already been issued.
Equation 5.13	$OC_{BL,rev,rp}$	Baseline emissions of organic carbon in soil and biomass in reporting period *y* for the acres affected by the reversal	tCO_2e	C	Per reversal event	The quantity of CRTs related to belowground organic carbon affected by the reversal.
Equation 5.14	BP	Buffer pool contribution	tCO_2e	C	Per reporting period	Based on risk rating for the project.
Equation 5.14	$Risk_{rev}$	Risk of unavoidable reversals	%	C	Per reporting period	Includes a default risk plus additional project-specific risks.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.14	$Risk_{FF}$	Risk related to financial failure	%	R	Once, unless the PIA is updated to change the subordination clause	The value is determined based on the specific subordination clause that is included in the PIA. Details can be found in Exhibit E of the PIA.
Equation 5.14	$Risk_{SV}$	Risk related to site visit schedule	%	R	Per reporting period	The value is determined based on whether the project or cooperative adheres to the recommended minimum site visit schedule.

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure across projects.

7.1 Time Periods for Reporting

Table 7.1 summarizes the various time periods that are relevant to AGC projects. Project Owners should recognize that recurring periods (such as reporting periods or verification periods) must always be contiguous, such that there are no gaps between recurring periods. CRTs can only be issued upon approval of a verification report by the Reserve.

Table 7.1. Guide to Relevant Time Periods for Grassland Projects

Description	Time Period	Protocol Section
Project lifetime	Up to 150 years	2.2
Conservation easement term	Perpetual	2.2
Pre-project land use history	No less than 10 years prior to project start date	2.2
Crediting period	No more than 50 years following project start date	3.4
Reporting period (first)	No more than 24 months	7.4
Reporting period (subsequent)	No more than 12 months	7.4
Verification period (first)	First reporting period	7.4
Verification period (subsequent)	No more than 6 reporting periods	7.4
Permanence period	100 years following crediting period	3.5
Monitoring period (easement enforcement)	No more than 6 years	7.5.1
Monitoring period (outside of easement enforcement)	No more than 3 years	7.5.2
Verification period (outside of easement enforcement)	No more than 15 years	7.5.2

7.2 Project Documentation

Project Owners must provide the following documentation to the Reserve in order to register a grassland project:

- Project Submittal form (or Cooperative Submittal form)*
- Property ownership documentation*
- Project conservation easement
- Project Implementation Agreement
- Project area map (this map is public; it is only required to show the outer extent of the project area and is not required to be in a georeferenced format)*
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

** Denotes items that are required at the time of project submittal.*

Project Owners must provide the following documentation for each verification period during the crediting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Signed Project Implementation Agreement (for the initial verification) or signed, amended Project Implementation Agreement (for subsequent verifications)
- Georeferenced project boundary map (this map is private; it must delineate the actual polygons of the eligible project area, and must be a shapefile or KML format)

Documentation requirements for the Permanence Period are explained in Section 7.5.

At a minimum, the above project documentation (except as noted) is available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.3 Record Keeping

For purposes of independent verification and historical documentation, Project Owners are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information is not publicly available, but may be requested by the verifier or the Reserve.

System information the Project Owner shall retain includes:

- Detailed, georeferenced project maps (created per guidance in Section 2.2.1)
- Ongoing monitoring reports or documentation related to the conservation easement
- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Documentation of the continued conservation of the grassland cover in the project area (see Section 6.1)
- Copies of all permits, Notices of Violations, and any relevant administrative or legal consent orders dating back at least 3 years prior to the project start date
- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Onsite fossil fuel use records, if applicable
- Onsite grid electricity use records, if applicable
- Grazing management plan, if applicable
- Nutrient management plan, if applicable
- Grazing management records
- Fertilizer use records, if applicable
- Documentation of fires, if applicable
- Results of annual CO_2e reduction calculations
- Initial and annual verification records and results

7.4 Reporting Period and Verification Cycle

The reporting period is the length of time over which GHG emission reductions from project activities are quantified. Project Owners must report GHG reductions resulting from project activities during each reporting period. A reporting period may not exceed 12 months in length, except for the initial reporting period, which may cover up to 24 months. The Reserve accepts verified emission reduction reports on a sub-annual basis, should the Project Owner choose to have a sub-annual reporting period and verification schedule (e.g., monthly, quarterly, or semi-annually). However, it is recommended that projects follow a calendar year reporting schedule to simplify the application of the quantification and monitoring requirements. Reporting periods must be contiguous; there must be no gaps in reporting during the crediting period of a project once the first reporting period has commenced.

The verification period is the length of time over which GHG emission reductions from project activities are verified. The initial verification period for a grassland project is limited to one reporting period. Subsequent verification periods may cover up to six reporting periods. It is required that a project verification occur at least every six years during a project's crediting period. CRTs will not be issued for reporting periods that have not been verified. Project Owners may choose to verify more frequently than every six reporting periods. For any reporting period that ends prior to the end of the verification period (i.e., years 1-5 of a 6 year verification period), an interim monitoring report must be submitted to the Reserve no later than 90 days following the end of the relevant reporting period. The interim monitoring report shall contain a summary of ownership (describing the entities and relationships detailed in Section 2.3), evidence of land use (as described in Section 5.1.3), and basic documentation of land management activities and project emissions during the relevant reporting period.[89] See Section 7.5 for guidance on reporting and verification activities after the crediting period is concluded.

To meet the verification deadline, the Project Owner must have the required verification documentation (see Section 7.2) submitted within 12 months of the end of the verification period. The end date of any verification period must correspond to the end date of a reporting period. No more than six reporting periods (a maximum of 72 months) can be verified at once during the project's crediting period.

7.5 Reporting and Verification of Permanence

When the crediting period for a grassland project ends, the project enters the permanence period. Per Section 3.5, the project area must be monitored to ensure against reversals for a period of 100 years following the last issuance of CRTs related to carbon pools at the project site (i.e., soil organic carbon). During the permanence period, no emission reductions are claimed and no new credits are issued. Projects may elect to begin the permanence period prior to the end of their maximum allowable crediting period by notifying the Reserve in writing prior to their next reporting deadline. This monitoring can take different forms depending on the terms of the conservation easement which binds the project area. In any case, monitoring must continue through the permanence period to confirm that no reversals have occurred, and the results of this monitoring must be reported to the Reserve periodically. There are two categories of monitoring scenarios: projects may either be monitored as part of their easement monitoring activities, or they may be monitored specifically for the carbon project. In both cases, the required periodic monitoring reports shall, at a minimum, contain the following:

[89] A template monitoring report is available at: http://www.climateactionreserve.org/how/program/documents/.

- Evidence to support the conclusion that no reversals have occurred on the project area since the previous reported time period
- Information related to ongoing activities on the site, including grazing
- Updated information related to ownership of the property, the easement, and the rights to the soil carbon

In certain cases (see Section 7.5.1) these reports are not required to be verified, but in all cases they must be reviewed and approved by the Reserve in order for the terms of the PIA to be satisfied. Project emissions are not quantified during the permanence period. If a reversal is identified, it must be reported to the Reserve and the guidance in Section 5.4 regarding compensation for reversals shall apply.

7.5.1 Monitoring through Easement Activities

If a project area is subject to the terms of a Qualified Conservation Easement (Section 3.5.1) which includes provisions for ongoing monitoring and specific mechanisms for enforcement, such monitoring activities may be considered sufficient for the purposes of this protocol. The Project Owner must submit a monitoring report at least every six years (i.e., this report is due no later than 72 months after the end date of the previous verification or monitoring period, whichever is relevant). The Reserve maintains the right to determine whether the terms of a conservation easement are sufficient to meet the requirements of this section. An easement may be amended at any time to meet these requirements, subject to approval by the Reserve. If the monitoring is not carried out according to the terms of the easement or the monitoring reports are not received by the Reserve, the Project Owner may be in breach of the PIA.

7.5.2 Monitoring for Carbon Separately

If the conservation easement does not contain monitoring and enforcement terms that satisfy Section 7.5.1, the Project Owner must continue monitoring and reporting activities through other means. Projects must prepare and submit a monitoring report to the Reserve at least every 3 years (i.e., this report is due no later than 36 months after the end date of the previous verification or monitoring period, whichever is relevant). These monitoring reports shall be verified at least every fifteen years, although verification may be more frequent. The verification deadlines described in Section 7.4 shall apply.

7.6 Joint Reporting of Project Cooperatives

Project cooperatives carry out a certain amount of joint effort for reporting. While the quantification section shall be applied to each project independently, the results may be collected and reported together to the Reserve by the Cooperative Developer. Reports and documentation may be combined for efficiency, but it must be possible to trace the evidence for the emission reductions from each individual project.

In the management of a cooperative, certain documents are required to be submitted for each individual project, while certain other documents may be submitted once for the entire cooperative. Table 7.2 details which documents belong to which category. The Cooperative Developer shall submit all documentation through their Reserve account. Once the verification report is registered, CRTs shall be issued to the Project Owner account associated with each project in the cooperative.

Table 7.2. Document Management for Project Cooperatives

May Apply to the Cooperative	Must be Submitted for Each Individual Project[90]
▪ Cooperative Submittal form ▪ Verification Report ▪ Verification Statement	▪ Property ownership documentation ▪ Attestation of Title form ▪ Attestation of Voluntary Implementation form ▪ Attestation of Regulatory Compliance form ▪ Project maps

7.6.1 Cooperative Verification Cycle

The verification period for the entire cooperative must end on the same date, unless a project reaches the end of its crediting period during the verification period. In that case, it is acceptable for that project to end reporting prior to the end of the cooperative's verification period. However, during a project's first verification as a member of a cooperative, it may begin reporting at a date that is different from other projects in the cooperative. It is likely that each project in a cooperative has a different start date, and thus during the initial verification for a cooperative each project begins reporting on a different date. The initial verification period shall cover a single reporting period, and the initial reporting period may be up to 24 months in length. Although the individual projects begin their reporting periods on different dates, they shall all end on the same date, such that subsequent verifications of the cooperative will cover the same length of time for every project. When a project joins a cooperative that has already undergone verification, that project's next reporting period must not begin prior to the end of the cooperative's previous verification period, but it may begin at a date that is later than the beginning of the cooperative's next reporting period. Table 7.3 describes various cooperative scenarios and the resultant outcomes for their respective verification cycles.

If an individual project within a cooperative is unable to meet the requirements of this protocol for one or more reporting periods, that project may report zero credits for that time period and continue to be verified as part of the cooperative. For reporting periods where a project claims zero credits, the verifier shall confirm that project emissions were not greater than baseline emissions, and that no reversals occurred. Additional guidance regarding zero-credit reporting periods can be found in the Reserve Offset Program Manual.[91]

Table 7.3. Example Cooperative Verification Scenarios

Example Scenario	Resulting Verification Cycle
1. Cooperative X contains two projects: Project A has a start date of 1/1/15 and Project B has a start date of 7/22/15.	The initial verification period for the cooperative would cover 1/1/15 – 12/31/16. Project A would report for the entire period, while Project B would report only for 7/22/15 – 12/31/16.
2. Project C wishes to join Cooperative X. Project C has a start date of 5/9/17.	The next reporting period for the cooperative is 1/1/17 – 12/31/17. The first reporting period for Project C would be 5/9/17 – 12/31/17.

[90] These documents for individual projects may be electronically combined into a single PDF (e.g., one digital file may contain the individual Attestation of Title forms for every project in the cooperative).
[91] Available at: http://www.climateactionreserve.org/how/program/program-manual/.

Example Scenario	Resulting Verification Cycle
3. Project D wishes to join Cooperative X. Project D has a start date of 1/1/16 and has not yet gone through verification.	There are two options: *Option i*: The project may undergo verification as a standalone project for the period 1/1/16 – 12/31/16, then subsequently join the cooperative for future reporting. *Option ii*: The project may join the cooperative immediately, taking a zero-credit reporting period for 1/1/16 – 12/31/16, and begin reporting on 1/1/17 with the cooperative's next verification period.
4. Project E wishes to transfer into Cooperative X from another, different cooperative, which has already undergone verification. The last verification period for Project E ended on 6/30/16.	There are two options: *Option i*: The project may undergo verification as a standalone project for the period 7/1/16 – 12/31/16, then subsequently join the cooperative for future reporting. *Option ii*: The project may join the cooperative immediately, taking a zero-credit reporting period for 7/1/16 – 12/31/16, and begin reporting on 1/1/17 with the cooperative's next verification period.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the project activity. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to grassland projects.

Verification bodies trained to verify grassland projects must be familiar with the following documents:

- Reserve Offset Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Grassland Protocol (this document)

The Reserve Offset Program Manual, Verification Program Manual, and protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only ANSI-accredited verification bodies trained by the Reserve for this project type are eligible to verify grassland project reports. Verification bodies approved under other protocol types are not permitted to verify grassland projects.[92]

8.1 Joint Verification of Project Cooperatives

Projects that participate in a project cooperative are verified together for every verification period. The Cooperative Developer has their own account on the Reserve through which they submit all documentation related to the cooperative. One set of verification documentation shall be submitted for the entire cooperative, but the project-specific attestations must be executed by the Project Owner for each project.

If the verifier cannot reach a positive verification opinion for one or more projects within a cooperative, the verification may still be completed, and emission reductions registered for the projects for which the verifier can reach a positive opinion. However, the verification of the cooperative as a whole cannot be approved by the Reserve unless an opinion is rendered on every project within the cooperative.

8.2 Standard of Verification

The Reserve's standard of verification for grassland projects is the Grassland Protocol (this document), the Reserve Offset Program Manual, and the Verification Program Manual. To verify a grassland project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

[92] Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/.

8.3 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record keeping are ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.4 Verifying Project Eligibility

Verification bodies must affirm a grassland project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for grassland projects. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for a Grassland Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing no more than 12 months after the project start date	Once during first verification
Start Date	Recordation of a conservation easement, submittal of the project to the Reserve, transfer of the project area to Federal Government ownership, or execution of a notarized contract	Once during first verification
Location	Conterminous United States and tribal areas	Once during first verification
Location	Project strata must have a positive baseline emission factor for soil organic carbon during the reporting period	Every verification
Performance Standard	Project county must pass the financial threshold at the time of project submittal	Once during first verification
Performance Standard	Project area must pass the suitability threshold	Once during first verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the legal requirement test	Every verification
Credit and Payment Stacking	Projects must meet credit and payment stacking requirements and disclose all credits or payments received in relation to the project area	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws	Every verification
Project Implementation Agreement	The Project Owner must execute a PIA with the Reserve prior to the initial registration, and sign an amended PIA prior to each subsequent registration	Every verification

8.5 Core Verification Activities

The Grassland Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with the avoided conversion of grasslands to croplands. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a grassland project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs (SSRs)
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, based on the guidance in Section 4.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the grassland Project Owner uses to gather data and calculate baseline and project emissions, based on the guidance in Sections 5 and 6.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This may involve site visits to the project area (or areas if verifying a project cooperative) to ensure the activities on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the Project Owner in order to double-check the calculations of GHG emission reductions.

8.5.1 Site Visits

Site visits during verification are strongly recommended, but are not mandatory for grassland projects. However, there is risk associated with a project that has never been visited for the purposes of a third-party verification. This risk is related to the lack of direct, physical inspection of the project area and personal, face-to-face interaction with the project participants, which are valuable components of typical offset project verification activities. The Reserve believes that this risk is low enough in the case of grassland projects that the site visit during verification has been made optional. However, an additional buffer pool contribution must be made to account for the increased risk for those projects which forego a site visit verification. Section 5.4.3 details how this contribution is determined. Although the site visit is optional, it may be carried out at the discretion of the Project Owner or the verifier.

When a site visit is carried out for the verification of a grassland project, the site visit may occur during the verification period or after its conclusion. During this visit the verifier confirms the eligibility of the existing land use, assess the accuracy of the project maps, assess the sources of project emissions, and assess the management and recordkeeping related to the project.

8.5.2 Desk Review Verification

For verifications that do not include a site visit, the verification body must follow the same standards and procedures, but is not required to physically visit the project site. Desk review verifications must achieve the same standard of reasonable assurance.

8.6 Grassland Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a grassland project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to grassland projects that must be addressed during verification.

8.6.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for grassland projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of a grassland project	No
2.2.1	Verify that the project area, and subsequent modifications, have been correctly delineated on a map (or maps) that meets the requirements of the protocol	No
2.3	Verify ownership of the GHG reductions by reviewing Attestation of Title and accompanying documentation	No
2.3	Verify the project and/or cooperative structure is appropriate	No
3.2	Verify project start date	No
3.2	Verify accuracy of project start date based on documentation	Yes
3.2	Verify that the project has documented and implemented a Monitoring Plan	No
3.3, 3.4	Verify that the entire reporting period is within the crediting period for the project	No
3.3.1	Verify that the project meets the performance standard test	No
3.3.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the legal requirement test	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
3.3.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that the project passes the legal requirement test at all times	No
3.3.3	Confirm that disclosure has been made of any other credits or payments received in relation to the project area, and that these conform to the requirements of the protocol	No
3.5.1	Confirm that the Project Owner has executed a PIA with the Reserve	No
3.6	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the Project Owner and performing a risk-based assessment to confirm the statements made by the Project Owner in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No

8.6.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and recalculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for (unless optional)	No
5	Verify that the emission factors are all correctly selected for the relevant parameters, both for baseline emissions and project emissions	No
5.1	Verify that the stratification procedures were carried out properly	Yes
5.2	Verify that the baseline emissions are properly aggregated (and pro-rated, if applicable)	No
5.2.1	Verify that the project employed the appropriate discount factors	No
5.3	Verify that the project emissions were calculated according to the protocol with the appropriate data	No
5.3.1	Verify that the Project Owner correctly monitored and quantified fires	No
5.3.2	Verify that the Project Owner correctly monitored, quantified, and aggregated fossil fuel use	Yes
5.3.3	Verify that the Project Owner correctly monitored and quantified fertilizer use	No
5.3.4	Verify that the Project Owner correctly monitored and quantified grazing activities	No
5.4	Verify that no reversals have occurred and that the correct contribution was calculated for the buffer pool	No

8.6.3 Risk Assessment

Verification bodies shall review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring practices are in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the Project Owner. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
7.3	Verify that all required records have been retained by the Project Owner	No

8.6.4 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for Project Owners.
Additionality	Project activities that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e., fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon rights	Legal ownership of carbon stored in pools located within the project area. Carbon rights may be separate from GHG reduction rights (defined below).
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Cooperative Developer	The entity responsible for management of a project cooperative. The Cooperative Developer may or may not be one of the Project Owners participating in the project cooperative.
Crediting period	The period of time over which CRTs may be quantified and registered under this protocol. For a grassland project, the crediting period may be a maximum of 50 years.
Cropland	Land whose management is primarily conducted through "cultural" treatments, such as human and/or mechanical labor, fertilization, irrigation, tillage, seeding, and/or planting. While cropland may include seasonal livestock grazing, at least a portion of the year it is specifically given over to cultivation of a crop which is intended to be harvested for off-site consumption.
Direct emissions	GHG emissions from sources that are owned or controlled by the reporting entity.
Easement monitoring report	Reports developed by an easement grantee that demonstrate easement terms have been met.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.

Grassland	An area of land dominated by native or introduced grass species with little to no tree canopy. Other plant species may include legumes, forbs, and other non-woody vegetation. Tree canopy may not exceed 10% of the land area on a per-acre basis. For the purpose of this protocol, grassland may include managed rangeland and/or pastureland.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reduction rights	Legal ownership of the GHG emission reductions resulting from avoided grassland conversion project activities on the project area during the reporting period. GHG reduction rights may be separate from carbon rights (defined above).
Grassland Owner	An individual or entity which has a right of ownership over a portion or all of the project area, or an ownership right whose exercise could reasonably be expected to impact soil carbon storage on a portion or all of the project area.
Grazing season	The period of time bounded by the first and last days of livestock grazing during the reporting period.
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Metric ton (t, tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.623 pounds or 1.102 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of employees, materials, products, and waste resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g., cars, trucks, tractors, dozers, etc.).
Non-reversible emission reductions	An emission reduction is not considered reversible if it represents the destruction or avoided emission of a GHG which does not rely on storage within a carbon pool. For example, the avoided emissions of N_2O due to cultivation activities are considered non-reversible.

Pastureland	An area of grassland which is managed through livestock grazing as well as other "cultural" treatments, such as human and/or mechanical labor, fertilization, irrigation, and/or seeding. For the purpose of this protocol, pastureland may not involve any level of tillage.
Permanence period	The period of time following the crediting period during which the Project Owner must continue monitoring, reporting, and verification activities under this protocol. The permanence period for a grassland project is 100 years following the last issuance of CRTs related to reversible emission reductions.
Project area	The area defined by the physical boundaries of the project activities. The project area only contains land which meets the eligibility requirements of this protocol.
Project baseline	A "business as usual" GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project Owner	An entity that has title to the emission reduction credits issued under this protocol and undertakes a GHG project, as identified in Section 2.2 of this protocol. The Project Owner may also be the Cooperative Developer and/or a Grassland Owner.
Rangeland	An area of grassland which is managed principally through the use of livestock grazing. For the purpose of this protocol, rangeland must meet the definition of grassland.
Reporting period	The length of time over which GHG emission reductions from project activities are quantified. Under this protocol, the reporting period can be no more than 12 months.
Reversible emission reductions	An emission reduction is considered reversible if it represents an avoided emission or enhanced sequestration of carbon which must be stored in a carbon pool. For example, the avoided emissions of soil organic carbon due to cultivation activities are considered reversible, and the carbon must be permanently maintained through conservation of the project area.
Shrub	A woody perennial plant, generally more than 1.5 feet and less than 16.5 feet in height at maturity and without a definite crown (24). Shrubs will usually have multiple stems no more than 3 inches in diameter (23).
Tree	A woody perennial plant, typically large and with a well-defined stem or stems carrying a more or less definite crown with the capacity to attain a minimum diameter at breast height of 5 inches and a minimum height of 15 feet with no branches within three feet from the ground at maturity (24).
Verification	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Verification period	The length of time over which GHG emission reductions from project activities are verified. Under this protocol, the verification period can cover up to six reporting periods during the crediting period, and up to ten reporting periods during the permanence period.

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Appendix A Development of the Performance Standard

The Reserve assesses the additionality of projects through application of a performance standard test and a legal requirement test. The purpose of a performance standard is to establish a standard of performance applicable to all grassland projects that serves as a proxy for a significant threat of conversion of the project area to crop cultivation. If this standard is met or exceeded by the Project Owner, the project satisfies the criterion of "additionality."[93]

A.1 Components of the Performance Standard Test

The Grassland Protocol performance standard test has two components:

1. Financial threshold
2. Suitability threshold

The intent of this two-part test is to create a standardized proxy for the complex decision-making process that leads to land use change. A project-specific approach would allow for the evaluation of all barriers to the project activity at the project site, but it would be fraught with subjectivity and uncertainty due to the counterfactual nature of the baseline scenario. Moreover, project-specific determinations of additionality tend to be very expensive and labor-intensive, thus rendering relatively low-volume projects, such as grassland projects, to be infeasible. While each individual component of the performance standard test would not, on its own, be a rigorous test of the additionality of the project, the Reserve believes that, taken as a whole with the other requirements for eligibility (e.g., location, legal surplus), the performance standard test does achieve such an outcome.

In addition to the two components of the performance standard test, projects are subject to a location-based emission reductions threshold, discussed in Section 3.1. Although this eligibility screen is not part of the performance standard test, it works in conjunction with the performance standard test to identify eligible projects.

A.1.1 Location-Based Emission Reductions Threshold

This component of the eligibility screening is quantitative. Its premise is that projects should only be eligible if, based on the quantification methodology used by this protocol, the project will generate creditable emission reductions. The main focus of this protocol is the avoided emission and permanent protection of soil organic carbon (SOC). Thus, SOC is the focus of the emission reductions threshold.

For the purposes of this protocol, the U.S. has been stratified in order to enable the development of baseline and project emissions estimates that correspond to local soil conditions, climatic conditions, starting condition, and agricultural practices. A stratum represents a unique combination of these variables. All baseline modeling was performed at the stratum level, enabling the resulting emissions estimates to represent relatively fine distinctions in the primary drivers of variation in emissions. In total, this protocol established emissions estimates for 1,002 total strata within the U.S. By stratifying the country in this manner, the emissions estimates used in this protocol provide greater local accuracy and representation than would emission estimates generated at a national scale or with fewer variables. These variables act as filters that each brings greater specificity to the emissions estimates by more

[93] See the Reserve Offset Program Manual for further discussion of the Reserve's general approach to determining additionality: http://www.climateactionreserve.org/how/program/program-manual/.

precisely estimating the conditions of the project. Land is first broken down by climate and geography, then further delineated by the major soil type and texture, and finally evaluated based on the previous land use.

The following variables were used to stratify the U.S:

- Geography and associated climate
- Soil texture
- Previous land use

A.1.1.1 Geography and Associated Climate

The first level of stratification used in this protocol delineates land based on its geography and associated climate, due to these factors important influence over carbon pools and sources in both natural and managed ecosystems (8). Regional climate and geographic conditions are determined through the use of Major Land Resource Area (MLRA) designations, as defined by the U.S. Department of Agriculture, Natural Resources Conservation Services (9). These designations are used for a variety of policy and planning decisions, as they represent information about land suitability for farming and other purposes. As such, they constitute a land area that has similar physical and climatic characteristics. In total, there are approximately 280 MLRAs in the U.S. However, some of these MLRAs contain very little cropland or grassland feasible for conversion. Appendix B provides an overview of the methodology used to screen out certain MLRAs based on the absence of significant areas of grassland or cropland, and constraints on data availability and modeling confidence.

A.1.1.2 Soil Texture

Soil texture has a significant impact on land productivity and carbon dynamics through influences on soil fertility and water balance and on soil organic matter stabilization processes (10). Accordingly, the second level of stratification requires differentiating by soil texture. While successively finer delineations of soil type and texture would yield greater precision, this protocol limits the stratification of soils into three major classes of surface soil texture as defined by USDA. These are:

- Coarse
- Medium
- Fine

By adding soil texture to the stratification, the quantification is improved in two ways. First, the texture itself plays a considerable role in the carbon dynamics being modeled (27), allowing more refined and representative results. Second, defining the stratum with the soil texture limits the cropping systems and management practices that are modeled to those suitable to these soils by evaluating only those systems seen on other similar soils within the MLRA. Use of soil texture therefore gives greater precision to the crop system inputs and resulting model accuracy.

A.1.1.3 Previous Land Use

Initial carbon pools at project commencement will be significantly influenced by previous land uses. Additionally, soil quality at project initiation influences nutrient inputs and farming practices in the baseline scenario. Because this protocol allows for the avoided conversion of grasslands with somewhat varied histories, the third level of stratification requires grasslands to be

delimited by the duration of time it has been in a grassland state. This protocol defines the following two categories for grasslands:

- Greater than 10, but less than 30 years continuous grassland or pastureland
- Greater than 30 years continuous, long-term permanent grassland or pastureland

To develop this threshold, the baseline scenario was modeled for a period of 50 years for each individual stratum. The outputs from the models were averaged over 10 year periods to smooth out any inter-annual variability and stochasticity inherent in the modeling. Due to the specific characteristics of the individual strata and the common management practices in those areas, some strata exhibit SOC loss after conversion to cropland, some do not, and some show consistent SOC gains. A stratum may only be eligible if we have an emission factor that shows a baseline loss of SOC for the first 10 year emission factor period. If the stratum shows baseline SOC gains for an emission factor period, then the project crediting period will end prior to that emission factor period. Table A.1 and Figure A.1 show a summary of the outcome of this test.

Table A.1. Summary of Strata Eligibility Based on Emission Reduction Potential

Categories	Number of Strata in Each Category
Total possible strata	1,668
Strata with no data for modeling	667
Strata with no emission reductions in first 10 years	331
Potentially eligible strata	670

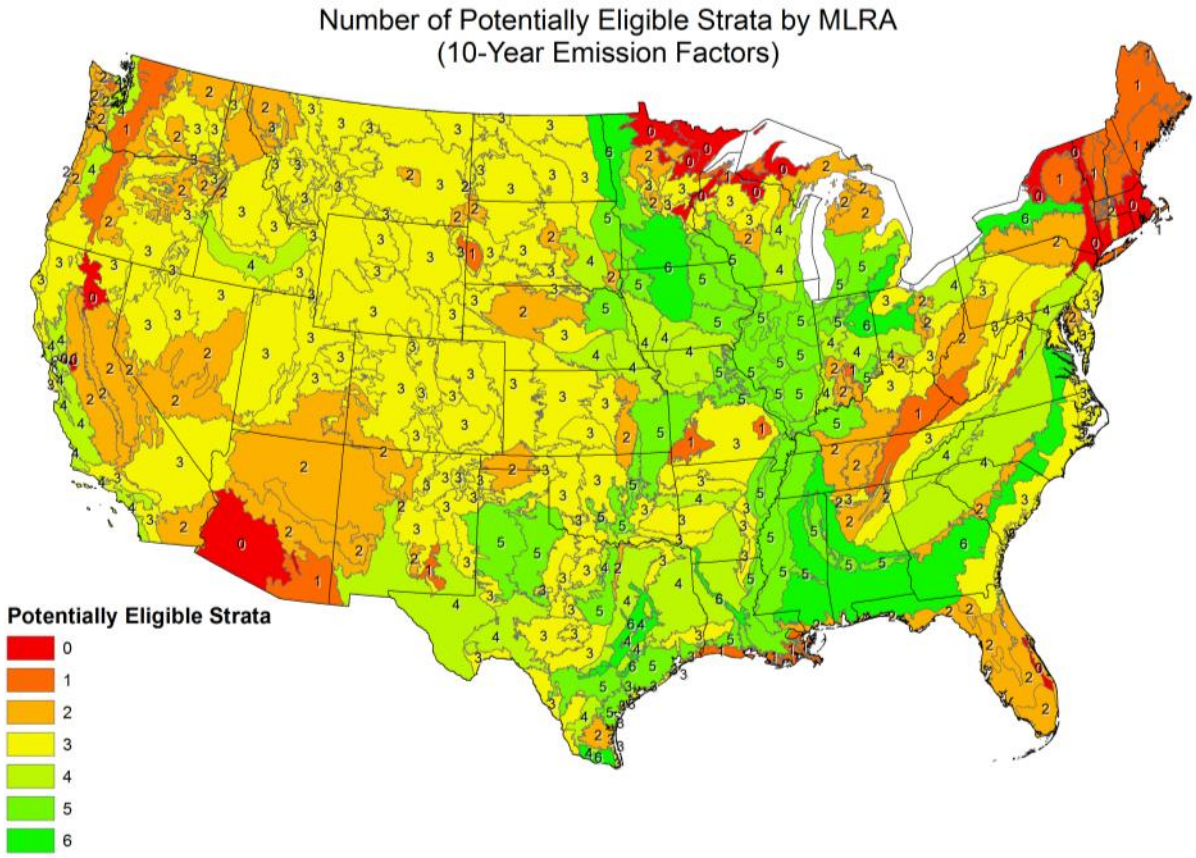

Figure A.1. Potentially Eligible Strata for Each MLRA

A.1.2 Financial Threshold

The first component of the performance standard test is a financial threshold. The concept is that the monetary incentive provided by offsets is needed to counteract the existing financial incentive to convert grassland to cropland. The incentive to convert to cropland is thus viewed as a barrier to the project. As a proxy for this financial incentive, the Reserve uses the concept of the "cropland premium." The cropland premium for a county value of the cash rent rate for cropland compared to the cash rent rate for pastureland. In other words, the cropland premium represents the increased value (either as a percentage or in absolute dollars per acre) of land that is converted from pasture to crop production.

This approach is also utilized by avoided conversion project type in the Reserve Forest Protocol,[94] which requires the Project Owner to obtain a certified real estate appraisal of the project area to identify the land's value as a forest (project scenario) and as the converted land use (baseline scenario). The percentage difference between these two must exceed 40% for eligibility and must exceed 80% to avoid the application of a discount, which is calculated on a sliding scale between the two thresholds.[95] The discount represents the uncertainty of the baseline conversion and recognizes that the threshold for the decision to convert will vary between landowners.

[94] Climate Action Reserve, Forest Project Protocol Version 3.3 (November 15, 2012). Section 3.1.2.3.
[95] Climate Action Reserve, Forest Project Protocol Version 3.3 (November 15, 2012). Equation 6.14.

A.1.2.1 Calculating the Cropland Premium

The rent rate data are collected through the annual cash rent survey of the USDA National Agricultural Statistics Service (NASS).[96] This dataset is robust and published on a regular, annual schedule. The cash rent survey provides a value, in dollars per acre, of the cash rent paid for non-irrigated cropland, irrigated cropland, and pastureland. The non-irrigated cropland rent rate is used as a proxy for the value of cropland. The pastureland rent rate is used as a proxy for the value of grassland. Cropland premiums were calculated by subtracting the average pastureland rent rate from the average non-irrigated cropland rent rates, then dividing by the average pastureland rent rate.

In order to smooth out inter-annual fluctuations and account for years with missing data, the financial threshold is based on an average of the cropland premium for the previous three years. If there are too few respondents in a particular county to ensure anonymity of the reported data, those counties are combined and averaged together by the NASS at the level of the Agricultural Statistics District (ASD) and identified in the data as "Other (Combined) Counties." Thus, where a county did not have a value listed for a particular rent category for a particular year, the average for the ASD for that year was used. If there was no ASD average reported, the value was left out. When averaging the rent values over the three year period, only years with reported values were considered (i.e., "no value" was not considered to equal zero). For projects with start dates during the calendar year 2015, rent rate data from 2012-2014 were used.

A.1.2.2 Setting the Threshold

Once the cropland premiums were determined, a policy decision was made as to where the threshold should be set. There are several options for how to consider the cropland premium as a proxy for the financial incentive to convert the project area. There were also several other decisions that ultimately influenced the threshold, such as the most appropriate geographic level of analysis (county, ASD, state, region) and the particular metric for the cropland premium (absolute $/acre or percent difference).

As the rent rate data are available at the county level, the Reserve chose to use this level for the analysis. Following the approach used in the Forest Protocol, the Reserve elected to continue to apply the financial threshold as a percent difference, rather than a dollar value, which limits the impact of other variables that affect land value. This approach is also used in the Avoided Conversion of Grasslands and Shrublands (ACoGS) methodology adopted by the American Carbon Registry, although that methodology does not rely on a standardized assessment of land value.

The Forest Protocol sets a threshold of 40% premium for eligibility, and 80% premium for undiscounted eligibility. The ACR ACoGS methodology sets a threshold of 40% premium for eligibility and 100% premium for undiscounted eligibility. The Reserve has elected to adopt the thresholds described in the ACoGS methodology. Cropland premiums between these two values are subject to a discount on a sliding scale, following the guidance in Equation 5.6.

Although the threshold will be applied to new rent rate data each year, the thresholds themselves will not change unless the Reserve carries out a new analysis and issues a new version of this protocol.

[96] Information available at: http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Cash_Rents_by_County/index.asp. Accessed October 13, 2014.

A.1.2.3 List of Eligible Counties

Once the threshold was determined, it was then applied to the rent rate data to determine the list of eligible counties. Following the procedures above, the Reserve determined the average cropland premiums for the most recent three year period (2012-2014). The financial thresholds were then applied to these data (Figure A.2). This exercise will be conducted as new rent rate data become available. For counties which are identified as having no data, a Project Owner may request that the Reserve examine the data for surrounding counties and determine whether the county may be considered eligible (and the appropriate value for DF_{conv}, if applicable). The revised list of eligible counties, along with their value for DF_{conv}, if applicable, will be published and be effective for new projects submitted during the following year. The current tables, as well as any future updates, are available by individual request (email to policy@climateactionreserve.org or call (213) 891-1444) or for download at: http://www.climateactionreserve.org/how/protocols/grassland/.

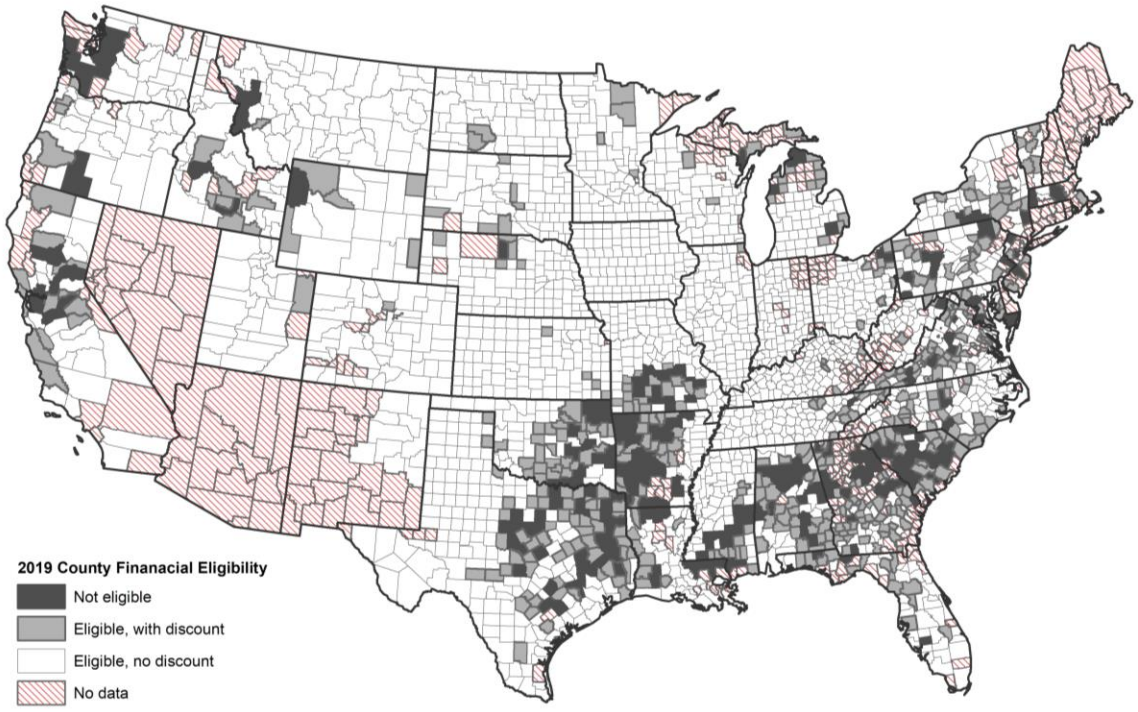

Figure A.2. Eligibility of Counties Based on the Financial Threshold for Additionality

A.1.3 Suitability Threshold

Projects should only be considered additional if the project area is actually suitable for conversion to crop cultivation. Otherwise, the baseline scenario is invalid, and the project area is not actually under threat of conversion to cropland. This is the premise behind the second component of the performance standard test: the suitability threshold. There are numerous parameters (slope, drainage, rockiness, etc.) that contribute to the overall suitability of a parcel for crop cultivation. The Natural Resources Conservation Service (NRCS) Land Capability Classification (LCC) system is widely used to simplify the description of land areas in regards to its suitability for cultivation (3). The Reserve has chosen to use the NRCS LCC system to assess the suitability threshold for grassland projects.

There are eight LCC classes, numbered I through VIII:

I. Soils have few limitations that restrict their use. (no subclasses)
II. Soils have some limitations that reduce the choice of plants or require moderate conservation practices. (all subclasses)
III. Soils have severe limitations that reduce the choice of plants or require special conservation practices or both. (all subclasses)
IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both. (all subclasses)
V. Soils have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover. (subclasses w, s, c)
VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover. (all subclasses)
VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife. (all subclasses)
VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply or to esthetic purposes. (all subclasses)

In addition, there are four subclasses, indicated by letter:

(e) Erosion
(w) Excess wetness
(s) Problems in the rooting zone
(c) Climatic limitations

Crop cultivation is generally not recommended for land classified above Class IV (3). We have received stakeholder feedback that would push this threshold in both directions, some saying that no land above Class III should be cultivated, and others saying that they have seen Class V and VI land being actively converted. Recent research has supported this conclusion (3). The Reserve has chosen to rely on the general recommendation that classes above IV are not suitable for cultivation, while recognizing that land characteristics tend to be more heterogeneous than legal boundaries by allowing for small components of the project area to be Class V or VI.

To determine the appropriate minimum threshold for NICC I-IV soils as a percentage of the total project area, the Reserve assessed the NICC for existing, non-irrigated cropland, as well as the NICC for non-irrigated cropland that was identified as being newly-converted. The irrigation data were from the most recent (2012) version of the Moderate Resolution Imaging Spectroradiometer (MODIS) Irrigated Agriculture Dataset for the United States (MIrAD-US).[97] The cultivated lands data used in the assessment, known as the USDA Cultivated Layer, were obtained by request from the USDA NASS[98]; the public CDL data portal, CropScape, only offers the most recent version of the Cultivated Layer. The Cultivated Layer is a 5-year composite of all land that has been identified as cropland. To align with the MIrAD-US data, the 2012 Cultivated Layer (showing cropland from 2008-2012) was used. The data regarding which of these lands were considerednewly-converted croplands were obtained from researchers at the University of Wisconsin (24). These data are also based on the 2008-2012 Cropland Data Layers.

For each state, the data for cultivation, irrigation, MLRA, and soil map unit were combined using ArcMap. The resulting data layer identifies all of this information for each 250m x 250m pixel; thus the resolution of the analysis is 15.44 acres. The tables were then combined into one large table, allowing for assessment of each MLRA, regardless of political boundaries. The area for each MLRA that is cultivated but not irrigated is summed according to its NICC, allowing for a determination of the percentage of non-irrigated cropland in that MLRA which is classified as NICC I-IV. The analysis was also conducted for irrigated lands, using the ICC. For any MLRAs with insufficient data to develop either a NICC or ICC threshold, the default threshold will be 100%. This is a conservative approach given that those MLRAs do not show significant crop cultivation activity. Of course, projects will still have the option for the local, site-specific LCC assessment.

The same analysis was then conducted using only areas of newly-converted cropland (2008-2012). For areas with sufficient amounts of new cropland, the resulting values from the existing cropland and the newly-converted cropland were then averaged together to obtain the default value for the suitability threshold for that MLRA. This approach seeks to recognize that recent conversion trends may be different than historical conversion trends. In many places, the LCC of new cropland is higher than existing cropland (i.e., newly converted cropland may be considered of “marginal” quality for crop cultivation).

A.1.4 Complete Performance Standard Test

While neither of the individual components of this performance standard test (or the eligibility section as a whole) would represent a comprehensive test for additionality on their own, when considered together, along with the eligibility limitations arising from the baseline stratification and modeling, they function to provide a holistic assessment of the threat of conversion of grassland to cropland in different areas of the country.

[97] The MIrAD-US data are available at: http://earlywarning.usgs.gov/USirrigation.
[98] Information regarding the Cropland Data Layer and the Cultivated Layer is available at: https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php.

Appendix B Development of Standardized Parameters and Emission Factors

The approach outlined in this appendix was developed and executed by the Reserve's technical contractor WSP. The team consisted of Tim Kidman and Michael Mondshine at WSP, and Dr. Keith Paustian, Ernest Marx, Mark Easter, Ben Johkne and Stephen Williams at Colorado State University. The effort described here has resulted in a fixed collection of emission factors. The Reserve will seek to replicate this process at a later date in order to generate updated emission factors for AGC projects.

B.1 Introduction

This appendix describes the standardized assumptions used by the Reserve's technical contractor in modeling baseline GHG emissions from the conversion of grasslands to croplands. It also describes the modeling approach used by the Reserve's contractor to estimate the baseline emissions from soil processes, soil organic carbon, below-ground biomass, and fertilizer N_2O emissions using the DAYCENT model and a combination of national data sources. The methodology and standardized baselines are intended to provide accurate estimates of baseline emissions, give certainty over expected project outcomes, minimize project setup and monitoring costs, and reduce verification costs. The resulting emission rates, applied in the protocol as per acre emission factors, preclude the need for project-level modeling by Project Owners.

Modeling was performed using the same build of the DAYCENT model that is used for estimation of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013[99] (U.S. Inventory) compiled by EPA, and which is incorporated in USDA's entity level GHG quantification tool, COMET-Farm[100]. To compute the emissions associated with baseline conversion scenarios, the contractors utilized a DAYCENT model inputs database developed for the U.S. Inventory. The Inventory Database (IDB) was derived from national level soils and weather data sources, the USDA's Natural Resources Inventory (NRI) as well as ancillary data sets on actual agricultural management practices across the U.S. The NRI is a statistically robust stratified sampling design that includes land use and management data since 1979 at ca. 400,000 non-federal cropland and grassland locations.

The DAYCENT model (i.e., daily time-step version of the Century model) simulates cycling of carbon, nitrogen, and other nutrients in cropland, grassland, forest, and savanna ecosystems on a daily time step. This includes CO_2 emissions and uptake resulting from plant production and decomposition processes, and N_2O emissions from the application of synthetic and manure fertilizer, the retention of crop residues and subsequent mineralization, and mineralization of soil organic matter. DAYCENT simulates all processes based on interactions with location-specific environmental conditions, such as soil characteristics and climate.

[99] Available at: http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Main-Text.pdf.
[100] Available at: http://cometfarm.nrel.colostate.edu.

B.2 Conceptual Overview

The approach to baseline determination and baseline modeling relies almost exclusively on geographic, historic, and physical characteristics of project parcels – most of which are publicly available in national geospatial databases – in assigning a baseline and associated emissions for any given project parcel. The methodology does not require project proponents to assert a single baseline cropping system, tillage, or management practice, support that assertion with detailed documentation, or justify why assertions represent reasonable baseline assumptions. Rather, this methodology establishes and dictates a composite baseline for any given parcel based on the practices documented on ecologically and geologically similar parcels using a variety of national databases. The methodology does not establish a single tillage practice, average fertilizer practice or other factors and use that as the baseline to model that single scenario to obtain baseline emission rates. Instead, the methodology acknowledges variability in practice, and the uncertainty associated with predicting future practice by assuming that there is a certain probability that the converted land could be managed in a variety of ways. The modeled management practices were generated based on survey data from land within the same eco-climatic region and soil type as the project parcel, based on the IDB and related data sources defined below.

Through this exercise 154,639 long term grassland points and 162,460 short term grassland points were modeled. The resulting emission rates for each stratum represent a weighted average of the potential practices on the parcel were it to be converted to cropland, with weighting based on the relative prevalence of each practice within the survey data. This approach to baseline determination eliminates subjectivity by standardizing the baseline determination based exclusively on stratification (see Section 5.1).

Similarly, the methodology does not require project proponents to execute complex biogeochemical process models. Instead, the methodology provides composite emission rates derived from these same biogeochemical process models utilizing geographic, soil, and cropping system assumptions representative of the project parcel.

Compared to the alternative in which project proponents would be responsible for asserting and documenting their baseline assumptions, and then conducting modeling themselves, this method has several important advantages, which are outlined in Section B.7.

B.3 Baseline Determination

The baseline for any given project parcel is defined probabilistically as a composite of the likely practices that might occur on that parcel were it to be converted from grassland to cropland.

The stratification regime defined in Section 5.1 of the protocol plays a fundamental role in establishing the range of practices and relative probabilities for baseline practice. Based on two of the three stratification elements – the Major Land Resource Area (MLRA) and the dominant surface soil texture from the Soil Survey Geographic Database (SSURGO) – the U.S. was first broken into individual super-strata (unique combinations of these two variables).[101] By first stratifying by MLRA and surface soil texture, the U.S. is effectively subdivided into land areas based on suitability to certain cropping systems and the practices associated with those systems in those geographies. Because MLRAs are based on agroecological classification, they define areas of similar climate, geomorphology, native vegetation and land management

[101] The third variable, previous land use, will be used later in the modeling of baseline emissions.

systems – all of which are the fundamental drivers of the biogeochemical processes involved in greenhouse gas emissions. Thus MLRAs are well-suited as stratification variables than other land area designations that are politically-based (e.g., states) or defined by a more limited set of criteria (e.g., NRCS Crop Management Zones (CMZ) based on farm management practices). By adding soil texture to the stratification, the quantification is improved in two ways. First, the texture itself plays a considerable role in the carbon dynamics being modeled (27), allowing more refined and representative results. Second, defining the stratum with the soil texture limits the cropping systems and management practices that are modeled to those suitable to these soils by evaluating only those systems seen on other similar soils within the MLRA. Use of soil texture therefore gives greater precision to the crop system inputs and resulting model accuracy.

For each unique super-strata, baseline practices were collected and estimated based on the real-world practices on agricultural land within the same super-stratum, as derived from the IDB, USDA National Resource Inventory (NRI), Economic Research Service Cropping Practice Survey (ERS), National Agricultural Statistics Service (NASS), and Natural Resources Conservation Service (NRCS) (29) (30).[102,103] These resources represent the best available data sources for agricultural practice in the U.S. A brief description of the relevant data sources is included below:

- **Inventory Database (IDB)**: Developed by Colorado State University as input data for the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013 (13), the IDB is derived from a variety of data sources including SSURGO, NRI, CTIC, ERS, NASS (described below). The IDB describes typical management practices for distinct regions and soils at MLRA and county scales.
- **Major Land Resource Area (MLRA)**: Agro-ecological classification developed NRCS that defines areas of similar climate, geomorphology, native vegetation, and land management systems across the U.S.
- **Soil Survey Geographic Database (SSURGO):** Developed and managed by NRCS, the SSURGO database contains geographically linked information on soil properties including texture. SSURGO data were collected by the USDA National Cooperative Soil Survey, covering the states, commonwealths and territories of the U.S. It was generated from soil samples and laboratory analysis, and represents the finest resolution soil map data available in the U.S.
- **National Resource Inventory (NRI):** Developed and managed by NRCS, the NRI is a statistical survey of land use and natural resource conditions on non-federal U.S. lands. It provides data on the status, condition, and trends of land, soil, water and related resources. The NRI utilizes established inventory sites for repeated sampling to provide national representation.
- **Conservation Tillage Information Center (CTIC)**: Since 1989, CTIC has conducted annual county-level surveys of tillage practices, by crop. These data are used to estimate probabilities for tillage practices and tillage transitions, for IDB locations within the surveyed counties.
- **Economic Research Service:** Housed within the USDA, ERS gathers a variety of data on crop and livestock practices through the use of its annual Agricultural Resource Management Survey (ARMS). ERS provides both annual and trend data, illustrating

[102] USDA-NASS: https://www.nass.usda.gov/.
[103] USDA-NRCS (2012) *Energy Estimator: Tillage*, available at: http://ecat.sc.egov.usda.gov/.

shifts in agricultural practice. ERS contains data on nutrient management, irrigation practices, and conservation practices.

- **National Agricultural Statistics Service (NASS):** Data on annual county-average crop area and yields from NASS are used as a secondary data source for availability control of model outputs.
- **Natural Resource Conservation Service (NRCS)/Energy Tools:** Data related to the energy inputs required for cropland management, including planting, tillage, fertilization, and harvesting. (http://energytools.sc.egov.usda.gov/)

For each super-stratum combination of MLRA and soil texture, relevant variables about baseline conditions were established using these data sources, with specific variables pulled from each as defined in Table B.1. In many cases, these variables are linked. For example, IDB data are used to establish the various cropping sequences, and then each crop is assigned nitrogen application rate distributions based on regional ERS data. The methodology used to link data and determine practices within regions is based on the methodology used in the U.S. Inventory (13). For further detail on how these datasets are used to set appropriate conditions, please refer to the sections Agriculture and Land Use, Land-Use Change, and Forestry in the U.S. Inventory.

Table B.1. Derivation of Baseline Scenario Input Variables

Baseline Variable	Data Source	Methodology
Tillage practice	IDB, CTIC	Assignment of tillage practices established using CTIC data in each super stratum and associated expansion factors. County-level CTIC data were recalculated at the MLRA level, with practices assigned to simulations through use of NIDB area-weights.
Typical cropping sequence	IDB, NASS	Assignment of each cropping sequence established using IDB data in each super stratum and associated area-weights, based on the cropping sequence from 2000-2007, supplemented by NASS data.
Fertilizer N application	ERS, NASS	Crop-specific N rates assigned based on state-level statistics, subdivided by MLRA, based on the most recent five years period.
Application of other nutrients/organic matter	NRCS	Livestock manure application frequency and rates estimated based on NRCS data and adjusted for county-level estimates of manure availability, based on the most recent five years period.
Irrigation practice	IDB	Irrigated vs. non-irrigated status are specified for each IDB location, based on the most recent five years period. For irrigated land, full irrigation (i.e., no significant water stress) is modeled.
Fuel consumption	NRCS	Energy consumption for each cropland management practice, based on CMZ, tillage practice, and crop.

Table B.2 provides an illustrative overview of some of the crop system data elements that went into the establishment of the composite baseline conditions for any given super-stratum, and a highly simplified example distribution. Based on the cropping systems established from historic data, additional nutrient input data were applied based on ERS and NASS data. In addition to the cropping and management variables extracted from these data sources, the methodology employs IDB area-weights to appropriately weight each practice based on its

representativeness across the landscape. IDB area-weights are based on the spatial resolutions of source data, including NRI expansion factors, SSURGO map unit areas, and spatial scales of fertilizer and tillage data. The IDB area-weights indicate the number of acres across the landscape that each IDB location point represents.

The baseline for this example super stratum would be, for example, 20% constructed from data point #1 which is a practice that includes the use of no till on irrigated land, and with a crop rotation of corn, soy, corn, soy, fallow. This is based on the existence of an IDB location with that practice and its area-weight (100) being 20% of the aggregate of IDB area-weights (500) within the super stratum.

Table B.2. Example Crop Systems and Resulting Probabilities in Baseline

IDB Data Point	Tillage Practice	Irrigation Practice	Cropping System	Area-weight	Probability
#1	No Till	Irrigated	Corn, soy, corn, soy, fallow	100	20%
#2	Conservation Till	Not Irrigated	Corn, soy, fallow, wheat, soy	150	30%
#3	Conservation Till	Irrigated	Wheat, fallow, wheat, wheat, fallow	50	10%
#4	Standard Till	Not Irrigated	Corn, soy, fallow, wheat, soy	200	40%

Using this methodology, each project parcel effectively has multiple baseline scenarios. One way to think about this approach would be that for every acre of a project in the above example, 0.2 acres would be converted according to practice #1, 0.3 acres according to practice #2, 0.1 acres according to practice #3, and 0.4 acres according to practice #4.

B.4 Modeling Approach

In order to model baseline emissions for use in quantifying emission reductions, the composite baseline practices defined in Section B.3 were combined with climatic and initial condition inputs. Local weather data inputs were based on values from the North America Regional Reanalysis Product (NARR).[104] Weather for each year in the future was modeled on actual weather from a year in the past (within the last 30 years). Thus, inputs such as temperature and precipitation should reflect recent trends. All modeling was performed using stochastic modeling techniques and the DAYCENT model to evaluate the change in carbon pools and emissions sources across multiple scenarios. More specifically, this was done by modeling the conversion to cropland of IDB locations throughout the U.S. that are currently categorized as grasslands. It includes analysis of the composite baselines defined in Section B.3 in a manner consistent with the compilation of the U.S. Inventory.

Modeling was conducted based on the strata delineated in Section 5.1 of the protocol, which include previous land use in addition to the variables used to define the super strata. For each stratum (unique combination of MLRA, soil texture, and previous land use), the following methodology was employed by utilizing the Colorado State University parallel computing capability, which includes dedicated database servers and a ca. 300 CPU computing cluster:

1. Grassland modeling points were pulled from the IDB or modified for modeling:

[104] NOAA/OAR/ESRL PSD, *North America Regional Reanalysis Product*, available at: http://www.esrl.noaa.gov/psd/.

a. For long term grassland (30+ years), all 154,639 IDB locations that have been continuous grassland were selected.

b. For short term grassland (10-30 years) a period of 12-28 years of grassland management preceding project implementation was randomly assigned and area-weighted to 162,460 IDB locations in continuous cropland.

2. Initial carbon pools at project start were established for each data point based on soil data and a long-term spin-up of the DAYCENT model using practices defined in the preceding step.
3. For the 30+ year grassland baseline scenario, each IDB location was modeled forward applying the baseline practices determined in Section B.3 through the DAYCENT model for 50 years. The baseline practices for each IDB location were pulled at random without replacement.
4. For the 10-30 year grassland baseline scenario, each IDB location was modeled forward applying the cropping practices associated with that point in the IDB through the DAYCENT model for 50 years.
5. For the project scenario, each IDB location was modeled forward applying a continuation of the management practices established for the U.S. national GHG inventory analysis.
6. DAYCENT output was summarized as average annual change or emission rates in ten year increments for the following:
    a. Soil organic carbon[105]
    b. N_2O emissions (direct and indirect)
7. The extracted emissions in ten year increments were area-weighted based on IDB area-weights and averaged across points within the strata and translated into average annual per acre emission rates applicable to corresponding ten year increments.

The resulting emission rates are provided by stratum in a tabular form and included as lookup tables[106] where they function as per acre emission factors. A sample of the table format is provided as Table B.3 below.

Table B.3. Sample Output of Emission Factor Table Format

Stratum	Annual Emission Factor (tCO_2e/acre)				
	Year 1-10	Year 11-20	Year 21-30	Year 31-40	Year 41-50

In addition to modeling baseline emissions, the DAYCENT modeling exercise was also performed to estimate project soil carbon emissions or sequestration, emissions from nitrous oxide, and dry matter estimates. The dry matter estimates are used in the quantification portion of this protocol to estimate CH_4 and N_2O emissions from burning on project lands.

Finally, fuel consumption was estimated by applying fuel consumption factors from the NRCS Energy Calculator to the practices modeled at each IDB location. The results from each IDB

[105] Other related pools including above- and below-ground biomass flow through this pool in the modeled carbon balance. Accordingly, this pool is intended to represent net system emissions or sequestration over longer time horizons such as the 50 years modeled in this exercise.
[106] See the Reserve's Grassland Protocol webpage at: http://www.climateactionreserve.org/how/protocols/grassland/.

location in the baseline scenario were area-weighted based on IDB area-weights to estimate fuel consumption per acre for each stratum.

B.5 Results

Over 317,099 individual grassland points were modeled to calculate composite emission rates based on 31.7 million point years. However, emission rates have been provided for only a subset of strata within the continental U.S. where data was available and deemed reliable. In order to maintain data integrity and robustness of modeling results, certain strata for which there was limited data were evaluated, but output results were not included in the published tables of emission rates. Specifically, strata with less than ten assigned IDB locations in grassland were excluded due to low sample size. Because strata include soil type (texture), the paucity of points in many cases (especially for coarse and fine soils) reflects the actual low occurrence of a particular soil type within a particular MLRA. Strata with 11-100 data points were considered to be of good availability, while those with more than 101 points were considered excellent data availability. The number of strata assigned to each category of data availability is summarized in Table B.4.

Table B.4. Stratum Availability

Count of strata deemed low availability (≤10 points), good availability (11-100 points), and excellent availability (>100 points)

	Fine		Coarse		Medium		Total Strata
	10-30 years	30+ years	10-30 years	30+ years	10-30 years	30+ years	
≤10 Points	89	70	70	54	45	26	**354**
11-100 Points	64	79	98	77	73	61	**452**
>100 Points	73	77	58	95	108	139	**550**
TOTAL	**226**	**226**	**226**	**226**	**226**	**226**	**1,356**

The maps in Figures B.1 through B.6 illustrate the distribution of the strata for which there was insufficient data to generate reliable emission rates (10 or fewer data points), and those for which there was good or excellent data availability.

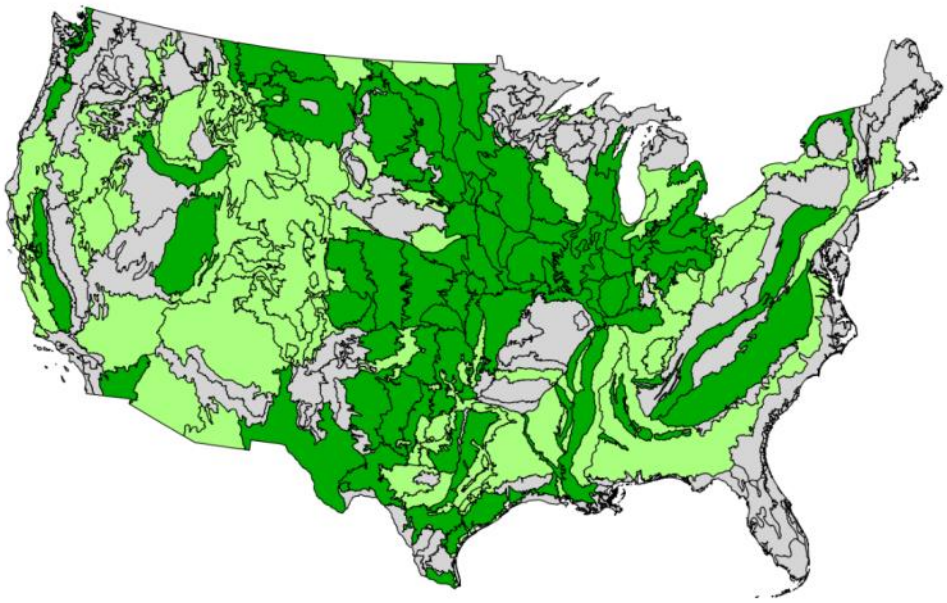

Figure B.1. Map of 10-30 Year Grassland Data Points on Fine Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

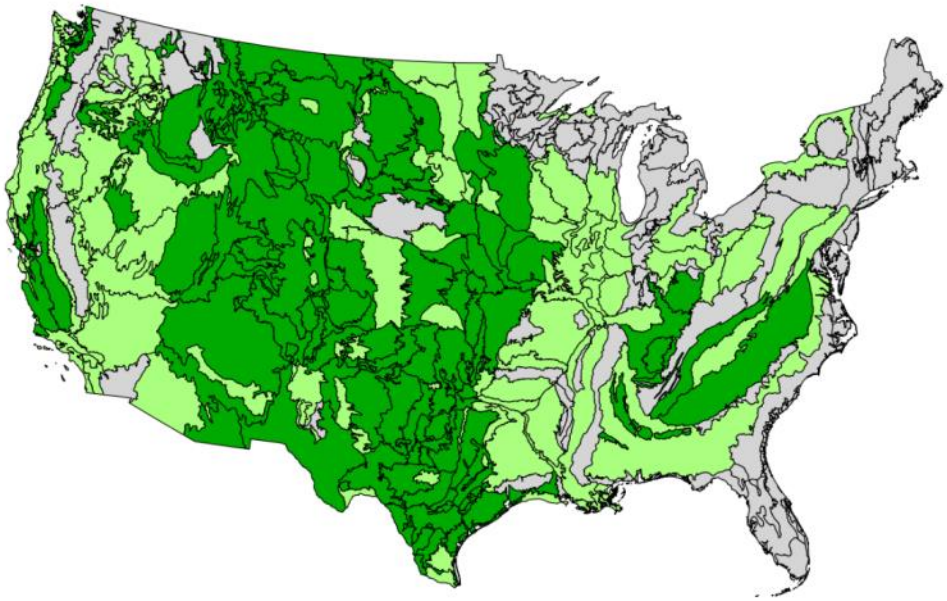

Figure B.2. Map of 30+ Year Grassland Data Points on Fine Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

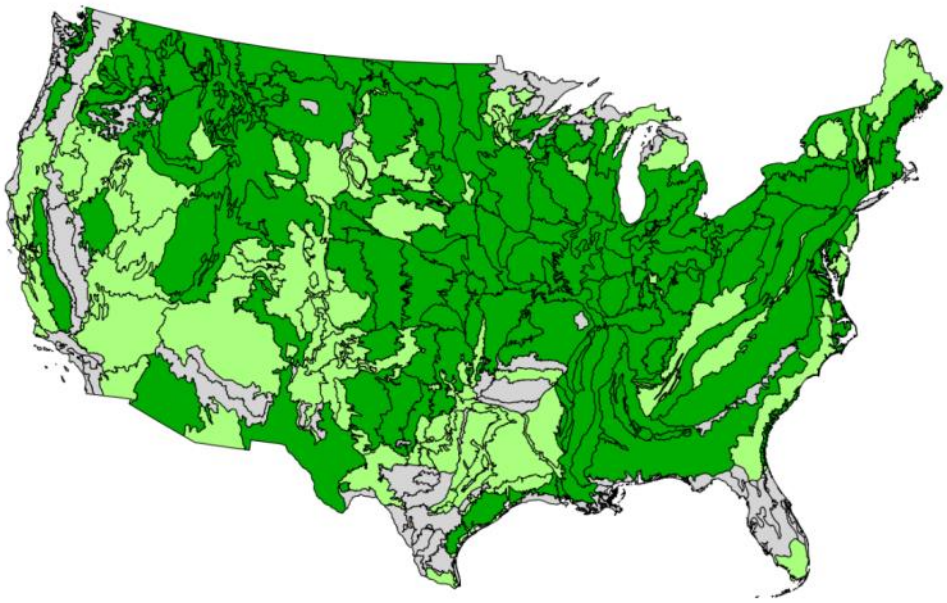

Figure B.3. Map of 10-30 Year Grassland Data Points on Medium Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

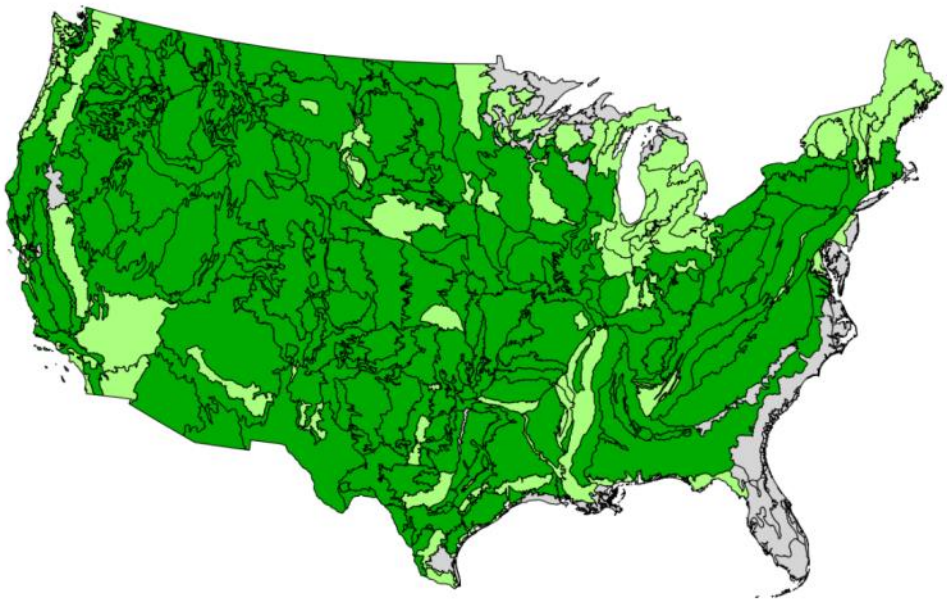

Figure B.4. Map of 30+ Year Grassland Data Points on Medium Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

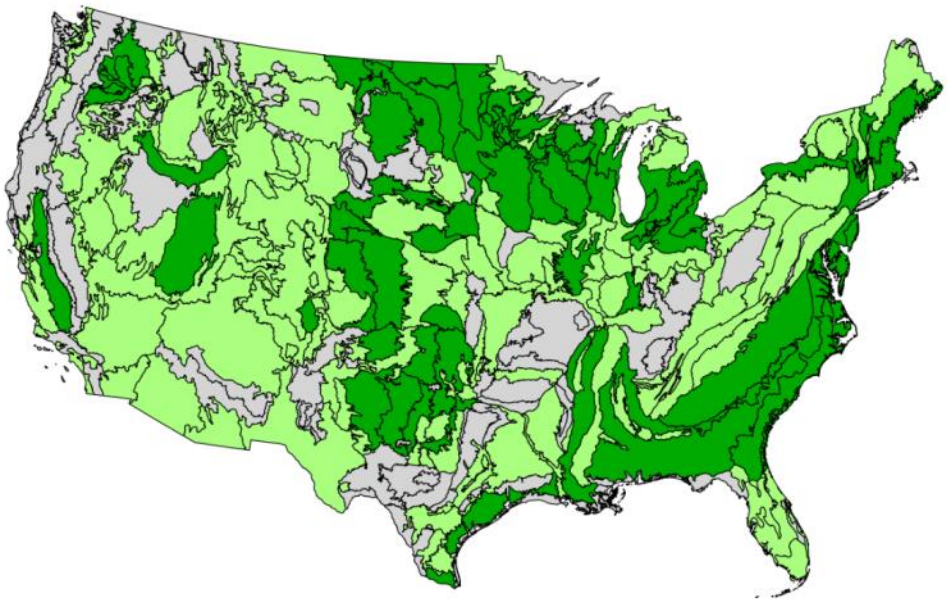

Figure B.5. Map of 10-30 Year Grassland Data Points on Coarse Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

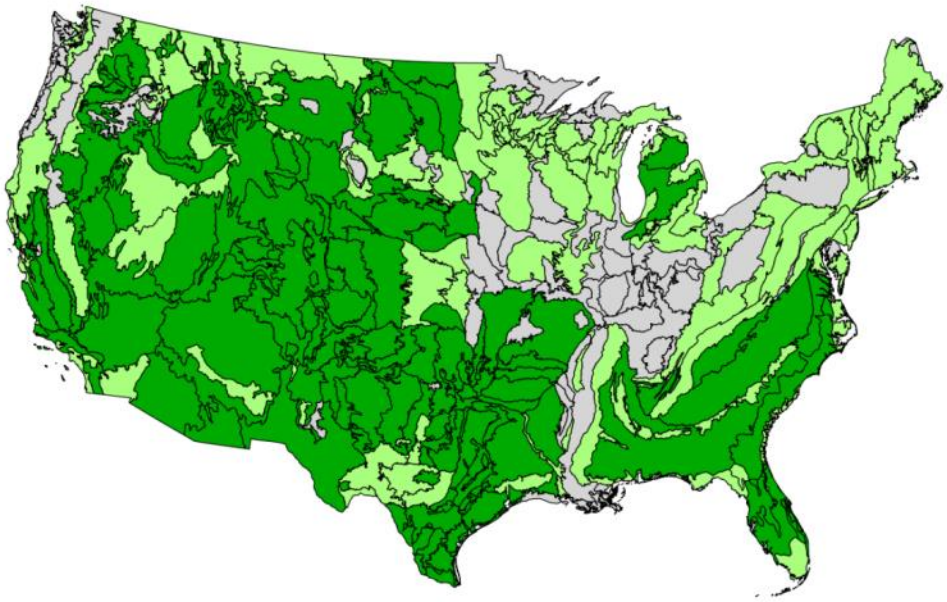

Figure B.6. Map of 30+ Year Grassland Data Points on Coarse Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

Due to the size and complexity of the emission rate output tables, results are not provided in the protocol, but instead are available for download in Microsoft Excel format from the Reserve's

website.[107] In addition to the emission rate tables, there is an additional file that contains summary statistics for each stratum for which modeling was performed, which is available upon request. Although many variables went into the inputs for each modeling run, this file displays the percent of land that was modeled as irrigated in each stratum, as well as the distribution of crops that contributed to the composite baseline.

B.6 Uncertainty

Although some level of uncertainty is inherent in any modeling exercise, there are several important uncertainties unique to the establishment of baseline conditions and modeling performed over a 50 year horizon. Several sources of uncertainty are particularly noteworthy:

- **Tillage Practice.** The use of no-till and conservation tillage practices in the U.S. has been increasing in recent decades, and this trend is expected to continue. The USDA ERS evaluated tillage data for a variety of crops and geographies across the U.S. and found that no-till has increased at a rate of 1.5% per year between 2000 and 2007, though there is considerable variation across crops and regions. No-till agriculture, particularly when practiced over a prolonged time, has the potential to lower soil carbon emissions or increase sequestration (31).
- **Fertilizer Use.** Inorganic and organic nitrogen are common inputs for many cropping systems in the U.S., and have considerable GHG impacts through both direct and indirect N_2O emissions. Nitrogen management best practices focus on minimizing excess nitrogen in the system by matching the rate, timing, placement, and source of nitrogen to the requirements of the crop system to efficiently utilize nitrogen and maximize crop yields. Despite data showing that nitrogen application rates on some crops have increased even since 1990 (e.g., corn, wheat) (32), emissions from this source may be flat or declining due to increased nitrogen use efficiency and yields. Shifts in practice and technology have the potential to reduce net N_2O emissions from fertilization per unit of yield.
- **Climate Change.** Over the coming decades, weather patterns across the country are expected to change in several ways. Temperatures are projected to rise; the intensity of the heaviest precipitation events is projected to increase; crop yields may be more strongly influenced by anomalous weather events; weeds, diseases and pests may increase crop stress; and other climate disruptions to agricultural production are projected to increase over the next 50 years (33). These impacts will vary considerably across regions, and will have varied impacts on agricultural GHG emissions.

During the workgroup consultation process, the concept of including shifts in tillage practice and fertilizer use within the modeling environment was evaluated. However, because of data and modeling limitations, uncertainty around inputs, and the assumptions required to conduct modeling that included these shifts, it was deemed more appropriate to account for the uncertainty outside of the modeling exercise rather than compromise the model's inherent strengths and data sources. Both tillage and nitrogen management practice will further interact with climate change and weather events, with the result being unknown net impacts to field-level GHG emissions. The quantification methodology includes a discount factor intended to conservatively address the uncertainty associated with these and other factors. The specific uncertainty related to these emission factors has not been quantified. In discussion with the contractor, the Reserve has set the discount as 1% per 10-year emission factor period. Thus, the discount increases as the time of quantification moves farther from the time the modeling

[107] See the Reserve's Grassland Protocol webpage at http://www.climateactionreserve.org/how/protocols/grassland/.

was completed. If the Reserve is able to update this modeling exercise at a later date, then the discount for uncertainty will be reset for the new emission factors.

B.7 Justification for a Standardized Baseline

This section provides a brief overview of the benefits associated with use of a highly standardized approach to baseline determination and quantification of baseline emissions.

B.7.1 Transaction Costs and Verifiability

One of the primary goals to standardization is to cut down to the extent practicable on project costs and verification complexity. If the project proponent is required to assert the baseline cropping system and management practice, this would necessitate considerable costs both in project development and verification. Existing protocols rely on resources such as appraisals, government surveys, and universities in establishing baseline cropping systems. While government surveys provide some insight into dominant crops in a region, they are not generally differentiated by relevant soil characteristics, and do not reveal detailed crop rotation information nor do they link across variables (e.g., crop rotations and tillage practices). Further, while appraisals are useful in establishing that land may have a higher value as "cropland" versus grassland, it is unclear that these appraisals would consider specific cropping systems, inputs and management practices. Instead, these appraisals may assess only the publicly available rent information on cropland in the region, itself a composite of multiple practices.

In short, relying on project proponent assertions would require considerable project proponent resources to identify and document the likely cropping system, provided it can reliably be done at all. Additionally, the asserted crop system would need to be verified by the verification body, adding additional costs and uncertainty. Alternatively, the standardized approach does not require the project proponent to assert a baseline cropping system or management practice at all, or the verifier to assure this data. The baseline scenario and emissions estimates are defined exclusively based on geographic, historic, and physical characteristics of the project parcels, most of which are publicly available in national geospatial databases.

B.7.2 Customizability and Opportunity for Gaming

One potential shortcoming of a standardized approach to baseline determination and baseline emissions modeling is that it limits the opportunity for projects to be customized. Greater project proponent input provides greater opportunity to reflect specific knowledge or greater detail. For example, there may be characteristics of the land (e.g., slope) or local market (e.g., proximity to processing) that cannot be captured in the standardized methodology that nonetheless can reasonably be expected to influence cropping or practice.

However, this shortcoming of standardization is also a potential benefit in the ability it provides to avoid gaming. For example, if emission rates for two cropping systems are different, then gaming could occur if project proponents take steps to establish the system with higher emissions as their baseline. Given the complexity of verification and the potential methodological flexibility due to varying levels of data availability that may need to be afforded project proponents in establishing the baseline practice, it is possible that this gaming could occur without detection. Use of standardized composite baselines essentially eliminates this gaming risk by basing stratification and the determination of baseline emissions purely on geographic, historic, and physical characteristics of project parcels, most of which are publicly available in national geospatial databases.

B.7.3 Future Uncertainty

While the uncertainty of knowing what may occur on grassland directly following conversion is obviously significant, the uncertainty about what may occur 10 years or 20 years hence is even greater. Given a crediting period of 50 years, it is therefore extremely important that the baseline determination and associated baseline emissions are not overly influenced by short-term considerations.

Means of evaluating the highest value cropping systems are highly dependent on short-term projections about commodity and crop prices, which are subject to change in the future. As such, even if one knew with certainty that a parcel would be converted to a given crop rotation and management practice tomorrow, there is no reasonable way to know that it would persist in that manner for 10 or 20 years. As such, it is more reasonable to treat each parcel as essentially a composite of a multitude of crop systems in the area reflecting longer term practices and trends.

Appendix C Default Parameters and Emission Factors

Most of the emission factors needed in this protocol can be found in the separate *Grassland Project Parameters* document, which can be downloaded from the protocol website. [108]

C.1 Development of Project Emission Factors for N_2O

To simplify the quantification of N_2O emissions from fertilizer and manure, the Reserve is relying on default values from the IPCC (6). Because of this, the full equation necessary for accounting for emissions from nitrogen volatilization and leaching can be collapsed and simplified by combining multiple constants into a single constant.

Equation 5.10 uses a value of 0.012 to represent direct emissions and emissions from the volatilization of fertilizer. This value is derived thusly:

$$\boldsymbol{A = B + (C \times D)}$$

Where,
A = Emission factor for direct and volatilized emissions of N_2O from organic fertilizer (0.012)
B = Emission factor for direction emissions of N_2O from organic fertilizer (0.01)
C = Fraction of organic fertilizer lost to volatilization (0.2)
D = Emission factor for N_2O due to volatilization and deposition (0.01)

Equation 5.10 uses a value of 0.00225 to represent emissions from the leaching of fertilizer. This value is derived thusly:

$$\boldsymbol{Leach = E \times F}$$

Where,
Leach = Default factor for the fraction and emission factor for N_2O emissions due to leaching (0.00225)
E = Fraction of organic fertilizer lost to leaching (0.3)
F = Emission factor for N_2O due to leaching (0.0075)

Equation 5.11 uses a value of 0.22 to represent direct emissions and emissions from the volatilization of manure nitrogen. This value is derived thusly:

$$\boldsymbol{G = H + (I \times J)}$$

Where,
G = Emission factor for direct and volatilized emissions of N_2O from manure (0.22)
H = Emission factor for direction emissions of N_2O from manure (0.02)
I = Fraction of organic fertilizer lost to volatilization (0.2)
J = Emission factor for N_2O due to volatilization and deposition (0.01)

Equation 5.11 uses a value of 0.00225 to represent emissions from the leaching of manure nitrogen. This value is the same as the leaching value derived for fertilizer, above.

[108] Default emission factors can be found in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Appendix D Legal Instruments

Registration of a grassland project under this protocol requires the use of a number of specific legal instruments. This appendix provides additional guidance on the intent and usage of these instruments, as well as any requirements for their use with a grassland project. Table D.1 lists the relevant legal instruments and their relatedprotocol sections.

Table D.1. Legal Instruments Relevant to Grassland Projects

Legal Instrument	When Required	Protocol Section(s)
GHG reduction rights contract	Required when ownership of GHG emission reduction rights are not determined in the conservation easement	2.3.2
Indemnification agreement	Required when there are multiple Grassland Owners who are not party to the legal instruments related to the project	2.3.2
Conservation easement	Required, unless project area is owned by the Federal government	2.2, 3.2
Qualified Conservation Easement	Required, unless project area is owned by the Federal government	3.5.1
Project Implementation Agreement	Required for all projects	3.5.2
Reserve attestations (title, voluntary implementation, regulatory compliance)	Required for all projects	2.3.2, 3.3.2, 3.6
Instruments associated with concurrently-joined conservation programs	Required only if the project area is enrolled in other conservation payment/credit programs	3.3.2.1

D.1 GHG Reduction Rights Contract

Purpose: This contract is required in order to clearly establish ownership over the GHG emission reductions associated with the grassland project. In order to meet the definition of a Project Owner, an entity must be able to demonstrate ownership of the GHG emission reductions associated with the project. Unless existing contracts specify otherwise, it is assumed that the Grassland Owner holds the rights to any GHG emission reductions that would be issued under this protocol. However, the recording of a conservation easement may create the expectation, on the part of the easement holder, that they hold ownership rights that include the GHG emission reductions. In addition, either the Grassland Owner or the easement holder may wish to transfer these rights to a third-party Project Owner. The grantee of the GHG Reduction Rights contract will be the Project Owner of record (the Account Holder) with the Reserve, and will be the entity to which the CRTs are issued upon successful registration of a reporting period. The Project Owner is also the entity who will execute the Project Implementation Agreement.

Parties involved: Grassland Owner, Project Owner, easement holder.

Timing: Ownership of the GHG emission reductions associated with the project activities must be documented during project verification.

Notes:

- May be a standalone document, or it may be incorporated into another legal document, such as the project's conservation easement. A standard, short form version is included as Exhibit B to the PIA.
- Must clarify the ownership of the GHG emission reductions at the time of their creation, rather than just the sale of those credits
- Must clearly define ownership of rights for GHG reductions related to the project activities
- Must be signed by the Grassland Owner, the easement holder, and the Project Owner.
- Must include clauses that specify steps to be taken if ownership changes for either the land, the GHG reduction rights, or the conservation easement
- Recommended inclusions:
    - Description of the project area
    - Description of the offset project and the offset project registry
    - Reference to the Grassland Protocol as the method of quantifying GHG emission reductions
    - Specific reference to sources of GHG emissions which are covered by GHG assessment boundary for the Grassland Protocol
    - Discussion of responsibilities in the event of a reversal (see Section 5.4)
    - Any potential exclusions (i.e., GHG or other benefits not covered by this contract)

D.2 Indemnification Agreement

Purpose: Where there may be multiple entities who could meet the definition of Grassland Owner, the Reserve must be indemnified against future GHG reduction claims by those entities which are not acting as Grassland Owner for the purposes of the protocol, and are not party to the GHG reduction rights contract.

Parties involved: Grassland Owner, Project Owner, Climate Action Reserve.

Timing: This agreement must be executed following the initial verification, prior to registration by the Reserve.

Notes: Must indemnify the Reserve in connection with any claims brought by other grassland owners or would-be grassland owners against the Reserve.[109]

D.3 Cooperative Contract

Purpose: For projects participating in a cooperative, this is a contract between the Project Owner and the Cooperative Developer. In general, this contract lays out the terms of the Project Owner's participation in the cooperative. However, its relevance for this protocol is its usefulness as a clear signal from the Project Owner of their intent to initiate a GHG offset project. This is particularly useful for determining the project start date, in order to ensure the additionality of the project.

Parties involved: Project Owner, Cooperative Developer.

Timing: If being used to denote the project start date, then the notarization date of this contract will be chosen by the Cooperative Developer as a date which will result in more efficient

[109] A sample indemnification agreement is available at: http://www.climateactionreserve.org/how/protocols/grassland/.

management of the cooperative. This date can be no earlier than the earliest recorded easement on any project in the cooperative.

Notes:

- This contract is only required for projects which wish to use it to denote the project start date. In those cases, this contract must be notarized

D.4 Qualified Conservation Easement (QCE)

Purpose: The conservation easement is the principle mechanism by which the project area is protected against land use change during the project period, and in perpetuity. The QCE is a label applied to a conservation easement whose terms either explicitly prevent reversals of CRTs by referencing the Grassland Protocol, or implicitly prevent reversals of CRTs by including land use limitations which are sufficient to prevent land use that would disturb soil carbon in the project area.

Parties involved: Grassland Owner, easement holder, Project Owner (optional).

Timing: In most cases, the execution of the QCE will denote the project start date. In all cases the QCE must be executed prior to completion of the initial verification.

Notes:

- It is recommended that the QCE also include clear discussion of both the carbon rights and the GHG emission reduction rights, as defined in Section 9 (see section above regarding the GHG emission reduction rights contract).
- It is required that the QCE include enforceable provisions for the ongoing monitoring of compliance with the terms of the easement.
- It is recommended that access rights be granted to the Project Owner and the Reserve for the purposes of monitoring and enforcing the provisions of the Protocol.
- If the project is at all likely to include livestock grazing, it is recommended that the QCE include prescriptive guidance for grazing management which explicitly limits grazing intensity.
- It is recommended that the QCE make reference to and incorporate the PIA.

D.5 Project Implementation Agreement (PIA)

Purpose: The PIA is a contract between the Reserve and the Project Owner which binds the Project Owner to the terms of the protocol, including the avoidance of and compensation for reversals, and the monitoring of the project during the permanence period. If the Grassland Owner is the Project Owner, they may elect to have the PIA recorded on the deed to the property, thus binding the landholder to the protocol and reducing the risk of uncompensated reversals.

Parties involved: Project Owner, Climate Action Reserve.

Timing: The PIA is executed during the initial verification of the project, prior to registration and CRT issuance. The terms of the PIA are applicable for 100 years following the issuance of CRTs. The PIA is updated at each subsequent registration in order to extend its term to cover the new CRT issuance, as well as to potentially reflect any changes in Project Ownership.

Notes:

- The Recorded PIA includes a clause specifying whether the PIA may be subordinated to any subsequent deed restrictions. The Project Owner will choose whether to use the Type I (not able to be subordinated) or the Type II (able to be subordinated) clause. Use of the Type II clause results in a value of 0.1 for the risk of financial failure in the calculation of the project's contribution to the risk buffer pool. Use of the Type I clause results in a value of 0 for this parameter.
- The Contract PIA, where the project area itself is not bound by the contract, always results in a value of 0.1 for the risk of financial failure in the calculation of the project's contribution to the risk buffer pool.

D.6 Reserve Attestations

Required attestations:

- Attestation of Title
- Attestation of Voluntary Implementation
- Attestation of Regulatory Compliance

Purpose: These attestations are legal documents whereby the Project Owner legally attests to the truth of the statements and facts necessary to support the conclusions of a positive verification report. The Attestation of Title confirms that the Project Owner is the legal owner of the rights to the GHG emission reductions represented by the CRTs which will be issued into their account. The Attestation of Voluntary Implementation confirms that the project passes the legal requirement test. The Attestation of Regulatory Compliance confirms that the project met the eligibility requirements of Section 3.6 during the reporting period(s).

Parties involved: Project Owner.

Timing: These attestations are completed during verification and apply to a specific period of time for which CRTs are to be issued. The Attestation of Title and Attestation of Regulatory Compliance are completed at every verification. The Attestation of Voluntary Implementation is only completed during the initial verification.

D.7 Other Instruments Associated with Concurrently-Joined Conservation Programs

Purpose: If a project area is enrolled in any other credit or payment program, the contracts or legal instruments associated with that program is relevant to the verification of the offset project. These contracts or instruments must be disclosed to the verifier during the verification process. The verifier shall assess each payment or crediting program against the guidance of Section #, conferring with the Reserve for guidance where appropriate.

Parties involved: Grassland Owner, others as relevant.

Timing: At every verification.

CLIMATE ACTION RESERVE

Version 2.2 | April 18, 2019

Nitric Acid Production

Project Protocol

Climate Action Reserve
www.climateactionreserve.org

Released April 18, 2019

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
2 The GHG Reduction Project 3
2.1 Background 3
2.2 Project Definition 5
2.2.1 Secondary Catalyst Project 6
2.2.2 Tertiary Catalyst Project 6
2.3 The Project Developer 6
3 Eligibility Rules 7
3.1 Location 7
3.2 Project Start Date 7
3.3 Project Crediting Period 7
3.4 Additionality 8
3.4.1 The Legal Requirement Test 8
3.4.2 The Performance Standard Test 10
3.5 Regulatory Compliance 10
4 GHG Assessment Boundary 11
4.1 Secondary Catalyst Project 11
4.2 Tertiary Catalyst Projects 13
5 Quantifying GHG Emission Reductions 18
5.1 Secondary Catalyst Projects 18
5.1.1 Determination of $HNO_{3,MAX}$ and $HNO_{3,MAX,scaled}$ 19
5.1.2 Allowable Operating Conditions 20
5.1.3 Quantifying Baseline Emissions 21
5.1.4 Quantifying Project Emissions 24
5.2 Tertiary Catalyst Project 26
5.2.1 Determination of $HNO_{3,MAX}$ and $HNO_{3,MAX,scaled}$ 27
5.2.2 Allowable Operating Conditions 28
5.2.3 Quantifying Baseline Emissions 28
5.2.4 Quantifying Project Emissions 30
6 Project Monitoring 35
6.1 Monitoring Requirements 35
6.1.1 System Installation and Certification 36
6.1.2 Calibration 37
6.1.3 Accuracy Testing 37
6.2 QA/QC Requirements 37
6.2.1 Frequency of Testing 38
6.2.2 Data Management 39
6.3 Missing Data Substitution 39
6.4 Monitoring Parameters for Secondary Catalyst Projects 40
6.5 Monitoring Parameters for Tertiary Catalyst Projects 44
7 Reporting Parameters 49
7.1 Project Documentation 49
7.2 Joint Project Verification 49
7.3 Record Keeping 50
7.4 Reporting Period and Verification Cycle 51
7.4.1 Sub-Campaign Verification 51
8 Verification Guidance 53

8.1 Verification of Multiple Projects at a Single Nitric Acid Production Facility 53
8.2 Sub-Campaign Verification 54
8.3 Standard of Verification 54
8.4 Monitoring Plan 54
8.5 Verifying Eligibility Criteria 54
8.6 Core Verification Activities 55
8.7 Nitric Acid Production Verification Items 56
8.7.1 Project Eligibility and CRT Issuance 56
8.7.2 Quantification of GHG Emission Reductions 57
8.7.3 Risk Assessment 58
8.8 Completing Verification 58
9 Glossary of Terms 60
10 References 62
Appendix A Summary of Performance Standard Development 64
Appendix B Emission Factor Tables 69

List of Tables

Table 2.1. Potential N_2O Abatement Measures 5
Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs for Secondary Catalyst Projects 12
Table 4.2. Summary of Identified Sources, Sinks, and Reservoirs for Tertiary Catalyst Projects 15
Table 5.1. 100-year Global Warming Potential for Non-CO_2 GHGs 18
Table 6.1. Monitoring Parameters for Secondary Catalyst Projects 40
Table 6.2. Monitoring Parameters for Tertiary Catalyst Projects 44
Table 8.1. Summary of Eligibility Criteria 55
Table 8.2. Eligibility Verification Items 56
Table 8.3. Quantification Verification Items 57
Table 8.4. Risk Assessment Verification Items 58
Table A.1. Current Industry Practice for Use of NO_X Emission Control Technologies 66
Table B.1. Default Baseline Emission Factor for New Production in Excess of $HNO_{3,MAX,scaled}$ (EF_{New}) and Tertiary Projects Operating Outside AOC, as needed (EF_{IPCC}) 69

List of Figures

Figure 2.1. Reactions in the Nitric Acid Production Process 3
Figure 2.2. Flow Diagram of a Typical Nitric Acid Plant Using Single-Pressure Process 4
Figure 4.1 Illustration of GHG Assessment Boundary for Secondary Catalyst Projects 11
Figure 4.2. Illustration of GHG Assessment Boundary for Tertiary Projects with Existing SCR De-NO_X Units Operating Prior to the Project Start Date 13
Figure 4.3. Illustration of GHG Assessment Boundary for Tertiary Projects without Existing SCR De-NO_X Units Operating Prior to the Project Start Date 14
Figure 5.1. Organizational Chart of Equations for Secondary Catalyst Projects 19
Figure 5.2. Organizational Chart of Equations for Tertiary Catalyst Projects 26

List of Equations

Equation 5.1. Emission Reductions for Secondary Catalyst Projects 18
Equation 5.2. Calculating $HNO_{3,MAX,scaled}$ 20
Equation 5.3. Baseline Emissions for Secondary Catalyst Projects 22
Equation 5.4. Baseline Emission Factor 24
Equation 5.5. Total N_2O Emissions during the Baseline Sampling Period 24
Equation 5.6. Project Emissions for Secondary Catalyst Projects 25
Equation 5.7. Total N_2O Emissions during the Project Campaign 26
Equation 5.8. Emission Reductions for Tertiary Catalyst Projects 27
Equation 5.9. Calculation of $HNO_{3,MAX,scaled}$ 27
Equation 5.10. Baseline Emissions for Tertiary Catalyst Projects 29
Equation 5.11. Project Emissions for Tertiary Catalyst Projects 30
Equation 5.12. Project N_2O Emissions in the Tail Gas 30
Equation 5.13. Project Emissions for Ammonia Input to Tertiary Catalyst 31
Equation 5.14. Project Emissions from Hydrocarbon Use 31
Equation 5.15. Project Carbon Dioxide Emissions from Hydrocarbon Use 32
Equation 5.16. Project Methane Emissions from Hydrocarbon Use 32
Equation 5.17. Project Emissions from Tail Gas Reheating 33
Equation 5.18. Project Emissions from Steam Export 33
Equation 5.19. Project Emissions from Tail Gas Utilization 33
Equation 5.20. Project Emissions from Tail Gas Heating 34

Abbreviations and Acronyms

AOC	Allowable operating conditions
AOR	Ammonia oxidation reactor or ammonia burner
BACT	Best available control technology
CAA	Clean Air Act
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CRT	Climate Reserve Tonne
EPA	United States Environmental Protection Agency
FTIR	Fourier transform infrared spectroscopy
GHG	Greenhouse gas
HNO_3	Nitric acid
MT	Metric ton (or tonne)
N_2	Nitrogen
N_2O	Nitrous oxide
NAP	Nitric acid plant
NDIR	Non-dispersive infrared sensor
NH_3	Ammonia
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Refers to NO_2 and NO
NSCR	Non-selective catalytic reduction
O_2	Oxygen
PSD	Prevention of Significant Deterioration
RATA	Relative Accuracy Test Audit
SCR	Selective catalytic reduction
SSRs	Sources, sinks, and reservoirs
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

The Climate Action Reserve (Reserve) Nitric Acid Production Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the installation and use of a nitrous oxide (N_2O) emission control technology to reduce N_2O emissions generated as a by-product of nitric acid production.

The Climate Action Reserve is an environmental nonprofit organization that promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. A pioneer in carbon accounting, the Reserve serves as an approved Offset Project Registry (OPR) for the State of California's Cap-and-Trade Program and plays an integral role in supporting the issuance and administration of compliance offsets. The Reserve also establishes high quality standards for offset projects in the North American voluntary carbon market and operates a transparent, publicly-accessible registry for carbon credits generated under its standards.

Project developers that initiate N_2O abatement projects use this document to register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual[1] and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a N_2O abatement project at a nitric acid plant.[2]

[1] Available at http://www.climateactionreserve.org/how/verification/verification-program-manual/.
[2] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Nitric acid (HNO_3) is an inorganic compound used primarily to make synthetic commercial fertilizers. Virtually all of the nitric acid produced in the United States is produced by the catalytic oxidation of ammonia. In this industrial process, ammonia (NH_3) is oxidized using a primary catalyst in an ammonia oxidation reactor (AOR) to produce nitric oxide (NO). NO is oxidized with air in the AOR to form nitrogen dioxide (NO_2). Then, NO_2 is absorbed in water in an absorption tower to form nitric acid. N_2O is formed as a by-product of the oxidation process in the AOR (during Stage 1 in Figure 2.1 below); it remains in the tail gas leaving the absorption tower and is eventually emitted with the stack gas to the atmosphere.[3] The reactions and stages of the nitric acid production process are illustrated in Figure 2.1.

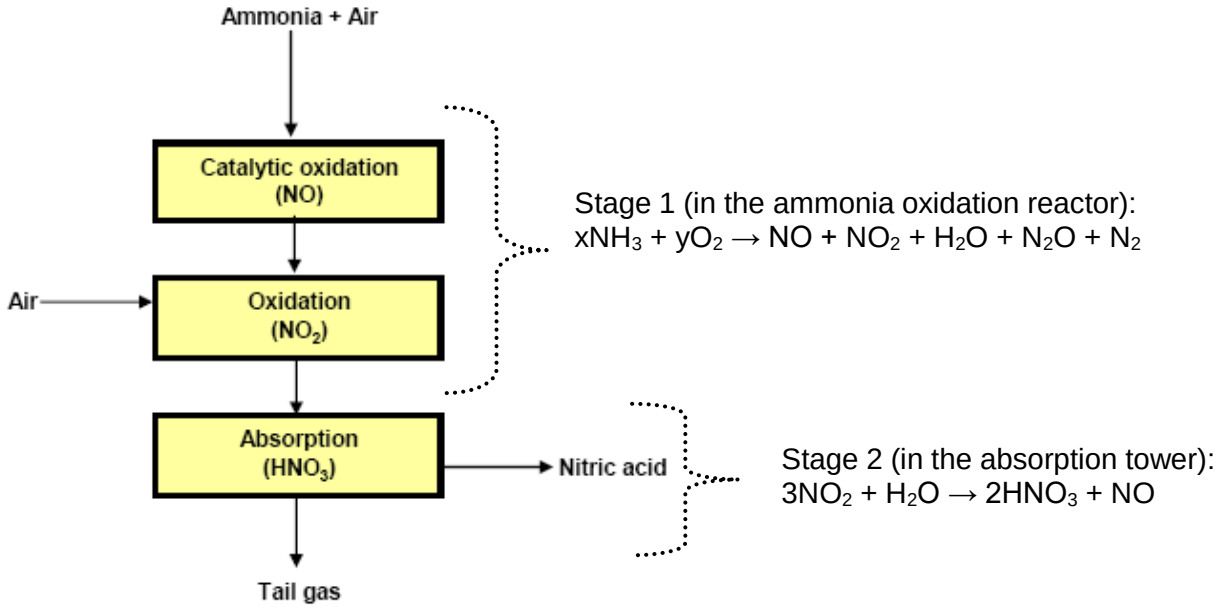
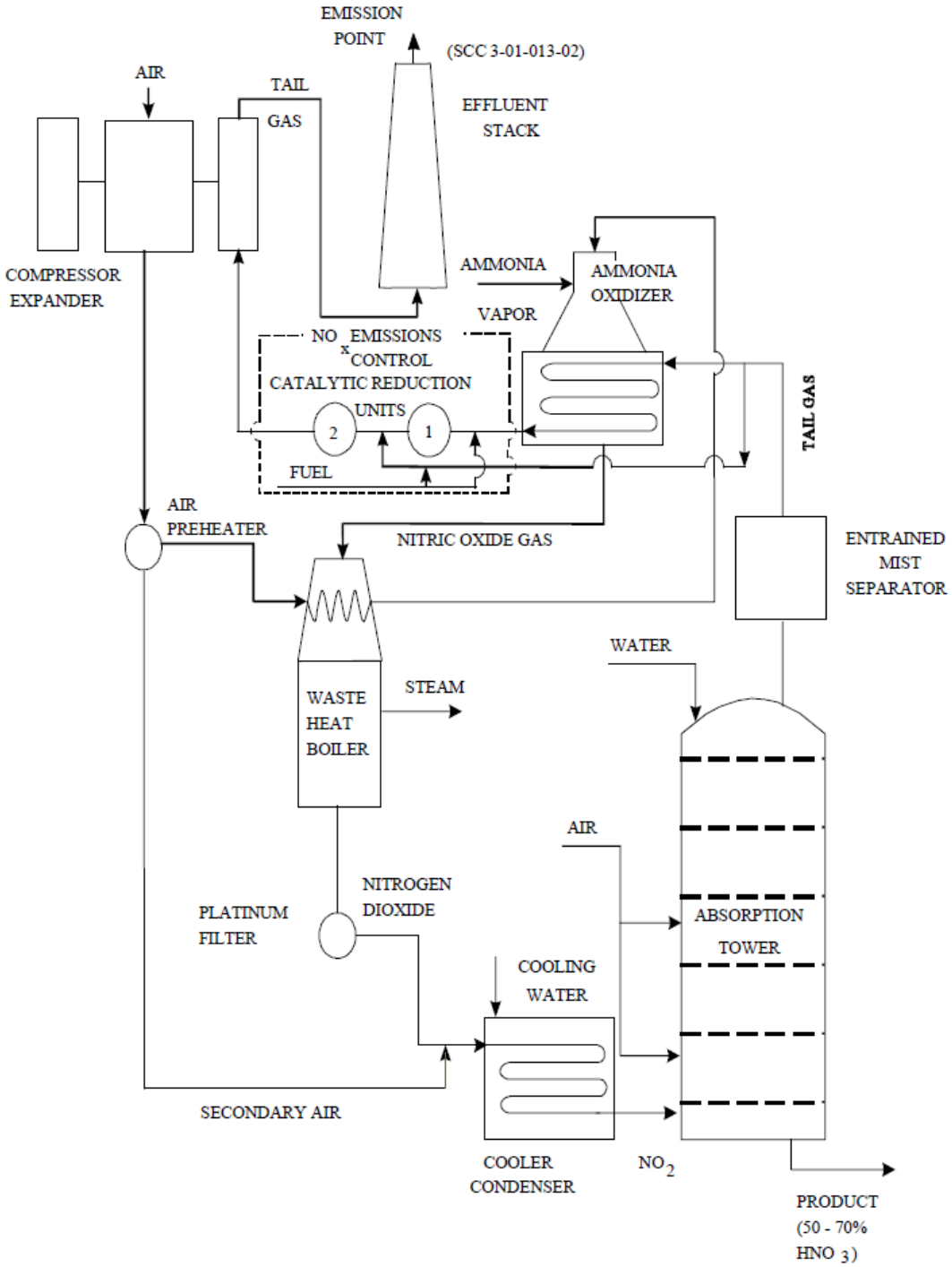


Figure 2.1. Reactions in the Nitric Acid Production Process

Nitric acid production facilities can operate one or more nitric acid plants (NAPs), where a plant encompasses a single process unit, i.e., the equipment and process used to produce nitric acid. Emissions from each plant at a facility are managed independently; process units at the same facility can operate under different conditions and have different emission controls in place. Figure 2.2 shows the physical set up and flows of inputs and gases in a generic NAP without any N_2O emission controls in place.

[3] NO_X is considered a criteria pollutant under the Clean Air Act and starting in the 1970s certain nitric acid plants were required to meet NO_X emission limits by installing a NO_X abatement technology.



Source: http://www.epa.gov/ttn/chief/ap42/ch08/final/c08s08.pdf and EPA-450/3-91-026: Alternative Control Techniques Document: Nitric and Adipic Acid Manufacturing Plants (1991).

Figure 2.2. Flow Diagram of a Typical Nitric Acid Plant Using Single-Pressure Process

There are two basic types of NAPs: single pressure and dual pressure. Single pressure designs, common in the United States, apply a single pressure throughout the reaction and absorption stages. Dual pressure designs use lower pressure in the AOR and higher pressure in the absorption tower. The amount of N_2O formed during the nitric acid production process depends

on combustion conditions (e.g., temperature and pressure), primary catalyst composition and age, and burner design.[4] Thus, the precise operating conditions of the NAP affect how much N_2O is formed.

In response to the federal Clean Air Act (CAA), most NAPs currently operate with some form of NO and NO_2 (i.e., NO_X) emission control, usually selective catalytic reduction (SCR) technology and less often non-selective catalytic reduction (NSCR) technology. SCR can have a minor impact on N_2O emissions (+/- <5% change), while NSCR destroys both NO_X and N_2O. However, NSCR is generally not preferred in modern plants because of high energy costs and associated high gas temperatures.

Intentional approaches to N_2O emissions abatement have been reviewed in the research literature[5] and highlighted by the Intergovernmental Panel on Climate Change (IPCC)[6], some of which have applicability in the United States. Potential measures for abating N_2O emissions are outlined below in Table 2.1. Specific measures that may qualify as a project under this protocol are discussed below in Section 2.2.

Table 2.1. Potential N_2O Abatement Measures

Measure	Point of Application
Primary abatement	Prevents N_2O formation in the ammonia burner by modification of (i.e., optimizing) the ammonia oxidation process and/or catalysts.
Secondary abatement	Removes N_2O from the intermediate stream, i.e., from the gases between the AOR and the absorption tower. Usually this will mean intervening at the highest temperature, immediately downstream of the ammonia oxidation catalyst and catalytically reducing the N_2O once it has been formed in the AOR.
Tertiary abatement	Treats the tail-gas leaving the absorption tower to destroy N_2O. N_2O abatement can be placed upstream or downstream of the tail-gas expansion turbine. These abatement measures may include catalytic decomposition or NSCR.

2.2 Project Definition

For the purposes of this protocol, a GHG reduction project is defined as the installation and operation of a N_2O abatement technology at a single NAP that results in the reduction of N_2O emissions that would otherwise have been vented to the atmosphere. Projects can only be implemented at existing, relocated, or upgraded NAPs provided historical HNO_3 production levels and allowable operating conditions can be established for such NAPs in accordance with Sections 5.1.1 and 5.2.1 of this protocol.

The protocol does not apply to projects at:

- NAPs that are restarted any time after December 2, 2007, after being out of operation for a period of 24 months or longer

[4] J. Perez-Ramirez, F. Kapteijn, K.Schoffel, J.A. Moulijn, Formation and control of N_2O in nitric acid production N: Where do we stand today? Applied Catalysis B: Environmental 44 (2003) 117-151.
[5] Ibid.
[6] Intergovernmental Panel on Climate Change (IPCC) 2006 National GHG Inventory Guidelines. Volume 3 Industrial Processes.

- New NAPs constructed after December 2, 2009, with the exception of new NAPs for which a permit application for construction was submitted to the appropriate government authorities prior to December 2, 2009
- Secondary catalyst projects at existing NAPs where NSCR is currently operating
- Secondary catalyst projects at existing NAPs that used NSCR technology for NO_X abatement at any point since December 2, 2007

If a tertiary catalyst project is installed at an existing NAP where NSCR has operated at any point since December 2, 2007, the NSCR must continue to operate during any period of time for which the project will claim CRTs (any N_2O abatement that occurs as a result of the pre-existing NSCR is not eligible for emission reduction credits).

Since the project definition is tied to a single NAP, it is possible to register multiple projects at a nitric acid facility with multiple NAPs, each with its own start date, crediting period, registration and verification. However, a single project shall not consist of more than one N_2O abatement technology. In other words, each project must consist of only one of the following N_2O abatement technologies.

2.2.1 Secondary Catalyst Project

A secondary catalyst project is one that installs and operates a dedicated N_2O abatement catalyst inside or immediately below the AOR.

2.2.2 Tertiary Catalyst Project

A tertiary catalyst project is one that installs and operates a dedicated N_2O abatement catalyst in the tail gas leaving the absorption tower (or the tail gas leaving a pre-existing NSCR unit). The specific N_2O abatement technology can either be catalytic decomposition or a NSCR NO_X abatement technology used to destroy N_2O along with NO_X.

It is possible to switch from one of the above project types to the other in cases where the initial installed technology negatively impacts the nitric acid production or fails to achieve the intended N_2O abatement levels. However, the initial technology must be decommissioned and GHG reductions will be based on the quantification methodology for the final implemented technology. In this situation, the project developer shall revise the project based on the new abatement technology; the project developer does not need to resubmit the project and can continue the existing crediting period based on the installation of the previous abatement technology.

2.3 The Project Developer

The “project developer” is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be owners of nitric acid facilities, entities that specialize in project development, or N_2O abatement technology suppliers. The project developer must have clear ownership of the project’s GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership by signing the Reserve’s Attestation of Title form.[7] The project developer must be the entity with liability for the emissions of the NAP (i.e., the entity named on the facility’s Title V permit), unless the rights to the emissions reductions have been transferred to another entity.

[7] Attestation of Title form available at http://www.climateactionreserve.org/how/program/documents/.

3 Eligibility Rules

Projects that meet the definition of a GHG reduction project in Section 2.2 must fully satisfy the following eligibility rules in order to register with the Reserve.

Eligibility Rule I:	Location	→	*U.S. and its territories*
Eligibility Rule II:	Project Start Date	→	*No more than 12 months prior to project submission*
Eligibility Rule III:	Project Crediting Period	→	*Ten-year crediting period, maximum of two crediting periods total*
Eligibility Rule IV:	Additionality	→	*Exceed legal requirements*
		→	*Meet performance standard*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Under this protocol, only projects located at nitric acid production facilities in the United States and its territories are eligible to register with the Reserve.[8]

3.2 Project Start Date

The project start date for a secondary catalyst project is defined as the date on which production first commences after the first installation of a secondary catalyst. The project start date must correspond to either the start of a campaign or commencement of nitric acid production after an outage. A campaign starts when production commences following the installation of a new charge of primary catalyst gauze or a new primary catalyst and ends when production ceases for the purpose of replacing or recharging the primary catalyst gauze.

The project start date for tertiary catalyst projects is defined as the date on which nitric acid production first commences after installation of the tertiary N_2O abatement technology.

To be eligible, the project must be submitted for listing on the Reserve no more than 12 months after the project start date.[9] Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Project Crediting Period

The crediting period is approximately ten years in length, aligning with the end of the last full campaign that begins in the tenth year of reporting. For example, if a project start date is June 15, 2018, the crediting period end date would be the end date of the final campaign which began prior to June 15, 2028. If the length of this final campaign has the potential to result in a

[8] The Reserve anticipates that this protocol could be applied throughout North America and internationally. To expand its applicability, data and analysis supporting an appropriate performance standard for other countries would have to be conducted accordingly. Refer to Appendix A for information on the performance standard analysis supporting application of this protocol in the United States.

[9] Projects are considered submitted for listing when the project developer has fully completed and filed the appropriate submittal documents, which include the Project Submittal form (available on the Reserve's website) and a project diagram.

crediting period of greater than 11 years, in total, the project developer must contact the Reserve for approval prior to the initiation of the final campaign.

If a project developer wishes to apply for eligibility under a second crediting period, they must do so within the final six months of the initial crediting period. However, the Reserve will cease to issue CRTs for GHG reductions if at any point in the future N_2O abatement becomes legally required at the project site or the project otherwise fails the Legal Requirement Test (Section 3.4.1). Thus, the Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of two crediting periods after the project start date, or until the project activity is required by law, whichever comes first. Section 3.4.1 defines the conditions under which a project is considered legally required, and Section 3.4.2 describes the requirements to qualify for a second crediting period.

3.4 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have otherwise occurred in the absence of a GHG market.

Projects must satisfy the following tests to be considered additional:

1. The Legal Requirement Test
2. The Performance Standard Test

3.4.1 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, rules, regulations, ordinances, court orders, governmental agency actions, enforcement actions, environmental mitigation agreements, permitting conditions, permits or other legally binding mandates requiring the abatement of N_2O at the project site. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[10] prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

As of the Effective Date of this protocol, the Reserve could identify no existing federal, state or local regulations that obligate nitric acid plants to abate N_2O emissions.[11] If an eligible project begins operation at a plant that later becomes subject to a regulation, ordinance or permitting condition that calls for the abatement of N_2O, emission reductions may be reported to the Reserve up until the date that N_2O is legally required to be abated. If the nitric acid plant's N_2O emissions are included under an emissions cap (e.g., under a state or federal cap-and-trade program), emission reductions may likewise be reported to the Reserve until the date that the emissions cap takes effect.

[10] Form available at http://www.climateactionreserve.org/how/program/documents/.

[11] NO_X emissions from nitric acid production facilities are regulated under the Clean Air Act and NO_X Transport Rule, both of which provide guidelines for NO_X emission controls. Regulations that limit NO_X emissions from nitric acid production facilities do not require the installation of specific NO_X control technologies; as a result, there is no direct or indirect regulatory requirement to control N_2O. While N_2O is incidentally controlled by the use of NSCR, this is taken into account in the Performance Standard Test.

3.4.1.1 U.S. EPA GHG Permitting Requirements under the Clean Air Act

Starting on January 2, 2011, the United States Environmental Protection Agency (U.S. EPA) has been phasing in[12] regulation of GHG emissions from major stationary sources under the Clean Air Act (CAA).[13]

Under this rule, commonly referred to as the "Tailoring Rule," all existing stationary sources emitting more than 100,000 tons (approximately 90,719 MT) of CO_2e emissions per year will be required to obtain Title V operating permits for GHG emissions. Title V generally does not add new pollution control requirements. However, sources will need to address GHG-related information in their Title V permit applications going forward, which may include estimates and/or descriptions of GHG emissions and abatement technologies. As such, a voluntarily-installed GHG abatement technology may likely be reflected in any new Title V permit operating conditions. However, because the issuance of the new or revised Title V permit will not itself require or mandate the implementation of any *new* GHG abatement, the Reserve expects that such permits will not affect the eligibility status of currently registered projects.

The Tailoring Rule also requires Prevention of Significant Deterioration (PSD) permits that address GHG emissions for (1) new source construction with emissions of 100,000 tons CO_2e per year or more and (2) major facility modifications resulting in GHG emission increases of 75,000 tons (approximately 68,000 MT) of CO_2e per year or more.[14] An assessment of "best available control technology" (BACT) for GHGs will be required as part of the PSD permitting process, with the permitting authority ultimately mandating installation of a selected BACT. It is possible that future PSD permits may require installation of the same abatement technologies that are currently being voluntarily deployed as part of carbon offset projects. By legally mandating these technologies, PSD permit requirements may make them ineligible for carbon offsets because implementation of these projects would no longer be voluntary.

Nitric acid production facilities that undertake significant expansion and increase GHG emissions by 75,000 tons or more per year will be subject to the new PSD requirements beginning on January 2, 2011.[15] If a facility triggers the PSD requirements and an official BACT review results in the mandatory installation of a technology that reduces N_2O emissions, this activity will not be eligible for carbon offsets. Projects at new facilities which would be subject to PSD requirements are already ineligible under this protocol.

Voluntarily-installed N_2O abatement projects should continue to be eligible for carbon offsets for the remainder of a project's crediting period(s), even if that project activity is later added to a Title V permit. Verifiers will need to review Title V and PSD permits to ensure that projects are able to pass the Legal Requirement Test.

[12] All major sources already subject to PSD and/or Title V under the Clean Air Act for other pollutants will be subject to EPA's GHG permitting rules starting January 2, 2011. All sources *not* previously subject to the Clean Air Act will come under the GHG permitting rules on July 1, 2011, assuming they trigger the thresholds noted herein.

[13] U.S. EPA published the final rulemaking, "Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule; Final Rule," in the Federal Register 3 June 2010. The rulemaking is commonly referred to as the "Tailoring Rule," and amended 40 CFR Parts 51, 52, 70, and 71. http://www.gpo.gov/fdsys/pkg/FR-2010-06-03/pdf/2010-11974.pdf#page=1

[14] "PSD and Title V Permitting Guidance for Greenhouse Gases," available at: http://www.epa.gov/nsr/ghgdocs/epa-hq-oar-2010-0841-0001.pdf

[15] Most NAPs are already subject to the Clean Air Act, and as such, the Tailoring Rule will be effective January 2, 2011. NAPs not previously subject to the Clean Air Act will be subject to these requirements July 1, 2011.

3.4.2 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e., a standard of performance applicable to all N_2O abatement projects, established on an *ex-ante* basis by this protocol.

The Performance Standard Test employed by this protocol is based on a national assessment of "common practice" for use of emission control technologies in NAPs to reduce N_2O emissions. The performance standard defines those technologies that the Reserve has determined will exceed common practice and therefore generate additional GHG reductions.[16]

By installing one of the following N_2O abatement systems as defined in Section 2.2, the project passes the Performance Standard Test:

1. A secondary N_2O abatement catalyst
2. A tertiary N_2O abatement catalyst, including catalytic decomposition or NSCR

The Performance Standard Test is applied as of the project start date, and is evaluated at the project's initial verification. Once a project is registered, it does not need to be evaluated against future versions of the protocol or the Performance Standard Test for the duration of its first crediting period. However, if the project chooses to upgrade to a newer version of the protocol, it must meet the Performance Standard Test of that version of the protocol, applied as of the original project start date.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Performance Standard Test, applied as of the project start date.

3.5 Regulatory Compliance

As a final eligibility requirement, project developers must attest that the project activities and project NAP are in material compliance with all applicable laws (e.g., air, water quality, safety, etc.) prior to verification activities commencing each time a project is verified. Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a project is in a state of recurrent non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance. Non-compliance solely due to administrative or reporting issues, or due to "acts of nature," will not affect CRT crediting. As part of this eligibility requirement, project developers must submit a signed Attestation of Regulatory Compliance form[17] prior to the commencement of verification activities each time the project is verified.

[16] A summary of the study to establish the Performance Standard Test is provided in Appendix A.
[17] Form available at http://www.climateactionreserve.org/how/program/documents/.

4 GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers in order to determine the total net change in GHG emissions caused by a NAP project.

As the protocol applies to two project types, the GHG Assessment Boundary specific to each project type is provided below.

4.1 Secondary Catalyst Project

Figure 4.1 provides a general illustration of the GHG Assessment Boundary for secondary catalyst projects, indicating which SSRs are included or excluded from the boundary.

Table 4.1 provides greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary.

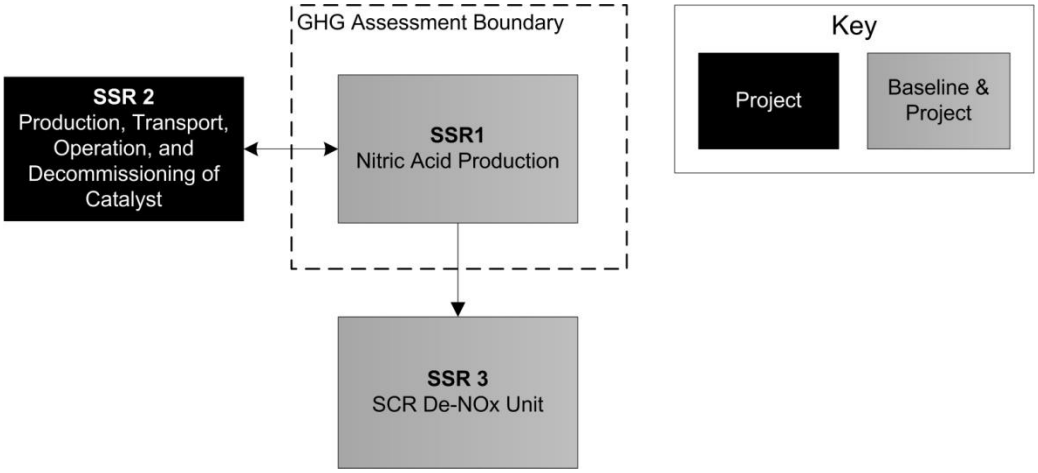


Figure 4.1 Illustration of GHG Assessment Boundary for Secondary Catalyst Projects

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs for Secondary Catalyst Projects

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/ Explanation
1. Nitric Acid Production	Nitric acid process unit (burner inlet to stack)	CO_2	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
		CH_4	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
		N_2O from reaction byproduct	I	Determination of emission factors based on continuously measured plant and production parameters	B, P	N_2O from production reaction is a primary effect and a major emission source
2. Secondary Catalyst	Emissions from production, transport, operation, and de-commissioning of the catalyst	CO_2, CH_4, N_2O	E	N/A	P	Considered insignificant, upstream and downstream secondary GHG effects
3. SCR De-NO_X Unit	SCR de-NO_X unit	N_2O	E	N/A	B, P	N_2O impact on existing SCR de-NO_X unit is small and a secondary effect

4.2 Tertiary Catalyst Projects

Figure 4.2 provides an illustration of the GHG Assessment Boundary for tertiary catalyst projects with existing SCR de-NO_X units operating prior to the project start date, indicating which SSRs are included or excluded from the boundary.

Figure 4.3 provides an illustration of the GHG Assessment Boundary for tertiary catalyst projects without existing SCR de-NO_X units operating prior to the project start date, indicating which SSRs are included or excluded from the boundary.

Table 4.2 provides greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary.

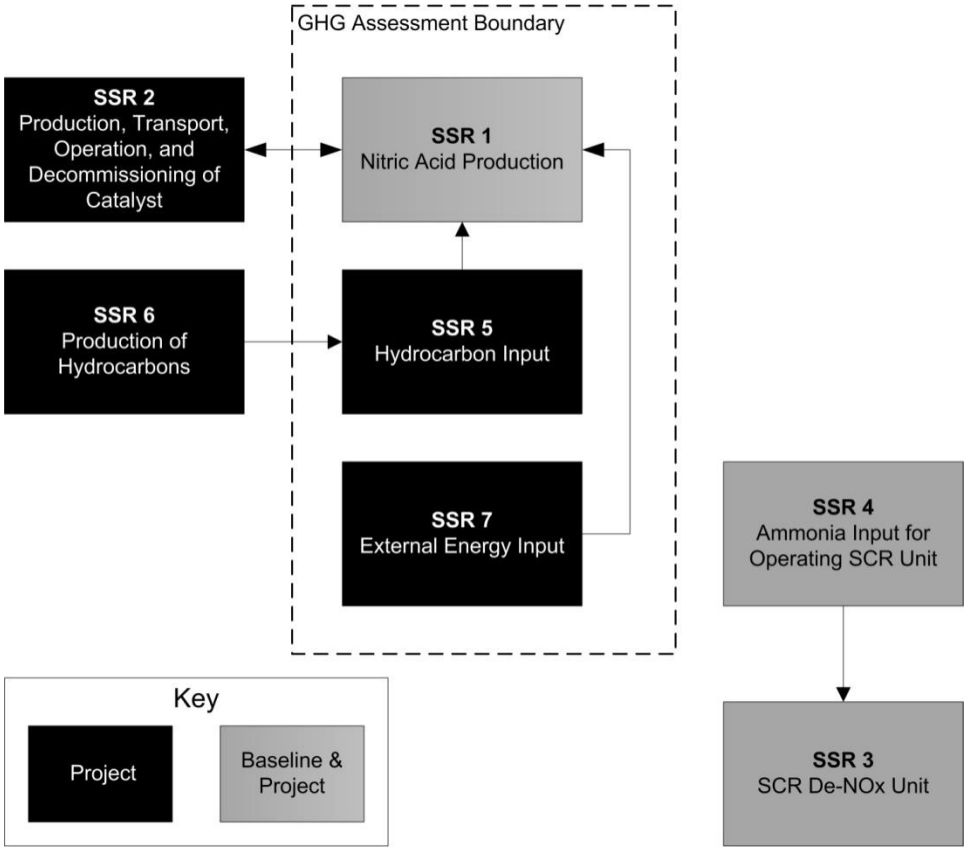


Figure 4.2. Illustration of GHG Assessment Boundary for Tertiary Projects with Existing SCR De-NO_X Units Operating Prior to the Project Start Date

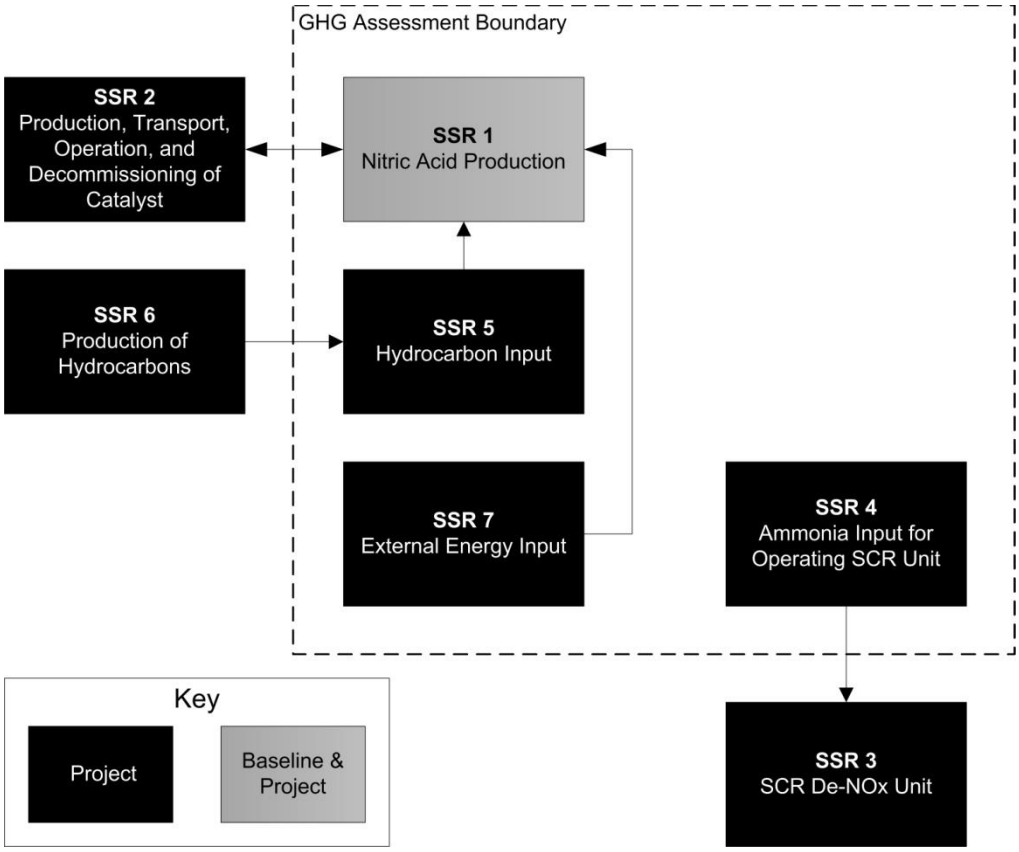


Figure 4.3. Illustration of GHG Assessment Boundary for Tertiary Projects without Existing SCR De-NO_X Units Operating Prior to the Project Start Date

Table 4.2. Summary of Identified Sources, Sinks, and Reservoirs for Tertiary Catalyst Projects

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/ Explanation
1. Nitric Acid Production	Nitric acid process unit (burner inlet to stack)	CO_2	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
		CH_4	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
		N_2O from reaction byproduct	I	N_2O sampled before and after N_2O destruction by tertiary catalyst	B, P	N_2O from production reaction is a primary effect and a major emission source
2. Tertiary Catalyst	Emissions from production, transport, operation, and de-commissioning of the catalyst	CO_2, CH_4, N_2O	E	N/A	P	Considered insignificant, upstream and downstream secondary GHG effects

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/ Explanation
3.	SCR De-NO_X Unit	N_2O from SCR de-NO_X unit	N_2O	E	N_2O concentrations sampled upstream of tertiary catalyst	B, P	N_2O impact of existing SCR unit is small and a secondary effect. While not an included SSR, in practice the placement of emissions monitoring will determine whether N_2O emission effects from an SCR de-NO_X unit are actually measured. Such effects will be measured when the SCR de-NO_X unit is located in between the N_2O gas analyzers that measure baseline and project N_2O gas concentrations. However, even if there is an effect, it is likely to be small and is considered negligible
4.	Ammonia Used to Operate SCR De-NO_X Unit	GHG emissions from production of ammonia used in tertiary abatement for N_2O destruction	CO_2, CH_4, N_2O	I (if ammonia is an input to the N_2O destruction facility)	GHG emissions based on additional amounts of ammonia input used during the project	B, P	If SCR is in place prior to project implementation, GHG emissions related to ammonia production used for operating the SCR de-NO_X unit will not be considered. However, if an SCR is installed as part of tertiary abatement, then GHG emissions from ammonia production will be considered as project emissions

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/ Explanation
5.	Hydrocarbon Input	Hydrocarbon used as reducing agent and/or reheating the tail gas	CO_2 and/or CH_4	I	GHG emissions based on additional amounts of reducing agent or energy used during the project	P	If hydrocarbons are used as a reducing agent to enhance efficiency of the N_2O catalyst, additional GHG emissions from the project activity will occur
6.	Production of Hydrocarbons	Emissions related to the production of hydrocarbon	CO_2, CH_4, N_2O	E		P	GHG emissions related to the production of hydrocarbons used as reducing agent are insignificant
7.	External Energy to Reheat Tail Gas	May be used to reheat the tail gas before entering the tertiary catalyst or NSCR	CO_2, CH_4, N_2O	I		P	If additional energy is used to reheat tail gas and that energy is not recovered and used within the system, additional GHG emissions from the project activity will occur

5 Quantifying GHG Emission Reductions

The GHG reduction calculations provided in this protocol are derived from internationally accepted methodologies.[18] Project developers shall use the calculation method provided in this protocol to quantify baseline and project GHG emissions in order to determine emission reductions. Figures 5.1 and 5.2 display the relationships between the various equations used in this section.

GHG emission reductions must be quantified and verified for each individual campaign. The length of time over which GHG emission reductions are quantified and verified is called the "reporting period." Reporting periods shall cover the same time period as a full campaign, unless a project developer chooses to report on a "sub-campaign" basis. See Section 7.4.1 for more information on sub-campaign reporting periods and verification.

As of this writing, the Reserve relies on values for global warming potential (GWP) of non-CO_2 GHGs published in the IPCC Fourth Assessment Report: Climate Change 2007 (AR4).[19] The values relevant for this protocol are provided in Table 5.1 below, and are to be used for all nitric acid production projects unless and until the Reserve issues written guidance to the contrary.

Table 5.1. 100-year Global Warming Potential for Non-CO_2 GHGs

Non-CO_2 GHG	100-Year GWP (CO_2e)
Methane (CH_4)	25
Nitrous Oxide (N_2O)	298

5.1 Secondary Catalyst Projects

GHG emission reductions from a secondary catalyst project are quantified by comparing actual project emissions to baseline emissions at the NAP. Baseline emissions are an estimate of the GHG emissions from within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

Equation 5.1. Emission Reductions for Secondary Catalyst Projects

$$\boldsymbol{ER = BE - PE}$$

Where,			Units
ER	=	Total emission reductions for the specific campaign	tCO_2e
BE	=	Total baseline emissions for the specific campaign	tCO_2e
PE	=	Total project emissions from the specific campaign	tCO_2e

[18] The Reserve's GHG reduction calculation method for N_2O abatement projects at nitric acid plants is adapted from the Kyoto Protocol's Clean Development Mechanism (AM0028 V.4.2 and AM0034 V.3.4). The methodology has been updated with the later adoption of ACM0019 V.1.0.

[19] Available here: https://ipcc.ch/publications_and_data/publications_and_data_reports.shtml

A secondary catalyst project involves the installation of a N_2O abatement catalyst directly beneath the primary catalyst within the AOR. Because these projects involve abatement within the AOR, the gas stream cannot be sampled between the primary and secondary catalysts. Thus, a baseline emission factor must be determined prior to installation of the secondary catalyst in order to estimate the project's baseline emissions, as will be discussed in Section 5.1.3. Similarly, project emissions are calculated for each campaign using a project emission factor which is derived based on data collected during that campaign (Section 5.1.4). This section begins with guidance regarding $HNO_{3,MAX}$ and the allowable operating conditions, which are relevant to both the baseline and project emissions calculations. Figure 5.1 illustrates the relationships between the various equations used in this section.

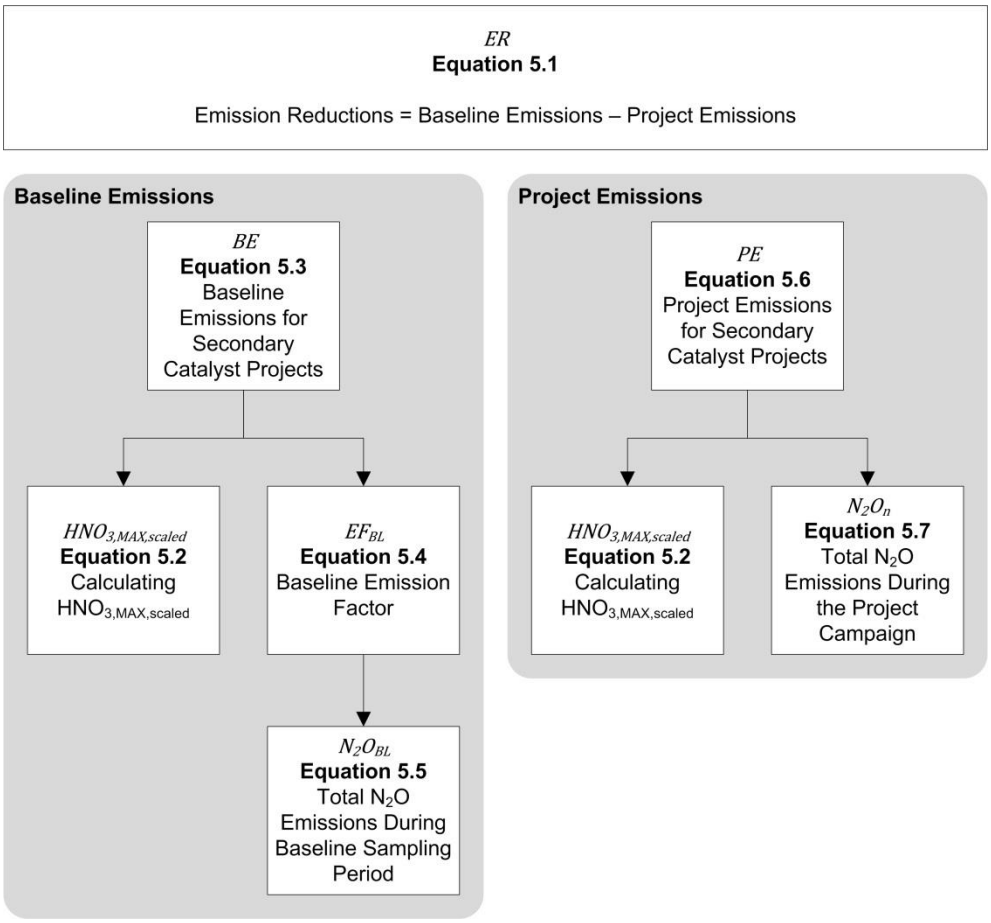


Figure 5.1. Organizational Chart of Equations for Secondary Catalyst Projects

5.1.1 Determination of $HNO_{3,MAX}$ and $HNO_{3,MAX,scaled}$

$HNO_{3,MAX}$ represents the historical maximum annual average total output of 100% concentration nitric acid. In order to use this factor for quantification of emission reductions, it must be scaled to the length of the campaign for which emission reductions are being calculated, which results in $HNO_{3,MAX,scaled}$.

In order to determine $HNO_{3,MAX}$, five consecutive years of historic data are used to calculate five values, each representing average HNO_3 production levels during a one year period at the process unit where the project is located. Average HNO_3 production can be calculated by

averaging daily HNO_3 production data over a 12 month period, excluding days when the nitric acid plant was not operating.

If five years of historical data are not available to calculate five average HNO_3 production values, then five historical average HNO_3 production values may be calculated from five consecutive campaigns of HNO_3 production data, reported as an average hourly, daily, or per-campaign value. If one of the five consecutive campaigns is determined to be justifiably anomalous, the project may instead use five non-consecutive historical campaigns (i.e., exclude the anomalous campaign and add another campaign from the next available historical record). Under these circumstances, an explanation and justification for excluding the anomalous campaign must be included in the verification report for the project. Otherwise, if data from five consecutive campaigns are not available, then the nameplate capacity of the NAP shall be used to determine $HNO_{3,MAX}$.

Equation 5.2. Calculating $HNO_{3,MAX,scaled}$

$$HNO_{3_{MAX,scaled}} = HNO_{3_{MAX}} \times OD_n$$

Where,			Units
$HNO_{3,MAX,scaled}$	=	Historical maximum annual average total output of 100% concentration nitric acid, scaled to the length of the campaign for which emissions reductions are being calculated	$tHNO_3$
$HNO_{3,MAX}$	=	Historical maximum annual average total output of 100% concentration nitric acid (see below)	$tHNO_3$/day
OD_n	=	Number of days of operation during the relevant campaign	days

5.1.2 Allowable Operating Conditions

Prior to the installation of the secondary catalyst at the project NAP, the project developer must carry out a baseline sampling period in order to quantify the N_2O emissions that would have occurred in the absence of the project activity. To ensure that N_2O emissions during the baseline sampling period are representative of typical historical N_2O emissions for the NAP and that operating conditions during the baseline sampling period are comparable to those during the project, the Reserve requires that allowable operating conditions (AOC) of the NAP be established for the following parameters, prior to beginning the baseline sampling period:

1. Oxidation temperature range
2. Oxidation pressure range
3. Maximum ammonia-to-air ratio input into the AOR (see Table 6.1 for secondary catalyst and Table 6.2 for tertiary catalyst)

The allowable ranges at the NAP shall be determined based on one of the following sources:

(a) The best available historical data for the operating range of temperature and pressure, and maximum ammonia-to-air ratio from the previous five campaigns.
(b) The best available historical data from less than five campaigns. This option is allowable only if limited historical data are available (e.g., an upgraded or relocated NAP that has not been operating for at least five campaigns).

(c) Specified range of temperature and pressure found in the operating manual[20] for the existing equipment, and maximum ammonia-to-air ratio as specified by the ammonia oxidation catalyst manufacturer or the operating manual for the NAP equipment if guidance from the ammonia oxidation catalyst manufacturer is not available. This option is only allowable if no historical data are available.

For NAPs that were upgraded or otherwise modified to increase production within 24 months prior to the project start date, AOC must be based on one of the options above using data collected after the commencement of production following completion of the upgrade, or the operating manuals for the upgraded plant. For NAPs that were upgraded or otherwise modified to increase production at any time during the project crediting period, AOC must be based on option (c) above.

For relocated NAPs, i.e., plants that were moved from one geographic location to another within 24 months prior to the project start date, AOC must be based on one of the options above using data collected after the plant was relocated.

If option (a) or (b) above is selected, the allowable range for temperature and pressure shall be determined through a statistical analysis of the historical data. All data that fall within the upper and lower 2.5 percentiles of the sample distribution are defined as potentially abnormal outliers and shall be eliminated. The allowable range of operating temperature and pressure is then assigned as the historical minimum and maximum operating conditions. Oxidation temperature and oxidation pressure data that are generated before ammonia begins flowing to the reactor shall be excluded prior to eliminating the upper and lower 2.5% of the observations.

Once the allowable ranges are determined, it must be demonstrated that these ranges are within the specifications of the facility by comparison with operating manuals for the existing equipment and ammonia catalyst specifications. If the AOC are not consistent with the above documentation, then additional campaigns should be undertaken until the allowable ranges can meet this criterion. However, if abnormal ammonia-to-air ratio levels are recorded during the historic campaigns used to establish the AOC for the project, and documentation or justification is available to support the assertion that the recorded levels are erroneous, the verification body may use professional judgment to review the documentation and make a determination as to whether the abnormal ammonia-to-air ratio levels should be eliminated from the historical dataset.

5.1.3 Quantifying Baseline Emissions

Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that would have occurred in the absence of the GHG reduction project.

[20] See definition of “operating manual” in Section 9, Glossary of Terms.

Equation 5.3. Baseline Emissions for Secondary Catalyst Projects

$$BE = \left[\left(EF_{BL} \times HNO_{3_{RP,scaled}}\right) + \left(EF_{New} \times HNO_{3_{New}}\right)\right] \times GWP$$

Where,			Units
BE	=	Total baseline emissions for the specific campaign	tCO_2e
EF_{BL}	=	Baseline emission factor (as calculated in Equation 5.4)	$tN_2O/tHNO_3$
$HNO_{3,RP,scaled}$	=	Quantity of nitric acid production used to quantify emission reductions, not exceeding $HNO_{3,MAX,scaled}$. Equal to the lesser of $HNO_{3,MAX,scaled}$ (calculated in Equation 5.2) or $HNO_{3,RP}$ (plant output of HNO_3 during the reporting period, further described in Table 6.1)	$tHNO_3$
EF_{New}	=	Default baseline emission factor for new production in excess of $HNO_{3,MAX,scaled}$ (Table B.1)	$tN_2O/tHNO_3$
$HNO_{3,New}$	=	Quantity of nitric acid production by which $HNO_{3,RP}$ (Table 6.1plant output of HNO_3 during the reporting period) exceeds $HNO_{3,MAX,scaled}$ (calculated in Equation 5.2). If $HNO_{3,RP} < HNO_{3,MAX,scaled}$, this value will be zero.	$tHNO_3$
GWP	=	Global warming potential for N_2O	tCO_2e/tN_2O

5.1.3.1 Baseline Sampling Period

A baseline sampling period must be conducted prior to the installation of the secondary catalyst at the project NAP. The baseline sampling period must encompass, at a minimum, the first ten weeks of a campaign, beginning with the resumption of nitric acid production following the installation of a new primary catalyst or new charge of primary catalyst gauze in the AOR.

A continuous emission monitoring system (CEMS) installed using the guidance in Section 6 shall be used to provide separate readings for N_2O concentration and gas flow volume in the stack gas during the baseline sampling period. As shown in Equation 5.5 the total N_2O produced during the baseline sampling period (N_2O_{BL}) is calculated from the sample data by multiplying the average N_2O concentration in the stack gas, the average hourly flow rate of stack gas, and total operating hours during the baseline sampling period.

Prior to calculating N_2O_{BL}, the data collected during the baseline sampling period shall be adjusted through the following steps:

Step 1: Elimination of data beyond the campaign production volume cap

To account for variations in the volume of nitric acid produced during individual campaigns and its influence on N_2O emissions, a cap is applied on the volume of production during the baseline sampling period. Campaign production volume is defined as the total metric tons of nitric acid at 100% concentration produced with one set of primary catalyst gauzes (i.e., HNO_3 produced in between new catalyst installations or new charges of catalyst gauze). The cap (CPV_{cap}) is defined as the average campaign production volume (in metric tons HNO_3) for the campaigns used to define the allowable operating conditions. If one of the campaigns used to define allowable operating conditions is determined to be justifiably anomalous, the project may instead use five non-consecutive historical campaigns (i.e., exclude the anomalous campaign and add another campaign from the next available historical record). If the project developer excludes an anomalous campaign, the verification body must use professional judgment

to review the justification and relevant data to make a determination as to whether the anomalous campaign is in fact justifiably anomalous and should be excluded from the CPV_{cap} calculations. If the amount of HNO_3 produced during the baseline sampling period exceeds CPV_{cap}, then N_2O values, HNO_3 production, and operating hours measured beyond CPV_{cap} (i.e., beyond the point in time when HNO_3 production met the production limit as defined by CPV_{cap}) are to be eliminated from the calculation of the baseline emission factor EF_{BL} in Equation 5.3 and N_2O_{BL} in Equation 5.4. If the amount of HNO_3 produced during the baseline sampling period does not exceed CPV_{cap}, all N_2O values measured, operating hours recorded, and total HNO_3 produced during the baseline sampling period shall be used for the calculation of EF_{BL} and N_2O_{BL} (subject to any elimination of data as required below).

Step 2: Elimination of data outside of allowable operating conditions

If the NAP operates outside of allowable temperature and pressure ranges or above the maximum ammonia-to-air ratio during the baseline sampling period, the following adjustments must be made prior to calculation of baseline emissions and the baseline emission factor:

1. Gas concentration and hourly flow rate recorded when the NAP was operating outside of allowable ranges shall be eliminated
2. The amount of time for which the NAP operated outside of allowable ranges shall be subtracted from the total operating hours
3. The amount of nitric acid produced during time periods during which the NAP operated outside of allowable ranges shall be subtracted from the total amount produced during the baseline sampling period

If the NAP operates outside of the established allowable range for more than 50% of the duration of the baseline sampling period, the baseline N_2O emissions data are considered invalid and sampling must be repeated.

Step 3: Elimination of outliers

Measurement results can be distorted before and after periods of downtime or malfunction of the monitoring system. To eliminate such extremes and to ensure a conservative approach, the following statistical valuation is to be applied to the data series of N_2O concentration and gas volume flow (not operating hours).

(a) Calculate the sample means (x)
(b) Calculate the sample standard deviations
(c) Calculate the 95% confidence intervals (equal to 1.96 times the standard deviations)
(d) Eliminate all data that lie outside the 95% confidence intervals (for gas flow and concentration only; do not eliminate operating hours in this step)
(e) Calculate the new sample means from the remaining values (flow of stack gas, F_{BL}, and N_2O concentration of stack gas, $N_2O_{conc,BL}$)

To further ensure that operating conditions during the baseline sampling period are representative of AOC, the Reserve requires the mean values for oxidation temperature, oxidation pressure, and ammonia-to-air ratio are within the corresponding ranges defined for the AOC. If the mean values for any of these parameters fall outside of the allowable ranges (or above the maximum for the ammonia-to-air ratio), then the baseline sampling period is invalid and must be repeated.

5.1.3.2 Baseline Emission Factor

As stated above, because the gas stream cannot be sampled between the primary and secondary catalysts, a baseline emission factor must be determined prior to installation of the secondary catalyst in order to estimate baseline emissions. As shown in Equation 5.4, the baseline emission factor represents the average N_2O emissions per metric ton of nitric acid over the baseline sampling period ($tN_2O/tHNO_3$.). The baseline emission factor shall remain static for the life of the project.

Equation 5.4. Baseline Emission Factor

$$EF_{BL} = \frac{N_2O_{BL}}{HNO_{3_{BL}}}$$

Where,			Units
EF_{BL}	=	Baseline N_2O emissions factor	$tN_2O/tHNO_3$
N_2O_{BL}	=	Total N_2O emissions during the baseline sampling period (Equation 5.5)	tN_2O
$HNO_{3,\ BL}$	=	Total nitric acid production during the baseline sampling period	$tHNO_3$

The term N_2O_{BL} represents the total N_2O emissions that were produced during the baseline sampling period, and is calculated using Equation 5.5.

Using the data for volume flow rate, N_2O concentration, and operating hours gathered during the baseline sampling period and adjusted per Section 5.1.3.1, the project developer shall calculate the total N_2O emissions during the baseline sampling period according to Equation 5.5.

Equation 5.5. Total N_2O Emissions during the Baseline Sampling Period

$$N_2O_{BL} = F_{BL} \times N_2O_{conc,BL} \times OH_{BL} \times 10^{-9}$$

Where,			Units
N_2O_{BL}	=	Total N_2O emissions during the baseline sampling period	tN_2O
F_{BL}	=	Mean gas volume flow rate at the stack during the baseline sampling period	m^3/hour
$N_2O_{conc,BL}$	=	Mean N_2O concentration in the stack gas during the baseline sampling period	mgN_2O/m^3
OH_{BL}	=	Total operating hours of the baseline sampling period	hours
10^{-9}	=	Unit conversion	t/mg

5.1.4 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of the project activity. Project emissions are calculated on an *ex-post* basis from measurements taken after the secondary catalyst is installed.

If the NAP operates outside of the established range for AOC for more than 50% of the duration of the campaign, the N_2O emissions data are considered invalid and no emission reductions can be claimed by the project for that campaign.

To further ensure that operating conditions during the project are representative of AOC, the Reserve requires the mean values for oxidation temperature, oxidation pressure, and ammonia-to-air ratio are within the corresponding ranges defined for the AOC. If the mean values for any of these parameters fall outside of the allowable ranges (or above the maximum for the ammonia-to-air ratio), no emission reductions can be claimed by the project for that campaign.

Equation 5.6. Project Emissions for Secondary Catalyst Projects

$$\boldsymbol{PE = N_2O_n \times GWP}$$

Where,			Units
PE	=	Total project emissions for the specific campaign	tCO_2e
N_2O_n	=	Total N_2O emissions of a specific project campaign (as calculated in Equation 5.7)	tN_2O
GWP	=	Global warming potential for N_2O	tCO_2e/tN_2O

5.1.4.1 Project Campaign Emission Factor

N_2O concentration and gas volume flow in the stack of the NAP, as well as the temperature and pressure, ammonia gas flow, and ammonia-to-air ratio, will be measured continuously for the duration of the project activity, and summarized over each campaign during the project lifetime. While in most cases data are summarized over each consecutive campaign length during the crediting period, if the baseline sampling period lasts for less than a full campaign and the secondary catalyst is installed in the middle of a campaign length then, for that period only, project emissions are calculated based on the time between catalyst installation and the end of the campaign. The guidance below is specific to a full campaign length but should be adapted for the exceptional case above as needed.

The same CEMS used during the baseline sampling period shall be used to monitor project emissions. The same statistical evaluation that was applied to the baseline data series shall be applied to the project data series of N_2O concentration and gas volume flow only (no elimination of data for operating hours or nitric acid production). For each campaign length:

(a) Calculate the sample mean (x)
(b) Calculate the sample standard deviation(s)
(c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
(d) Eliminate all data that lie outside the 95% confidence interval
(e) Calculate the new sample mean from the remaining values

After the above steps, campaign-specific N_2O emissions are calculated using Equation 5.7. The value of OH_n represents a total for the campaign, and no data are to be eliminated from this dataset for the calculation of Equation 5.7. Furthermore, no project data are eliminated that fall outside the AOC.

Equation 5.7. Total N_2O Emissions during the Project Campaign

$$N_2O_n = F_n \times N_2O_{conc,n} \times OH_n \times 10^{-9}$$

Where,			Units
N_2O_n	=	Total N_2O emissions during the n^{th} project campaign	tN_2O
F_n	=	Mean stack gas volume flow during the n^{th} project campaign	m^3/ hour
$N_2O_{conc,n}$	=	Mean concentration of N_2O in the stack gas during the n^{th} project campaign	mgN_2O/ m^3
OH_n	=	Total number of hours of operation during the n^{th} project campaign	hours
10^{-9}	=	Unit conversion	t/mg

5.2 Tertiary Catalyst Project

ER
Equation 5.8

Emission Reductions = Baseline Emissions – Project Emissions

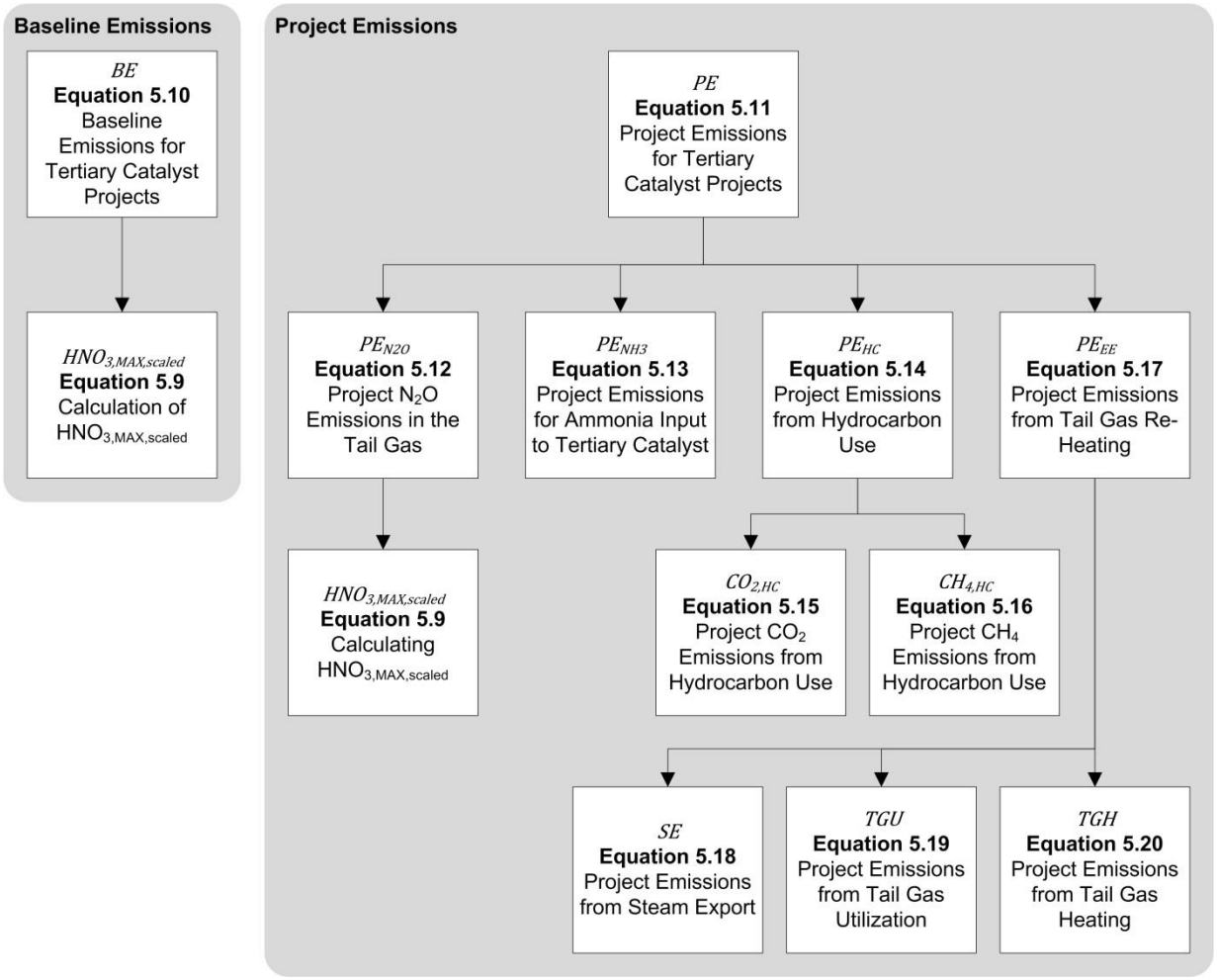


Figure 5.2. Organizational Chart of Equations for Tertiary Catalyst Projects

Equation 5.8 provides the quantification approach that shall be used for calculating the emission reductions from tertiary catalyst N_2O abatement projects.

Equation 5.8. Emission Reductions for Tertiary Catalyst Projects

$$\boldsymbol{ER = BE - PE}$$

Where,			Units
ER	=	Emission reductions during the reporting period	tCO_2e
BE	=	Baseline emissions during the reporting period (as calculated in Equation 5.10)	tCO_2e
PE	=	Project emissions during the reporting period (as calculated in Equation 5.11)	tCO_2e

5.2.1 Determination of $HNO_{3,MAX}$ and $HNO_{3,MAX,scaled}$

$HNO_{3,MAX}$ represents the historical maximum annual average total output of 100% concentration nitric acid. In order to use this factor for quantification of emission reductions, it must be scaled to the length of the campaign for which emission reductions are being calculated, which results in a second factor: $HNO_{3,MAX,scaled}$. To determine $HNO_{3,MAX}$, five consecutive years of historic data are used to calculate five values, each representing average HNO_3 production levels during a one year period at the process unit where the project is located. Average HNO_3 production can be calculated by averaging daily HNO_3 production data over a 12 month period, excluding days when the nitric acid plant was not operating.

If five years of historical data are not available to calculate five average HNO_3 production values, then five historical average HNO_3 production values may be calculated from five consecutive campaigns of HNO_3 production data, reported as an average hourly, daily or per-campaign value. If one of the five consecutive campaigns is determined to be justifiably anomalous, the project may instead use five non-consecutive historical campaigns (i.e., exclude the anomalous campaign and add another campaign from the next available historical record). Under these circumstances, an explanation and justification for excluding the anomalous campaign must be included in the verification report for the project. Otherwise, if data from five consecutive campaigns are not available, then use the nameplate capacity of the NAP to determine $HNO_{3,MAX}$.

Equation 5.9. Calculation of $HNO_{3,MAX,scaled}$

$$\boldsymbol{HNO_{3_{MAX,scaled}} = HNO_{3_{MAX}} \times OD_n}$$

Where,			Units
$HNO_{3,MAX,scaled}$	=	Historical maximum annual average total output of 100% concentration nitric acid, scaled to the length of the campaign for which emission reductions are being calculated	$tHNO_3$
$HNO_{3,MAX}$	=	Historical maximum annual average total output of 100% concentration nitric acid (see below)	$tHNO_3$/day
OD_n	=	Number of days of operation during the project campaign	days

5.2.2 Allowable Operating Conditions

As in secondary catalyst projects, it is necessary with tertiary catalyst projects to determine the allowable operating conditions (AOC) for the NAP to ensure operating conditions during the project are consistent with historical operating conditions. Follow the steps in Section 5.1.2 to determine the allowable range of operating conditions for the NAP where the tertiary catalyst project is being implemented.

If actual average daily operating conditions for pressure, temperature, and ammonia-to-air ratio are outside of the allowable range anytime during interval *i*, baseline emissions during interval *i* are calculated from the lowest of the following options:

(a) N_2O emissions calculated using the conservative IPCC default emission factor corresponding to the calendar year of the reporting period (see Table B.1) multiplied by $HNO_{3,i}$ (HNO_3 production in interval *i*); or
(b) N_2O emissions calculated over the interval *i*, where $BE_i = F_i \times N_2O_{conc,in,i} \times OH_I \times GWP$ (see Equation 5.9 for definition of variables).

If the NAP operates outside of the established range for AOC for more than 50% of the reporting period, the N_2O emissions data are considered invalid and no emission reductions can be claimed by the project for that reporting period.

To further ensure that operating conditions during the project are representative of AOC, the Reserve requires the mean values for oxidation temperature, oxidation pressure, and ammonia-to-air ratio are within the corresponding ranges defined for the AOC. If the mean values for any of these parameters fall outside of the allowable ranges or above the maximum ammonia-to-air ratio, no emission reductions can be claimed by the project for that campaign.

5.2.3 Quantifying Baseline Emissions

Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that would have occurred in the absence of the GHG reduction project (
Equation 5.8). Baseline GHG emissions are based on the quantity of N_2O in the tail gas before it enters the tertiary project abatement technology. Projects that involve the installation of a tertiary catalyst at a NAP with a pre-existing NSCR system must sample the tail gas after it leaves the pre-existing NSCR unit, prior to entering the tertiary project abatement technology. GHG emissions from the use of a reducing agent or energy to reheat tail gas and from production of input ammonia, for the purposes of operating the tertiary catalyst, are considered to be zero in the baseline.

The baseline is calculated from data collected during project operations by monitoring N_2O concentrations before the tail gas enters the tertiary catalyst or NSCR.

Equation 5.10. Baseline Emissions for Tertiary Catalyst Projects

$$BE = \sum_{i}^{n}\left(F_i \times N_2O_{conc,in,i} \times OH_i\right) \times GWP$$

When $HNO_{3,RP} \leq HNO_{3,MAX,scaled}$
Otherwise,

$$BE = \left[\left[\sum_{i}^{n}\left(F_i \times N_2O_{conc,in,i} \times OH_i\right) \times GWP\right] \times \frac{HNO_{3,MAX,scaled}}{HNO_{3,RP}}\right] + \left[EF_{New} \times GWP \times \left(1 - \frac{HNO_{3,MAX,scaled}}{HNO_{3,RP}}\right)\right]$$

Where,			Units
BE	=	Baseline emissions during the reporting period	tCO_2e
F_i	=	Volume flow rate in the destruction facility[21] during interval *i*[22]	m^3/hour
$N_2O_{conc,in,i}$	=	N_2O concentration at the inlet to the destruction facility during interval *i*	tN_2O/m^3
OH_i	=	Operating hours in interval *i*	hours
i	=	Interval number	
n	=	Number of intervals in the reporting period	
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O
$HNO_{3,RP}$	=	Amount of nitric acid produced during the reporting period	$tHNO_3$
$HNO_{3,MAX,scaled}$	=	Maximum annual average nitric acid production (see below) during an amount of time equivalent to the reporting period	$tHNO_3$
EF_{New}	=	Default baseline emission factor for new production in excess of $HNO_{3,MAX,scaled}$ (Table B.1)	$tN_2O/tHNO_3$

For any intervals where the NAP operates outside of AOC and the IPCC default is to be used:

$$BE_i = HNO_{3_i} \times EF_{IPCC} \times GWP$$

Where,			Units
BE	=	Baseline emissions during interval *i* when the NAP is operating outside of AOC	tCO_2e
$HNO_{3,i}$	=	Total nitric acid production in interval *i*	$tHNO_3$
EF_{IPCC}	=	IPCC default emission factor corresponding to the calendar year of the reporting period (Table B.1)	$tN_2O/tHNO_3$
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O

[21] Destruction facility refers to the equipment housing the tertiary catalyst or other N_2O abatement technology if applicable (i.e., NSCR).
[22] It is only necessary to measure volume flow rate in one location, either upstream or downstream of the destruction facility because the system is closed and thus flow rate should be constant.

5.2.4 Quantifying Project Emissions

Project emissions are comprised of three sources: N_2O emissions in the tail gas downstream of the tertiary catalyst facility, GHG emissions from the use of ammonia as input to the tertiary catalyst facility, and use of hydrocarbons as a reducing agent or to reheat tail gas.

Equation 5.11. Project Emissions for Tertiary Catalyst Projects

$$\boldsymbol{PE = PE_{N_2O} + PE_{NH_3} + PE_{HC} + PE_{EE}}$$

Where,			Units
PE	=	Project emissions during the reporting period	tCO_2e
PE_{N2O}	=	GHG emissions from N_2O in the tail gas during the reporting period (as calculated in Equation 5.12)	tCO_2e
PE_{NH3}	=	GHG emissions from the ammonia input used to operate the tertiary catalyst facility during the reporting period (as calculated in Equation 5.13)	tCO_2e
PE_{HC}	=	GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas during the reporting period (as calculated in Equation 5.14)	tCO_2e
PE_{EE}	=	GHG emissions from external energy used to reheat tail gas during the reporting period (as calculated in Equation 5.17)	tCO_2e

5.2.4.1 Calculating Project N_2O Emissions in the Tail Gas

Tertiary catalyst N_2O abatement is not 100% efficient; therefore, N_2O emissions that are not destroyed by the catalyst are measured and included as project emissions.

Equation 5.12. Project N_2O Emissions in the Tail Gas

$$\boldsymbol{PE_{N_2O} = \sum_{i}^{n} \left(F_i \times N_2O_{conc,out,i} \times OH_i \right) \times GWP}$$

Where,			Units
PE_{N2O}	=	N_2O emissions from tail gas during the reporting period	tCO_2e
F_i	=	Volume flow rate in the destruction facility during interval *i*[23]	m^3/hour
$N_2O_{conc,out,i}$	=	N_2O concentration at the outlet to the tertiary catalyst during interval *i*	tN_2O/m^3
OH_i	=	Operating hours in interval *i*	hours
i	=	Interval number	
n	=	Number of intervals in the reporting period	
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O

[23] It is only necessary to measure volume flow rate in one location, either upstream or downstream of the destruction facility because the system is closed and thus flow rate should be constant.

5.2.4.2 Calculating Project Emissions from Ammonia Input

When an existing SCR unit is operating at the NAP prior to the project start date, the baseline and project ammonia input will be considered equal. This is because either (1) the function of the existing SCR is replaced by a combined unit (SCR and tertiary catalyst) or (2) the original SCR continues to operate and the new tertiary catalyst is not combined with an SCR unit. In both of these cases, the amount of ammonia input required to operate the NAP will not change relative to the baseline.

In cases where SCR is not operating at the NAP prior to the project start date and SCR is installed with the tertiary catalyst to improve N_2O destruction efficiency, project emissions related to the production of ammonia used to run the SCR shall be calculated using Equation 5.13.

Equation 5.13. Project Emissions for Ammonia Input to Tertiary Catalyst

$$\boldsymbol{PE_{NH_3} = Q_{NH_3} \times 2.14}$$

Where,			Units
PE_{NH3}	=	GHG emissions from the ammonia input used to operate the tertiary catalyst facility during the reporting period	tCO_2e
Q_{NH3}	=	Ammonia input to the destruction facility during the reporting period	tNH_3
2.14	=	GHG emission factor for ammonia production[24]	tCO_2e/ tNH_3

5.2.4.3 Calculating Project Emissions from Hydrocarbon Use

Hydrocarbons can be used as a reducing agent or to reheat tail gas to enhance the catalytic N_2O reduction efficiency, which leads to CO_2 and CH_4 emissions. The project emissions related to hydrocarbon input to the project shall be calculated using Equation 5.14.

Equation 5.14. Project Emissions from Hydrocarbon Use

$$\boldsymbol{PE_{HC} = CO_{2_{HC}} + CH_{4_{HC}}}$$

Where,			Units
PE_{HC}	=	GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas during the reporting period	tCO_2e
$CO_{2,HC}$	=	GHG emissions as CO_2 from hydrocarbon use during the reporting period (as calculated in Equation 5.15)	tCO_2e
$CH_{4,HC}$	=	GHG emissions as CH_4 from hydrocarbon use during the reporting period (as calculated in Equation 5.16)	tCO_2e

Hydrocarbons (organic compounds made up of carbon and hydrogen) are used primarily as a combustible fuel source (e.g., natural gas, which is mostly methane, propane, and butane). When hydrocarbons are combusted they produce heat, steam, and CO_2. For calculation of the GHG emissions related to hydrocarbons, assume all hydrocarbons other than CH_4 are

[24] CDM methodology AM0028.

completely converted to CO_2 (see Equation 5.15) and all CH_4 in the fuel or reducing agent is emitted directly as CH_4 to the atmosphere and is not converted to CO_2 (see Equation 5.16). In Equation 5.15, the hydrocarbon CO_2 emission factor (EF_{HC}) is given by the molecular weight of the hydrocarbon and CO_2 and the chemical reaction when hydrocarbons are converted.[25]

Equation 5.15. Project Carbon Dioxide Emissions from Hydrocarbon Use

$$CO_{2_{HC}} = \rho_{HC} \times Q_{HC} \times EF_{HC}$$

Where,			Units
$CO_{2,HC}$	=	Converted hydrocarbon emissions during the reporting period	tCO_2e
ρ_{HC}	=	Hydrocarbon density	t/m^3
Q_{HC}	=	Quantity of hydrocarbon, with two or more molecules of carbon, input during the reporting period (i.e., not methane)	m^3
EF_{HC}	=	Carbon emission factor of hydrocarbon, with two or more molecules of carbon	tCO_2e/tHC

Equation 5.16. Project Methane Emissions from Hydrocarbon Use

$$CH_{4_{HC}} = \rho_{CH_4} \times Q_{CH_4} \times GWP$$

Where,			Units
$CH_{4,HC}$	=	Unconverted hydrocarbon emissions (methane) during the reporting period	tCO_2e
ρ_{CH4}	=	Methane density	t/m^3
Q_{CH4}	=	Methane used during the reporting period	m^3
GWP	=	Global warming potential of methane	tCO_2e/tCH_4

5.2.4.4 Calculating Project Emissions from Tail Gas Reheating

If an external energy source is used to adjust tail gas temperatures at the inlet of the N_2O destruction facility and the additional energy is not recovered before the tail gas is released to the atmosphere, then GHG emissions from the energy used shall be calculated and included in as project emissions using Equation 5.17.

[25] For example, where CH_4 is used as hydrocarbon, each converted tonne of CH_4 results in 44/16 tonnes of CO_2, thus the hydrocarbon emission factor is 2.75. (CDM methodology AM0028)

Equation 5.17. Project Emissions from Tail Gas Reheating

$$PE_{EE} = SE + TGU + TGH$$

Where,			Units
PE_{EE}	=	Project emissions from external energy during the reporting period	tCO_2e
SE	=	Emissions from net change in steam export during the reporting period (Equation 5.18)	tCO_2e
TGU	=	Emissions from net change in tail gas utilization during the reporting period (Equation 5.19)	tCO_2e
TGH	=	Emissions from net change in tail gas heating during the reporting period (Equation 5.20)	tCO_2e

Equation 5.18. Project Emissions from Steam Export

$$SE = \left[\frac{(ST_{BL} - ST_{PR}) \times OH_{RP}}{\eta_{ST}}\right] \times EF_{ST}$$

Where,			Units
SE	=	Emissions from net change in steam export during the reporting period	tCO_2e
ST_{BL}	=	Baseline steam export during a reporting period	MW
ST_{PR}	=	Project steam export during the reporting period	MW
OH_{RP}	=	Operating hours during the reporting period	hours
η_{ST}	=	Efficiency of steam generation	%
EF_{ST}	=	Fuel emission factor for steam generation	tCO_2e/MWh

Equation 5.19. Project Emissions from Tail Gas Utilization

$$TGU = \left[\frac{(EE_{BL} - EE_{PR}) \times OH_{RP}}{\eta_r}\right] \times EF_r$$

Where,			Units
TGU	=	Emissions from net change in tail gas utilization during the reporting period	tCO_2e
EE_{BL}	=	Baseline energy export from tail gas utilization during a reporting period	MW
EE_{PR}	=	Project energy export from tail gas utilization during the reporting period	MW
OH_{RP}	=	Operating hours during the reporting period	hours
η_r	=	Efficiency of replaced technology	%
EF_r	=	Fuel emission factor for replaced technology	tCO_2e/MWh

Equation 5.20. Project Emissions from Tail Gas Heating

$$\boldsymbol{TGH} = \left[\frac{\boldsymbol{EI_{TGH}}}{\boldsymbol{\eta_{TGH}}}\right] \times \boldsymbol{EF_{TGH}}$$

Where,			Units
TGH	=	Emissions from net change in tail gas heating during the reporting period	tCO_2e
EI_{TGH}	=	Energy input for additional tail gas heating during the reporting period	MWh
η_{TGH}	=	Efficiency of additional tail gas heating	%
EF_{TGH}	=	Emission factor for additional tail gas heating	tCO_2e/MWh

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 or Table 6.2 (below) will be collected and recorded.

At a minimum, the Monitoring Plan shall stipulate the frequency of data acquisition, a record keeping plan, the frequency of instrument field check and calibration activities, the role of individuals performing each specific monitoring activity, as well as quality assurance/quality control (QA/QC) provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision.

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.4.1).

To ensure that all aspects of monitoring and reporting are met, the project developer shall follow the relevant guidance in this section as well as the relevant sections of the United States Code of Federal Regulations Title 40 (40 CFR), Part 60 and Part 75 as indicated below. Part 60 and Part 75 provide guidance on the standards of performance for stationary emission sources and continuous emission monitoring systems (CEMS) for NO_X emission testing, which is also applicable to N_2O emission testing at nitric acid production facilities. These parts outline the minimum requirements for the installation, evaluation, monitoring, and record keeping for CEMS (see Section 7.3 of this protocol for Reserve minimum record keeping requirements). Specifically, the project developer shall follow Appendix B of Part 75 that covers QA/QC procedures for CEMS.

If both Part 60 and Part 75 appear to address the same matter, then to the extent that their provisions are irreconcilably inconsistent, the Reserve intends the more specific provision to control/govern the subject and Part 75 to prevail over Part 60.

Project developers are responsible for monitoring the performance of the project and ensuring that the operation of the N_2O abatement system is consistent with the manufacturer's recommendations for each component of the system. Installation and certification of the emission monitoring system in accordance with this section of this protocol should take place prior to the project start date. In addition, for secondary catalyst projects only, emission monitoring to establish baseline emissions should take place immediately prior to the project start date.

6.1 Monitoring Requirements

Direct measurements of the N_2O concentration in the stack gas (and tail gas in the case of tertiary projects) and the flow rate of the stack gas/tail gas shall be made using a continuous emission monitoring system. CEMS is the most accurate monitoring method because N_2O

emissions are measured continuously from a specific source.[26] Elements of a CEMS include a platform and sample probe within the stack to withdraw a sample of the stack gas, an analyzer to measure the concentration of the N_2O (typically a non-dispersive infrared sensor (NDIR) or Fourier transform infrared (FTIR) spectroscopy) in the stack gas, and a flow meter within the stack to measure the flow rate of the stack gas. The emissions are calculated from the concentration of N_2O in the stack gas/tail gas and the flow rate of the stack gas/tail gas. A CEMS continuously withdraws and analyzes a sample of the gas and continuously measures the N_2O concentration and flow rate of the gas.[27]

6.1.1 System Installation and Certification

The project developer shall follow the requirements for CEMS installation and initial certification detailed in section 60.13 of 40 CFR Part 60, Performance Specification 2 of Appendix B of 40 CFR Part 60, and section 6 of Appendix A of 40 CFR Part 75. CEMS must be installed and operational before conducting performance tests on the system. In order to achieve operational status, the project developer must show that the CEMS also meets manufacturer's requirements or recommendations for installation, operation, and calibration.

Projects utilizing a CEMS that was initially installed for a purpose other than the monitoring of a N_2O abatement project (e.g., to monitor NO_X abatement) must still meet all of the requirements of this section. If any of the required tests listed below were not conducted or the requirements were not met at the time of initial installation and certification, the project developer must conduct the tests and ensure that the requirements are met prior to beginning the baseline campaign.

The following initial certification requirements are summarized from 40 CFR Part 75. Please refer to the CFR sections referenced above for all installation and certification requirements.

- 7-day calibration error test to evaluate the accuracy and stability of a gas analyzer's or flow monitor's calibration over a period of unit operation.
- Linearity check to determine whether the response of the N_2O concentration monitor is linear across its range by challenging CEMS with three different levels of calibration gas concentrations.
- Relative Accuracy Test Audit (RATA) to determine the accuracy of the system by comparing N_2O emissions data recorded by the CEMS to data collected concurrently with an emission reference test method. All RATA of CEMS must be conducted by a testing body conforming to the requirements of ASTM D7036-04.[28]
- Bias test to ensure that the monitoring system is not biased low with respect to the reference method, based on RATA results.
- Cycle time test to ensure that the monitoring system is capable of completing at least one cycle of sampling, analyzing, and data recording every 15 minutes.[29]
- Automated data acquisition and handling system (DAHS) verification to ensure that all emission calculations are performed correctly and that the missing data substitution methods are applied properly.

[26] This method is consistent with Approach 1 from the World Business Council for Sustainable Development and the "A" rated approach from the U.S. Department of Energy.
[27] U.S. EPA *Technical Support Document for the Nitric Acid Production Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases*, Office of Air and Radiation, January 22, 2009.
[28] 40 CFR Part 75, Appendix A, section 6.1.2(a).
[29] 40 CFR Part 60, 60.13(e)(2).

6.1.2 Calibration

The calibration procedures from Performance Specification 2 of Appendix B of 40 CFR Part 60 and Appendix A of 40 CFR Part 75 shall be followed for CEMS measuring N_2O emissions according to this protocol. Calibration test procedures are outlined in Performance Specification 2, Appendix B of Part 60 and section 6.3, Appendix A of Part 75. The performance specifications for the 7-day calibration error test and linearity check are described in section 3.1 and 3.2 of Appendix A of Part 75.

6.1.3 Accuracy Testing

The relative accuracy and RATA procedures from Appendix A and B (Performance Specification 2) of 40 CFR Part 60 and Appendix A of 40 CFR Part 75 shall be followed for CEMS used in nitric acid production projects. The guidance for NO_X CEMS shall be used for N_2O emission monitoring where the CEMS relative accuracy shall not exceed 10% at any operating level at which a RATA is performed.[30]

Because there is not a standard reference test method for N_2O CEMS at this time, a RATA for the verification of a FTIR or NDIR installation for N_2O analysis may use any of the following:

- U.S. EPA test method 320[31] for the measurement of vapor phase organic and inorganic emissions by extractive FTIR spectroscopy[32]
- ASTM D6348-03 method for the determination of gaseous compound by extractive direct interface FTIR spectroscopy[33]
- ISO/DIS 21258 stationary source emissions determination of the mass concentration of N_2O reference method for NDIR[34]
- Other NDIR methods used in AM0034 or AM0028, or performance specification based reference method such as EPA method 7E.[35]

6.1.3.1 Sampling

For all RATA, a minimum of nine test runs have to be conducted for a period of at least 21 minutes for each run. More test runs may be completed with the option to exclude up to three test runs from the audit. However, all data must be reported, including the rejected data.[36] For details on RATA sampling, see the relative accuracy test procedures and performance specifications in Performance Specification 2, Appendix B of 40 CFR Part 60 and Appendix A of 40 CFR Part 75.

6.2 QA/QC Requirements

The quality assurance and quality control (QA/QC) provisions required for this protocol shall be included in the Monitoring Plan and consistent in stringency, data reporting, and documentation with the CEMS QA/QC program described in Appendix B of 40 CFR Part 75 (see Section 7 of this protocol for further record-keeping requirements).

[30] 40 CFR Part 75, Appendix A, section 3.3.4(a).
[31] http://www.epa.gov/ttn/emc/methods/method320.html
[32] 40 CFR Part 63, Appendix A.
[33] 40 CFR Part 60, 60.17(a)(82).
[34] http://www.iso.org/iso/catalogue_detail.htm?csnumber=40113
[35] http://www.epa.gov/ttn/emc/promgate/method7E.pdf
[36] 40 CFR Part 60, Appendix B, section 8.4.4.

The following QA/QC requirements are summarized from Appendix B of 40 CFR Part 75. Please refer to the CFR sections referenced above for all QA/QC requirements.

- Procedures for preventative maintenance of the monitoring system
- Record keeping and reporting procedures
- Testing, maintenance, and repair activity records for CEMS or any component of CEMS
- Calibration error test and linearity check procedures
- Calibration and linearity adjustment procedures
- RATA procedures, such as sampling and analysis methods

6.2.1 Frequency of Testing

The schedule for the frequency of testing required for CEMS is described in section 2, Appendix B of 40 CFR Part 75. At a minimum, the following schedule must be followed for tests relevant to N_2O analysis using CEMS.

Daily assessments to quality-assure the hourly data recorded by the CEMS as of the date when CEMS completes certification testing:

- Calibration error test for N_2O analyzer
- Calibration adjustments for N_2O analyzer
- Data validation
- Quality assurance
- Data recording

Quarterly assessments apply as of the calendar quarter following the calendar quarter in which the CEMS is provisionally certified:

- Calibration error test for flow meter
- Calibration adjustments for flow meter
- Linearity check in quarters for which there is no RATA
- Leak check for CEMS utilizing differential pressure flow meters
- Data validation
- Linearity and leak check grace period
- Flow-to-load ratio or gross heat rate evaluation for projects located at a nitric acid plant that produces either electrical or thermal output

Semiannual and annual assessments apply as of the calendar quarter following the calendar quarter in which the CEMS is provisionally certified:

- RATA
- Data validation
- RATA grace period
- Bias adjustment factor applied if a monitor fails the bias test

For CEMS that were installed and certified for NO_X abatement prior to implementation of the N_2O abatement project, the daily, quarterly, semi-annual, and annual assessments detailed above only need to be performed, documented, and verified as of the start of the baseline campaign, not as of the date when the CEMS originally completed certification testing for NO_X abatement. For CEMS that were installed specifically for N_2O abatement project

implementation, assessments must be performed, documented, and verified as of the date that the CEMS was certified.

If the quarterly calibration error test reveals accuracy outside of a +/- 3% threshold, calibration by the manufacturer or a certified service provider is required for the flow meter. For the interval between the last successful calibration error test and the calibration error test that revealed accuracy outside +/- 3% threshold, conservativeness will determine what flow meter data are used in emission reduction calculations. Whether the calibration error is detected in a baseline or project campaign determines whether the metered values are used without correction or are adjusted based on the greatest calibration drift recorded at the time of calibration. The verification body shall confirm that any adjustments to the metered values result in the most conservative calculation of emission reductions. Any adjustments shall be made for the entire period from the last successful calibration error test until such time that the meter is properly calibrated and re-installed.

6.2.2 Data Management

Data management procedures are an important component of a comprehensive QA/QC plan. Data management procedures are described throughout Appendix B of 40 CFR Part 75 and include the following items.[37]

- Check for temporal consistency in production data and emission estimates. If outliers exist, an explanation could be required as to changes in the facility operations or other factors. A monitoring error is probable if differences between annual data cannot be explained by changes in activity levels, changes concerning fuels or input material, or changes concerning the emitting process.
- Determine the reasonableness of the emission estimate by comparing it to previous year's estimates.
- Maintain data documentation, including comprehensive documentation of data received through personal communication.
- Check that changes in data or methodology are documented.

6.3 Missing Data Substitution

In situations where the N_2O CEMS is missing data, the project developer shall follow the missing data substitution procedures for NO_X CEMS found in section 75.33 of 40 CFR Part 75. In summary, missing data from the operation of the CEMS may be replaced with substitute data to determine the N_2O emissions during the period for which CEMS data are missing. The owner or operator of the CEMS can substitute for missing N_2O concentration data using the procedures specified in section 75.33.[38]

For each hour of missing data, the project developer shall calculate substitute data for N_2O concentration based on the previous 2,160 quality-assured monitor operating hours for the CEMS. The data substitution procedures depend on the percentile of available monitoring data from the system and the length of the missing data period. If there are no prior quality-assured data or minimal available data (the minimum percent is specified in section 75.33), the owner or operator must substitute the minimum potential N_2O concentration for missing data in the

[37] The data management items are gathered from section 7.3 of the U.S. EPA *Technical Support Document for the Nitric Acid Production Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases*, Office of Air and Radiation, January 22, 2009.

[38] 40 CFR75, 75.33, Standard missing data procedures for SO_2, NO_X, Hg, and flow rate.

baseline and the maximum potential N_2O concentration for missing data in the project, per the following:

- Minimum – Baseline:
  - Secondary projects: N_2O monitoring to establish the baseline
  - Tertiary projects: N_2O monitoring at the inlet of the tertiary catalyst
- Maximum – Project:
  - Secondary projects: N_2O monitoring for the project
  - Tertiary projects: N_2O monitoring at the outlet of the tertiary catalyst

6.4 Monitoring Parameters for Secondary Catalyst Projects

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Monitoring Parameters for Secondary Catalyst Projects

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
General Project Parameters						
	Regulations	Project developer attestation of compliance with legal requirements relating to the project	All applicable regulations	n/a	Each verification	Information used to: 1) Demonstrate ability to meet the Legal Requirement Test – where regulation would require the abatement of N_2O or the installation of certain NO_X emission control technology that will impact N_2O emissions 2) Demonstrate compliance with all applicable regulations, e.g., criteria pollutant emission standards, health and safety, etc.
	OT_h	Oxidation temperature	°C	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation temperature according to this protocol
	OP_h	Oxidation pressure	bar	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation pressure according to this protocol

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
	OT_{normal}	Allowable range for oxidation temperature	°C	c	Once	To be obtained from the operating condition campaigns
	OP_{normal}	Allowable range for oxidation pressure	bar	c	Once	To be obtained from the operating condition campaigns
		Ammonia-to-air ratio	%	m, c	Every hour	This parameter is monitored during the baseline and project campaigns. This percentage is calculated as $NH_3/(NH_3 + air)$, using units of either mass or volume
		Maximum ammonia-to-air ratio	%	c	Once	To be obtained from the operating condition campaigns
	CPV_{cap}	Campaign production volume cap	$tHNO_3$	c	Once	This limits the length of the baseline sampling period by ending data collection when nitric acid production meets the value of the cap
5.1	ER	Emission reductions for the reporting period	tCO_2e	c	Per reporting period	
5.2	$HNO_{3,MAX,scaled}$	$HNO_{3,MAX}$, scaled to the length of the campaign	$tHNO_3$	c	Once	
5.2	$HNO_{3,MAX}$	Historical maximum annual average nitric acid production	$tHNO_3$/day	c	Once	Calculated from historical production data, averaged over 12 month intervals
5.2	OD_n	Days of operation in the campaign for which $HNO_{3,MAX,scaled}$ is being calculated	days	o	Per campaign	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Baseline Calculation Parameters						
5.1, 5.3	BE	Baseline emissions for the reporting period	tCO_2e	c	Per reporting period	Emissions that would have occurred in the absence of the project activity, determined through the baseline sampling period
5.3, 5.4	EF_{BL}	Baseline emission factor	$tN_2O/tHNO_3$	c	Per reporting period	
5.3	$HNO_{3,RP,scaled}$	Quantity of nitric acid production used to quantify emission reductions, not exceeding $HNO_{3,MAX,scaled}$	$tHNO_3$	c	Per reporting period	Equal to the lesser of $HNO_{3,MAX,scaled}$ or $HNO_{3,RP}$
5.3, 5.10	EF_{New}	Default baseline emission factor for production above $HNO_{3,max,scaled}$	$tN_2O/tHNO_3$	r	Per reporting period, whenever necessary	Choose the default factor corresponding to the calendar year of the reporting period (see Table B.1). If a reporting period spans multiple calendar years, the more conservative (i.e., lower) EF_{New} should be used.
5.3	$HNO_{3,New}$	Quantity of nitric acid production by which $HNO_{3,RP}$ exceeds $HNO_{3,MAX,scaled}$	$tHNO_3$	c	Per reporting period	Equal to the difference between $HNO_{3,MAX,scaled}$ and $HNO_{3,RP}$
5.4, 5.5	N_2O_{BL}	Total N_2O emissions during the baseline sampling period	tN_2O	m	Continuously, totaled for the campaign	
5.4	$HNO_{3,BL}$	Nitric acid (100% concentrated) produced over baseline campaign	$tHNO_3$	o	Daily, totaled for the entire campaign	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.5	F_{BL}	Volume flow rate of the stack gas expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	m	Every one minute	The data are collected using a gas volume flow meter and the data output will be processed using appropriate software programs
5.5	$N_2O_{conc,BL}$	N_2O concentration in the stack gas at normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3 (converted from ppm if necessary)	m	Every one minute	The data are collected using a N_2O analyzer and the data output will be processed using appropriate software programs
5.5	OH_{BL}	Operating hours	hours	o	Daily, totaled for the entire campaign	Plant manager records the hours of full operation of the plant during a campaign
Project Calculation Parameters						
5.1, 5.6	PE	Project emissions for the reporting period	tCO_2e	c	Per reporting period	Emissions resulting from project activities
5.6, 5.7	N_2O_n	Total N_2O emissions during the project campaign	tN_2O	c	Per campaign	
5.7	F_n	Volume flow rate of the stack gas expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	m	Every one minute	The data are collected during a project campaign using a gas volume flow meter and the data output will be processed using appropriate software programs. The analyzer will be calibrated according to vendor specifications and recognized industry standards

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.7	$N_2O_{conc,n}$	N_2O concentration in the stack gas at normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3 (converted from ppm if necessary)	m	Every one minute	The data are collected during a project campaign using a N_2O analyzer and the data output will be processed using appropriate software programs. The analyzer will be calibrated according to vendor specifications and recognized industry standards
5.7	OH_n	Operating hours during the project campaign	hours	o	Daily, totaled for the entire campaign	Plant manager records the hours of full operation of the plant during a campaign

6.5 Monitoring Parameters for Tertiary Catalyst Projects

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.2.

Table 6.2. Monitoring Parameters for Tertiary Catalyst Projects

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
General Project Parameters						
	Regulations	Project developer attestation of compliance with legal requirements relating to the project	All applicable regulations	n/a	Each verification	Information used to: 1) Demonstrate ability to meet the Legal Requirement Test – where regulation would require the abatement of N_2O or the installation of certain NO_X emission control technology that will impact N_2O emissions 2) Demonstrate compliance with all applicable regulations, e.g., criteria pollutant emission standards, health and safety, etc.
	OT_h	Allowable range for oxidation temperature	°C	c	Once	To be obtained from the operating condition campaigns

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
	OT_a	Actual operating temperature range	°C	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation temperature according to this protocol
	OP_h	Allowable range for oxidation pressure	bar	c	Once	To be obtained from the operating condition campaigns
	OP_a	Actual oxidation pressure	bar	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation pressure according to this protocol
		Ammonia-to-air ratio	%	m, c	Every hour	This percentage is calculated as $NH_3/(NH_3$ + air), using units of either mass or volume
		Maximum ammonia-to-air ratio	%	c	Once	To be obtained from the operating condition campaigns
5.8	ER	Emission reductions for the reporting period	tCO_2e	c	Per reporting period	
5.9, 5.10	$HNO_{3,MAX,scaled}$	Historical maximum annual average nitric acid production	$tHNO_3$	c	Once	Calculated from campaign-specific production data, averaged over 12 month intervals and scaled to the length of the reporting period
5.9	$HNO_{3,MAX}$	The historical maximum annual average total output of 100% concentration nitric acid	$tHNO_3$/day	o	Once	
5.9	OD_n	Number of days of operation during the project campaign	days	o	Per campaign	
Baseline Calculation Parameters						
5.8, 5.10	BE	Baseline emissions for the reporting period	tCO_2e	c	Per reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.10, 5.12	F_i	Volume flow rate, expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	m	Every one minute	The data is collected using a gas volume flow meter and the data output will be processed using appropriate software programs
5.10	$N_2O_{conc,in,i}$	N_2O concentration at inlet to tertiary catalyst, expressed in normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3	m	Every one minute	The data is collected using a N_2O analyzer and the data output will be processed using appropriate software programs
5.10, 5.12	OH_i	Operating hours during interval i	hours	m, r	After every interval is completed	
5.10, 5.12	$HNO_{3,RP}$	Plant output of HNO_3 during the reporting period	$tHNO_3$	m	Daily, totaled for the reporting period	
5.10	BE_i	Baseline emissions during interval i when NAP is operating outside of AOC	tCO_2e	c	Per interval whenever necessary	
5.10	$HNO_{3,i}$	Total nitric acid produced during interval i when NAP is operating outside of AOC	$tHNO_3$	m	Daily, totaled for the interval whenever necessary	
5.10	EF_{IPCC}	IPCC default emission factor	$kgN_2O/tHNO_3$	r	Per interval whenever necessary	Choose the default factor corresponding to the calendar year of the reporting period (see Table B.1)
5.18	ST_{BL}	Baseline steam export	MW	c	Once	
5.19	EE_{BL}	Baseline energy export from tail gas utilization	MW	c	Once	
Project Calculation Parameters						
5.8, 5.11	PE	Project emissions for the reporting period	tCO_2e	c	Per reporting period	
5.11, 5.12	PE_{N2O}	GHG emissions from N_2O in the tail gas during the reporting period	tCO_2e	c	Per reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.11, 5.13	PE_{NH3}	GHG emissions from the ammonia input used to operate the tertiary catalyst during the reporting period	tCO_2e	c	Per reporting period	
5.11, 5.14	PE_{HC}	GHG emissions from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.11, 5.17	PE_{EE}	GHG emissions from external energy used during the reporting period	tCO_2e	c	Per reporting period	
5.12	$N_2O_{conc,out,i}$	N_2O concentration at outlet of tertiary catalyst facility, expressed in normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3	m	Every one minute	The data is collected using a N_2O analyzer and the data output will be processed using appropriate software programs
5.13	Q_{NH3}	Project ammonia input	tNH_3	m	Monthly	Measured if no SCR de-NO_X unit is installed in the baseline scenario
5.14, 5.15	$CO_{2,HC}$	GHG emissions as CO_2 from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.14, 5.16	$CH_{4,HC}$	GHG emissions as CH_4 from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.15	ρ_{HC}	Hydrocarbon density	t/m^3	m	Per reporting period	
5.15	Q_{HC}	Quantity of hydrocarbon input during the reporting period (not methane)	m^3	o	Daily	
5.15	EF_{HC}	Hydrocarbon emission factor (not methane)	tCO_2/tHC	c	Per reporting period	Given by the molecular weight of the hydrocarbon and CO_2 and the chemical reaction when hydrocarbons are converted (CDM AM0028)

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.16	ρ_{CH4}	Methane density	t/m^3	m	Per reporting period	
5.16	Q_{CH4}	Quantity of methane used during the reporting period	m^3	o	Daily	
5.17, 5.18	SE	Emissions from net change in steam export during the reporting period	tCO_2e	c	Per reporting period	
5.17, 5.19	TGU	Emissions from net change in tail gas utilization during the reporting period	tCO_2e	c	Per reporting period	
5.17, 5.20	TGH	Emissions from net change in tail gas heating during the reporting period	tCO_2e	c	Per reporting period	
5.18	ST_{PR}	Project steam export	MW	c	Once	
5.18, 5.19	OH_{RP}	Operating hours during the reporting period	hours	o	Totaled once for reporting period	
5.18	η_{ST}	Steam generation efficiency	%	c	Once	Based on manufacturer information
5.18	EF_{ST}	Steam generator emission factor	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value
5.19	EE_{PR}	Project energy export from tail gas utilization	MW	c	Once	
5.19	η_r	Efficiency of replaced technology	%	c	Once	Based on manufacturer information
5.19	EF_r	Fuel emission factor for replaced technology	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value
5.20	EI_{TGH}	Additional energy input for tail gas heating	MWh	m or c	Monthly	
5.20	η_{TGH}	Efficiency of additional tail gas heating	%	c	Once	Based on manufacturer information
5.20	EF_{TGH}	Fuel emission factor for external tail gas heating	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value

7 Reporting Parameters

This section provides guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit verified emission reduction reports to the Reserve for every reporting period (i.e., at least once per complete campaign).

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register a N_2O abatement project.

- Project Submittal form
- Project diagram (diagram of the NAP showing where the project is located within the NAP, as well as location of monitoring equipment)
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form

At a minimum, the above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available by the project developer on a voluntary basis. Project submittal forms and project registration information can be found at http://www.climateactionreserve.org/how/program/documents/.

7.2 Joint Project Verification

Because the protocol allows for multiple projects at a single nitric acid production facility, project developers have the option to hire a single verification body to verify multiple projects at a facility through a "joint project verification." This may provide economies of scale for the project verifications and improve the efficiency of the verification process.

Under joint project verification, each project, as defined by the protocol, is submitted for listing, listed, and registered separately in the Reserve system. Furthermore, each project requires its own separate verification process and Verification Statement (i.e., each project is assessed by the verification body separately as if it were the only project at the facility). However, all projects may be verified together by a single site visit to the facility. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Regardless of whether the project developer chooses to verify multiple projects through a joint project verification or pursue verification of each project separately, the documents and records for each project must be retained according to this section.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Copies of all solid waste, air, water, and land use permits, Notices of Violations (NOVs), and any administrative or legal consent orders dating back at least 3 years prior to the project start date, and for each subsequent year of project operation
- Project developer attestation of compliance with regulatory requirements relating to the N_2O abatement project
- Plant design information (nameplate capacity and operating parameters per manufacturer's operating manual) and diagrams/drawings of the NAP
- Diagram schemes showing the type of and detailed components of the N_2O abatement system and where it is or where it will be installed
- Automated extractive gas analyzer or monitor information (model number, serial number, calibration procedures)
- Gas volume flow meter information (model number, serial number, calibration procedures)
- Plans or diagram schemes showing the selection of data measuring points upstream and/or downstream to the N_2O abatement system
- Calibration results for all meters
- Information relevant to the primary (ammonia oxidation) catalysts (composition, campaign lengths, installation, and maximum permitted ammonia gas flow rates and ammonia-to-air ratio as specified by the catalyst manufacturer)
- Information relevant to the N_2O abatement catalysts (composition, campaign lengths, and installation)
- The total production of nitric acid per campaign and the number of operating hours
- CO_2e annual tonnage calculations
- Verification records and results
- All maintenance records relevant to the N_2O abatement system and monitoring equipment

Calibrated gas analyzer information that the project developer should retain includes:

- Date, time, and location of N_2O measurement
- N_2O measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.4 Reporting Period and Verification Cycle

Project developers must report GHG reductions resulting from project activities during each reporting period. A reporting period must represent a full campaign, defined as the full length of operation of one set of primary catalyst gauzes (i.e., the time between new catalyst installations or new charges of catalyst gauze), except as otherwise allowed in Section 7.4.1 (sub-campaign verification). A reporting period may exceed 12 months in length when a single campaign exceeds 12 months, in which case the reporting period may match the length of the campaign. One site visit is required per verification or per year, whichever is less frequent. Reporting periods must be contiguous; there must be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced. Occasionally, certain types of maintenance activities may be required at the plant that may interrupt project activities. Such maintenance periods, defined as a period during which no ammonia is flowing and no nitric acid is produced, are permissible with the following caveats to ensure continuous reporting for the project:

- Maintenance periods must be included within the dates of a reporting period to ensure continuous reporting.
- The data generated during the maintenance period (e.g., OH, F, N_2O_{conc}, T, P) shall be excluded when performing the calculations in Section 5.
- Monitoring equipment may be removed during these maintenance periods, as necessary, and the related QA/QC requirements may be suspended during that time.
- Once production commences following a maintenance period, daily QA/QC requirements must be met, and the schedule of quarterly, semi-annual, and annual QA/QC requirements must resume in a timely manner, so as to continue to meet the requirements of Section 6.
- The project developer must demonstrate to the verifier that no ammonia was flowing and no nitric acid was produced during a maintenance period.

If a campaign spans multiple calendar years, then the emission reductions shall be calculated for the entire campaign, and then scaled for each vintage year based on operating hours.

7.4.1 Sub-Campaign Verification

A project developer may choose to verify a reporting period that spans less than a full campaign (as defined above). Any such reporting period is referred to as a "sub-campaign reporting period." For any sub-campaign reporting period whose end date is prior to the completion date of a full campaign, the project developer must apply a 5% discount to the total emission reductions quantified and reported for that reporting period (the results of either Equation 5.1 or Equation 5.8). Upon completion of the full campaign, the project developer must quantify the emission reductions for the entire campaign, following the guidance in Section 5. The emission reductions reported for the final sub-campaign reporting period shall be equal to the reductions quantified over the full campaign minus the sum of emission reductions that were reported for prior sub-campaign reporting periods within the same campaign (see Box 7.1 for an example).

Box 7.1. Quantification of Sub-Campaign Reporting Periods

This methodology was developed to allow project developers increased flexibility in the reporting and registration of emission reductions from nitric acid production projects. Due to the potential risk of overestimation from this practice, the quantification of sub-campaign reporting periods differs slightly from the quantification of a full campaign reporting period.

Example:

A nitric acid plant operates a full campaign of its primary gauze from the first day of January through the last day of October of the same year. The project developer wishes to split this campaign into two reporting periods of equal length, each representing five months of data. The tables below illustrate the emission reductions that would be reported in this scenario, compared to what would be reported if the developer chose full campaign verification.

Sub-campaign quantification

Reporting Period	Baseline Emissions	Project Emissions	Calculated Emission Reductions	Deduction	Reported Emission Reductions
January – May	300,000	200,000	100,000	5,000 (5% discount)	**95,000**
June – October	600,000	400,000	200,000	95,000 (previously reported emission reductions)	**105,000**
				Total for campaign	**200,000**

Full campaign quantification

Reporting Period	Baseline Emissions	Project Emissions	Calculated Emission Reductions	Deduction	Reported Emission Reductions
January – October	600,000	400,000	200,000	0	**200,000**
				Total for campaign	**200,000**

Note: This example and the calculations are simplified for illustrative purposes.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions from projects developed to the standards of this protocol. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities in the context of reducing nitrous oxide emissions through secondary and tertiary abatement projects at nitric acid plants.

Verification bodies trained to verify nitric acid production projects must conduct verifications to the standards of the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Nitric Acid Production Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify nitric acid production project reports. Verification bodies approved under other project protocol types are not permitted to verify nitric acid production projects. Information about verification body accreditation and Reserve project verification training can be found in the Verification Program Manual.

8.1 Verification of Multiple Projects at a Single Nitric Acid Production Facility

Because the protocol allows for multiple projects at a single nitric acid production facility, project developers have the option to hire a single verification body to verify multiple projects under a joint project verification. This may provide economies of scale for the project verifications and improve the efficiency of the verification process. Joint project verification is only available as an option for a single project developer; joint project verification cannot be applied to multiple projects registered by different project developers at the same facility.

Under joint project verification, each project, as defined by the protocol, must be registered separately in the Reserve system and requires its own verification process and Verification Statement (i.e., each project is assessed by the verification body separately as if it were the only project at the facility). However, all projects may be verified together by a single site visit to the facility. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Finally, the verification body may submit one Notification of Verification Activities/Conflict of Interest (NOVA/COI) Assessment form that details and applies to all of the projects at a single facility that it intends to verify.

If during joint project verification, the verification activities of one project are delaying the registration of another project, the project developer can choose to forego joint project verification. There are no additional administrative requirements of the project developer or the verification body if joint project verification is terminated.

8.2 Sub-Campaign Verification

Per Section 7.4.1, a project developer may choose to verify a reporting period that spans less than a full campaign (i.e., sub-campaign reporting period). When a project developer has reported on a sub-campaign basis, the verification body must ensure that the discounts and deductions in Section 7.4.1 have been applied correctly. Specifically, when verifying the final reporting period of a campaign, the verification body must confirm the emission reduction calculations for the entire campaign, not just the final reporting period. The verification body does not need to reconfirm any eligibility requirements, QA/QC requirements or calculations for previously registered sub-campaign reporting periods. The verification body does need to confirm that the calculations for the final reporting period of a campaign are based on data from the full campaign, including any data previously verified for the prior sub-campaign reporting periods.

8.3 Standard of Verification

The Reserve's standard of verification for nitric acid production projects is the Nitric Acid Production Project Protocol, the Reserve Program Manual, and the Verification Program Manual. To verify a nitric acid production project developer's project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.4 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 and Table 6.2 are collected and recorded.

8.5 Verifying Eligibility Criteria

Verification bodies must affirm nitric acid production project eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for a nitric acid production project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items lists in Section 8.6.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Start date may be no more than 6 months prior to project submittal	Once during first verification
Location	United States and its territories	Once during first verification
Performance Standard	▪ Secondary catalyst projects: installation of a secondary N_2O abatement catalyst in a nitric acid plant ▪ Tertiary catalyst projects: installation of a tertiary N_2O abatement catalyst or NSCR in a nitric acid plant	Once during first verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures that lay out procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance attesting that project is in material compliance with all applicable laws	Every verification
Exclusions	▪ Nitric acid plants that are restarted any time after December 2, 2007, after being out of operation for a period of 24 months or longer ▪ New nitric acid plants constructed after December 2, 2009, with the exception of new nitric acid plants for which a permit application for construction was submitted to the appropriate government authorities prior to December 2, 2009 ▪ Secondary catalyst projects at existing nitric acid plants where NSCR is currently operating ▪ Secondary catalyst projects at existing nitric acid plants that used NSCR technology at any point since December 2, 2007	Every verification

8.6 Core Verification Activities

The Nitric Acid Production Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with reducing N_2O emissions at nitric acid plants. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a nitric acid production project, but verification bodies shall also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the facility operator uses to gather data on plant operations and N_2O emissions and to calculate baseline and project emissions.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.7 Nitric Acid Production Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a nitric acid production project. The tables include references to the section in the protocol where requirements are further described. The tables also identify items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables should not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to nitric acid production projects that must be addressed during verification.

8.7.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance regarding eligibility and Climate Reserve Tonne (CRT) issuance for nitric acid production projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.1 – 2.1.3	Verify that the project meets the project definition and is properly defined as a secondary catalyst or tertiary catalyst project	No
2.1	Verify whether the nitric acid plant is existing, upgraded, relocated or restarted	No
2.2	Verify ownership of the reductions by reviewing the Attestation of Title	No
3.1	Verify that the project only consists of activities at a single nitric acid plant at a nitric acid production facility operating within the U.S. or its territories	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that the project campaign began less than 10 years after the start date of the current crediting period	No
3.4.1	Verify that the project meets the appropriate Performance Standard Test for the project type	No
3.4.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.4.2	Confirm that neither the Title V nor PSD permit for the NAP includes language requiring installation of a secondary or tertiary catalyst	No
3.4.2	Verify that the Monitoring Plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
3.5	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No
6.1 – 6.3	Verify that all components of the CEMS adhered to the field check and calibration schedule specified in the protocol. If they do not, verify that a variance has been approved for monitoring variations or that adjustments have been made to data per the protocol requirements	No
6.1.1	Verify that installation and initial certification of the N_2O CEMS were completed according to manufacturer specifications and the requirements of this protocol	No
6.1.2	Verify that the calibration test procedures were properly followed, including the calibration error test and linearity check	No
6.1.3	Verify that the relative accuracy test audits were completed according to the required procedure and schedule	No
6.3	If used, verify that data substitution methodology was properly applied	No
n/a	If any variances were granted, verify that variance requirements were met and properly applied	Yes

8.7.2 Quantification of GHG Emission Reductions

Table 8.3 lists the items that verification bodies shall include in their risk assessment and recalculation of the project GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project diagram for the reporting period	No
5.1.1, 5.2.1	Verify that the project developer has correctly calculated and applied $HNO_{3,MAX,scaled}$	No

Protocol Section	Quantification Item	Apply Professional Judgment?
5.1.2, 5.2.2	Verify that the project developer correctly calculated allowable operating ranges for temperature and pressure, and maximum ammonia flow rates and ammonia-to-air ratios, and note which method was used	No
5.1.3.1	Verify that the project developer correctly accounted for the operating conditions and parameters in the baseline sampling period for the secondary catalyst project	No
5.1.3.2, 5.1.4.1	Verify that the project developer correctly calculated the baseline and project N_2O emission factors for the secondary catalyst project	No
5.2.3, 5.2.4	Verify that the project developer correctly accounted for N_2O emissions at the inlet and outlet of the destruction facility for the tertiary catalyst project	No
5.2.4.2	Verify that the project developer correctly quantified ammonia input to the tertiary catalyst project or correctly assumed no change in ammonia input	No
5.2.4.3	Verify that the project developer correctly quantified hydrocarbon use for tertiary catalyst project	No
5.2.4.4	Verify that the project developer correctly quantified external energy inputs or was correct in not estimating this source due to capture and use of the additional energy within the system	Yes
5.1.4, 5.2.4	Verify that the project emissions calculations were calculated according to the protocol with the appropriate data	No
7.4.1	If the project developer has elected to divide a campaign into sub-campaign reporting periods, verify that the quantification is executed according to guidance in the protocol	No

8.7.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project monitoring plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6, 7.3	Verify that all required records have been retained by the project developer	No

8.8 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report,

preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

As stated in Section 8.1, project developers may choose to have a verification body conduct multiple project verifications at a single facility under a joint project verification. The verification body must verify the emission reductions entered into the Reserve system for each project and upload a unique Verification Statement for each project within the joint verification. The verification body can prepare a single Verification Report that contains information on all of the projects, but this must also be uploaded to every project under the joint verification.

9 Glossary of Terms

Allowable operating conditions (AOC)	Operating conditions of the nitric acid plant must be established for the oxidation temperature range, oxidation pressure range, and the maximum ammonia-to-air ratio input to the ammonia oxidation reactor. These conditions ensure that N_2O emissions during the baseline sampling period are representative of typical historical N_2O emissions for the nitric acid plant and that baseline conditions are comparable to project conditions. See Section 5.1.2 for further detail.
Ammonia-to-air ratio	The ammonia-to-air ratio is represented as $NH_3/(NH_3 + air)$, using units of either mass or volume. The term AIFR or 'air input flow rate' is sometimes used to refer to the ammonia-to-air ratio.
Baseline sampling period	Determination of baseline emission factor through continuous monitoring of N_2O concentration and gas flow volume for a minimum of the first ten weeks after the start of a campaign and prior to secondary catalyst installation.
Campaign	The full length of operation of one set of primary catalyst gauzes (i.e., the time between new catalyst installations or new charges of catalyst gauze).
Continuous emission monitoring system (CEMS)	The monitoring system required under this project protocol for all projects for the direct measurement of the N_2O concentration in the stack gas and the flow rate of the stack gas.
Crediting Period	The crediting period is approximately ten years in length, aligning with the end of the last full campaign that begins in the tenth year of reporting.
Effective Date	The date of adoption of this protocol by the Reserve Board.
Existing NAP	Refers to a NAP with an existing ammonia oxidation reactor operating at existing production capacity.
Joint project verification	Project verification option where a project developer hires a verification body to verify multiple projects at a nitric acid production facility.
Nitric acid (HNO_3)	100% concentrated nitric acid.
Nitric acid plant (NAP)	A facility producing nitric acid by either a pressure or atmospheric pressure process from a single process unit.
NSCR	Non-selective catalytic reduction system designed originally for NO_X abatement, which may qualify as a tertiary catalyst project provided the project requirements under this protocol are met.
Operating manual	An operating manual for NAP equipment is defined as one or more current, detailed, engineering document(s) that establish operational constraints and optimal ranges for temperature, pressure, and ammonia-to-air ratio, developed for the NAP by either the NAP equipment manufacturer or a third-party engineering firm that manages NAP equipment use, upgrade, and replacement.
Project diagram	A diagram of the NAP equipment and processes.
Relocated NAP	A NAP that has been moved from another geographic location to its current location.

Reporting period	Specific time period of project operation for which the project developer has calculated and reported emission reductions and is seeking verification and registration. Reporting periods are equal to the length of one campaign, unless the project developer elects to conduct a sub-campaign verification according to the requirements of Section 7.4.1.
Restarted NAP	A NAP that commenced production after December 2, 2007 after being out of operation for 24 months or less.
Secondary catalyst project	A N_2O emission reduction project that installs and operates a dedicated N_2O abatement catalyst inside or immediately below the ammonia oxidation reactor.
Stack gas	Gases in the stack, after any NO_X or tertiary abatement, to be emitted into the atmosphere.
Sub-campaign reporting period	A reporting period that spans a period of time less than a full length of a campaign.
Tail gas	All gases (e.g., NO_X and N_2O) exiting the absorbing tower before any NO_X or tertiary abatement.
Tertiary catalyst project	A N_2O emission reduction project that installs and operates a dedicated N_2O abatement catalyst in the tail gas leaving the absorption tower (catalytic decomposition) or a NSCR unit.
Upgraded NAP	A NAP that has been modified in any way to increase production capacity and/or design capacity prior to the project start date or any time during the project crediting period.
Verification cycle	The Reserve requires verification of projects separately for each reporting period, but does not require verifications to be completed on specific dates. Project developers define the reporting period to be verified. Thus, each project has a unique verification cycle that begins the first time a project is verified, occurs at least once per reporting period, and ends once the crediting period expires or the project is no longer eligible, whichever happens first.

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Appendix A Summary of Performance Standard Development

The following performance standard analysis was conducted for the development of the Nitric Acid Production Project Protocol Version 1.0. Regulatory requirements affecting nitric acid production facilities have been fully updated in Section 3 of this protocol.

A.1 Federal and State Regulations

A comprehensive review of federal regulations and standards that apply to monitoring and controlling air emissions from nitric acid plants was undertaken by the Reserve, including the New Source Performance Standard and New Source Review programs under the Clean Air Act. The review found that while N_2O emissions from nitric acid production are not regulated – entities responsible for the production of nitric acid are not required to report on or limit N_2O emissions from their facilities – existing federal air quality regulations do limit NO_X emissions from nitric acid production, which may require the use of NO_X emission controls for some facilities.

Under 1998 EPA NO_X Transport Rule (also known as the EPA NO_X SIP Call),[39] EPA called for 23 states in Eastern U.S. to revise their State Implementation Plans (SIPs) and NO_X budget or emission targets for each of these states to achieve ozone attainment. It also set up a NO_X emissions trading program in which the states could participate. The definition of NO_X under the NO_X SIP is "the sum of nitric oxide and nitrogen dioxide in the flue gas or emission point, collectively expressed as nitrogen dioxide."[40] There is no specific federal mandate to the states to regulate or monitor N_2O in the revision of their SIPs.

In response to federal and state regulations, most nitric acid production facilities in the United States are operating some form of NO_X emission controls. As discussed further below, NO_X emission controls can indirectly impact N_2O emissions and therefore the extent to which specific technologies are deployed at nitric acid plants was evaluated to identify common practice for NO_X and incidentally N_2O emission controls.

Nitric acid plants with a Title V permit or that are subject to NSPS are required to implement certain monitoring requirements in accordance with Title 40 of the Code of Federal Regulations Part 75 on continuous emission monitoring systems. EPA has also issued a Rule for Mandatory Reporting of Greenhouse Gases under which nitric acid plants are required to report annual GHG emissions data starting in 2010. Nitric acid plants are to undergo an annual performance test under normal operating conditions, without N_2O emissions controls operating, and to use the emissions data to derive a site specific emission factor. Alternatively, nitric acid plants can use CEMS for N_2O to measure and report N_2O emissions. The mandatory reporting rule does not require implementation of actions to reduce N_2O emissions.

Under the Clean Air Act, the EPA has also been developing the Clean Power Plan, which will set standards for power plants and drive emission reductions at the state level. Though the U.S. Supreme Court stayed implementation of the Clean Power Plan on February 9, 2016, the Reserve does not anticipate the Clean Power Plan requiring any emission reductions or

[39] See 40 CFR. §51.121 & §51.122 and http://www.epa.gov/air/urbanair/nox/effrt.html.
[40] See 40 CFR. §51.9.

installation of emission reduction technology at nitric acid plants, such as those eligible under this protocol.[41]

A.2 NO_X Emission Controls

There are three commonly used NO_X emission control technologies in the U.S.: NSCR, SCR, and extended absorption, with average NO_X control efficiencies of 97.7%, 86.0-97.2%, and 94.6%, respectively.[42]

NSCR

NSCR is added after the ammonia burner and treats the absorber tail gas before it is emitted to the atmosphere. It uses a catalyst to consume oxygen in the tail gas of the absorber, converts NO_2 to NO (to decolor the tail gas) and reduces NO to elemental N.[43] Additional fuel is required to run NSCR and an energy recovery unit must also be installed to handle excess heat generated by NSCR. The process is "non-selective" because all oxygen present in the tail gas is consumed, thus limiting all reactions requiring O_2, including reactions that produce N_2O. Some suggest that NSCR may destroy up to 80-90% of all N_2O produced during nitric acid production.[44] Others report NSCR N_2O control efficiency of about 70%.[45]

NSCR was commonly installed in new plants built in the 1970s. NSCR can be operated at any pressure, retrofitted to new plants, used in conjunction with other NO_X control techniques, and heat generated by NSCR can be recovered and used to supply energy for process compression.

SCR

Like NSCR, SCR is also added after the ammonia burner and treats the absorber tail gas before it is emitted to the atmosphere. However, SCR uses ammonia, O_2, and a catalyst to reduce NO_X to elemental N. The ammonia preferentially reacts with NO_X, making it a selective process.[46] SCR requires the use of additional ammonia, can operate at any pressure, can be retrofitted to existing low-pressure plants and is well suited for new plant applications. There are costs savings to SCR relative to NSCR because it does not cause the same high temperatures and thus energy recovery equipment is not required.[47] Beginning in the late 1970s, NSCR technology started to be replaced by SCR technology. However, older plants designed around NSCR would likely require a complete redesign of the existing plant to replace the NSCR NO_X control system with SCR and this is not considered by industry to be practical or economic.[48] SCR can have at least a slight unintentional impact on N_2O emissions (+/- <5% of total emissions).

Extended Absorption

Extended absorption improves production efficiency of HNO_3 by increasing the absorption of NO_2 in the absorption tower. As a result, less NO_2 is available to convert to NO_X, thereby

[41] EPA, "Clean Power Plan for Existing Power Plants," https://www.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants
[42] EPA-450/3-91-026: Alternative Control Techniques Document: Nitric and Adipic Acid Manufacturing Plants (1991).
[43] Ibid.
[44] Personal communication with project developers.
[45] Value provided by ClimeCo (project developers) based on NSCR N2O removal testing by a few of their customers.
[46] Ibid.
[47] Ibid.
[48] Based on a stationary source permit review for the construction and operation of modifications at a PCS Nitrogen facility located in Augusta, Georgia, published by the Georgia Department of Natural Resources.

lowering NO_X emissions. This is achieved by increasing the volume and number of absorption trays, which is accomplished either by adding a second absorption tower or extending the height of an existing tower.[49] Because of the production efficiencies involved, extended absorption is a standard component of new facilities and a common add-on to old ones. New plants are generally designed with a single large tower and retrofits typically involve adding a second absorption tower in series. Extended absorption is believed to have no impact on N_2O emissions.

A.3 Current Industry Practice for using NO_X Emission Controls

The U.S. EPA maintains a facility-level database to support development of the U.S. national greenhouse gas inventory and published a summary of these data in a technical support document (TSD) for the mandatory GHG reporting rule.[50] The EPA database was assembled from permit data and personal communications with nitric acid facility contacts.

Members of the Nitric Acid Production Project Protocol stakeholder workgroup (assembled for the development of this protocol) provided additional information to expand the database. For example, Terra Industries provided the Reserve with data on nine process units it owns and operates in the U.S. These data were used to fill some gaps in the EPA database and to describe two additional process units not in the EPA database.

According to the EPA database, there are 45 nitric acid production facilities operating in 25 states with a total of 65 process units (plants). The EPA database and information provided by Terra Industries were used to summarize data on NO_X emission control technologies currently in use at 34 N_2O plants in the U.S. In addition, two workgroup members provided summary data based on their knowledge of the industry and confidential industry surveys. Trends from all sources are shown in Table A.1.

All data sources show SCR as the most common NO_X emission control technology currently in use, with market penetration of at least 75%. However, the EPA database appears to under-represent the number of process units with NSCR currently installed. Therefore, market penetration for NSCR is more difficult to pinpoint. These data suggest NSCR installations range from 6% to 20% (i.e., 4 to 13 process units).

Table A.1. Current Industry Practice for Use of NO_X Emission Control Technologies

	EPA Database (N=34) % (n)	Workgroup Report 1 (N≈40) % (n)	Workgroup Report 2 (N=60) % (n)
SCR	76.47% (26)	75% (30)	80% (48)
Extended absorption	11.76% (4)	---	---
NSCR	5.88% (2)	20% (8)	20% (12)
None	5.88% (2)	2.5% (1)	---
Other (peroxide-based NO_X abatement)	---	2.5% (1)	---

According to the EPA data, extended absorption is used by less than a quarter of process units. No information on extended absorption was provided by workgroup members, because it is not

[49] Ibid.
[50] http://epa.gov/climatechange/emissions/downloads/tsd/TSD%20Nitric%20Acid%20_EPA%201-22-09.pdf

widely considered by the industry as an emission control technology *per se*, but rather a standard for production efficiency. The EPA data are surprising, given reports that extended absorption is a cost-effective means to increase HNO_3 production and a standard component of facilities. The Reserve suspects that the EPA database underestimates the number of plants operating with extended absorption.

The most commonly used technology for NO_X emission control is SCR. NSCR, which also controls N_2O, was more common before the 1970s; however since then, SCR technology has been widely applied because of its cost effectiveness. While NSCR is less common, it is still used by as many as 20% of existing process units. Therefore, N_2O is being abated currently at as many as 12 process units. As a result, the opportunities to further destroy N_2O from these facilities are limited.

A.4 Current Industry Practice for Using N_2O Emission Controls

Installation of N_2O emission controls is not standard industry practice anywhere globally and it has only been recently that the technologies were developed (i.e., since the onset of compliance and voluntary GHG markets). At the time of protocol development, CDM methodologies have been approved for both secondary (AM0034) and tertiary abatement (AM0028). At that time, 42 projects using secondary abatement (following AM0034) were being implemented outside of North America with estimated reductions of 9,942,836 tCO_2e/year. Fifteen tertiary abatement projects were being implemented outside North America using AM0028 with estimated reductions of 7,415,849 tCO_2e/year. Since 2010, when the Reserve completed development of its Nitric Acid Plant Project Protocol, Version 1.0, the CDM methodologies have undergone a number of revisions. Since May 31, 2013, the CDM methodology which address N_2O abatement from nitric acid production has been ACM0019 (version 2.0), which is the CDM methodology upon which the NAPPP Version 2.1 protocol update is based.

The EPA database does not cover use of dedicated N_2O emission control technologies (NSCR is reported because of its use as a NO_X control technology). However, according to the Terra Industries representative and others on the workgroup, there are only two N_2O abatement units operational in the United States. Both are secondary abatement units operated by Terra Industries. They have been installed at two process units in different locations to demonstrate the efficacy of the technology and to demonstrate positive action towards reducing GHG emissions.

A.5 Baseline Scenarios for NO_X Emission Controls and N_2O Emissions

The most plausible baseline scenario for nitric acid plants with regard to NO_X emission controls is for the continued use of SCR technology, which has minimal impact on N_2O emissions. This includes at existing, upgraded, relocated, or restarted plants. SCR technology enables compliance with existing NO_X regulations, is cost effective compared to other NO_X control technologies, and is considered the industry standard. Historically, there was a transition from using the older, now outdated NSCR technology to SCR and there is little chance for reversing that trend under business as usual conditions.

Nitric acid plants currently operating with NSCR are likely to continue using this technology unless they undergo a significant plant upgrade. In cases where NSCR is replaced with SCR, there are implications for N_2O emissions (i.e., a shift from NSCR to SCR would increase N_2O emissions in the baseline scenario). In addition, the opportunity for additional N_2O emissions

reductions from plants operating NSCR are relatively small compared to plants operating SCR or no NO_X controls.

There are believed to be very few process units operating without some form of NO_X emission control and in the event that emission controls would need to be added to these process units, it is probable that SCR would be the chosen technology.

A.6 Common Practice for Nitric Acid Production Levels

If a facility produces HNO_3 in excess of what would be produced under business as usual, a case can be made that more N_2O is generated and controlled by the abatement technology than would otherwise, resulting in emission reductions than should not be considered additional. Industry representatives on the stakeholder workgroup for this protocol contend that the economics of HNO_3 production make this scenario implausible as production levels are driven entirely by natural gas prices and market demand for raw and upgraded nitric acid products, and the cost to produce HNO_3 exceeds the potential revenue from carbon credits, based on current market conditions. (According to the workgroup, the current cost to produce one metric ton of 100% HNO_3 is approximately $90, with the corresponding potential to reduce about 2.5 metric tons of CO_2e.)

Appendix B Emission Factor Tables

Table B.1. Default Baseline Emission Factor for New Production in Excess of $HNO_{3,MAX,scaled}$ (EF_{New}) and Tertiary Projects Operating Outside AOC, as needed (EF_{IPCC})

Year	Emission Factor ($tN_2O/tHNO_3$)
2014	0.0035
2015	0.0034
2016	0.0032
2017	0.0030
2018	0.0028
2019	0.0027
2020	0.0025
After 2020	0.0025

Source: Clean Development Mechanism (CDM) ACM0019, Version 02.0.0, EB73.

CLIMATE ACTION RESERVE

Version 2.0 | October 17, 2018

Nitrogen Management

Project Protocol

Climate Action Reserve
www.climateactionreserve.org

Released October 17, 2018

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 3
2 The GHG Reduction Project 4
2.1 Background 4
2.2 Project Definition 4
2.2.1 Eligible Project Activities 7
2.2.2 Eligible Crops 9
2.2.3 Eligible Project Area 9
2.3 Defining the Cultivation Year 12
2.4 Project Ownership Structures and Terminology 12
2.4.1 Project Owners issued CRTs 13
2.4.2 Entities with Project Management Roles 14
2.4.3 Entering a Project 14
2.4.4 Leaving a Project 15
2.4.5 Forming or Entering a Cooperative 15
2.4.6 Leaving a Cooperative 16
3 Eligibility Rules 17
3.1 Location 17
3.2 Start Date 17
3.3 Reporting Period 17
3.4 Crediting Period 18
3.5 Additionality 19
3.5.1 The Performance Standard Test 19
3.5.2 The Legal Requirement Test 23
3.5.3 Ecosystem Services Payment Stacking 24
3.6 Regulatory Compliance 27
4 The GHG Assessment Boundary 29
5 Quantifying GHG Emission Reductions 33
5.1 Primary Effect N_2O Emission Reductions 35
5.1.1 N_2O Emission Reductions from Eligible Project Activities (NMQuanTool) 35
5.1.2 Baseline N Rates 36
5.1.3 Project Synthetic N Rates 40
5.1.4 N_2O Emissions from Increases in Organic N Rates 45
5.2 Secondary Effect GHG Emissions 51
5.2.1 GHG Emissions from Increased Electricity Usage 52
5.2.2 GHG Emissions from Increased Fossil Fuel Consumption 52
6 Project Monitoring 54
6.1 Project Monitoring Plan 54
6.2 Cooperative Monitoring Plans 55
6.3 Field and Project Data Monitoring Requirements 55
6.4 Supplemental Field Data Monitoring 70
7 Reporting and Record Keeping 71
7.1 Project Submittal Documentation 71
7.1.1 Determining Field Serial Numbers 71
7.2 Annual Reports and Documentation 71
7.2.1 Project Monitoring Report 72
7.2.2 Cooperative Monitoring Report 72
7.3 Record Keeping 72
7.3.1 Record Keeping for Projects 72

7.4 Project Reporting Period and Verification Cycle 73
7.4.1 Additional Reporting and Verification Options for Projects 73
8 Verification Guidance 75
8.1 Preparing for Verification 75
8.2 Verification Sampling and Schedule for Projects and Cooperatives 76
8.2.1 Verification Schedule 77
8.3 Standard of Verification 78
8.4 Monitoring Plan 78
8.4.1 Annual Reports 78
8.5 Verifying Eligibility at the Field Level 78
8.6 Core Verification Activities 79
8.7 Nitrogen Management Verification Items 80
8.7.1 Project Eligibility and CRT Issuance 81
8.7.2 Quantification 82
8.7.3 Risk Assessment 83
8.8 Successful and Unsuccessful Verifications 83
8.8.1 Field-Level and Project-Level Errors 83
8.8.2 Project-Level Errors 84
8.9 Completing Verification 85
9 Glossary of Terms 86
10 References 89
Appendix A Nitrogen Management Review 97
A.1 Nitrogen Management Stakeholder Survey 97
A.2 Literature Review 98
A.2.1 NMPP V1.0 Science Advisory Committee Findings 98
A.2.2 Results 99
A.3 Assessment of Excess Nitrogen Use 99
A.3.1 CEAP Cropland Survey Reports 99
A.3.2 USDA ERS Reports 102
A.3.2.1 *Conservation-Practice Adoption Rates Vary Widely by Crop and Region* 103
A.3.2.2 *Nitrogen in Agricultural Systems: Implications for Conservation Policy* 103
A.3.3 IPNI Nutrient Use Geographic Information System (NuGIS) 104
A.4 Summary of Findings 108
Appendix B Summary of Performance Standard Test Development and Additionality Assessment 109
B.1 Practices and Data Availability 109
B.2 Nitrogen Cycling and Nitrogen Use Efficiency 111
B.3 Partial Factor Productivity (PFP) as N Rate Reduction Performance Standard Threshold 113
B.4 Development of County- and Crop-Specific PFP Benchmarks 114
B.4.1 Database Overview 115
B.4.2 Estimating State Average N Rates for Non-Survey Years 117
B.5 Nitrogen Management Project Eligibility Lookup Tool 119
B.6 Use of Nitrification Inhibitor or Switch to Slow Release Fertilizer Performance Standard 120
B.7 Assessing Additionality in California 121
Appendix C Overview of Water Quality Regulations: Impacts on Legal Requirements and Regulatory Compliance 123
C.1 Clean Water Act 123
C.2 California Dairy General Order 125
C.3 California Irrigated Lands Regulatory Program 126

C.4 Coastal Zone Management Act....127
C.5 Safe Drinking Water Act....127
C.6 Fertilizer Content Labeling Laws....128
Appendix D Methodology for Determining $Frac_{LEACH}$ Values....129
Appendix E Default Values for Average Fertilizer N Concentration and Fertilizer Weights....131
Appendix F Modeling to Develop Nitrogen Management Quantification Tool (NMQuanTool) 132
F.1 Overview....132
F.2 Stratification: Geography and Associated Climate 133
F.3 Baseline Determination....134
F.4 Modeling Approach....136
F.5 Results....138
F.6 Tillage Practice and Increased N_2O Emissions 138
F.7 Uncertainty 139

List of Tables

Table 2.1. Eligible Project Activities.... 5
Table 2.2. Eligible Crops and Regions 6
Table 2.3. Project Ownership Types & Account Types....12
Table 3.1. Payment Stacking Scenarios....27
Table 4.1. Description of all Sources, Sinks, and Reservoirs....31
Table 5.1. 100-year Global Warming Potential for Non-CO_2 GHGs....33
Table 6.1. Field Monitoring Parameters....56
Table 6.2. Additional Field Management Data....68
Table 8.1. Summary of Field-Level Eligibility Criteria for a Nitrogen Management Project....79
Table 8.2. Eligibility Verification Items....81
Table 8.3. Quantification Verification Items....82
Table 8.4. Risk Assessment Verification Items....83
Table A.1. Priority Practices and Resources Supporting Consistent N_2O Emission Reductions 98
Table A.2. Findings from CEAP Cropland Reports on Regions Applying Appropriate N Rates 102
Table A.3. Shares of Treated Acres that Did Not Meet the Rate Criterion, by Crop, in 2006 ...104
Table A.4. Total Nitrogen Applications Above Criterion Rate by Farm Production Region, 2006 104
Table B.1. List of Priority Practices and Data Availability....110
Table B.2. NASS Crop-Specific Chemical Usage Survey Years....118
Table B.3. Yield Conversion Factors....119
Table D.1. Evapotranspiration Conversion Factors 129

List of Figures

Figure 2.1. Eligible County-Crop Combination 11
Figure 2.2. Example Cooperative Ownership/Management Structure 13
Figure 4.1. General Illustration of the GHG Assessment Boundary....30
Figure 5.1.Quantification of GHG Emission Reductions Overview....34
Figure A.1. 12 Watersheds (in yellow) for CEAP Cropland Regional Assessments....101
Figure A.2. 2014 IPNI NuGIS County-Level N Balance Data....106
Figure A.3. 2014 IPNI NuGIS County-Level N Use Data....107
Figure B.1. Nitrogen Sources, Cycling, and Losses in Agricultural Systems....111
Figure F.1. Cropland areas included in the analysis, overlaid with county-rectified CEAP regions....134

List of Equations

Equation 3.1. Annual Partial Factor Productivity (PFP) 20
Equation 3.2. Annual Total N Rate for Field in Project....20
Equation 3.3. Passing Performance Standard Test for Reducing Synthetic N Rates....21
Equation 3.4. Average Total N Rate for Field over Baseline Look-Back Period....22
Equation 3.5. Demonstrating Total N Rate Reduced from the Baseline to the Project....22
Equation 5.1. GHG Emission Reductions....35
Equation 5.2. Percentage Reduction in Synthetic N Rate from Baseline to Project....36
Equation 5.3. Sum of Primary Effect Emission Reductions for all fields in Project....36
Equation 5.4. Baseline Average Synthetic Fertilizer N Rate on Field....38
Equation 5.5. Baseline Annual Synthetic Fertilizer N Rate on Field in Year of Baseline Look-Back Period....39
Equation 5.6. N Rates for Dry N-Containing Synthetic Fertilizer in Year of Baseline Look-Back Period....39
Equation 5.7. N Rates of Liquid N-Containing Synthetic Fertilizer in Year of Baseline Look-Back Period....39
Equation 5.8. Baseline Average Organic Fertilizer N Rate on Field....39
Equation 5.9. Baseline Annual Organic Fertilizer N Rate on Field in Year of Baseline Look-Back Period....40
Equation 5.10. N Rates of Solid N-Containing Organic Fertilizer in Year of Baseline Look-Back Period....40
Equation 5.11. N Rates of Liquid N-Containing Organic Fertilizer in Year of Baseline Look-Back Period....40
Equation 5.12. Project Synthetic Fertilizer N Rate for Field....41
Equation 5.13. N Rates for Dry N-Containing Synthetic Fertilizer in Project....41
Equation 5.14. N Rates of Liquid N-Containing Synthetic Fertilizer in Project....41
Equation 5.15. Change in Synthetic N on Field from Previous Cultivation Year Not Claiming CRTs....42
Equation 5.16. Previous Cultivation Year Synthetic Fertilizer N Rate for Field....42
Equation 5.17. Normalized Project Yield for Each Year in the Baseline....44
Equation 5.18. Increase in Project Synthetic N Rate Due to Production Shifting (Leakage)....45
Equation 5.19. Primary Effect GHG Emissions from Increases in Organic N....45
Equation 5.20. Direct N_2O Emissions from Organic N Changes in the Corn Belt....46
Equation 5.21. Direct N_2O Emissions from Organic N Changes Outside the Corn Belt....46
Equation 5.22. N_2O Emissions from LVRO from Increases in Organic N Per Field....47
Equation 5.23. Change in N Rate of Organic Fertilizer for Field in Project....49
Equation 5.24. Project Organic Fertilizer N Rate for Field....49
Equation 5.25. N Rates of Solid N-Containing Organic Fertilizer in Project....49
Equation 5.26. N Rates of Liquid N-Containing Organic Fertilizer in Project....50
Equation 5.27. Change in N Rate of Organic Fertilizer for Field in Previous Cultivation Year....50
Equation 5.28. Previous Cultivation Year Organic Fertilizer N Rate for Field....51
Equation 5.29. Direct Secondary Effect Emissions from Project Activities....51
Equation 5.30. Increased Secondary Emissions from Electricity Use in Project....52
Equation 5.31. Option 1 – Increased Secondary Emissions from Fossil Fuel Use in Project....53
Equation 5.32. Option 2 – Increased Secondary Emissions from Fossil Fuel Use in Project....53

Abbreviations and Acronyms

ac	Acre or Acres
ARMS	USDA Agricultural Resource Management Survey
BMP	Best management practices
C-AGG	Coalition on Agricultural Greenhouse Gases
CFR	United States Code of Federal Regulations
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CPS	NRCS Conservation Practice Standard
CRT	Climate Reserve Tonne
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DNDC	DeNitrification-DeComposition (biogeochemical process model)
EEF	Enhanced efficiency fertilizer
EPA	United States Environmental Protection Agency
GHG	Greenhouse gas
GIS	Geographic Information System
HEL	Highly erodible land
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
lb	Pound
LVRO	Leaching, volatilization, and runoff
Mg	Megagram
MRTN	Maximum return to nitrogen
MRV	Monitoring, Reporting and Verification
MSU-EPRI	Michigan State University and Electric Power Research Institute
N_2O	Nitrous oxide
N	Nitrogen
NASS	USDA National Agricultural Statistics Service
NCR	North Central Region of the United States
NH_3	Ammonia
NH_4^+	Ammonium
NI	Nitrification inhibitor
NMPP	Nitrogen Management Project Protocol
NMP	Nutrient or Nitrogen Management Plan
NO_3^-	Nitrate
NO_x	Nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration

NPS	Nonpoint source
NRCS	Natural Resource Conservation Service of the USDA
NUE	Nitrogen use efficiency
PFP	Partial Factor Productivity
RCPP	Climate Action Reserve Rice Cultivation Project Protocol
Reserve	Climate Action Reserve
SAC	Climate Action Reserve Science Advisory Committee
SRF	Slow release fertilizer
SSR	Source, sink, and reservoir
T-AGG	Technical Working Group on Agricultural Greenhouse Gases
TMDL	Total maximum daily load
TSP	Technical Service Provider (recognized by NRCS)
USDA	United States Department of Agriculture

1 Introduction

The Climate Action Reserve (Reserve) Nitrogen Management Project Protocol (NMPP) provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the implementation of cropland nitrogen management best practices. This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a nitrogen management project.

The Climate Action Reserve is an environmental nonprofit organization that promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. A pioneer in carbon accounting, the Reserve serves as an approved Offset Project Registry (OPR) for the State of California's Cap-and-Trade Program and plays an integral role in supporting the issuance and administration of compliance offsets. The Reserve also establishes high quality standards for offset projects in the North American voluntary carbon market and operates a transparent, publicly-accessible registry for carbon credits generated under its standards.

Project developers that initiate nitrogen management projects use this document to quantify and register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual[1] and Section 1 of this protocol.

[1] Available online at http://www.climateactionreserve.org/how/verification/verification-program-manual/.

2 The GHG Reduction Project

2.1 Background

Nutrient management refers to the addition and management of nutrients and soil amendments to agricultural soils to increase the supply of essential nutrients to crops. Nitrogen is generally the most important nutrient from an agronomic standpoint, as it is typically the primary nutrient limiting crop yields and must often be added more frequently and in greater amounts than other nutrients such as phosphorus and potassium. Nitrogen is also the major soil nutrient of concern regarding GHG emissions, because once nitrogen enters the soil, it can be converted to nitrous oxide (N_2O), a potent GHG with a relatively high Global Warming Potential (GWP).[2] Nutrient management then, for the purposes of this protocol, is the management of nitrogen applied to agricultural soils, primarily via synthetic and organic fertilizers, and is hereafter referred to as Nitrogen Management.

Agricultural N_2O emissions are a key source of GHG emissions in the United States. In 2016, they accounted for approximately 76.7 percent of total N_2O emissions and 4.4 percent of total GHG emissions. Estimated emissions from this source in 2016 were 283.6 million metric tons of carbon dioxide equivalent (MMT CO_2e), which were 13.2 percent higher than 1990 levels. From 1990 to 2016, on average, cropland specifically accounted for approximately 70 percent of total direct N_2O emissions[3] and 81 percent of total indirect[4] N_2O emissions.[5]

The objective of a nitrogen management project under the Nitrogen Management Project Protocol (NMPP) is to reduce N_2O emissions by adopting practices that further improve Nitrogen Use Efficiency (NUE) beyond what is projected to typically happen in the future as standard nitrogen management practices, absent any incentives provided by a carbon market. The NMPP provides eligibility criteria for approved nitrogen management practices and approaches for quantifying N_2O emission reductions that occur as a result of adopting the approved practices for eligible crops in eligible regions across the United States.

2.2 Project Definition

For the purpose of this protocol, a nitrogen management project ("project") is defined as the adoption and maintenance of one or more *eligible project activities* during the cultivation year of an *eligible crop,* on one or more fields in an *eligible project area*, that reduce nitrous oxide (N_2O) emissions. Multiple fields, each employing a different combination of crops and project activities, may be managed together under a *single project*, across multiple owners and multiple regions. *Multiple projects* may also be managed together as a "project cooperative" or "cooperative", as described in Section 2.4.

[2] The global warming potential of N_2O in this protocol shall be 298 based on the IPCC's Fourth Assessment Report. This GWP will be used until further guidance is issued by the Reserve.
[3] N_2O emissions from the mineral N available at the site of the management activity(ies) for transformation through the nitrification-denitrification cycle; GHG sources, sinks, and reservoirs (SSR) 1 in this protocol.
[4] N_2O emissions that occur offsite as a portion of N escapes from the site via leaching, volatilization, or runoff (LVRO), and is subsequently converted to N_2O in another location where conditions are favorable; SSR 2 in this protocol.
[5] U.S. Environmental Protection Agency (2018a). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016*. EPA 430-R-18-003*, 5-26. Washington, D.C. Available at https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2016

Table 2.1 and Table 2.2 below provide a quick overview of the combinations of activities, crops, and regions that are approved under this protocol, as determined by:

1. The results of a literature review of nitrogen management practices shown to consistently reduce N_2O emissions (see Appendix A);
2. The data available for the development of performance standard tests for additionality (see Appendix B); *and*
3. The capabilities of an applicable quantification approach (see Appendix F).

As of the date of adoption of this protocol by the Reserve Board, only project activities listed in Table 2.1 are considered eligible for credit issuance.

Please note that the combination of eligible activities, crops and regions will change over time, as new data allows for the updating of the performance standard tests. The information contained in these tables is illustrative, representing eligible combinations at the time of protocol adoption.

Table 2.1. Eligible Project Activities

Category	Eligible Project Activities	Description
Required	Synthetic N Rate Reduction	Reduction in the annual synthetic nitrogen application rate compared to baseline levels, without going below N demand
Optional	Use of an Enhanced Efficiency Fertilizer (EEF)	*Either,* Application of *nitrification inhibitor* (NI) as defined by AAPFCO[6] and accepted for use by a state's fertilizer control agency, or similar authority *or,* Conversion from conventional fertilizer(s) to *slow release fertilizer* (SRF) as defined by AAPFCO and accepted for use by a state's fertilizer control agency, or similar authority

[6] Association of American Plant Food Control Officials. See http://www.aapfco.org/

Table 2.2. Eligible Crops and Regions

Crop	State[7]
Barley	AZ, CA, CO, ID, MN, MT, ND, OR, PA, VA, WA, WY
Corn (Grain)	CO, GA, IL, IN, IA, KS, KY, MI, MN, MO, NE, NY, NC, ND, OH, PA, SD, TX, WI
Corn (Silage)	IA, MN, NY, ND, PA, WI
Cotton[8]	AR, GA, MS, MO, NC, TN, TX
Oats	IL, IA, KS, MI, MN, NE, NY, ND, OH, PA, SD, TX, WI
Sorghum (Grain)	CO, KS, NE, OK, SD, TX
Spring Wheat (Durum)	MT, ND
Spring Wheat (excluding Durum)	MN, MT, ND, SD
Tomatoes (Processing)	CA
Winter Wheat	CO, ID, IL, KS, MO, MT, NE, OH, OK, OR, SD, TX, WA

Eligible Project Activities are described further in Section 2.2.1, Eligible Crops in Section 2.2.2, and Eligible Project Area in Section 2.2.3. All eligible project activities may be implemented for any eligible crop in any eligible region (assessed at the county level). All eligible activity-crop-county combinations are contained in the Nitrogen Management Project Eligibility Lookup Tool,[9] which was developed to simplify the process for project developers to self-assess the eligibility of each of their fields This tool is mandatory for all projects to determine if select activity-crop-county combinations are eligible. It is made available upon request to the Reserve and will be updated outside of the protocol as new data becomes available (See Appendix B for more information).

This protocol employs the use of an emission factor-based nitrogen management quantification tool (NMQuanTool[10]), built in Microsoft Excel, to calculate N_2O emission reductions resulting from the implementation of eligible nitrogen management project activities. In addition to the eligible activities discussed in Section 2.2.1, the NMQuanTool also incorporates the impacts of a given field's tillage practice, specifically the maintenance of conventional till or the switch from conventional till to no till from the baseline to the project, and its impact on N_2O emissions. Certain activity-crop-region scenarios, in combination with a switch to no till in the short-term (i.e., less than 10 continuous years of practicing no till), were found to generate an increase in N_2O emissions from the baseline to the project.[11] All such scenarios are ineligible and have

[7] Note, eligibility is assessed at the county level; eligible States are provided in Table 2.2 for ease.
[8] Cotton eligibility determination is based on "Upland Cotton" data from the USDA National Agricultural Statistics Service (NASS). Insufficient county data existed for "Cotton" for the development of crop- and county-specific average fertilizer rates and nitrogen use efficiency benchmarks, though recent state data is comparable. Either may be cultivated. See Section 2.2, Section 3.5.1 and Appendix B for more information.
[9] The Nitrogen Management Project Eligibility Lookup Tool is an easy to use Microsoft Excel tool for project developers to check if their prospective fields' activity-crop-county scenarios are eligible. Detailed guidance on how to use the tool will be made available upon request to the Reserve. It also contains the multi-year county- and crop-specific average N rates, yields, and partial factor productivity (PFP) values for all eligible combinations. See Section 3.5.1 and Appendix B for more information.
[10] Detailed guidance on how to use the NMQuanTool can be found in the first spreadsheet of the tool, which will be made available upon request to the Reserve here: http://www.climateactionreserve.org/how/protocols/nitrogen-management/.
[11] Climate regime and the duration of tillage practice have been found in the scientific literature to have varying effects on N_2O emissions. Regional climate has been identified as a major driver for the change in N_2O emissions with the adoption of no till, with emissions increasing in humid climates and decreasing in dry climates. Time since

been incorporated in the Nitrogen Management Project Eligibility Lookup Tool.[12] For more information see Appendix F, Section F.6.

2.2.1 Eligible Project Activities

The project activity must be defined very precisely, as it sets what action must be done to earn credits, and thus sets the scope for the project, as well as setting the boundary for regulatory compliance and other key project attributes. As described in Table 2.1, there are two approved project activities for this protocol, both of which have consistent N_2O effects in terms of directional certainty, and the application of which leads to quantifiable reductions in N_2O emissions in comparison to baseline emissions.

The adoption of N rate reductions is mandatory for all projects, whereas the use of Enhanced Efficiency Fertilizers (EEFs) is an optional additional approved project activity.[13] The eligible project activity of N rate reductions in this version of the NMPP is limited to reductions in synthetic N rates. All projects will be eligible to generate CRTs for percentage reductions in the application rate of synthetic N compared to baseline application rates, and projects will be eligible to generate CRTs from one of the optional nitrification inhibitors or slow release fertilizers when applied in combination with the synthetic N rate reduction. Projects that employ N rate reductions and both nitrification inhibitors and slow release fertilizers are eligible, however, the NMQuanTool is only capable of quantifying emission reductions associated with the implementation of one of the EEFs and not their combined impacts. Both EEF products achieve the same objective and stacking one another would not be expected to result in cumulative benefits (i.e., benefits are not additive).[14] Additionally, it is not anticipated that multiple EEFs would be applied simultaneously in practice. If seeking CRTs for either of the EEFs, project developers must select only one of them in the NMQuanTool.

With respect to N rate reductions, it's important to note that reductions in annual synthetic nitrogen application rate should not go significantly below N demand. Reducing N rates below crop needs will eventually cause crop yields to decline. To prevent N rates going below N demand, this protocol includes a performance standard based on a NUE metric involving yield (see Section 3.5.1) and addresses significant decreases in yield via the approach to account for leakage (see Section 5.1.3.2).

2.2.1.1 N Rate Reductions

For the purposes of this protocol, N rate reductions are defined as reductions in the annual *synthetic* nitrogen application rate (i.e., the mass applied per acre for the cultivation year of an eligible crop) compared to baseline levels. Multiple safeguards are utilized in this protocol to

adoption of no till also plays a role, with higher emissions initially after adoption (< 10 years) in both humid and dry climates, but over time (≥ 10 years), lower emissions relative to previous emissions from conventional tillage systems.

[12] A table containing all such scenarios can be made available upon request by the Reserve.

[13] EEFs are fertilizer products that can reduce nutrient losses to the environment while increasing nutrient availability for the crop by either slowing the release of nutrients for uptake or altering the conversion of nutrients to other forms that may be less susceptible to losses.

[14] Due to minimal adoption and additive benefit, the modeling to develop the new quantification methodology for v2.0 did not include the effects of NIs and SRFs used together. As a result, the quantification methodology is unable to calculate emission reductions associated with the combined use of a NI and SRF. See Section 5, for more information. Growers have the flexibility to apply the EEF product to best meet their fields' soil and climatic conditions and take into consideration other factors, such as management capabilities and economics.

ensure that growers do not reduce N rates to the extent that yield is significantly reduced,[15] and four hierarchical options are provided for determining baseline N rates (see Section 5.1.2.1). N application rate may vary across the field (i.e., may be applied at different times throughout the cultivation year), so long as the total N applied is used as the input for the performance standard test and in all field-level equations in Section 5. Total organic N applied may increase or decrease in the project area, however, total annual N applied (synthetic and organic) in the project must decrease below baseline levels (see Section 3.5.1.1).[16]

Synthetic fertilizers may be applied in dry form (e.g., granular urea, ammonium nitrate) or liquid form (e.g., urea ammonium nitrate, UAN). Urea is also considered a 'synthetic" fertilizer for the purposes of this protocol. Organic fertilizers may be liquid or solid, and may include unprocessed manure (e.g., beef cattle manure, hog manure, digester effluent and/or solids), other unprocessed organics (e.g., compost) and processed commercial organic fertilizers.

The fertilizer source, application timing and placement are at the discretion of the grower.

2.2.1.2 Use of Enhanced Efficiency Fertilizers

Nitrification inhibitors (NIs) and slow release fertilizers (SRFs) are each a type of an enhanced efficiency fertilizer (EEF) with a similar function, that can make nitrogen available to crops over a longer portion of the cultivation year to better match the crop uptake needs. NIs are substances that when applied in addition to the use of an ammonia (NH_3) or ammonium (NH_4^+) fertilizer, delay the nitrification process (the conversion of NH_3 or NH_4^+ to nitrate (NO_3^-)) by depressing the activity of *Nitrosomonas* bacteria, until the NO_3^- can be readily used by crops.[17] SRFs, as their name implies, slow or control the release of soluble nitrogen (NH_4^+ and NO_3^-) to the soil compared to conventional fertilizers, extending N availability to the crop and improving the synchronization between crop uptake and N availability[18]. Both allow the crop to take up more of the nitrogen applied, and ultimately reduce the release of N_2O to the atmosphere.

For the purposes of this protocol, in order for the use of NIs or the switch to SRFs to be eligible, such activities may not have occurred in a field's baseline look-back period (Section 5.1.2, Table 6.2). If NIs or SRFs have been utilized in a given field's baseline look-back period the field will be ineligible due to complications with quantification.[19]The use of SRFs and the use of NIs in conjunction is permissible, however, as both types of EEFs work to reduce the conversion rate of supplied nitrogen to N_2O, the additive emissions benefits are either minimal or nonexistent, and thus difficult to quantify. The EEFs should be applied according to manufacturer recommendations, as well as relevant regulatory or expert recommendations.[20]

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[15] Yield is taken into consideration in the Performance Standard eligibility criteria, and yield also determine whether emissions associated with production leakage must be taken into account, see Section 3.5.1.1 and Section 5.1.3.2 respectively.

[16] Please note, this protocol does not credit for the switch from synthetic N sources to organic N sources. While organic N amendments are allowed, the synthetic N rate must decline from the baseline to the project, and any N_2O emissions associated with increases in organic N rate from the baseline to the project are quantified and deducted from the final emission reductions (See Equation 3.5).

[17] CSP (2014b).

[18] ICF (2013).

[19] Due to their low uptake, the modeling to develop the new quantification methodology for v2.0 maintained the assumption of no EEFs in the baseline. As a result, the quantification methodology is unable to calculate baseline emissions associated with the use of a NI or SRF. See Section 5, for more information.

[20] International Plant Nutrition Institute (IPNI), Nutrient Source Specifics one-page fact sheet: No. 26, *Nitrification Inhibitors* downloaded 07/31/2018 at:
http://www.ipni.net/publication/nss.nsf/0/21B8084A341C98E085257E3C0077595B/$FILE/NSS-

2.2.2 Eligible Crops

For the purposes of this protocol, all eligible crops are specifically listed in Table 2.2 above.

The list of eligible crops will be expanded as the requisite data become available to allow inclusion of further crops in an updated quantification methodology.[21]

Please note, this protocol does not credit the removal or replacement of more nitrogen intensive crops from the rotation, with less nitrogen intensive crops (e.g., eliminating corn to avoid or substantially reduce use of nitrogen fertilizer). Emission reductions are quantified annually on a field by field basis, comparing the cultivation of one crop in the project's reporting period against the cultivation of the same crop on the same field in the baseline period (e.g., corn data are always compared to corn data). Thus, crop rotations and other interannual impacts (e.g., crop residues incorporated) are not directly accounted for, but each crop grown in the rotation should be compared to the cultivation of the same crop on the same field in the baseline.

Eligible crops may have either been historically grown on the given field, in which case yield records will need to be provided, or be newly introduced in the project.

2.2.3 Eligible Project Area

For the purposes of this protocol, the project area is defined as an eligible crop field or fields on which eligible project activities take place, located in an eligible region. Fields should be configured to exclude areas that do not meet the eligibility requirements set out below (for instance, the field boundary should be drawn to exclude areas containing histosol soils, as those are ineligible). Fields that are split by minor breaks consisting of ineligible areas (i.e., fields split by roads or watercourses) can still be considered a single field.

The project area must adhere to the following criteria:

- Each field must be clearly delineated
- The area within each field must be continuous
- The same primary crop must be grown throughout each field within a reporting period
- The field on which the baseline crop is grown must be the same field on which the project crop is grown[22]
- Exclude roads, watercourses and other physical boundaries (i.e., such areas will not be included in project area acreage)
- The project area shall not contain any histosols[23]
- The project may contain tile-drained fields, as long as tile-drains were in place during the baseline period (i.e., not installed for the purposes of the project)

26%20Nitrification%20Inhibitors.pdf. NRCS CSP NI Guidance essentially states that if not applied at planting the NI will be ineffective and goes on to give specific recommendations for how many days certain products should be applied relative to planting date. Project developers and verifiers should consult guidance from the manufacturers as to any application timing guidance for the product in question.

[21] An addendum to the 2014 USDA *Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory* of field measurement datasets on N_2O emissions in California specialty crops is anticipated at some point in 2018, or sometime thereafter, and may provide the necessary data for expansion of the Reserve's NMPP offset protocol to include California specialty crops.

[22] See Section 5.1.2 for further details on baseline setting requirements.

[23] Histosols are found at all altitudes, but the vast majority occurs in lowlands. Common names are peat soils, muck soils, and bog soils. See USDA-NRCS, Keys to Soil Taxonomy. Available at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/taxonomy/?cid=nrcs142p2_053580.

- If the project area includes land classified as highly erodible land (HEL)[24], that land must meet the Highly Erodible Land Conservation provisions to be eligible under this protocol
- If the project area includes land classified as wetlands,[25] that land must meet the Wetlands Conservation provisions to be eligible under this protocol[26]

To be an *eligible project area* the field must also be located in a region for which there are applicable NUE benchmarks for use in the performance standard test for additionality. All eligible activity-crop-region combinations, and their respective NUE benchmarks and average N rates, can be found in the Nitrogen Management Project Eligibility Lookup Tool. Figure 2.1 highlights the eligible counties based on these conditions, and the number of possible crops eligible within each county. Not all fields within a project or cooperative are required to be located in the same region.

[24] Highly erodible land is defined as "land that has an erodibility index of 8 or more" in Title 7 of the Code of Federal Regulations, Subpart A, Part 12.2. Part 12.21 further outlines how HEL is identified and how the erodibility index is calculated.

[25] Wetlands generally have a predominance of hydric soil and are inundated or saturated by surface or groundwater for various durations over the year. See Title 7 of the Code of Federal Regulations, Subpart A, Part 12.2 for the definition of wetlands. It is also worth noting that wetlands in the project area may also be impacted by the applicability conditions in Section 1.10 of this protocol.

[26] As outlined in Title 7 of the Code of Federal Regulations, Subpart A, Part 12.5(b), and in Section 510.10 of the National Food Security Act Manual. Such exemptions may include wetlands farmed prior to 1985, wetlands with minimal effect, or wetlands with mitigation measures in place.

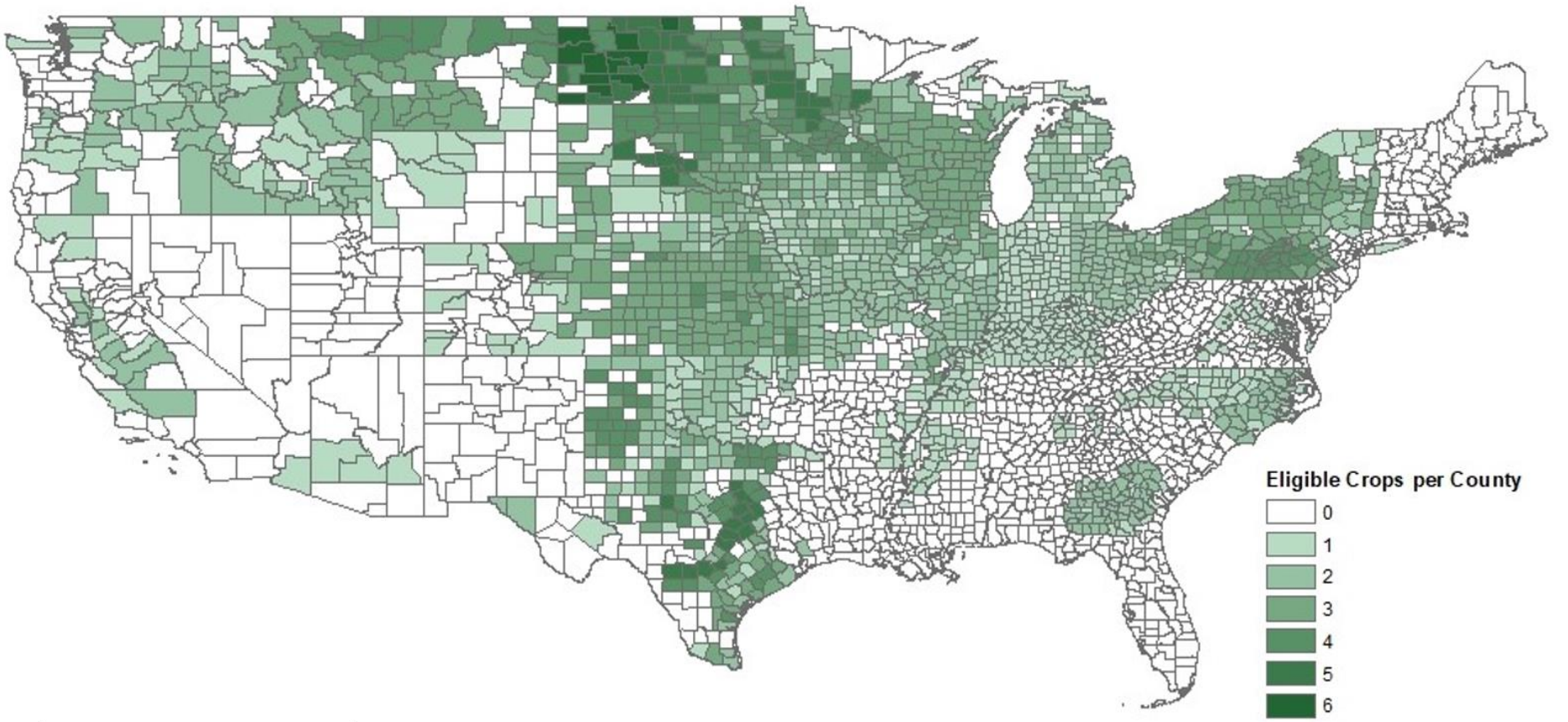

Figure 2.1. Eligible County-Crop Combination

2.3 Defining the Cultivation Year

For the purposes of this protocol, a cultivation year is generally defined as the period between the first day after harvest of the last primary crop on a field and the last day of harvest of the current primary crop on a field. A primary crop is defined as the main production crop grown on a field in a given year (e.g., corn is a primary crop and may be grown on its own or with a cover crop). A cover crop is defined as a crop planted for seasonal vegetative cover during non-crop production periods in a primary crop rotation, that is not harvested and is instead returned to the soil[27]. If there are multiple primary crops in rotation, each type of primary crop (e.g., corn in a corn-soybean rotation) has a distinct cultivation year. Since this protocol is currently only applicable to annual primary crops, the cultivation year is approximately 12 months.[28] One complete cultivation year for corn in a corn-soy rotation, for example, begins with post-harvest residue management for the soy crop harvested in the fall of one calendar year, continues with field preparation, seeding, and cultivation of the corn crop, and culminates upon completion of the corn harvest in the fall of the next calendar year. Cover crops established between the successive production of primary crops shall be included as part of the cultivation year of the subsequent primary crop (See Section 5.1.3). See Section 3.5.1.1 for guidance relating to fertilizer applications during the cultivation of crops for which CRTs are not being sought.

2.4 Project Ownership Structures and Terminology

A NMPP project can be implemented using various ownership structures. Table 2.3 below sets out the terminology used to describe the different parties involved in a Nitrogen Management project, whether such parties are necessary in different circumstances, and associated account types that will be necessary.

Table 2.3. Project Ownership Types & Account Types

Term	Definition	Required?	Registry account type
Field Manager	The entity with management control of the project activities. Unless we see evidence to the contrary, we assume this person/entity holds the GHG rights). This may or may not be the landowner, Project Owner, project developer, Cooperative Developer, or cooperative participant.	Yes. There will ALWAYS be a field manager identified, but they may not play any role in the monitoring, reporting and verification (MRV)	Depends. May be any of the following: ▪ None ▪ Project Owner ▪ Project Developer
Landowner	The entity listed on the deed to the property as the landowner.	No, unless they play one of these other roles.	None (unless they are a Project Owner or Cooperative Developer)
Project Owner (PO)	The entity which holds rights to the CRTs from the project at time of issuance.	Yes. There will ALWAYS be a PO identified.	Either Project Owner (if they are simply a cooperative participant), or Project Developer.

[27] CSP (2017)

[28] As the protocol expands in future versions, primary crops with cultivation years shorter than a calendar year (e.g., lettuce) or longer than a calendar year (e.g., perennials) may be included, which would likely necessitate changes in the definition of "cultivation year" as approximately twelve months.

Term	Definition	Required?	Registry account type
project developer	The entity which does the MRV required by the protocol.	Yes, although it may or may not be a separate entity.	A project developer who solely provides guidance and is not also issued credits, may not be an account holder.
Cooperative Developer (CD)	The entity which manages a cooperative. The CD may or may not also be a PO.	Yes, if there is a cooperative to manage.	Project Developer
cooperative participant	A Project Owner whose project is being managed as part of a cooperative, with a separate CD.	Yes, if the project is part of a cooperative.	Project Owner or Project Developer, depending on the desired functionality.

Every field will need to have a Field Manager, and every project will need to have a Project Owner. If those are not the same entity (e.g., Company A signs agreements with 1000 farmers saying that Company A will own the GHG rights, and Company A is thus the Project Owner), then the verifier would need to confirm that the Project Owner has a written contract with (and signed by) the Field Manager. Field Managers and landowners may choose not to be directly involved in the project, or they may choose to be Project Owners or project developers. For every single project, at least one of these entities will have a Project Developer registry account. We would only have a Project Owner registry account in the case of cooperative participants. See Figure 2.2 below for a graphical illustration of a potential project ownership and management structure.

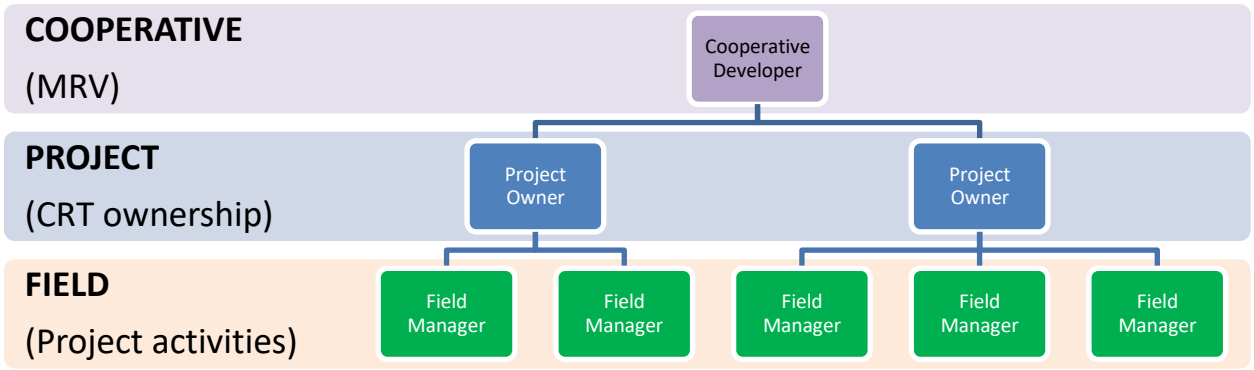

Figure 2.2. Example Cooperative Ownership/Management Structure

2.4.1 Project Owners issued CRTs

A single entity must be designated to be the Project Owner for each project, and only that party will be issued CRTs for that project. As set out in Table 2.3 the type of account needed by the Project Owner will depend on whether they also play a management role in the project and take on MRV responsibilities for that project. Project management responsibilities will be discussed in Section 2.4.2 below.

The Project Owner is responsible for the accuracy and completeness of all information submitted to the Reserve, and for ensuring compliance with this protocol, even if they contract with an outside entity to carry out project development activities. The Project Owner must have a Reserve registry account and must sign all required legal attestations (e.g., Attestation of Title,

Attestation of Voluntary Implementation, and Attestation of Regulatory Compliance).[29] In the case of project cooperatives, each Project Owner must sign an attestation for their respective project.

2.4.2 Entities with Project Management Roles

A single entity must be designated to take on formal management of a project and be responsible for the MRV for that project. The entity taking on management of the project will be referred to generically as the "project developer". The project developer may also be the Project Owner for a given project, or not. The project developer will be responsible for all aspects of MRV for the project, except for signing the attestations, which must be done by the Project Owner.

A "Cooperative Developer" is the entity that manages reporting and verification for a project cooperative (i.e., two or more individual NMPP projects that report and verify jointly). A cooperative may consist of NMPP projects each involving a unique Project Owner. A Cooperative Developer must have an account with the Reserve. The term "project developer" will be used throughout this document to refer to both the responsible management entity for each project and, in the case of cooperatives, the entity responsible for managing the cooperative.

A Cooperative Developer must open a Project Developer account on the Reserve and must remain in good standing throughout the duration of the projects and cooperative(s) it manages. Failure to remain in good standing will result in all account activities of the participant projects in the cooperative(s) managed by the respective Cooperative Developer being suspended until issues are resolved to the satisfaction of the Reserve. In order for a Cooperative Developer to remain in good standing, Cooperative Developers must perform as follows:

- Complete cooperative contracts with Project Owners (see Section 2.4.5 on Joining a Cooperative)
- Engage the services of a single verification body for all NMPP projects enrolled in the cooperative in any given verification period
- Coordinate the submittal, monitoring, and reporting activities required by this protocol for all projects in the cooperative(s), observing all project/cooperative deadlines
- Coordinate a verification schedule that maintains appropriate verification status for the cooperative. Document the verification work and report to the Reserve on an annual basis how completed verifications demonstrate compliance (see Section 8.2)
- Maintain a Reserve account in good standing

2.4.3 Entering a Project

Individual fields may join a project by being added to the project's Project Submittal Form (if joining a project at initiation) or by being added through the Field Enrollment & Transfer Form (if joining once the project is underway).

The project developer managing the project that receives the new fields will be responsible for submitting the Field Enrollment & Transfer Form, listing the field(s) that are now joining their project, as well as updating a list of enrolled fields contained within the form. Emission reductions occurring on new fields entering a project may start counting toward the project's CRTs in the reporting period during which the field joined the project. Emission reductions will

[29] Information regarding Reserve accounts and the process for project submittal and registration is available here: http://www.climateactionreserve.org/how/projects/register/.

be reported as a single combined project for the reporting period in which the transfer occurred. Any period of time that has already been reported and verified under a single project will not be included in reporting under the newly combined project.

Each field will only be eligible for a maximum of ten reporting periods (or less if they join a project already underway, as the project as a whole will only be eligible for a maximum of ten reporting periods). All fields in a project must use the same version of this protocol, and if a field from one project joins another project, then the newest version of the protocol in use between them must be adopted for the newly combined project.

Projects that have already been submitted to the Reserve may choose to join another existing project by submitting a Field Enrollment & Transfer Form to the Reserve. Again, it will be the project developer managing the receiving project that is responsible for submitting the Field Enrollment & Transfer Form to the Reserve.

2.4.4 Leaving a Project

Fields must meet the requirements in this section in order to change projects or leave to become their own project and continue reporting emission reductions to the Reserve. In all cases, emission reductions must be attributed to one project for a complete reporting period, as defined in Section 3.3, and no CRTs may be claimed by a project for a field that does not participate and report data for a full reporting period. Project activities on an individual field may be terminated and the field may be removed from the project at any time. Reporting for each field must be continuous.

In order for a field or fields to leave a project and join another existing project, the Project Owner for the receiving project must submit a Field Enrollment & Transfer Form to the Reserve, noting that it is a "transfer project" and identifying the project from which it transferred, and the project to which it is being transferred. Reporting under the destination project shall continue according to the guidance in Section 7.2.

For fields that leave a project to become an individual project, the deadline for submittal of the subsequent monitoring or verification report (whichever is sooner) is extended by 12 months beyond the deadline specified in Section 7.4. The Project Owner must submit either a monitoring report or verification report (whichever is due) by this new deadline in order to keep the project active with the Reserve. The project developer setting up the new project will need to submit a Project Submittal Form to the Reserve to initiate the new project.

2.4.5 Forming or Entering a Cooperative

The Cooperative Developer functions as the project developer for each project enrolled in the cooperative(s) they manage. The Cooperative Developer will initiate the creation of the cooperative by submitting a Cooperative Submittal Form. Individual nitrogen management projects may join a cooperative by being included in the cooperative's Cooperative Submittal Form[30] (if joining a cooperative at initiation) or by being added through the submission of a Cooperative Enrollment & Transfer Form (if joining once the cooperative is underway). If the Cooperative Developer is not the Project Owner for one or more projects within the cooperative, the appropriate Project Owner account(s) will be confirmed at the time of project submittal. All documentation related to the cooperative and its participant projects is submitted by the

[30] All forms referenced in this section are available at: http://www.climateactionreserve.org/how/program/documents/.

Cooperative Developer. After successful verification, CRTs are issued to the accounts of the Project Owners for each project.

Emission reductions occurring on individual projects or new projects entering a cooperative are reported as part of the cooperative during the reporting period in which the transfer occurred.[31] The project will begin reporting with the cooperative no earlier than the beginning of the cooperative's current verification period. If the project has already been registered, either as an individual project or as part of another cooperative, reporting under the new cooperative may not include any period of time that has already been reported and verified.

The crediting periods of the individual projects within a cooperative are derived from their individual project start dates (See Section 3.2) and are not affected by the crediting periods of other projects within the cooperative. All projects within a cooperative must follow the same version of this protocol. If a project that is subject to a more recent version of the protocol wishes to enter an existing cooperative, the rest of the projects in that cooperative must elect to upgrade to the newer version of the protocol.

2.4.6 Leaving a Cooperative

Individual nitrogen management projects must meet the requirements in this section in order to leave or change cooperatives and continue reporting emission reductions to the Reserve. Reporting must be continuous.

Individual Project Owners may elect to leave a cooperative and participate as an individual nitrogen management project for the duration of their crediting period, effective as of the day after the end date of the project's most recently registered reporting period. To leave a cooperative and become an individual nitrogen management project, the Project Owner must submit a Project Submittal Form to the Reserve, noting that it is a "transfer project" and identifying the cooperative from which it is transferring. The Project Owner must also designate a new project developer for the project and ensure that entity has a Project Developer account with the Reserve. For projects that leave a cooperative to become an individual project, the deadline for submittal of the subsequent monitoring or verification report (whichever is sooner) is extended by 12 months beyond the deadline specified in Section 7.2. The new project developer must submit either a monitoring report or verification report (whichever is due) by this new deadline in order to keep the project active in the Reserve.

To leave one cooperative and enter another cooperative, the Project Owner must submit a Cooperative Enrollment & Transfer Form to the Reserve prior to enrolling in the new cooperative. Reporting under the destination cooperative shall continue according to the guidance in Section 7.2.

[31] The transfer is considered to have occurred once the Reserve has approved the Cooperative Transfer Form and the New Project Enrollment Form.

3 Eligibility Rules

Projects must fully satisfy all the eligibility rules set out in this section in order to register a NMPP project with the Reserve. All fields participating in a project must meet the following key criteria, as well as the definition of a nitrogen management project (Section 2.2), in order for the project to be eligible.

Section 3.1:	Location	→	*U.S. and U.S. tribal areas, in areas corresponding to approved quantification approaches*
Section 3.2:	Start Date	→	*No more than 12 months prior to submission*
Section 3.5:	Additionality	→	*Meet performance standard*
		→	*Exceed regulatory requirements*
		→	*Meet payment/credit stacking requirements*
Section 3.6:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Project fields must be located in regions in the United States (U.S.) as listed in Table 2.2 and seen in Figure 2.1.[32]

3.2 Start Date

The project developer must nominate a start date for the nitrogen management project, as well as for each field within the project. The start date for a nitrogen management project is defined as the first day of the cultivation year of an eligible crop, on an eligible field (nominated as the field that triggers the start date), in which eligible project activities are implemented. Projects must be submitted to the Reserve for listing within 12 months of the project start date (i.e., before the end of the nominated field's initial cultivation year).[33] For all other fields, the project developer must nominate a start date for each field, and each field must be submitted within 24 months of the field's start date.

3.3 Reporting Period

The reporting period is the period of time over which GHG emission reductions from project activities are quantified. The reporting period under this protocol is one complete cultivation year of an eligible crop, hereafter referred to as an "eligible crop year" *(*typically a 12-month period).

When a project comprises multiple eligible crop fields, the reporting period in a given year starts on the earliest date that a field being submitted for credits begins its cultivation year, and the reporting period ends on the latest date that a field being submitted for credits ends its cultivation year. This will mean that a project may experience overlapping reporting periods, i.e., a reporting period may end in November of a given year, but if a winter crop is grown on a field submitted to the project for crediting in the next cultivation year, the subsequent project reporting period may actually begin that same November, potentially prior to the end of the last reporting period.

[32] A complete listing of eligible counties and their applicable crop systems can be found in the Nitrogen Management Project Eligibility Lookup Tool, available from the Reserve upon request.

[33] Projects are considered submitted when the Project Developer has fully completed and filed the appropriate Project Submittal Form, available at: http://www.climateactionreserve.org/how/program/documents/.

Despite this, there will be no risk of double issuance of emission reductions, for several reasons:

- quantification of emission reductions occurs on a field by field basis, based on the cultivation year of the given field
- fields can only be registered to one project at any given point in time, therefore fields can only have emission reductions issued to one project for any given reporting period
- field reporting periods cannot overlap, because they are defined by the field's cultivation year. The new cultivation year will only start once the previous crop harvest *on that field* has concluded.

Each field will be eligible to be credited for a maximum of ten cultivation years, and each project will be eligible for a maximum of ten reporting periods. If one or more fields are claiming CRTs in a given cultivation year, then that will count towards both the field's 10 maximum cultivation years, and the project's maximum 10 reporting periods. If no CRTs are being sought at all, on any field, in a given cultivation year, then that cultivation year will not be counted towards the respective fields' ten cultivation year limit, nor will it be considered a reporting period towards the project's crediting period limit of 10 reporting periods (see Section 3.4 for guidance on crediting periods). During the initial reporting period, a project may seek CRTs for one or two cultivation years (if the latter, there may only be one ineligible cropping year in between the eligible cultivation years, i.e., two eligible crops spread out over a maximum of three years).

Activities that will *not* count as a reporting period include:

- Fields left fallow;
- Fields cultivating an ineligible crop; and
- Fields cultivating an eligible crop, but either do not meet protocol requirements (such as the performance standard, verification requirements, regulatory compliance requirements, etc.), or are voluntarily withdrawn for that eligible crop year

The field must continue to meet continuous monitoring and reporting requirements, even if not eligible to generate CRTs in a given cultivation year. See Section 5.1.3.1 and Section 5.1.4.4.1 for guidance regarding N usage for cultivation years where CRTs are not being sought.

3.4 Crediting Period

The crediting period for projects under this protocol is defined as ten reporting periods. The crediting period applies at the project level, so that a project may have a maximum of ten reporting periods, but each field also has a limit of ten reporting periods.

Only eligible crop years in which CRTs are being sought will be treated as reporting periods and count towards a project's crediting period (and towards the ten-year reporting period limit for each field being credited). Thus, in any given year if no CRTs are being sought on any field enrolled in the project, that year will not be counted as a reporting period towards the project's crediting period (or any of the fields enrolled in the project). If CRTs are being claimed for one or more fields in a year, then that will count as a reporting period towards the project's crediting period. Continuous reporting must be maintained throughout the crediting period (see Section 7.2 for reporting requirements).

Crediting periods may be renewed one time. Thus, a project may have a maximum of two crediting periods, each comprising of a maximum of ten reporting periods, for a total maximum

of twenty reporting periods. During the 12 months before or after the end of a project's tenth reporting period, project developers may apply for a project's eligibility under a second crediting period. The project must meet the eligibility requirements of the most recent version of this protocol, including any updates to the performance standard test (Section 3.5.1.1). The baseline established in the first crediting period of the project shall be used for the project's second crediting period.

The Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of two crediting periods after the project's start date. If, at any point in the future, the approved project activity adopted on a field becomes legally required, emission reductions may be reported to the Reserve for that field up until the commencement of the cultivation year during which the practice is required by law to be adopted. Upon the effective date of the new legal requirement, the Reserve will cease to issue CRTs for GHG reductions for the legally required project activity for that field (see Section 3.5.2 for further guidance).

3.5 Additionality

The Reserve intends to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy all of the following tests to be considered additional:

1. The performance standard test (Section 3.5.1)
    a. N rate reductions
    b. Use of Enhanced Efficiency Fertilizer Products
2. The legal requirement test (Section 3.5.2)
3. The credit/payment stacking test (Section 3.5.3)

3.5.1 The Performance Standard Test

Projects pass the performance standard test by meeting a performance threshold, i.e., a standard of performance applicable to all nitrogen management projects, established by this protocol. The performance standard test is applied at the field level, rather than to the project as a whole. Performance standards are specified below according to the type of project activity being implemented. All projects must pass the performance standard test for reducing nitrogen application rate (Section 3.5.1.1) in order to be eligible. All projects that pass the performance standard test for reducing nitrogen rate and adopt the use of nitrification inhibitors or a switch to slow release fertilizers, are deemed to automatically pass the performance standard test for the use of the enhanced efficiency fertilizer (see Section 3.5.1.2).

The performance standard research and rationale for the specific performance standards outlined below are summarized in Appendix B.

3.5.1.1 Performance Standard for Reducing Nitrogen Application Rate

The performance standard for this project activity is based on a nitrogen use efficiency (NUE) metric termed the partial factor productivity (PFP). The PFP measures how productive the cropping system is in comparison to its nitrogen input, and is simply calculated in units of crop yield per unit of nitrogen applied, as demonstrated in Equation 3.1 below.[34] Gains in the PFP

[34] Dobermann, A (2007). Nutrient use efficiency – measurement and management. International Plant Nutrition Institute (IPNI), USA. Fertilizer Best Management Practices: General Principles, Strategy for their Adoption and

can be realized from N rate reductions to levels that do not go below N demand and affect crop yield, and from yield improvements via the implementation of other fertilizer best management practices.

Equation 3.1. Annual Partial Factor Productivity (PFP)

$$PFP_{P,f} = \frac{Y_{P,f}}{NR_{P,f}}$$

Where,			Units
$PFP_{P,f}$	=	Partial factor productivity calculated for field *f* during the cultivation year in the current reporting period of the project *P*	
$Y_{P,f}$	=	Annual eligible crop yield for field *f* during the cultivation year in the current reporting period of the project *P*; see Table B.3. Yield Conversion Factors in Appendix B for crop production unit conversion factors	lb/ac
$NR_{P,f}$	=	Total annual[35] N rate (including synthetic and organic forms of N) for field *f* during the cultivation year in the current reporting period of the project *P*, see Equation 3.2	lb/ac

Equation 3.2. Annual Total N Rate for Field in Project

$$NR_{P,f} = NR_{P,S,f} + NR_{P,O,f}$$

Where,			Units
$NR_{P,f}$	=	Total annual N rate (including synthetic and organic forms of N) for field *f* during the cultivation year in the current reporting period of the project *P*	lb/ac
$NR_{P,S,f}$	=	Annual synthetic N rate for field *f*, during the cultivation year in the current reporting period of the project *P*; see Equation 5.12	lb/ac
$NR_{P,O,f}$	=	Annual organic N rate for field *f,* during the cultivation year in the current reporting period of the project *P*; see Equation 5.24	lb/ac

Annual yield ($Y_{P,f}$) is defined as the average yield (gross weight (pounds) of crop removed from field, *f*, per acre) for each eligible crop grown per field, *f*, in the project, *P*, during the current reporting period. Total annual N rate ($NR_{P,f}$) is defined as the total nitrogen rate (synthetic N fertilizer rate ($NR_{P,S}$) plus organic N fertilizer rate ($NR_{P,O}$), pounds N per acre), applied to each field, *f*, throughout the cultivation year (~12 months) in the current reporting period of the project, *P*. This includes any synthetic and organic N applied to the primary crop and subsequent cover crop in the current cultivation year, and via any application method, including N applied through irrigation (i.e., fertigation).

A field, *f*, passes the performance standard test when its reporting period (i.e., annual) PFP, calculated for each eligible crop cultivation year of the project, *P*, meets or exceeds the applicable county- and crop-specific PFP benchmarks ($PFP_{avg,Co,c}$) found in the Nitrogen Management Project Eligibility Lookup Tool, as exemplified in Equation 3.3 below. The county-

Voluntary Initiatives vs Regulations. Papers presented at the IFA International Workshop on Fertilizer Best Management Practices 7-9 March 2007, Brussels, Belgium. International Fertilizer Industry Association (IFA). 1-28. Available at: https://www.fertilizer.org/ItemDetail?iProductCode=8387Pdf&Category=AGRI&WebsiteKey=411e9724-4bda-422f-abfc-8152ed74f306

[35] In this context, "annual" is used to mean "one cultivation year," as defined by the protocol.

and crop-specific PFP benchmarks represent the estimated three-year, crop-specific county average PFP based on data from the International Plant Nutrition Institute (IPNI) Nutrient Use Geographic Information System (NuGIS) and USDA National Agricultural Statistics Service (NASS).[36] Three-year average county and crop-specific N rate estimates can also be found in the Nitrogen Management Project Eligibility Lookup Tool. Both the PFP benchmarks and county average N rates will be updated following the publication of new data by IPNI and NASS. Project developers should use the most up to date tool and data available at the time of submitting or verifying each project or field. More information on the development of the PFP benchmarks can be found in Appendix B.

Equation 3.3. Passing Performance Standard Test for Reducing Synthetic N Rates

$$\boldsymbol{PFP_{P,f} > PFP_{avg,Co,c}}$$

Where,			Units
$PFP_{P,f}$	=	Partial factor productivity calculated for field *f* during the cultivation year in the current reporting period of the project *P*	
$PFP_{avg,Co,c}$	=	Multi-year average partial factor productivity for crop, *c*, in county, *Co*; found in Nitrogen Management Project Eligibility Lookup Tool (see Appendix B for more information)	

Each eligible field within a project must pass the performance standard test each reporting period (i.e., each cultivation year) in order to be awarded CRTs for that reporting period. Note, for projects with an initial reporting period spanning two cultivation years, the partial factor productivity ($PFP_{P,f}$), annual yield ($Y_{P,f}$), and total annual N rate ($NR_{P,f}$) must be calculated separately for each cultivation year within the reporting period. PFPs must be calculated *ex post* for each reporting period (i.e., after completion of the cultivation year), but can be estimated *ex ante* based on yield goals and planned fertilizer application rates. However, if a field does not pass the performance standard in an eligible crop year, it does not forfeit eligibility for the remainder of the crediting period, so long as the field maintains continuous reporting to the Reserve and is able to pass the performance standard in the subsequent reporting period for the same eligible crop.

Likewise, a field growing both eligible and ineligible crops (in successive cultivation years) does not need to pass the performance standard test during the ineligible crop years to maintain eligibility, but continuous reporting to the Reserve is required. If the N application rates (synthetic and/or organic) while growing ineligible crops increases relative to their average baseline N rates, rather than forfeiting eligibility for the subsequent eligible cultivation year, the associated increases in N must be included in the subsequent eligible cultivation year's project N rates (see Section 5.1.3.1 and Section 5.1.4.4.1). The same mechanisms are used during the cultivation year of an eligible crop in which CRTs are not being sought. These restrictions are intended to ensure excessive N is not applied in intervening years, with the intent to have residual N then affect the subsequent eligible cultivation year[37]. Verifiers shall review ineligible

[36] The Reserve calls this the "estimated three-year, crop-specific county average PFP" because this value is calculated based on annual county average farm fertilizer N inputs per cropland acre from IPNI NuGIS, and on crop-specific state average N rate applications and crop-specific county average yields from USDA NASS for the years 2010-2012. Data for calculating the true mean PFP of each crop and county are not currently available.

[37] This prevents the project from increasing the ineligible crop's N use to intentionally build residual N on the field, which would result in N reductions in subsequent eligible years that may be larger than would have otherwise been possible without risk of yield loss.

crop year reporting data as part of their eligibility assessment for the next eligible crop year. See Section 6.3 for reporting requirements.

Lastly, while synthetic N rate must be reduced from the baseline to the project to be eligible for CRTs, organic N rate is allowed to increase from the baseline to the project, so long as *total N rate* decreases. Projects must demonstrate that the total N rate applied to the given field in the project is less than the total N rate applied to field over the baseline look-back period, as calculated in Equation 3.4 and Equation 3.5 below. The baseline look-back period and additional guidance on baseline setting are detailed in Section 5.1.2. Section 5.1.2.1 sets out flexible alternative means to set average baseline N rates in the absence of historical records.

Equation 3.4. Average Total N Rate for Field over Baseline Look-Back Period

$$NR_{B,f,avg} = NR_{B,S,f,avg} + NR_{B,O,f,avg}$$

Where,			Units
$NR_{B,f,avg}$	=	Total average N rate (including synthetic and organic forms of N) over the baseline look-back period for field *f*	lb/ac
$NR_{B,S,f,avg}$	=	Baseline average N rate of total synthetic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period, see Equation 5.4	lb/ac
$NR_{B,O,f,avg}$	=	Baseline average N rate of total organic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period, see Equation 5.8	lb/ac

Equation 3.5. Demonstrating Total N Rate Reduced from the Baseline to the Project

$$NR_{P,f} < NR_{B,f,avg}$$

Where,			Units
$NR_{P,f}$	=	Total annual N rate (including synthetic and organic forms of N) for field *f* during the cultivation year in the current reporting period of the project *P*, see Equation 3.2	lb/ac
$NR_{B,f,avg}$	=	Total average N rate (including synthetic and organic forms of N) over the baseline look-back period for field *f*, see Equation 3.4	lb/ac

3.5.1.1.1 Grace Period

At the beginning of a project's first crediting period, each field shall be given a grace period for the first two eligible cultivation years to meet or exceed the applicable PFP performance benchmark in the Nitrogen Management Project Eligibility Lookup Tool. During the grace period, a modified performance standard shall be applied in which the field passes the performance standard so long as the eligible crop field's PFP increases each reporting period. Implementation of the approved project activity shall be fully creditable during this grace period. However, CRT issuance will be delayed for all CRTs generated by a field during its grace period, until such time as the field's PFP meets or exceeds the PFP benchmark established in the Nitrogen Management Project Eligibility Lookup Tool. If a field passes the PFP threshold and completes verification in its third eligible cultivation year (e.g., for corn, the third time CRTs are sought for growing corn on that field, after the field's start date), then CRTs shall be issued for any credits for the grace period. If the field does not pass the PFP in its third eligible cultivation year, CRTs generated during the grace period will be forfeited.

3.5.1.2 Performance Standard for the Use of Enhanced Efficiency Fertilizer (EEF) Products

The Reserve has determined that the use of a nitrification inhibitor or slow release fertilizer is not common practice (see Appendix B for a complete breakdown of the Reserve's evaluation) and the implementation of either activity is considered additional when applied in combination with N rate reduction.[38] All growers applying an eligible EEF pass the performance standard test for the use of a nitrification inhibitor or switch to slow release fertilizer, so long as they pass the performance standard test for N rate reductions and demonstrate an N rate reduction in the project. However, if nitrification inhibitors or slow release fertilizers have been utilized in a given field's baseline look-back period, the field will not be eligible in the project due to quantification limitations.

3.5.2 The Legal Requirement Test

All fields enrolled in a project are subject to a legal requirement test to ensure that the GHG reductions achieved by approved project activities on those fields would not otherwise have occurred due to federal, state or local regulations, or other legally binding mandates. A field passes the legal requirement test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, binding contractual obligations,[39] or other legally binding mandates (including, but not limited to, legally mandated nutrient management plans,[40] conservation management plans, and deed restrictions) that require adoption or continued use of approved nitrogen management project activities on the field. Additionally, if any law, regulation, or legally binding mandate requiring the implementation of project activities at the field(s) in which the project is located exists, only emission reductions resulting from the project activities that are in excess of what is required to comply with those laws, regulations, and/or legally binding mandates are eligible for crediting under this protocol. The legal requirement test is applied to each field, so if project activities on one field in a project become legally required, it shall not affect the other fields in the project.

The Reserve has determined that unless a regulatory program imposes a quantitative restriction on N rate applications or requires the explicit use of a nitrification inhibitor or switch to slow release fertilizer, then implementing project activities will remain additional. Even where quantitative N rate application limits are imposed, emission reductions resulting from the implementation of project activities that are in excess of what is required to comply with those laws, regulations, and/or legally binding mandates are eligible for crediting under this protocol.

To satisfy the legal requirement test, Project Owners must sign an Attestation of Voluntary Implementation form on behalf of the project.[41] Attestations of Voluntary Implementation must be signed and submitted to the Reserve prior to the commencement of verification activities each time the project is verified (see Section 8). Individuals who are part of a project but are not the Project Owner will not be required to attest to the voluntary nature of project activities to the

[38] Best management practices may be used individually by farmers, but their simultaneous adoption on all crop acres is rare. See Wade et al., 2015.

[39] Contracts with NRCS that must be signed by a grower in order to receive Environmental Quality Incentives Program (EQIP) funds are not considered "legally binding mandates" for the purposes of this legal requirement test, if the only repercussion of violating the contract is not receiving the aforementioned financial incentive (e.g., there is no fine, Notice of Violation, or other legal penalty levied).

[40] If Nutrient Management Plans are legally required, but do not require N rate reductions or specify N rate targets that would require reductions, or do not require the use of a nitrification inhibitor or switch to slow release fertilizer, the field passes the legal requirement test because the project activities are not specifically required. Verification bodies shall evaluate such plans and use their professional judgment to make a determination.

[41] Form available at http://www.climateactionreserve.org/how/program/documents/.

Reserve. However, supporting documentation should be made available to the verification body during verification, if requested. In addition, the Project Monitoring Plan (Section 6.1) must include procedures that the project developer will follow to ascertain and demonstrate that the project field at all times passes the legal requirement test.

As of the effective date of this protocol, the Reserve could identify no existing federal regulations that explicitly obligate agricultural producers to adopt the nitrogen management practices approved under this protocol. The Reserve did however identify an existing state regulation that explicitly obligates agricultural producers to adopt one of the nitrogen management practices approved under this protocol: the California Central Valley Regional Water Quality Board's Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies (Dairy General Order). Due to crop-specific restrictions on nitrogen rate, the Dairy General Order poses a concern regarding the regulatory additionality of offsets generated under the NMPP for fields subject to this Order. Any field subject to the Order will only be eligible for emission reductions associated with reductions in N rates beyond the legal mandate. It is important to note though, that the Dairy General Order is only applicable to farms applying manure; farms only applying synthetic N fertilizer are not subject to the Order. More information on the Dairy General Order is provided in Appendix C.2.

A summary of research performed on federal and state requirements is provided in Appendix C.

3.5.3 Ecosystem Services Payment Stacking

When multiple ecosystem services credits or payments are sought for a single activity on a single field, it is referred to as "credit stacking" or "payment stacking," respectively.[42] Under this protocol, credit stacking is defined as receiving more than one mitigation credit for the same activity on spatially overlapping areas (i.e., on the same acre). Mitigation credits are used to offset the environmental impacts of another entity such as emissions of GHGs, removal of wetlands, or discharge of pollutants into waterways, to name a few. Payment stacking is defined as issuing a payment for a best management or conservation practice that is funded by the government or other parties via grants, subsidies, payments, etc. Any type of conservation or ecosystem service payment or credit received for activities on the project area must be disclosed by the project developer to the verification body and the Reserve on an ongoing basis.

3.5.3.1 Credit Stacking

Based on a review of mitigation credit markets in the U.S., the additionality of carbon credits under this protocol might be affected by Water Quality Trading (WQT) programs that credit agricultural land (nonpoint sources) for reducing nitrogen runoff to water bodies. The programs can credit practices eligible and ineligible under this protocol. As of 2016, sixteen programs were actively transacting, or beginning transactions of water quality offset credits[43]. Some examples of these markets are:

- Pennvest Nutrient Credit Trading Program (Susquehanna and Potomac watersheds in Pennsylvania)
- Pennsylvania's Chesapeake Bay Watershed Nutrient Credit Trading Program
- Virginia's Chesapeake Bay Watershed Nutrient Credit Exchange Program
- National Pollutant Discharge Elimination System (NPDES) Water Quality Trading (Oregon)

[42] Cooley, D., & Olander, L., September 2011.

[43] Ecosystem Marketplace. (2016). Alliances for Green Infrastructure: State of Watershed Investment 2016. Washington, D.C: Forest Trends. Available at http://forest-trends.org/releases/p/sowi2016

- North Carolina Nutrient Mitigation Program
- Nutrient Offset Program in Santa Rosa, California
- Ohio River Basin Trading Project (Indiana, Kentucky, and Ohio)

Stacking water quality credits with CRTs for practices eligible under this protocol is allowed if any of the following conditions are met:

- The WQT offset agreement is signed after the project field's start date or submittal to the Reserve, whichever is earlier
- The WQT offset program credits practices[44] additional to any practices credited by a nitrogen management offset project
- The Water Quality Credit is measured by a defined unit of reduction such as pounds of nitrogen instead of ecosystem-wide measurement such as acres managed[45]

Lands contracting WQT credits (before or after project field's start date) from the application of practices ineligible for CRTs under this protocol are eligible since they are not considered "stacked." Fields that have received WQT credits in the past, but have not received credits in the year before the field's start date, are also eligible. Fields seeking to stack credits must also meet all other eligibility requirements in this protocol, including the start date requirement in Section 3.2. Upon project commencement, new WQT agreements must be disclosed to the verifier and the Reserve on an ongoing basis. The Reserve maintains the right to determine if credit stacking has occurred and whether it would impact project eligibility.

3.5.3.2 Payment Stacking

The Reserve has identified two USDA Natural Resource Conservation Service (NRCS) programs that provide payments nationwide to support the implementation of agricultural best management practices (BMPs). Authorized by the 2014 Farm Bill, the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP) are implemented at the state and county level. Through EQIP, NRCS provides agricultural farmers with payments for implementing Conservation Practice Standards (CPS).[46] Through the Conservation Stewardship Program (CSP), NRCS pays farmers for implementing conservation enhancements above minimum Conservation Practice Standards criteria. NRCS expressly allows the sale of environmental credits from enrolled lands but does not provide any additional guidance on ensuring the environmental benefit of any payment for ecosystem services stacked with an NRCS payment.

The Reserve has identified the following four NRCS standards as being relevant to NM projects:

- Conservation Practice Standard for *Nutrient Management* (CPS 590)[46]
- Conservation Enhancement Activity E590130Z for *improving nutrient uptake efficiency and reducing risk to air quality*
- Conservation Enhancement Activity E590119Z for *improving nutrient uptake efficiency and reducing risk of nutrient losses to groundwater*

[44] Considering total soil nitrogen reductions from both reducing fertilizer application and applying slow release fertilizers.
[45] According to Gardner and Fox, 2014, crediting different ecosystem services in defined units avoids double crediting the same ecosystem benefit.
[46] Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA) (2012). "Conservation Practice Standard: Nutrient Management – Code 590". *National Handbook of Conservation Practices (NHCP),* January 2012. Available online at https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/. Accessed May 2018.

- Conservation Enhancement Activity E590118Z for *improving nutrient uptake efficiency and reducing risk of nutrient losses to surface water*

The four standards listed above encompass practices credited under this protocol. The use of NRCS payments to help support reductions in N_2O emissions under this protocol is allowed if the agreement with NRCS to implement CPS 590, E590130Z, E590119Z or E590118Z was signed after the project field's start date or after the field's submittal to the Reserve, whichever is earlier. Fields seeking to stack payments must also meet all other eligibility requirements in this protocol, including the start date requirement in Section 3.2.

Note that if a field is under an agreement with NRCS to receive payments for activities that do not include reductions in fertilizer application, use of nitrification inhibitors or switch to slow release fertilizers, those payments do not affect field eligibility since the payments were awarded for different activities than those credited by this protocol and are therefore not considered "stacked." The same criteria applies for any other NRCS payments under any other CPS or enhancement that does not include the practices credited under this protocol. Fields that have received CPS 590, E590130Z, E590119Z or E590118Z payments for eligible activities in the past (e.g., before the field's start date) but have not received payments for at least one year are also eligible. To be conservative, fields stacking NRCS CPS 590, E590130Z, E590119Z or E590118Z payments are only eligible to receive CRTs for the portion of the project not funded by public dollars. For example, EQIP payment rates are estimated to provide 50 percent, 75 percent or 90 percent of the cost of practice implementation, with higher percentages awarded if the farmer qualifies as "historically underserved" or as a "limited resource farmer." If a farmer receives an EQIP payment for CPS 590 at the 50 percent level, the number of CRTs issued is to be reduced by 50 percent.

A "yes" response to the question "Is the project stacking?" in Table 3.1 below denotes that the project is only eligible to receive CRTs for the portion of the project not funded by public dollars, as discussed in the paragraph immediately above.

Table 3.1. Payment Stacking Scenarios

Scenario	Is the Project Eligible?	Is the Project Stacking?
1. Field under CPS 590, E590130Z, E590119Z or E590118Z agreement that includes a reduction in fertilizer application, application of nitrification inhibitors or application of slow release fertilizers and agreement was signed *before* the project field's start date or submittal to the Reserve (whichever is earlier).	No	n/a
2. Field under CPS 590 E590130Z, E590119Z or E590118Z agreement for activities that do not include reductions in fertilizer application, application of nitrification inhibitors or application of slow release fertilizers.	Yes	No
3. Field under NRCS agreement for any other CPS or enhancement	Yes	No
4. Field under CPS 590, E590130Z, E590119Z or E590118Z agreement that includes a reduction in fertilizer application, application of nitrification inhibitors or application of slow release fertilizers and agreement was signed *after* the project field's start date or submittal to the Reserve (whichever is earlier).	Yes	Yes[47]
5. Field that ended a contract under CPS 590, E590130Z, E590119Z or E590118Z agreement that includes a reduction in fertilizer application, application of nitrification inhibitors or application of slow release fertilizers during the year before the project field's start date.	No	n/a
6. Field that contracted under CPS 590, E590130Z, E590119Z or E590118Z agreement that includes a reduction in fertilizer application, application of nitrification inhibitors or application of slow release fertilizers in the past but has not received payment for more than one year before the project start date.	Yes	No

3.6 Regulatory Compliance

As a final eligibility requirement, Project Owners must attest that activities on project fields (including, but not limited to, project activities) do not cause material violations of applicable laws (e.g., air, water quality, water discharge,[48] safety, labor, endangered species protection, etc.). To satisfy this requirement, Project Owners must submit a signed Attestation of Regulatory Compliance form prior to verification activities commencing each time a project is verified.[49] Project developers are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by activities on project fields.

If a verifier finds that activities on any given project field(s) have caused a material violation, then CRTs will not be issued for GHG reductions that occurred on that given field during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurrent administrative violations directly related to activities on project fields may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If

[47] Project may only credit fertilizer application reductions, nitrification inhibitor reductions or application of slow release fertilizers for the portion not funded by public dollars.
[48] See Appendix C for an overview of water quality rules and regulations that may impact a farm's legal requirements or regulatory compliance.
[49] Attestation of Regulatory Compliance form available at http://www.climateactionreserve.org/how/program/documents/.

the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

Additional information on legal requirements potentially relevant to the regulatory compliance of project activities is included in Appendix C.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project developers in order to determine the net change in emissions caused by a nitrogen management project.[50]

The GHG Assessment Boundary encompasses all the GHG SSRs that may be significantly affected by project activities, including sources of N_2O and CH_4 emissions from the soil, biological CO_2 emissions and soil carbon sinks, and GHG emissions from fossil fuel consumption. For accounting purposes, the SSRs included in the GHG Assessment Boundary are organized according to whether they are predominantly associated with a nitrogen management project's "primary effect" (i.e., the project's intended N_2O reduction), or its "secondary effects" (i.e., unintended changes in carbon stocks, CH_4 emissions, or other GHG emissions).[51] Primary effect emissions include direct and indirect N_2O emissions, the latter coined "LVRO" in this protocol.[52] Secondary effects may include increases in CO_2 emissions associated with fossil fuel consumption from site preparation, as well as increased GHG emissions caused by the shifting of cultivation activities from the project area to other agricultural lands (often referred to as "leakage").[53] Projects are required to account for all SSRs that are included in the GHG Assessment Boundary regardless of whether the particular SSR is designated as a primary or secondary effect.

Figure 4.1 below provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the project boundary.

Table 4.1 provides a comprehensive list of the GHG SSRs that may be affected by a nitrogen management project and indicates which SSRs must be included in the GHG Assessment Boundary.

[50] The definition and assessment of sources, sinks, and reservoirs is consistent with ISO 14064-2 guidance.
[51] The terms "primary effect" and "secondary effects" come from World Business Council on Sustainable Development / World Resources Institute. (2005). The Greenhouse Gas Protocol for Project Accounting, *World Resources Institute*, Washington, DC. Available at http://www.ghgprotocol.org.
[52] To avoid confusion with secondary effects, this protocol refers to emissions from leaching, volatilization, and runoff as emissions from "LVRO," instead of "indirect N_2O emissions."
[53] Note that leakage emissions are now accounted for as part of PE emissions.

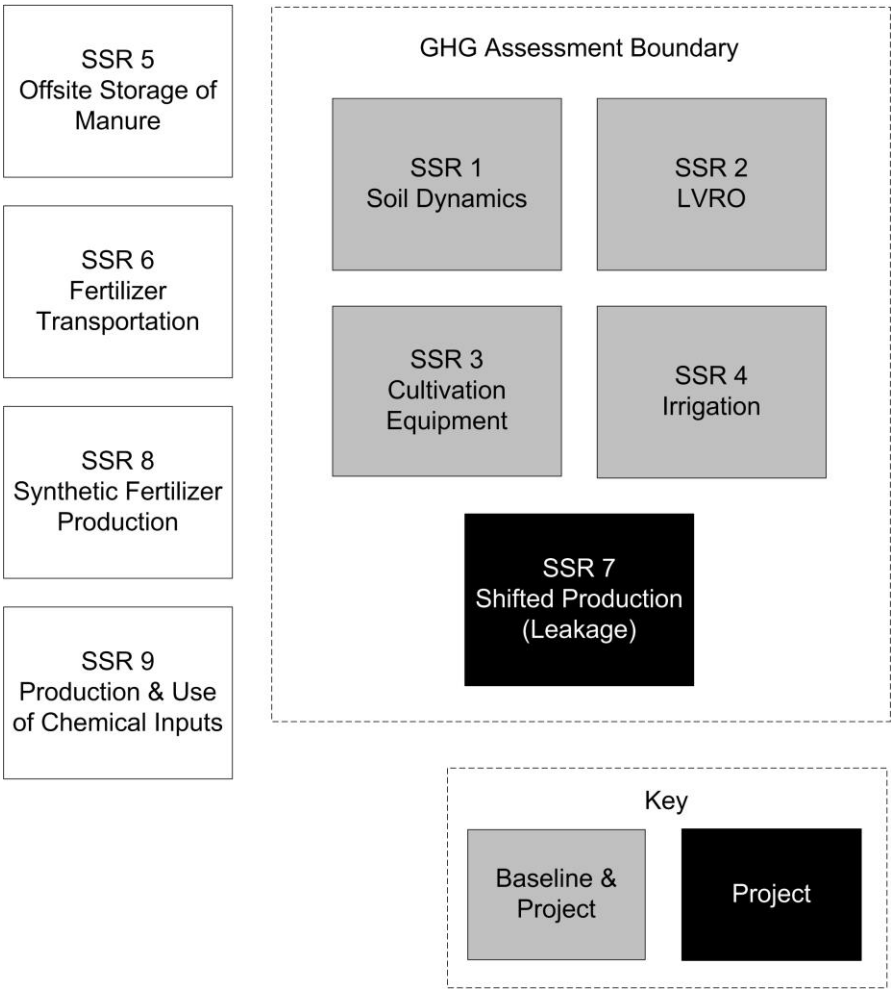

Figure 4.1. General Illustration of the GHG Assessment Boundary

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs					
1. Soil Dynamics	Soil interactions produce emissions of nitrous oxide, carbon dioxide (biogenic), and possibly methane.	CO_2	E	N/A	Soil carbon is expected to increase slightly or remain stable, therefore excluding it is conservative.
		CH_4	E	N/A	Methane production and oxidation is insignificant for non-flooded soils.
		N_2O	I	Emissions impacts of changes in: ▪ synthetic fertilizers are calculated using the NMQuanTool, (see Section 5.1). ▪ organic fertilizers are calculated using MSU-EPRI Tier II or IPCC Tier I default emission factors (see Section 5.1.4).	The primary effect of a nitrogen management project is a reduction in N_2O emissions from soil.[54]
2. LVRO	Leaching, volatilization, and runoff (LVRO) of applied nitrogen, followed by denitrification into N_2O.	N_2O	I	Indirect emissions impacts from changes in: ▪ synthetic fertilizers are calculated using the NMQuanTool (see Section 5.1) ▪ organic N rate are calculated using protocol equations (see Section 5.1.4.3).	A primary effect of nitrogen management projects, this may be a significant portion of overall N_2O emission reductions.
Secondary Effect Sources, Sinks, and Reservoirs					
3. Cultivation Equipment	Fossil fuel emissions from project equipment.	CO_2	I	Method in Section 5.2	Increased emissions associated with changes in use of cultivation equipment may be significant and must be accounted for.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
4. Irrigation	Irrigation impacts soil N_2O emissions, and changes in irrigation may increase	CO_2	I	Method in Section 5.2	Changes in irrigation caused by the project may increase associated fossil fuel usage.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.

[54] These N_2O emissions are referred to as "direct N_2O emissions from soils" by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
	associated fossil fuel usage.	N_2O	I	Irrigation status recorded in NMQuanTool (see Section 5.1).	Irrigation may significantly impact soil dynamics.
5. Offsite Storage of Manure	Indirect emissions from changes in storage of manure source.	CO_2	E	N/A	Supply of manure is relatively inelastic, and end-of-life fate is likely to remain land application, therefore this source is excluded.
		CH_4	E	N/A	
		N_2O	E	N/A	
6. Fertilizer Transport ation	Changes in fertilizers used may change associated transport emissions.	CO_2	E	N/A	Excluded, as this emission source is assumed to be very small.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
7. Shifted Production (Leakage)	Decreased project yields may result in increased cultivation outside the project area.	CO_2	E	Method in Section 5.2	Any significant decreases in yield must be accounted for, as production is assumed to shift outside of project area.
		CH_4	E		
		N_2O	I		
8. Synthetic Fertilizer Production	Decreases in synthetic fertilizer use may affect a decrease in fertilizer production.	CO_2	E	N/A	It is conservative to exclude this category as emissions from this SSR will decrease.
		N_2O	E	N/A	
		CH_4	E	N/A	
9. Production and Use of Chemical Inputs	Changes in nutrient management practices may impact how much lime or herbicides are used on fields.	CO_2	E	N/A	Excluded, as approved project activities are unlikely to materially increase the use of lime or herbicide on fields.
		CH_4	E		
		N_2O	E		

5 Quantifying GHG Emission Reductions

GHG emission reductions from a nitrogen management project are quantified by using both the equations in this section, as well as the NMQuanTool. Emission reductions are quantified (using Equation 5.1 below) by calculating the emission reductions (in metric tons of carbon dioxide equivalents (tCO_2e)) associated with the implementation of eligible nitrogen management project activities (Equation 5.3), and then subtracting any increases in emissions associated with both increases in organic N rates (e.g., manure N) (see Section 5.1.4) and/or secondary emissions (see Section 5.2). Project developers will need to use Equation 5.2 and the guidance in Section 5.1 to calculate the percentage reduction in synthetic N rate for each field in the project reporting period, and select the percentage reduction to the nearest percentage reduction value available in the NMQuanTool. More information on how to use the NMQuanTool to calculate emission reductions from implementing eligible project activities can be found in the tool and in Section 5.1.1. Background information on the modeling effort to produce NMQuanTool can be found in Appendix F. Baseline and project synthetic N rates are calculated in Section 5.1.2 and Section 5.1.3, respectively. Crop production shifting (leakage) and its impact on project synthetic N rate are assessed in Section 5.1.3.2.

Primary effect emissions associated with increases in organic N rates are calculated in Section 5.1.4.4. Baseline and project organic N rates are calculated in Section 5.1.2 and Section 5.1.4, respectively. Finally, increases in secondary effect emissions associated with increases in cultivation equipment usage are addressed in Section 5.2.

An overview of the quantification process can be seen in Figure 5.1.

As of this writing, the Reserve relies on values for global warming potential (GWP) of non-CO_2 GHGs published in the IPCC Fourth Assessment Report: Climate Change 2007 (AR4).[55] The value relevant for this protocol is provided in Table 5.1 below, and is to be used for all nitrogen management projects unless and until the Reserve issues written guidance to the contrary.

Table 5.1. 100-year Global Warming Potential for Non-CO_2 GHGs

Non-CO_2 GHG	100-Year GWP (CO_2e)
Nitrous Oxide (N_2O)	298

The timeline over which emission reductions are quantified is specified in Section 3.3 and Section 7.4. The quantification of emission reductions is carried out separately for each individual field within a project. Similarly, the quantification of emission reductions is carried out separately for each individual project within the cooperative; the cooperative structure does not change the quantification methodology contained within this section. CRTs are serialized and issued to individual projects, rather than the cooperative.

[55] Available here: https://ipcc.ch/publications_and_data/publications_and_data_reports.shtml

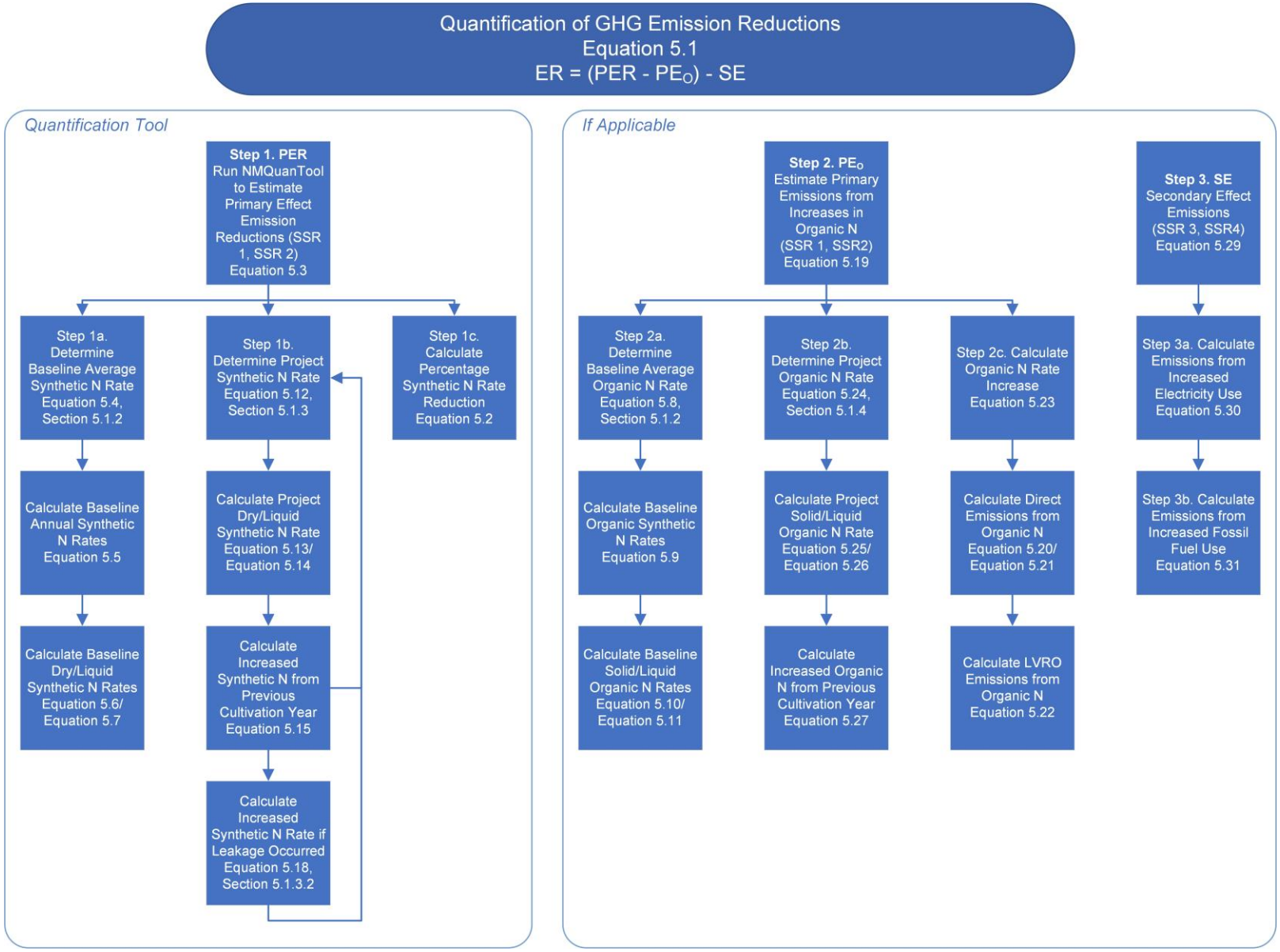

Figure 5.1.Quantification of GHG Emission Reductions Overview

Equation 5.1. GHG Emission Reductions

$$ER = (PER - PE_O) - SE$$

Where,			Units
ER	=	Total emission reductions from the project area for the reporting period*	tCO_2e
PER	=	Total primary effect GHG emission reductions from implementation of eligible project activities over the entire project area, see Equation 5.3 and Section 5.1	tCO_2e
PE_O	=	Total primary effect GHG emissions from organic N rate increases over the entire project area, see Equation 5.19 and Section 5.1.4	tCO_2e
SE	=	Increased emissions from cultivation equipment and irrigation,[56] see Equation 5.29 and Section 5.2	tCO_2e

** It is important to note that the reporting period (other than the initial) for this protocol is one cultivation year (~12 months). As such, the protocol refers frequently to annual N rates, which should be thought of as the N rate over one complete cultivation year.*

5.1 Primary Effect N_2O Emission Reductions

Primary effect emission reductions are the intended reductions in N_2O emissions from the primary SSRs (SSR1, SSR2) within the GHG Assessment Boundary stemming from project activities. They are determined by following the steps in this section.

5.1.1 N_2O Emission Reductions from Eligible Project Activities (NMQuanTool)

Emission reductions resulting from the implementation of eligible project activities are calculated using the Nitrogen Management Quantification Tool (NMQuanTool). Prior to using the NMQuanTool, project developers must first check the Nitrogen Management Project Eligibility Lookup Tool to confirm their fields' activity-crop-count combinations are eligible. The NMQuanTool calculates the changes in both direct and indirect N_2O emissions from the baseline to the project, associated with percentage reductions in synthetic N rates in fixed increments, and optionally also the use of a nitrification inhibitor or the switch to a slow release fertilizer. Project developers must calculate percentage reductions in synthetic N rates from the baseline per project field, per eligible cultivation year, pursuant to Equation 5.2 and the guidance set out in Section 5.1.2 and Section 5.1.3 for determining baseline average and project annual synthetic N rates, respectively. Project developers must then round down the reduction in synthetic N rate to the nearest applicable value and select that percentage reduction as the Nitrogen Fertilizer Reduction (%) in the NMQuanTool. The use of a nitrification inhibitor or slow release fertilizer, region, crop, irrigation and tillage practice are also all selected from drop-down menus in the NMQuanTool. Complete guidance on the data required and how to run the NMQuanTool can be found in Sheet 1 of the NMQuanTool (see Table 6.1 for a summary of NMQuanTool inputs). A copy of the latest version of the NMQuanTool can be made available upon request through the Reserve website.[57] The NMQuanTool calculates the primary effect emission reductions per field and provides a sum total of emission reductions for the project up to a limited number of fields, as exemplified in Equation 5.3 below.

[56] Throughout Section 5, equations will distinguish between calculations which must be performed at the field versus project level. When guidance is provided for a project, but not a field, the guidance should be assumed to apply to both.

[57] http://www.climateactionreserve.org/how/protocols/nitrogen-management/.

Equation 5.2. Percentage Reduction in Synthetic N Rate from Baseline to Project

$$NR_{\Delta P,S,f} = \frac{(NR_{B,S,f,avg} - NR_{P,S,f})}{NR_{B,S,f,avg}} \times 100$$

Where,			Units
$NR_{\Delta P,S,f}$	=	Percentage synthetic N rate reduction from baseline to project on field *f**	
Δ	=	Change from baseline to project	
$NR_{B,S,f,avg}$	=	Average baseline N rate of total synthetic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period, see Equation 5.4	lb/ac
$NR_{P,S,f}$	=	N rate of total synthetic fertilizer for field *f* in project *P*, see Equation 5.12	lb/ac

** The percent reduction in N rate should be rounded down to the nearest increment allowed for in the most current version of the NMQuanTool.*

Equation 5.3. Sum of Primary Effect Emission Reductions for all fields in Project

$$PER = \sum_{f} PER_f$$

Where,			Units
PER	=	Total primary effect GHG emission reductions from implementation of eligible project activities over the entire project area, see Section 5.1 and NMQuanTool	tCO_2e
PER_f	=	Total primary effect GHG emission reductions from implementation of eligible project activities per field, *f*, see Section 5.1 and NMQuanTool	tCO_2e

5.1.2 Baseline N Rates

The baseline scenario is the continuation of the historical cultivation and N management practices where, in the absence of the nitrogen management project, N fertilizer is applied in a "business as usual" manner. As stipulated in Section 2.2.3, N fertilizer application during the baseline and project crediting period must be compared using the same crop(s) grown on the same field.

This protocol utilizes a baseline look-back period to set baseline average N rates for comparison against annual N rates applied each cultivation year in the project. The baseline look-back period is defined as the three most recent cultivation years of the given crop on the given field, prior to the field's project start date. Depending on the historical cultivation at the project field, the baseline look-back period could, for example, consist of the previous three years (monoculture), six years (three cultivation years of a two-crop rotation), or nine years (three cultivation years of a three-crop rotation) prior to the field's start date. The baseline average N rate (either synthetic and/or organic) is defined as the average amount of N applied to the eligible crop in the project field over the baseline look-back period.

Once an appropriate baseline look-back period is identified, the baseline average synthetic N rate ($NR_{B,S,f,avg}$) and baseline average organic N rate ($NR_{B,O,f,avg}$) (if applicable) must be calculated using Equation 5.4 and Equation 5.8, respectively. There are multiple approaches for determining baseline average N rates, as set out in Section 5.1.2.1. Depending on the approach followed, Equation 5.5 and Equation 5.9 must be used to calculate the *annual* synthetic N rates ($NR_{B,S,f,t}$) and *annual* organic N rates ($NR_{B,O,f,t}$,) applied during each eligible crop cultivation year within the baseline look-back period, as necessary to determine the baseline average N rates.

Any N applied to cover crops historically during the baseline look-back period should not be included.

Fertilizer N rates used in the equations throughout this protocol are in units of pounds per acre (lb/ac). Equation 5.6 and Equation 5.7 are used to determine each field's respective baseline synthetic N rate in terms of pounds of nitrogen applied per acre for each type of synthetic fertilizer (i.e., dry and/or liquid), and Equation 5.10 and Equation 5.11 are used to determine each field's respective baseline organic N rate in terms of pounds of nitrogen applied per acre for each type of organic fertilizer (i.e., solid and/or liquid), using information more readily available to the project (such as fertilizer mass and volume and field size). In general, the amount of N-containing fertilizer is multiplied by the N concentration (NC_j) of the fertilizer. Default information on N concentrations and weights of various N-containing fertilizers is provided in Appendix E, though farm management records, commercial fertilizer labels, and/or laboratory tests on the N content of organic sources are preferable, when available, as discussed in Section 5.1.2.1.1.

5.1.2.1 Hierarchical Approaches for Determining Baseline N Rates

The determination of the baseline average N rate for synthetic and organic N is carried out using one of the following three hierarchical approaches:

1. Historical N management records for that crop and field
2. Historical records of N rate recommendations from independent third-party agronomic experts for that crop and field for the years in the baseline look-back period
3. Estimated historical county average N using the Nitrogen Management Project Eligibility Lookup Tool

Note for Approach 1, historical eligible crop yield records must also be provided to demonstrate previous crop cultivation and authenticate the corresponding N rates.

5.1.2.1.1 Historical N Management Records (Approach 1)

Due to its finer spatial resolution (site specificity) and closest depiction of the historical cultivation and N management practices at the field, project developers *must* use Approach 1 if grower-specific historical application records or data to support historical application are available. Records that may satisfy a verifier as to historical N management may include fertilizer application records, precision agriculture technology records, invoices or receipts for fertilizer purchases, fertilizer inventories, as-applied maps, and/or grower spreadsheets or other recording systems. This list is not exhaustive and is meant to provide a few examples of evidence that may satisfy a verifier. Written records of some or all of the above will be necessary. Project developers are encouraged to seek guidance from the Reserve to ensure the records they intend to provide are sufficient. If insufficient data exists for Approach 1, then project developers may use either Approach 2 or Approach 3. In all cases written records will be necessary.

5.1.2.1.2 Historical Agronomic Expert Recommendations (Approach 2)

If a project developer or grower had historically solicited an independent third-party agronomic expert[58] for N application recommendations for the specific crop and field in question, in line with the years in the give crop and field's baseline look-back period (See Section 5.1.2), these recommendations may be provided to set the baseline N rate, from which N rate reductions

[58] For the purposes of this protocol, an agronomic expert is considered any individual with specialized knowledge, skill, education, experience, or training in crop and/or soil science; no official certification is implied or required.

must be made in the project. Such guidance must be in writing. Agronomic rate recommendations must be based on field specific soil conditions (such as utilizing soil samples), climate, and crop needs. If multiple N rates are recommended, the baseline N rate must be based on the lowest recommended application rate for the specific field and crop. At least one years' worth of data from the baseline look-back period is required, though three years' worth is preferable to set an average synthetic and an average organic N rate (Equation 5.4, Equation 5.8). Additionally, if the agronomic guidance did or does not specify organic N rate application recommendations apart from synthetic or total N rate application records, then the baseline organic N rate is given a value of zero by default. As such, any organic N rate applied in the project will be accounted for as an increase in organic N rate, as calculated in Equation 5.23 and Equation 5.24, and addressed in Section 5.1.4.

Project developers pursuing Approach 2 should seek guidance from the Reserve to ensure the guidance and records they intend to use are sufficient.

5.1.2.1.3 County Average Benchmarks (Approach 3)

If historical application records (Approach 1) or agronomic guidance (Approach 2) are unavailable or insufficient for the given field and crop, the three-year average county- and crop-specific N rate estimates, retrievable from the Nitrogen Management Project Eligibility Lookup Tool, may be used as the baseline average synthetic N rate ($NR_{B,S,f,avg}$) from which synthetic N rate reductions must be made in the project. Approach 3 is not applicable for the determination of baseline organic N fertilizer rate; thus, the baseline organic N input is given a value of zero by default for any projects using this approach. As such, like with Approach 2, any organic N rate applied in the project will be accounted for as an increase in organic N rate, as calculated in Equation 5.23 and Equation 5.24, and addressed in Section 5.1.4.

5.1.2.2 Baseline Synthetic N Rates

Equation 5.4. Baseline Average Synthetic Fertilizer N Rate on Field

$$NR_{B,S,f,avg} = \frac{\sum_t NR_{B,S,f,t}}{3}$$

Where,			Units
$NR_{B,S,f,avg}$	=	Baseline average N rate of total synthetic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period	lb/ac
$NR_{B,S,f,t}$	=	Baseline annual N rate of total synthetic fertilizer for field *f* in year *t* of the baseline look-back period, see Equation 5.5	lb/ac
3	=	Number of eligible crop years included in the baseline look-back period	

Equation 5.5. Baseline Annual Synthetic Fertilizer N Rate on Field in Year of Baseline Look-Back Period

$$NR_{B,S,f,t} = \sum_j NR_{B,DS,j,f,t} + \sum_j NR_{B,LS,j,f,t}$$

Where,			Units
$NR_{B,S,f,t}$	=	Baseline annual N rate of total synthetic fertilizer for field *f* in year *t* of the baseline look-back period	lb/ac
$NR_{B,DS,j,f,t}$	=	N rate of dry synthetic, *DS*, fertilizer type *j* on field *f* in year t of the baseline look-back period, see Equation 5.6	lb/ac
$NR_{B,LS,j,f,t}$	=	N rate of liquid synthetic, *LS*, fertilizer type *j* on field *f* in year t of the baseline look-back period, see Equation 5.7	lb/ac

Equation 5.6. N Rates for Dry N-Containing Synthetic Fertilizer in Year of Baseline Look-Back Period

$$NR_{B,DS,j,f,t} = MF_{B,DS,j,f,t} \times NC_{B,DS,j,t}$$

Where,			Units
$NR_{B,DS,j,f,t}$	=	N rate of dry synthetic fertilizer *j* for field *f* in baseline *B* in year *t*	lb/ac
$MF_{B,DS,j,f,t}$	=	Mass of dry synthetic N-containing fertilizer *j* applied to field *f* per acre in baseline *B* in year *t*	lb/ac
$NC_{B,DS,j,t}$	=	N concentration of dry synthetic fertilizer *j* in baseline *B* in year *t*, see Farm Records or Appendix E	

Equation 5.7. N Rates of Liquid N-Containing Synthetic Fertilizer in Year of Baseline Look-Back Period

$$NR_{B,LS,j,f,t} = VF_{B,LS,j,f,t} \times MF_{B,LS,j,t} \times NC_{B,LS,j,t}$$

Where,			Units
$NR_{B,LS,j,f,t}$	=	N rate of liquid synthetic fertilizer *j* for field *f* in baseline *B* in year *t*	lb/ac
$VF_{B,LS,j,f,t}$	=	Volume of liquid synthetic N-containing fertilizer *j* applied to field *f* per acre in baseline *B* in year *t*	gallon/ac
$MF_{B,LS,j,t}$	=	Mass of liquid synthetic fertilizer *j* per gallon of fertilizer in baseline *B* in year *t*	lb/gallon
$NC_{B,LS,j,t}$	=	N concentration of liquid synthetic fertilizer *j* in baseline *B* in year *t*, see Farm Records or Appendix E	

5.1.2.3 Baseline Organic N Rates

Equation 5.8. Baseline Average Organic Fertilizer N Rate on Field

$$NR_{B,O,f,avg} = \frac{\sum_t NR_{B,O,f,t}}{3}$$

Where,			Units
$NR_{B,O,f,avg}$	=	Average baseline N rate of total organic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period	lb/ac
$NR_{B,O,f,t}$	=	Annual baseline N rate of total organic fertilizer for field *f* in year *t* of the baseline look-back period, see Equation 5.9	lb/ac
3	=	Number of eligible crop years included in the baseline look-back period	

Equation 5.9. Baseline Annual Organic Fertilizer N Rate on Field in Year of Baseline Look-Back Period

$$NR_{B,O,f,t} = \sum_{j} NR_{B,SO,j,f,t} + \sum_{j} NR_{B,LO,j,f,t}$$

Where,			Units
$NR_{B,O,f,t}$	=	Baseline annual N rate of total organic fertilizer for field *f* in year *t* of the baseline look-back period	lb/ac
$NR_{B,SO,j,f,t}$	=	N rate of solid organic, *SO*, fertilizer type *j* on field *f* in year *t* of the baseline look-back period, see Equation 5.10	lb/ac
$NR_{B,LO,j,f,t}$	=	N rate of liquid organic, *LO*, fertilizer type *j* on field *f* in year *t* of the baseline look-back period, see Equation 5.11	lb/ac

Equation 5.10. N Rates of Solid N-Containing Organic Fertilizer in Year of Baseline Look-Back Period

$$NR_{B,SO,j,f,t} = MF_{B,SO,j,f,t} \times NC_{B,SO,j,t}$$

Where,			Units
$NR_{B,SO,j,f,t}$	=	N rate of solid organic fertilizer *j* for field *f* in baseline *B* in year *t*	lb/ac
$MF_{B,SO,j,f,t}$	=	Mass of solid organic N-containing fertilizer *j* applied to field *f* per acre in baseline *B* in year *t*	lb/ac
$NC_{B,SO,j,t}$	=	N concentration of solid organic fertilizer *j* in baseline *B* in year *t*, see Farm Records or Appendix E[59]	

Equation 5.11. N Rates of Liquid N-Containing Organic Fertilizer in Year of Baseline Look-Back Period

$$NR_{B,LO,j,f,t} = VF_{B,LO,j,f,t} \times MF_{B,LO,j,f,t} \times NC_{B,LO,j,t}$$

Where,			Units
$NR_{B,LO,j,f,t}$	=	N rate of liquid organic fertilizer *j* for field *f* in baseline *B* in year *t*	lb/ac
$VF_{B,LO,j,f,t}$	=	Volume of liquid organic N-containing fertilizer *j* applied to field *f* per acre in baseline *B* in year *t*	gallon/ac
$MF_{B,LO,j,f,t}$	=	Mass of liquid organic N-containing fertilizer *j* applied to field *f* in baseline *B* in year *t*	lb/gallon
$NC_{B,LO,j,t}$	=	N concentration of liquid organic fertilizer *j* in baseline *B* in year *t*, see Farm Records or Appendix E[60]	

Note that where sufficient baseline look-back period data are not available to calculate annual baseline N rates, alternative approaches set out in Section 5.1.2.1 may be used.

5.1.3 Project Synthetic N Rates

For each reporting period, the project synthetic N rates applied over the eligible crop cultivation year for each field is calculated using Equation 5.12 through Equation 5.18 below. When calculating the project N rates, any synthetic N applied to cover crops grown between the harvest of the previous primary crop and the subsequent eligible crop, shall be included in the

[59] For processed commercial organic fertilizer, N contents following manufacturer's specifications can be used. For unprocessed manure, default manure N contents are shown in Appendix E and are consistent with Edmonds et al. (2003) cited in U.S. Environmental Protection Agency. (2011). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. EPA 430-R-11-005*. Washington, D.C.

[60] *Ibid.*

synthetic N rate for the eligible cultivation crop in question. Project synthetic N rate (Equation 5.12) always includes the total amount of synthetic N (both dry and/or liquid sources) applied to the field during the eligible crop cultivation year (Equation 5.13, Equation 5.14), and depending on the project, may need to be increased for increases in synthetic N rate applied to the field during a previous cultivation year where CRTs were not sought (Equation 5.15) and/or for production shifting leakage (Equation 5.18). The percentage reduction between the baseline average synthetic N rate and the project synthetic N rate must then be calculated for each field, see Equation 5.2, and entered in the NMQuanTool, as discussed in Section 5.1.1.

Equation 5.12. Project Synthetic Fertilizer N Rate for Field

$$NR_{P,S,f} = \sum_j NR_{P,DS,j,f} + \sum_j NR_{P,LS,j,f} + NR_{\delta S,f} + NR_{ps,f}$$

Where,			Units
$NR_{P,S,f}$	=	N rate of total synthetic fertilizer for field *f* in project *P*	lb/ac
$NR_{P,DS,j,f}$	=	N rate of dry synthetic fertilizer type *j* on field *f,* see Equation 5.13	lb/ac
$NR_{P,LS,j,f}$	=	N rate of liquid synthetic fertilizer type *j* on field *f,* see Equation 5.14	lb/ac
$NR_{\delta S,f}$	=	Change in synthetic N rate between baseline look-back period and previous cultivation year (prior to project cultivation year) in which CRTs were not earned. If synthetic N rate did not increase from the previous cultivation year, then $NR_{\delta S,f}$ = 0. See Equation 5.15	lb/ac
δ	=	Change from baseline look-back period to previous cultivation year	
$NR_{ps,f}$	=	Increase in synthetic N rate due to production shifting, if applicable, see Equation 5.18	lb/ac

Equation 5.13. N Rates for Dry N-Containing Synthetic Fertilizer in Project

$$NR_{P,DS,j,f} = MF_{P,DS,j,f} \times NC_{P,DS,j}$$

Where,			Units
$NR_{P,DS,j,f}$	=	N rate of dry synthetic fertilizer *j* for field *f* in project *P*	lb/ac
$MF_{P,DS,j,f}$	=	Mass of dry synthetic N-containing fertilizer *j* applied to field *f* in project *P*	lb/ac
$NC_{P,DS,j}$	=	N concentration of dry synthetic fertilizer *j* in project *P*, see Farm Records or Appendix E	

Equation 5.14. N Rates of Liquid N-Containing Synthetic Fertilizer in Project

$$NR_{P,LS,j,f} = VF_{P,LS,j,f} \times MF_{P,LS,j} \times NC_{P,LS,j}$$

Where,			Units
$NR_{P,LS,j,f}$	=	N rate of liquid synthetic fertilizer *j* for field *f* in project *P*	lb/ac
$VF_{P,LS,j,f}$	=	Volume of liquid synthetic N-containing fertilizer *j* applied to field *f* per acre in project *P*	gallon/ac
$MF_{P,LS,j}$	=	Mass of liquid synthetic fertilizer *j* per gallon of fertilizer in project *P*	lb/gallon
$NC_{P,LS,j}$	=	N concentration of liquid synthetic fertilizer *j* in project *P*, see Farm Records or Appendix E	

5.1.3.1 Increases in Synthetic N from Cultivation Years in which CRTs are Not Claimed

To be eligible for CRTs, the synthetic N rate must be reduced from the baseline to the project. The NMPP allows flexibility in dealing with instances where the project developer either cannot or does not want to claim CRTs for a given crop cultivation year (See Section 3.5.1.1). These restrictions are intended to ensure excessive N is not applied in intervening years, with the intent to have residual N then affect the subsequent eligible crop cultivation year.

If CRTs are not earned in the previous cultivation year (prior to the project cultivation year) and if synthetic N rate increased from baseline levels in the previous cultivation year, that increase in synthetic N rate must be included in the project cultivation year. The project developer must include the increase in Equation 5.12 when calculating the synthetic N rates for the project cultivation year. Increases in synthetic N rates for cultivation years in which CRTs are not being sought will be calculated using Equation 5.15 and Equation 5.16 below, and then included in Equation 5.12 above.

If CRTs are earned in the previous cultivation year (prior to the project cultivation year), proceed to Section 5.1.3.2.

Equation 5.15. Change in Synthetic N on Field from Previous Cultivation Year Not Claiming CRTs

$$NR_{\delta S,f} = NR_{pcy,S,f} - NR_{B,S,f,avg}$$

Where,			Units
$NR_{\delta S,f}$	=	Change in synthetic N rate on field *f* between baseline look-back period and previous cultivation year (prior to project cultivation year) in which CRTs were not earned. If synthetic N rate did not increase from the previous cultivation year, then $NR_{\delta S,f} = 0$	lb/ac
δ	=	Change from baseline look-back period to previous cultivation year	
$NR_{pcy,S,f}$	=	N rate of total synthetic N fertilizer for field *f* from a previous cultivation year, *pcy*, for which CRTs were not earned, see Equation 5.16	lb/ac
$NR_{B,S,f,avg}$	=	Baseline average N rate of total synthetic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period, see Equation 5.4	lb/ac

Equation 5.16. Previous Cultivation Year Synthetic Fertilizer N Rate for Field

$$NR_{pcy,S,f} = \sum_{j} NR_{pcy,DS,j,f} + \sum_{j} NR_{pcy,LS,j,f}$$

Where,			Units
$NR_{pcy,S,f}$	=	N rate of total synthetic N fertilizer for field *f* from a previous cultivation year, *pcy*, in which CRTs were not earned	lb/ac
$NR_{pcy,DS,j,f}$	=	N rate of dry synthetic fertilizer type *j* on field *f,* see Equation 5.13	lb/ac
$NR_{pcy,LS,j,f}$	=	N rate of liquid synthetic fertilizer type *j* on field *f,* see Equation 5.14	lb/ac

5.1.3.2 Increases in Synthetic N Rate from Shifting Crop Production Outside Project Boundaries (Leakage)

Econometric studies have reported considerable price elasticity for corn.[61] Therefore, it is assumed in this protocol that a statistically significant decrease in corn yields due to project

[61] Huang, H., & Khanna, M., 2010.

activities would result in an increase of production outside of the project area. The same assumption is held true for all eligible crops. The increased emissions associated with this shift in production must be estimated if project-related yield losses are statistically-significant compared to historical average yields in the baseline look-back period. If yield decreases in a statistically significant manner compared to historical average yields, then significant leakage would have occurred, and the project synthetic N rate in Equation 5.3 will be increased proportionately to the shift in production.

The historical average yield is calculated from the three eligible crop years in the baseline look-back period prior to the start date in alignment with the same three years for the baseline fertilizer records. If a catastrophic yield loss occurred due to anomalous weather during a historical eligible crop year, yield data for that year may be excluded from the calculation of average historical yield; however, if those yield data are excluded, the historical period over which the average historical yield is calculated must be extended to include another historical eligible year (i.e., so that the same number of valid eligible crop years is used to determine the average historical yield). Verifiers shall use their professional judgment to determine whether it was appropriate to exclude an anomalous yield for calculating Y_f. The average historical yield value shall be fixed for the duration of a field's crediting period, but shall be (re)calculated at the start of each crediting period.

In order to determine if crop yields have decreased in a statistically significant manner across the project area during the cultivation year as a result of project activities, the annual yield from the project area must be compared to the historical average yield over the baseline look-back period from the same project area. Because yields fluctuate annually depending on numerous climatic drivers, for this evaluation yields are normalized to historical average annual county yields using USDA National Agricultural Statistics Service (NASS) statistics,[62] according to the procedure below.

This normalization procedure must be followed for each cultivation year to demonstrate that the yields from the project area have not declined due to project activities. The following procedure is applicable at the field level and must be applied to each field in the project.

1. For each year *t* in the baseline look-back period (see Section 5.1.2), normalize (y_norm_t) the yield of the project field ($Y_{P,f}$) by the county average for that historical year ($Y_{Co,t}$) using Equation 5.17. The distribution of y_norm_t will have the same number data points as the number of eligible crop years in the baseline look-back period (i.e., three years).

[62]This dataset is robust and published on a regular, annual schedule. Available at http://quickstats.nass.usda.gov. See Appendix B for more information.

Equation 5.17. Normalized Project Yield for Each Year in the Baseline

$$y_norm_t = \frac{Y_{P,f}}{Y_{Co,t}}$$

Where,			Units
y_norm_t	=	Normalized yield of field *f* in project *P* for year *t*	
$Y_{P,f}$	=	Yield of field *f* in project *P*	yield/ac
$Y_{Co,t}$	=	County, *Co*, average yield in year *t* (based on USDA NASS statistics)	yield/ac
t	=	Year in 3-year baseline look-back period	

y_norm_t must be determined for each year t in the baseline look-back period (t_1, t_2, and t_3) and for the current cultivation year, t_0.

2. Take the standard deviation, *s*, and mean of the y_norm_t distribution:

$$s = stdev(y_norm_{t1}, y_norm_{t2}, y_norm_{t3})$$

$$\overline{y_norm_t} = average(y_norm_{t1}, y_norm_{t2}, y_norm_{t3})$$

3. Calculate the minimum yield threshold below which normalized yields are significantly smaller than the historical average. This shall be done as follows:

$$y_\min = \overline{y_norm_t} - (2.92 \times s)$$

Where 2.92 is the t-distribution value with 95 percent confidence for a one-tailed test with two degrees of freedom (i.e., *n* is 3),[63] and *s* is the standard deviation of the y_norm_t distribution, as calculated in Step 2.

4. For the cultivation year, t_0, for the current reporting period, normalize (y_norm_{t0}) the yield of the project field ($Y_{P,f}$) by the county average ($Y_{Co,t0}$) for the current cultivation year, using Equation 5.17 but replacing *t* with t_0, and compare this value to *y_min*. **If y_norm_{t0} is smaller than y_min, it must be assumed that leakage occurred, and emissions increased outside of the project area**. The project must account for the shifted production via an increase in the project synthetic N rate, as set out in Equation 5.18. If y_norm_{t0} is greater than or equal to *y_min*, any leakage associated with production shifting is reasonably expected to be *de minimis*, and no adjustments to the project synthetic N rate are required.

[63] The t-distribution value of 2.920 = t(0.05, n-1), where n is 3, and n-1 degrees of freedom is 2. If there are less than three data points (e.g., less than three eligible crop years in the baseline look-back period), a different t-distribution value must be substituted for 2.920. Specifically, where n=2, t-value=6.314.

Equation 5.18. Increase in Project Synthetic N Rate Due to Production Shifting (Leakage)

$$NR_{ps,f} = \left(1 - \frac{y_norm_{t0}}{y_min}\right) \times NR_{P,S,f}$$

Where,			Units
$NR_{ps,f}$	=	Increase in synthetic N rate due to production shifting, *ps*, outside of the project boundary for field *f*	lb/ac
y_norm_{t0}	=	Normalized project yield for field *f*	yield/ac*
y_min	=	Minimum yield threshold below which normalized yields are significantly smaller than the historical average for field *f*	yield/ac
$NR_{P,S,f}$	=	N rate for total synthetic fertilizer for field *f,* see Equation 5.12**	lb/ac
t_0	=	Cultivation year in the current reporting period	

** Any appropriate unit of yield for given crop can be used, as long as the units for y_norm_{t0} are the same as the units for y_min.*
*** Note that $NR_{P,S,f}$ should first be imported into this equation* from *Equation 5.12 prior to adding $NR_{ps,f}$. Then $NR_{ps,f}$ should be included in the final total synthetic N rate in Equation 5.12, thus avoiding a circular reference.*

5.1.4 N_2O Emissions from Increases in Organic N Rates

If organic N rates increase in the project as compared to the baseline average organic N rate, emissions associated with these increases must be subtracted from the total calculated primary effect GHG reductions for each reporting period. Two main sources of primary effect N_2O emissions from increases in organic N rates must be taken into account: 1) direct N_2O emissions from soil (SSR1) and 2) emissions from leaching, volatilization, and runoff (LVRO) (SSR 2). The total primary effect emissions are summed together at the project level using Equation 5.19. Direct N_2O emissions from soil, from increases in organic N rate, must be calculated using one of two equations, depending upon whether the fields in question are cultivating corn and are located in the North Central Region[64] (i.e., the corn belt) (Equation 5.20), or cultivating eligible crops other than corn and/or are outside the North Central Region (Equation 5.21). LVRO from increases in organic N rate are calculated using Equation 5.22.

Equation 5.19. Primary Effect GHG Emissions from Increases in Organic N

$$PE_O = \sum_f (N_2O_{O,Dir,f} + N_2O_{O,LVRO,f})$$

Where,			Units
PE_O	=	Total primary effect N_2O emissions from organic N for the project	tCO_2e/ac
$N_2O_{O,Dir,f}$	=	Direct N_2O emissions from increased organic N applied to field *f*, see Equation 5.20 or Equation 5.21	tCO_2e/ac
$N_2O_{O,LVRO,f}$	=	N_2O emissions from leaching, volatilization, and runoff from increased organic N applied field *f*, see Equation 5.22	tCO_2e/ac

5.1.4.1 Direct N_2O Emissions from Corn in the North Central Region

The direct N_2O emissions from increases in organic N rates when growing corn in the North Central Region are calculated using the increase in organic N rate in the project (Equation 5.23)

[64] The U.S. States in the North Central Region include: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

and the MSU-EPRI Tier 2 emission factor developed for cropping systems in the North Central Region of the U.S.,[65] as seen in Equation 5.20.

Equation 5.20. Direct N_2O Emissions from Organic N Changes in the Corn Belt

$$N_2O_{O,Dir,f} = \frac{EF_{NCR} \times \frac{44}{28} \times GWP}{2204.62}$$

Where,			Units
$N_2O_{O,Dir,f}$	=	Direct N_2O emissions from eligible crop years from field *f*	tCO_2e/ac
EF_{NCR}	=	Adjusted MSU-EPRI Tier 2 emission factor for corn cropping systems in the North Central Region	
44/28	=	Unit conversion from lb N_2O-N to lb N_2O, where 44 is the molecular weight of N_2O and 28 is twice the atomic weight of N	
GWP	=	Global warming potential of N_2O. This value shall be 298 until further guidance is issued by the Reserve. See Table 5.1	
2204.62	=	Conversion from lb CO_2e to tCO_2e	lb/t

and,

$$EF_{NCR} = 0.67 \times \left[e^{(0.0067 \times NR_{\Delta O,f})} - 1\right]$$

Where,			Units
$NR_{\Delta O,f}$	=	Increase in organic N rate on field *f,* see Equation 5.23	lb/ac

5.1.4.2 Direct N_2O Emissions other than from Corn in the North Central Region

The direct N_2O emissions from increases in organic N rates outside the North Central Region are calculated using the increase in the increase in organic N rate in the project (Equation 5.23) and the IPCC Tier 1 default emission factor for N_2O emissions from organic N, using Equation 5.21.

Equation 5.21. Direct N_2O Emissions from Organic N Changes Outside the Corn Belt

$$N_2O_{O,Dir,f} = \frac{0.01 \times NR_{\Delta O,f} \times \frac{44}{28} \times GWP}{2204.62}$$

Where,			Units
$N_2O_{O,Dir,f}$	=	Direct N_2O emissions from increased organic N applied to field *f*	tCO_2e/ac
0.01	=	IPCC Tier 1 default emission factor for N_2O emissions from organic N	
$NR_{\Delta O,f}$	=	Increase in organic N rate on field *f,* see Equation 5.23	lb/ac
44/28	=	Unit conversion from lb N_2O-N to lb N_2O, where 44 is the molecular weight of N_2O and 28 is twice the atomic weight of N	
GWP	=	Global warming potential of N_2O. This value shall be 298 until further guidance is issued by the Reserve. See Table 5.1	
2204.62	=	Conversion from lb CO_2e to tCO_2e	lb/t

[65] Millar et al. (2012). *Methodology for Quantifying Nitrous Oxide (N_2O) Emissions Reductions by Reducing Nitrogen Fertilizer Use on Agricultural Crops*. American Carbon Registry, Winrock International, Little Rock, Arkansas. July 2012.

5.1.4.3 N_2O Emissions from Leaching, Volatilization, and Runoff from Increases in Organic N

N_2O emissions from LVRO from increases in organic N must be accounted for in determining primary effect GHG reductions and are determined according to Equation 5.22 below.

Equation 5.22. N_2O Emissions from LVRO from Increases in Organic N Per Field

$$N_2O_{O,LVRO,f} = \frac{\left[\left(NR_{\Delta O,f} \times 0.20 \times 0.01\right) + \left(NR_{\Delta O,f} \times Frac_{LEACH} \times 0.0075\right)\right] \times \frac{44}{28} \times GWP}{2204.62}$$

Where,			Units
$N_2O_{O,LVRO,f}$	=	N_2O emissions from leaching, volatilization, and runoff from increased organic N applied to field *f* for the reporting period	tCO_2e/ac
$NR_{\Delta O,f}$	=	Increase in organic N rate on field *f,* see Equation 5.23	lb/ac
0.20	=	IPCC default factor for the fraction of all organic fertilizer N inputs that volatizes as NH_3 and NO_x (IPCC parameter name: FracGASM)	
0.01	=	IPCC default emission factor for N_2O emissions from atmospheric deposition of N on soil and water surfaces and subsequent volatization (IPCC parameter name: EF4)	
$Frac_{LEACH}$	=	Fraction of organic N inputs that is lost through leaching and runoff. See Box 5.1 and Appendix D	
0.0075	=	IPCC default emission factor for N_2O emissions from N leaching and runoff (IPCC parameter name: EF5)	
44/28	=	Unit conversion from lb N_2O-N to lb N_2O	
GWP	=	Global warming potential of N_2O. This value shall be 298 until further guidance is issued by the Reserve. See Table 5.1	
2204.62	=	Conversion from lb CO_2e to tCO_2e	lb/t

Box 5.1. Determining $Frac_{LEACH}$ for Increased Project Organic N Rates

The fraction of N inputs lost through leaching and runoff ($Frac_{LEACH}$) is an important input in Equation 5.22 where LVRO emissions associated with increases in organic N are calculated. Whether or not leaching occurs may vary due to inter-annual variability in levels of precipitation and evapotranspiration.

Most fields will apply a $Frac_{LEACH}$ value calculated based on precipitation and evaporation data from a nearby weather station, according to the methodology outlined in Appendix D.[66]

Fields with certain site-specific characteristics, however, are required by this protocol to use fixed default $Frac_{LEACH}$ values. Specifically, fields with tile drains shall use the fixed default value of $Frac_{LEACH}$ = 0.3, even if that county otherwise would have applied a $Frac_{LEACH}$ value of 0.[67]

All other fields, including those fields using irrigation, shall apply the $Frac_{LEACH}$ value calculated according to Appendix D. The IPCC recommends a $Frac_{LEACH}$ default of 0.3 for all irrigated fields (except those receiving drip irrigation). The Reserve assumes that "emergency irrigation" years will have $Frac_{LEACH}$ values more similar to fields receiving drip irrigation.[68] Because of this, any non-irrigated fields receiving emergency irrigation in year of severe or extreme drought shall apply the $Frac_{LEACH}$ value determined by comparing precipitation and potential evapotranspiration data (i.e., calculating $Frac_{LEACH}$) instead of the 0.3 value. The Reserve believes this methodology maintains consistency with IPCC guidelines for determining $Frac_{LEACH}$.

5.1.4.4 Changes in Project Organic N Rates

This section provides the calculation method for primary effect N_2O emissions (PE_O) from *increases* in organic N rate applications. Organic N rate is allowed to increase from the baseline to the project, so long as total N rate decreases from the baseline to the project (see Equation 3.5, Section 3.5.1.1).If organic N rate increases in the project from the baseline, emissions associated with these increases must be subtracted from the total calculated primary effect GHG reductions (Equation 5.1), for each reporting period. If organic N rate remains the same or decreases from the baseline and the project on the given field, then $PE_O = 0$ in Equation 5.1. Project developers must follow Equation 5.23 through Equation 5.27 below to determine the increase in organic N rate per field. The associated increase in N_2O emissions at the field and project levels are then calculated in Section 5.1.4.

[66] Once data becomes available, the Reserve plans to streamline project accounting by calculating the value for $Frac_{LEACH}$ by county and publishing those values on the Reserve website.

[67] This default value for tile-drained fields is consistent with the IPCC methodology, based on analysis performed in Nevison, Cynthia. "Background Paper on Indirect N_2O Emissions from Agriculture," G*ood Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Background paper published 2003 to inform the 2006 update to the Revised 1996 National Inventory Guidelines, Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_6_Indirect_N2O_Agriculture.pdf. Nevison's analysis reviewed case studies that took place in the Midwestern U.S., generally in fields of corn or soybeans, underlain with tile drains to confirm whether the IPCC methodology was appropriate for these systems.

[68] "Emergency irrigation" is requisite irrigation to prevent crop failure in years of severe drought in systems that are typically not irrigated, for example, in a county that has received a USDA Secretarial disaster designation due to severe drought in a given cultivation year.

Equation 5.23. Change in N Rate of Organic Fertilizer for Field in Project

$$NR_{\Delta O,f} = NR_{P,O,f} - NR_{B,O,f,avg}$$

Where,			Units
$NR_{\Delta O,f}$	=	Change in organic N rate on field *f*. If the organic N rate decreases in the project relative to the baseline, then $NR_{\Delta O,f} = 0$	lb/ac
$NR_{P,O,f}$	=	N rate of total organic fertilizer for field *f* in project *P*, see Equation 5.24	lb/ac
$NR_{B,O,f,avg}$	=	Average baseline N rate of total organic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period, see Equation 5.8	lb/ac

The total organic fertilizer N rate for a particular field *f* is calculated as the sum of N rates of all solid and liquid (slurry) organic N sources and calculated in Equation 5.24 below.

Equation 5.24. Project Organic Fertilizer N Rate for Field

$$NR_{P,O,f} = \sum_{j} NR_{P,SO,j,f} + \sum_{j} NR_{P,LO,j,f} + NR_{\delta O,f}$$

Where,			Units
$NR_{P,O,f}$	=	N rate of total organic fertilizer for field *f*	lb/ac
$NR_{P,SO,j,f}$	=	N rate of solid organic fertilizer type *j* on field *f,* see Equation 5.25	lb/ac
$NR_{P,LO,j,f}$	=	N rate of liquid organic fertilizer type *j* on field *f,* see Equation 5.26	lb/ac
$NR_{\delta O,f}$	=	Increase in organic N rate between baseline and previous cultivation year for which CRTs were not earned, if applicable, see Equation 5.27	

Equation 5.25. N Rates of Solid N-Containing Organic Fertilizer in Project

$$NR_{P,SO,j,f} = MF_{P,SO,j,f} \times NC_{P,SO,j}$$

Where,			Units
$NR_{P,SO,j,f}$	=	N rate of solid organic fertilizer *j* for field *f* in project *P*	lb/ac
$MF_{P,SO,j,f}$	=	Mass of solid organic N-containing fertilizer *j* applied to field *f* per acre in project *P*	lb/ac
$NC_{P,SO,j}$	=	N concentration of solid organic fertilizer *j* in project *P*, see Farm Records or Appendix E[69]	

[69] For processed commercial organic fertilizer, N contents following manufacturer's specifications can be used. For unprocessed manure, default manure N contents are shown in Appendix E and are consistent with Edmonds et al. (2003) cited in U.S. Environmental Protection Agency. (2011). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. EPA 430-R-11-005*. Washington, D.C.

Equation 5.26. N Rates of Liquid N-Containing Organic Fertilizer in Project

$$NR_{P,LO,j,f} = VF_{P,LO,j,f} \times MF_{P,LO,j,f} \times NC_{P,LO,j}$$

Where,			Units
$NR_{P,LO,j,f}$	=	N rate of liquid organic fertilizer *j* for field *f* in project *P*	lb/ac
$VF_{P,LO,j,f}$	=	Volume of liquid organic N-containing fertilizer *j* applied to field *f* per acre in project *P*	gallon/ac
$MF_{P,LO,j,f}$	=	Mass of liquid organic N-containing fertilizer *j* applied to field *f* in project *P*	lb/gallon
$NC_{P,LO,j}$	=	N concentration of liquid organic fertilizer *j* in project *P*, see Farm Records or Appendix E[70]	

5.1.4.4.1 Increases in Organic N from Cultivation Years in which CRTs are not Claimed

As discussed in Section 5.1.3.1 with synthetic N rates, if CRTs are not earned in the previous cultivation year (prior to the project cultivation year) and if organic N rate increased from baseline levels in the previous cultivation year, that increase in organic N rate must be included in the project cultivation year. The project developer must include the increase in Equation 5.24 when calculating the organic N rates for the project cultivation year. Increases in organic N rates for cultivation years in which CRTs are not being sought will be calculated using Equation 5.27 and Equation 5.28 below, and then included in Equation 5.24 above.

If CRTs are earned in the previous cultivation year (prior to the project cultivation year), proceed to Section 5.2.

Equation 5.27. Change in N Rate of Organic Fertilizer for Field in Previous Cultivation Year

$$NR_{\delta O,f} = NR_{pcy,O,f} - NR_{B,O,f,avg}$$

Where,			Units
$NR_{\delta O,f}$	=	Change in organic N rate on field *f* between baseline look-back period and previous cultivation year (prior to project cultivation year) for which CRTs were not earned. If organic N rate did not increase from the previous cultivation year, then $NR_{\delta O,f} = 0$	lb/ac
δ	=	Change from baseline look-back period to previous cultivation year	
$NR_{pcy,O,f}$	=	N rate of total organic N fertilizer for field *f* from a previous cultivation year, *pcy*, in which CRTs were not earned, see Equation 5.28	lb/ac
$NR_{B,O,f,avg}$	=	Baseline average N rate of total organic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period, see Equation 5.8	lb/ac

[70] *Ibid.*

Equation 5.28. Previous Cultivation Year Organic Fertilizer N Rate for Field

$$NR_{pcy,O,f} = \sum_{j} NR_{pcy,SO,j,f} + \sum_{j} NR_{pcy,LO,j,f}$$

Where,			Units
$NR_{pcy,O,f}$	=	N rate of total organic N fertilizer for field *f* from a previous cultivation year, *pcy*, in which CRTs were not earned	lb/ac
$NR_{pcy,SO,j,f}$	=	N rate of solid organic fertilizer type *j* on field *f* in previous cultivation year, *pcy,* see Equation 5.25	lb/ac
$NR_{pcy,LO,j,f}$	=	N rate of liquid organic fertilizer type *j* on field *f* in previous cultivation year, *pcy,* see Equation 5.26	lb/ac

5.2 Secondary Effect GHG Emissions

Secondary effect emissions are unintentional changes in GHG emissions from the secondary SSRs within the GHG Assessment Boundary. Secondary effect emissions may increase, decrease or go unchanged as a result of the project activities. If emissions from secondary SSRs *increase* as a result of the project, these emissions must be subtracted from the total calculated primary effect GHG reductions for each reporting period in Equation 5.1.

However, if the project can demonstrate that electricity and/or fossil fuel usage is reasonably expected to increase by 5 percent or less, relative to baseline usage, the emissions associated with such increased usage need not be accounted for. In order to assess whether usage has increased by more than 5 percent relative to baseline usage, levels of electricity and fossil fuel usage may be estimated through a conservative method proposed by the project developer and deemed acceptable by the verifier. The project developer could assert to their verifier and demonstrate that no significant changes have occurred in their management practices (e.g., the same or commensurate equipment is being used, the same number of fertilizer applications are being made, the same irrigation frequency is maintained, etc.). If the verifier is satisfied that electricity and/or fossil fuel usage did not increase by more than 5 percent, then there is no need to calculate such emissions. If electricity and/or fossil fuel usage is reasonably expected to have increased by more than 5 percent, then the project developer must account for emissions associated with such increases by using the equations in this section. Equation 5.29 accounts for any increased CO_2 emissions from increased consumption of fossil fuels or electricity associated with the operation of cultivation equipment (SSR 3) and irrigation systems (SSR 4).

Equation 5.29. Direct Secondary Effect Emissions from Project Activities

$$SE = \sum_{f} \left(SE_{EL,f} + SE_{FF,f} \right)$$

Where,			Units
SE	=	Net secondary effect GHG emissions for projects due to project activities	tCO_2e
$SE_{EL,f}$	=	Net secondary effect GHG emissions from increased electricity use in the project cultivation year relative to baseline look-back period for field *f*, as calculated using Equation 5.30	tCO_2e
$SE_{FF,f}$	=	Net secondary effect GHG emissions from increased fossil fuel consumption in the project cultivation year relative to the baseline look-back period for field *f*, as calculated using either Option 1 in Equation 5.31 or Option 2 in Equation 5.32	tCO_2e

5.2.1 GHG Emissions from Increased Electricity Usage

Emissions from the additional usage of electricity needs to be quantified and accounted for, as seen in Equation 5.30.

Equation 5.30. Increased Secondary Emissions from Electricity Use in Project

$$SE_{EL,f} = \frac{\left(QE_f \times EF_{EL,f}\right)}{1000}$$

Where,			Units
$SE_{EL,f}$	=	Net secondary effect GHG emissions from increased electricity use in the project cultivation year relative to baseline look-back period for field *f*	tCO_2e
QE_f	=	Total increase in electricity consumed during the project cultivation year relative to the baseline look-back period for field *f*	kWh
$EF_{EL,f}$	=	Carbon emission factor for electricity used, referenced from the most recent U.S. EPA eGRID emission factor publication.[71] Projects shall use the annual total output emission rates for the subregion where the project is located	kg CO_2e/kWh
1000	=	Conversion from kg CO_2e to tCO_2e	kg/t

5.2.2 GHG Emissions from Increased Fossil Fuel Consumption

Emissions from the additional consumption of fossil fuels from the increased usage of cultivation equipment and irrigation systems needs to be quantified and accounted for. Two options are provided below.

Option 1, Equation 5.31, calculates emissions based on the time needed for each nitrogen management-related field operation, the horsepower required for this field operation, and a default emission factor for GHG emissions per horsepower-hours. If fuel consumption records are insufficient, Option 1 must be used. Option 1 is designed to require minimal documentation. The project developer must provide manufacturers' specifications on the horsepower requirements for the N application equipment used, and the time needed per acre for N application. The time needed for N application should be reported based on work-hour records. However, lacking those records, they may be derived based on the average operation or ground speed of the equipment and the application width per pass (e.g., width of boom).

Option 2, Equation 5.32, calculates emissions based on the fuel consumption for field operations related to nitrogen management and a default emission factor for GHG emissions per unit of fuel consumed.

[71] Available online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/

Equation 5.31. Option 1 – Increased Secondary Emissions from Fossil Fuel Use in Project

$$SE_{FF,f,1} = \left(\sum_i \left(EF_{HP-hr,P,i,f} \times HP_{P,i,f} \times t_{P,i,f}\right) - \sum_k \left(EF_{HP-hr,B,k,f} \times HP_{B,k,f} \times t_{B,k,f}\right)\right) \times 10^{-6}$$

Where,		Units
$SE_{FF,f,1}$	= Option 1 for calculating the increase in secondary emissions from an increase in fossil fuel use on field *f*	tCO_2e/ac
$EF_{HP-hr,P,i,f}$	= Emission factor for project operation *i* on field *f*. Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations[72]	g CO_2e/HP-hr
$HP_{P,i,f}$	= Horsepower requirement for project operation *i* on field *f*	HP
$t_{P,i,f}$	= Time required to perform project operation *i* on field *f*	hr/field
$EF_{HP-hr,B,k,f}$	= Default emission factor for baseline operation *k* on field *f.* Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations[73]	g CO_2e/HP-hr
$HP_{B,k,f}$	= Horsepower requirement for baseline operation *k* on field *f*	HP
$t_{B,k,f}$	= Time required to perform baseline operation *k* on field *f*	hr/field
10^{-6}	= Conversion from g CO_2e to tCO_2e	

Optional Method for Determination of *t*

If time records are not available, use the method below in both baseline and project estimates.

$$t = \frac{4046.86}{(width \times speed \times 1000)} \times A_f$$

Where,		Units
t	= Time requirement for field operation	hr
4046.86	= Area unit conversion	m^2/ac
width	= Application width covered by equipment	m
speed	= Average ground speed of the operation equipment	km/hr
1000	= Length unit conversion	m/km
A_f	= Size of field *f*	ac

Equation 5.32. Option 2 – Increased Secondary Emissions from Fossil Fuel Use in Project

$$SE_{FF,f,2} = \frac{\sum_j \left[(FF)_{PR,j} \times EF_{FF,j}\right]}{1000}$$

Where,		Units
$SE_{FF,f,2}$	= Option 2 for calculating the increase in secondary emissions from an increase in fossil fuel use on field *f*	tCO_2e/ac
$FF_{PR,j}$	= Total change in fossil fuel consumption for field *f* during the reporting period, by fuel type *j*	gallon
$EF_{FF,j}$	= Fuel-specific emission factor. Default values are 17.4 for gasoline and 13.7 for diesel[74]	kg CO_2/gallon
1000	= Conversion from kg CO_2e to tCO_2e	kg/t

[72] California Air Resources Board, OFFROAD2007. Available at https://www.arb.ca.gov/msei/offroad2007_docs.htm.
[73] *Ibid*.
[74] *Ibid*.

6 Project Monitoring

The Reserve requires a Monitoring Plan and Monitoring Report to be established for all monitoring and reporting activities associated with the project or cooperative. The Monitoring Plan serves as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and continue to be met, and that consistent, rigorous monitoring and record keeping is ongoing at the project fields. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 are collected and recorded. Projects must develop a Project Monitoring Plan (PMP) in accordance with the guidance in Section 6.1. Cooperatives must develop Cooperative Monitoring Plans (CMPs) both at an aggregate-level and field-level in accordance with the guidance in Section 6.2.

At a minimum, the Monitoring Plans shall include a description of management of the fields and ownership of the emission reductions; the methods and frequency of data acquisition; a record keeping plan (see Section 7.3 for minimum record keeping requirements), and the role of individuals performing each specific monitoring activity. The Monitoring Plan should include quality assurance/quality control (QA/QC) provisions to ensure that data acquisition and recordkeeping are carried out consistently and with precision.

Finally, the Monitoring Plan must include procedures that the project developer follows to ascertain and demonstrate that the project at all times passes the legal requirement test and the regulatory compliance requirements (Section 3.3.2 and 3.6, respectively).

Project developers are responsible for monitoring the performance of the project.

6.1 Project Monitoring Plan

The PMP, together with the Project Monitoring Report (PMR) outlined in Section 7.2.1, will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in Sections 6 and 7 are met for individual projects, and that consistent, rigorous monitoring and recordkeeping is ongoing at the project field(s). The PMP must be developed and maintained by the project developer. The PMP must specify how required field data (Section 6.3) are collected, recorded, and managed at each field. The PMP must also outline procedures for developing and submitting a complete PMR in accordance with Section 7.2.1. It is the responsibility of the project developer to ensure that the PMP meets all requirements specified and is kept on file and up-to-date for verification.

The PMP must outline the following:

- Number of fields of the project
- Description of entities involved in the management of project field(s)
- The methods and frequency of data acquisition, including a plan for monitoring the field data outlined in Section 6.3, which includes a plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 7.3.1
- The role of individuals performing each specific monitoring activity
- QA/QC provisions to ensure that data acquisition and recordkeeping are carried out consistently and with precision
- Procedures describing how the field perimeter GIS shape file and/or *.kml file will be created

- Procedures describing how the reporting period, crediting period, verification schedule, and quantification results will be tracked for each field
- Procedures or methods for ensuring that the Project Owner holds title to the GHG emission reductions as required in Section 2.5.2
- Procedures that the project developer will follow to ascertain and demonstrate that the project field at all times passes the legal requirement test and regulatory compliance (Section 3.5.2 and Section 3.6 respectively)
- Procedures the project developer will follow to track which fields have passed the performance standard and which are in a grace period with delayed crediting (see Section 3.5.1.1.1)

6.2 Cooperative Monitoring Plans

There can be gains in efficiency through centralized monitoring for cooperatives. A Cooperative Developer may organize their Cooperative Monitoring Plan (CMP) such that information from individual projects is collected and processed together. However, all information and documentation must be organized in such a manner that the verifier can assess that the requirements of this protocol have been met for each individual project field. For example, it is acceptable to submit a single spreadsheet of nitrogen application data for the cooperative, but the nitrogen application data for each individual project field must still be clearly defined within that spreadsheet The CMPs must adhere to the same criteria listed for PMPs in Section 6.1 for each individual project within the cooperative.

6.3 Field and Project Data Monitoring Requirements

Table 6.1 below sets out all the prescribed monitoring parameters necessary to calculate baseline and project emissions. Field monitoring parameters must be determined according to the data source and frequency specified for all eligible crop years. Table 6.1 specifies monitoring requirements for field monitoring parameters required of all project fields.

Table 6.1 below sets out all the additional field management data that must be collected for both eligible and ineligible crop years. Section 7.3 provides further guidance on specific record-keeping requirements.

Table 6.1. Field Monitoring Parameters

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 3.1 Equation 3.3	$PFP_{P,f}$	Partial factor productivity calculated for field *f* during the current cultivation year for purposes of the performance standard		c, o	Annual	Calculated from farmer records
Equation 3.1 Equation 5.17	$Y_{P,f}$	Annual yield on field *f* in project *P*	lb/ac	o	Annual	Farmer records
Equation 3.1 Equation 3.2 Equation 3.5	$NR_{P,f}$	Annual total project N rate for all fertilizers on field *f*	lb/ac	c, o	Annual	Farmer records
Equation 3.2 Equation 5.2 Equation 5.12 Equation 5.18	$NR_{P,S,f}$	Annual synthetic N rate for field *f*, during the current cultivation year of the project *P*	lb/ac	o	Annual	Farmer records
Equation 3.2 Equation 5.23 Equation 5.24	$NR_{P,O,f}$	Annual total project organic nitrogen application rate for field *f*	lb/ac	c, o	Annual	Farmer records
Equation 3.3	$PFP_{avg,Co,c}$	Multi-year county-and crop-specific PFP used as benchmark in performance standard test for additionality		r	Annual	Found in Nitrogen Management Project Eligibility Lookup Tool

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 3.4 Equation 3.5	$NR_{B,f,avg}$	Total average N rate (synthetic and organic) over the baseline look-back period for field *f*	lb/ac	c	Annual	Farmer records
Equation 3.4 Equation 5.2 Equation 5.4 Equation 5.15	$NR_{B,S,f,avg}$	Average baseline N rate of total synthetic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period	lb/ac	o	Annual	Farmer records
Equation 3.4 Equation 5.8 Equation 5.23 Equation 5.27	$NR_{B,O,f,avg}$	Average baseline N rate of total organic fertilizer for field *f*, calculated from all eligible crop years during the field's baseline look-back period	lb/ac	o	Annual	Farmer records
N/A	$NR_{avg,Co,c}$	Multi-year county- and crop-specific N rate for use in baseline Approach 3	lb/ac	o	Annual	Found in Nitrogen Management Project Eligibility Lookup Tool
Equation 5.1	ER	Total emission reductions for project area for the reporting period	tCO_2e	c	Annual	
Equation 5.1 Equation 5.3	PER	Total primary effect GHG emission reductions from implementation of eligible project activities over the entire project area	tCO_2e	c	Annual	Calculated from farmer records using NMQuanTool

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.1 Equation 5.19	PE_O	Total primary effect GHG emissions from organic N rate increases over the entire project area	tCO_2e	c	Annual	Calculated from farmer records
Equation 5.1 Equation 5.29	SE	Net secondary effect GHG emissions for project due to project activities	tCO_2e	c	Annual	Calculated from farmer records
N/A	Field Name	Field ID		o	Annual	Farmer records; NMQuanTool input
N/A	State	State in which field is located		o	Annual	Farmer records; NMQuanTool selection
N/A	County	County in which field is located		o	Annual	Farmer records; NMQuanTool selection
N/A	CEAP Region	CEAP Region – number and name – in which field is located		o	Annual	Farmer records; NMQuanTool determined
N/A	Crop	Eligible crop cultivated on field		o	Annual	Farmer records; NMQuanTool selection
N/A Equation 5.31	Field Acres A_f	Size of field	acres	o	Annual	Farmer records; NMQuanTool input
N/A	Irrigated	No – non-irrigated field; Yes- irrigated field		o	Annual	Farmer records; NMQuanTool selection

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
N/A	Enhanced Efficiency Fertilizer	None – no EEF used on field; Slow Release – Slow release fertilizer used on field; Nitrification Inhibitor – nitrification inhibitor used on field		o	Annual	Farmer records; NMQuanTool selection
N/A	Conversion to No-Till	No – maintain till Yes – switch from till to no-till		o	Annual	Farmer records; NMQuanTool selection
Equation 5.2	$NR_{\Delta P,S,f}$	Percentage synthetic N rate reduction from baseline to project on field *f*		c, o	Annual	Calculated from Farmer records; NMQuanTool input
Equation 5.4 Equation 5.5	$NR_{B,S,f,t}$	Annual baseline N rate of total synthetic fertilizer for field *f* in year *t* of the baseline look-back period	lb/ac	c, o	Once	Farmer records
Equation 5.5	$NR_{B,S,f,t}$	Baseline annual N rate of total synthetic fertilizer for field *f* in year *t* of the baseline look-back period	lb/ac	c, o	Annual	Farmer records
Equation 5.5 Equation 5.6	$NR_{B,DS,j,f}$	N rate of dry synthetic, *DS*, fertilizer type *j* on field *f* in year *t* of the baseline look-back period	lb/ac	c, o	Annual	Farmer records
Equation 5.5 Equation 5.7	$NR_{B,LS,j,f}$	N rate of liquid synthetic, *LS*, fertilizer type *j* on field *f* in year *t* of the baseline look-back period	lb/ac	c, o	Annual	Farmer records

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.7	$VF_{B,LS,j,f,t}$	Volume of liquid synthetic N-containing fertilizer *j* applied to field *f* per acre in baseline *B* in year *t*	gallon/ac	c, o	Annual	Farmer records
Equation 5.7	$MF_{B,LS,j,t}$	Mass of liquid synthetic fertilizer *j* per gallon of fertilizer in baseline *B* in year *t*	lb/gallon	c, o	Annual	Farmer records
Equation 5.7	$NC_{B,LS,j,t}$	N concentration of liquid synthetic fertilizer *j* in baseline *B* in year *t*		o, m, r	Annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Appendix E)
Equation 5.8 Equation 5.9	$NR_{B,O,f,t}$	Annual baseline N rate of total organic fertilizer for field *f* in year *t* of the baseline look-back period	lb/ac	c, o	Once	Farmer records
Equation 5.9 Equation 5.10	$NR_{B,SO,j,f,t}$	N rate of solid organic, *SO*, fertilizer type *j* on field *f* in year *t* of the baseline look-back period	lb/ac	c, o	Annual	Farmer records
Equation 5.9 Equation 5.11	$NR_{B,LO,j,f,t}$	N rate of liquid organic, *LO*, fertilizer type *j* on field *f* in year *t* of the baseline look-back period	lb/ac	c, o	Annual	Farmer records
Equation 5.10	$MF_{B,SO,j,f,t}$	Mass of solid organic N-containing fertilizer *j* applied to field *f* per acre in baseline year *t*	lb/ac	o, m	Annual	Farmer records

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.10	$NC_{B,SO,j,t}$	N concentration of solid organic fertilizer *j* in baseline year *t*		o, m, r	Annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Appendix E)
Equation 5.11	$VF_{B,LO,j,f,t}$	Volume of liquid organic N-containing fertilizer *j* applied to field *f* per acre in baseline year *t*	gallon/ac	o, m	Annual	Farmer records
Equation 5.11	$MF_{B,LO,j,f,t}$	Mass of liquid organic N-containing fertilizer *j* applied to field *f* in baseline *B* in year *t*	lb/gallon	o, m	Annual	Farmer records
Equation 5.11	$NC_{B,LO,j,t}$	Nitrogen concentration of liquid organic fertilizer *j* in baseline year *t*		o, m, r	Annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Appendix E)
Equation 5.12 Equation 5.13	$NR_{P,DS,j,f}$	N rate of dry synthetic fertilizer type *j* on field *f*	lb/ac	c, o	Annual	Farmer records
Equation 5.12 Equation 5.14	$NR_{P,LS,j,f}$	N rate of liquid synthetic fertilizer *j* for field *f* in project	lb/ac	c	Annual	Farmer records
Equation 5.12 Equation 5.15	$NR_{\delta S,f}$	Change in synthetic N rate on field *f* between baseline and previous cultivation year	lb/ac	c,o	Annual	Farmer records

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.12 Equation 5.18	$NR_{ps,f}$	Increase in synthetic N rate due to production shifting, *ps*, outside of the project boundary for field *f*	lb/ac	c,o	Annual	Farmer records
Equation 5.13	$MF_{P,DS,j,f}$	Mass of dry synthetic N-containing fertilizer *j* applied to field *f*	lb/ac	c, o	Annual	Farmer records
Equation 5.13	$NC_{P,DS,j}$	N concentration of dry synthetic fertilizer *j*		r	Annual	Farmer records
Equation 5.14	$VF_{P,LS,j,f}$	Volume of liquid synthetic N-containing fertilizer *j* applied to field *f* per acre in project *P*	gallon/ac	o, m	Annual	Farmer records
Equation 5.14	$MF_{P,LS,j}$	Mass of liquid synthetic fertilizer *j* per gallon of fertilizer in project *P*	lb/gallon	o, m	Annual	Farmer records
Equation 5.14	$NC_{P,LS,j}$	Nitrogen concentration of liquid synthetic fertilizer *j* in project *P*		o, m, r	Annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Appendix E)
Equation 5.15 Equation 5.16	$NR_{pcy,S,f}$	N rate of total synthetic N fertilizer for field *f* from a previous cultivation year, *pcy*, for which CRTs were not earned	lb/ac	c	Annual	Farmer records
Equation 5.16	$NR_{pcy,DS,j,f}$	N rate of dry synthetic fertilizer type *j* on field *f*	lb/ac	c	Annual	Farmer records

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.16	$NR_{pcy,LS,j,f}$	N rate of liquid synthetic fertilizer type *j* on field *f*	lb/ac	c	Annual	Farmer records
Equation 5.17 Equation 5.18	y_norm_t; y_norm_{t0}	Normalized yield for each year *t* in the baseline look-back period and for the current cultivation year t_0	yield/ac	r, o	Annual	Farmer records; USDA NASS statistics
Equation 5.17	$Y_{Co,t}$; $Y_{Co,t0}$	County, *Co*, average yield in year *t in the baseline look-back period and in the current cultivation year* t_0 (based on USDA NASS data)	yield/ac	r	Annual	USDA NASS statistics
N/A	s	Standard deviation of the y_norm_t distribution	yield/ac	c	Annual	Farmer records; See Section 5.1.3.2
N/A	$\overline{y_norm_t}$	Mean of the y_norm_t distribution	yield/ac	c	Annual	Farmer records; See Section 5.1.3.2
Equation 5.18	y_min	Minimum yield threshold below which normalized yields are significantly smaller than the historical average for field *f*	yield/ac	c	Annual	
Equation 5.19 Equation 5.20 Equation 5.21	$N_2O_{O,Dir,f}$	Direct N_2O emissions from increased organic N applied to field *f*	tCO_2e/ac	c	Annual	Farmer records

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.19 Equation 5.22	$N_2O_{O,LVRO,f}$	N_2O emissions from leaching, volatilization, and runoff from increased organic N applied field *f*	tCO_2e/ac	c	Annual	Farmer records
Equation 5.20	EF_{NCR}	Adjusted MSU-EPRI Tier 2 emission factor for corn cropping systems in the North Central Region		r, c	Annual	Default values; Farmer records
Equation 5.20 Equation 5.21 Equation 5.22 Equation 5.23 Equation 5.24 Equation 5.27	$NR_{\Delta O,f}$	Increase in organic N rate on field *f*	lb/ac	o	Annual	Farmer records
Equation 5.22	$Frac_{LEACH}$	Fraction of organic N inputs that is lost through leaching and runoff		r	Annual	Box 5.1 and Appendix D and available per reporting year on Reserve website
Equation 5.24 Equation 5.25	$NR_{P,SO,j,f}$	N rate of solid organic, *SO*, fertilizer type *j* on field *f*	lb/ac	c, o	Annual	Farmer records
Equation 5.24 Equation 5.26	$NR_{P,LO,j,f}$	N rate of liquid organic fertilizer *j* on field *f* in project *P*	lb/ac	o, m	Annual	Farmer records

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.24	$NR_{\delta O,f}$	Increase in organic N rate between baseline and previous cultivation year for which CRTs were not earned, if applicable	lb/ac	c, o	Annual	Farmer records
Equation 5.25	$MF_{P,SO,j,f}$	Mass of solid organic N-containing fertilizer *j* applied to field *f* per acre in project *P*	lb/ac	o, m	Annual	Farmer records
Equation 5.25	$NC_{P,SO,j}$	N concentration of solid organic fertilizer *j* in project *P*		o, m, r	Annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Appendix E)
Equation 5.26	$VF_{P,LO,j,f}$	Volume of liquid organic N-containing fertilizer *j* applied to field *f*	gallon/ac	o, m	Annual	Farmer records
Equation 5.26	$MF_{P,LO,j,f}$	Mass of liquid organic N-containing fertilizer *j* applied to field *f*	lb/gallon	o, m	Annual	Farmer records
Equation 5.26	$NC_{P,LO,j}$	Nitrogen concentration of liquid organic fertilizer *j*		o, m, r	Annual (unless unchanged)	Farmer records, fertilizer N-content label or laboratory tests preferable (default reference data also included in Appendix E)

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.27 Equation 5.28	$NR_{pcy,O,f}$	N rate of total organic fertilizer for field *f* from previous cultivation year in which CRTs were not earned	lb/ac	c, o	Annual	Farmer records
Equation 5.28	$NR_{pcy,SO,j,f}$	N rate of solid organic fertilizer type *j* on field *f* in previous cultivation year *pcy*	lb/ac	c, o	Annual	Farmer records
Equation 5.28	$NR_{pcy,LO,j,f}$	N rate of liquid organic fertilizer type *j* on field *f* in previous cultivation year *pcy*	lb/ac	c, o	Annual	Farmer records
Equation 5.29 Equation 5.30	$SE_{EL,f}$	Net secondary effect GHG emissions from increased electricity use in the project cultivation year relative to baseline look-back period for field *f*	tCO_2e	c	Annual	Farmer records
Equation 5.29 Equation 5.31 Equation 5.32	$SE_{FF,f}$	Net secondary effect GHG emissions from increased fossil fuel consumption in the project cultivation year relative to the baseline look-back period for field *f*	tCO_2e	c	Annual	Farmer records
Equation 5.30	QE_f	Total increase in electricity consumed during the project cultivation year relative to the baseline look-back period	kWh	o	Annual	Farmer records

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.30	$EF_{EL,f}$	Carbon emission factor for electricity used	kg CO_2e/kWh	r	Annual	From the most recent U.S. EPA eGRID emission factor publication. Projects shall use the annual total output emission rates for the subregion where the project is located
Equation 5.31	$EF_{HP\text{-}hr,P,i,f}$	Emission factor for project operation *i* on field *f*	g CO_2e/HP-hr	r	Annual	Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations
Equation 5.31	$HP_{P,i,f}$	Horsepower requirement for project operation *i* on field *f*	HP	o, r	Annual	
Equation 5.31	$t_{P,i,f}$	Time required to perform project operation *i* on field *f*	hr/field	c, o	Annual	Farmer records or calculated
Equation 5.31	$EF_{HP\text{-}hr,B,k,f}$	Default emission factor for baseline operation *k* on field *f*	g CO_2e/HP-hr	r	Annual	Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations
Equation 5.31	$HP_{B,k,f}$	Horsepower requirement for baseline operation *k* on field *f*	HP	o, r	Annual	

Equation Reference	Parameter	Description	Data Unit	Calculated(c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.31	$t_{B,k,f}$	Time required to perform baseline operation *k* on field *f*	hr/field	c, o	Annual	Farmer records or optional method
Equation 5.32	$FF_{PR,j}$	Total change in fossil fuel consumption for field *f* during the reporting period, by fuel type *j*	gallon	o	Annual	
Equation 5.32	$EF_{FF,j}$	Fuel-specific emission factor	kg CO_2/gallon	r	Annual	Default value is 17.4 for gasoline and 13.7 for diesel

Table 6.2. Additional Field Management Data

Description	Calculated (c) Measured (m) Referenced (r) Operating Records (o)	Measurement Frequency	Comment
Copy of NMQuanTool used to calculate emission reductions for reporting period	c	Each reporting period	
Copy of Nitrogen Management Project Eligibility Lookup Tool	c	Each reporting period	
GIS shapefile for each field	r	Each cultivation year	Delineate areas of fertilizer application for given cultivation year
Serial number for each field	r	Once	See Section 7.1.1
Start date for each field	r	Once	
Field size	o	Each cultivation year	
Crop grown (previous cultivation year, current cultivation year & planned for next cultivation year)	o	Each cultivation year	
Planting dates	o	Each cultivation year	
Harvesting dates	o	Each cultivation year	

Description	Calculated (c) Measured (m) Referenced (r) Operating Records (o)	Measurement Frequency	Comment
Regulatory violations	o	Each cultivation year	All information regarding problems identified by relevant regulators (i.e., Notices of Violations, Consent Orders, OSHA citations, ECHO reports etc).
Evidence LRT met	o	Each cultivation year	Copies of air, water, and land use permits relevant to project activities
Evidence of emission reduction ownership			Contractual arrangements between project developer and Project Owner(s) (if applicable).
Fertilizer application method	o	Each cultivation year	Method and type of equipment used
Nitrification inhibitor application dates	o	Each cultivation year	NIs must be applied with nitrogen applications that take place within 30 days prior to planting time[75]
Fertilizer purchases	o	Each cultivation year	Records / receipts & inventory
Agronomic guidance for project fields	o	Each cultivation year	Including any test results for analysis of soil, plant tissue, fertilizer N content etc.
Cover crop	o	Each cultivation year	
Cover crop – planting date	o	Each cultivation year	
Cover crop – termination date	o	Each cultivation year	
Baseline historical use of EEFs	o	Once	

[75] International Plant Nutrition Institute (IPNI), Nutrient Source Specifics one-page fact sheet: No. 26, *Nitrification Inhibitors*, accessed 6/13/2018, here: http://www.ipni.net/publication/nss.nsf/0/21B8084A341C98E085257E3C0077595B/$FILE/NSS-26%20Nitrification%20Inhibitors.pdf.

6.4 Supplemental Field Data Monitoring

In addition to the required field-level data and information specified in Section 6.3, project developers may choose to monitor and keep records of additional field data. Project developers are encouraged to monitor and retain supplemental records for *all* nitrogen management activities and *all* crops once a project is underway, including practices and crops not currently eligible for crediting at this time. Additional records may be of use in the event that quantification methodologies become available for currently ineligible practices and crops in future versions of this protocol. Further, while not required, supplemental data collected for eligible crop years may further assist project developers in successfully completing verification by providing verification bodies with additional information to corroborate project implementation activities and emission reductions from the project.

Supplemental monitoring parameters could include detailed records of dates and other aspects of management data collected and/or test results from the implementation of any enabling or adaptive management practices (e.g., variable rate technology and the results of supplemental pre-plant or pre-sidedress[76] soil nitrate tests, field-composite soil tests, and replicated strip trials).

[76] An application of fertilizer between the rows of growing crops is known as a “sidedress” application.

7 Reporting and Record Keeping

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers.

7.1 Project Submittal Documentation

For each nitrogen management project, project developers must provide the following documentation to the Reserve in order to submit a project for listing on the Reserve.

- Project Submittal form
- Project Submittal *.csv file

The Project Submittal form will be available for individual projects and cooperatives. Both individual projects and cooperatives will also be required to submit a project submittal *.csv file, which shall include the initial "List of Enrolled Fields"; each field's serial number (according to Section 7.1.1 below), county and state, CEAP region; and the names of project developers for each field. The List of Enrolled Fields shall include all fields enrolled in the project or cooperatives at the time of submittal. Once verification commences (i.e., at the NOVS/COI stage), projects and cooperatives will be required to update the list to include all fields actually enrolled in the project or cooperative at that point (e.g., if fields have been added or removed from the project or cooperative between submittal and contracting a verifier [77]). The list must also be updated prior to each subsequent annual verification.

7.1.1 Determining Field Serial Numbers

The field serial number, which must be included in the List of Enrolled Fields, shall be determined by the following algorithm, with each element separated by a dash (-):

First State postal abbreviation, followed by the first letter of the County, followed by degrees of the most north-western point of the field (latitude then longitude, both reported to four decimal places), followed by the acreage of the field.[78] (Example: CA-B-39.6123-121.5332-76 would be a 76-acre field in Butte County, CA.)

7.2 Annual Reports and Documentation

Once a project has been listed on the Reserve, project developers must provide the following documentation to the Reserve in order to register a nitrogen management project with the Reserve. This documentation must be submitted to the Reserve within 12 months of the end of each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.

The following documentation is required of both individual projects and cooperatives:

- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Title form

[77] See the Reserve Verification Program Manual at http://www.climateactionreserve.org/how/program/program-manual/.

[78] Because all fields will be located in the United States, the latitude will always be positive (i.e., degrees north of the equator), and longitude will always be negative (i.e., degrees west of the Prime Meridian). Therefore, in the example serial number, the field in Butte County California is at *+39.6123º latitude, and -121.5332º longitude.*

- Project Monitoring Reports (as outlined in Sections 7.2.1)
- Verification Report
- Verification Statement

With the exception of the Project Monitoring Reports, outlined in Section 7.2.1, all of the above project documentation will be available to the public via the Reserve's online registry. Further disclosure (e.g., of the Project Monitoring Reports) and other documentation may be made available on a voluntary basis through the Reserve, at the request of the project developer.

7.2.1 Project Monitoring Report

For each cultivation year, for each *field* within a project, the following information must be included in an annual Project Monitoring Report (PMR) that will be submitted to the Reserve as a *.csv file:

- All the data set out in Section 6.3
- Whether the field had previously been enrolled in a different nitrogen management project
    - If so, include the name of the project, dates of enrollment, and a brief description of the circumstances for leaving the previous project
- Whether the field includes land classified as HEL or wetlands
- The field's emission reduction calculation results for the current verified cultivation year *OR* a statement indicating that the field is in an ineligible crop year or CRTs are not being pursued for the given cultivation year[79]
- Total project ERs

7.2.2 Cooperative Monitoring Report

Projects taking part in a cooperative may utilize a common Cooperative Monitoring Report (CMR) template, with information common to all projects in the cooperative, but each project must submit their own PMR, with sufficient information necessary to ensure verification of all NMPP requirements for that project. If a project had previously been enrolled in a different cooperative, the name of the cooperative, dates of enrollment, and a brief description of the circumstances for leaving the previous cooperative must be included in the CMR for the applicable project.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of fifteen years after the information is generated or credits are issued utilizing such information (whichever is longer). This information will not be publicly available, but may be requested by the verifier or the Reserve.

7.3.1 Record Keeping for Projects

The project developer should retain the following records and documentation, as well as documentation to substantiate the information in the annual PMR and all field-level data and calculations. These records include:

- All data set out in Section 6.3

[79] Note that a project must report continuously (e.g., submit a project report annually), for all enrolled fields, even if CRTs are not being claimed for any given field in a given cultivation year.

- Copies of any USDA NRCS determinations and/or documentation of NRCS approval of conservation systems, if field includes wetlands or HEL land, respectively
- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Records demonstrating any material change (or lack thereof) in equipment type or usage for crop cultivation, fertilizer application, and/or irrigation (e.g., purchase or lease records for equipment, field-level fossil fuel use records, manufacturer's HP specifications, hours spent on N application)
- Results of annual emission reduction calculations
- Initial and annual verification records and results
- Time-stamped digital photographs of fields and fertilizer management activities (where available)
- As-applied maps

7.4 Project Reporting Period and Verification Cycle

Project emission reductions must be quantified and verified on an annual basis. As detailed in Section 3.3, the reporting period is the length of time over which GHG emission reductions are quantified and reported to the Reserve. Project developers must report GHG reductions resulting from project activities during each reporting period.

Both reporting periods and cultivation years must be contiguous; there can be no time gaps in reporting during the crediting period of a project or a cooperative once the initial reporting period has commenced.[80] If the crop rotation on the project field includes ineligible crops (e.g., soy in a corn/soy rotation), the project field must report continuously on the field's management practices, even though the project field shall only receive credit for project activities implemented on eligible crop fields. Similarly, if CRTs are not being sought in any given cultivation year for eligible crops, reporting must continue.

The "verification period" is the length of time over which GHG emission reductions from project activities are verified. To provide flexibility and help manage verification costs associated with nitrogen management projects, there are four verification options to choose from after a project's initial verification and registration. Regardless of the option selected, project developers must report GHG reductions resulting from project activities during each reporting period. Under this protocol, a verification period may cover multiple reporting periods (see Section 7.4.1). The end date of any verification period must correspond to the end date of a reporting period.

A project developer may choose to utilize one option for the duration of a project's crediting period, or may choose different options at different points during a single crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.

7.4.1 Additional Reporting and Verification Options for Projects

For individual projects, there are four verification options to choose from, which provide the project developer more flexibility and help manage verification costs associated with nitrogen management projects. The project developer may choose two options for the initial reporting

[80] An project can willingly forfeit CRTs for an entire cultivation year in accordance with the zero-credit reporting period policy in Section 3.3.3 of the Reserve Program Manual.

period and an additional two options after a project has completed its initial verification and has been issued credits.

A project developer may choose to use one option for the duration of a project's crediting period. Project developers must continue reporting during ineligible crop years (see Section 6.3 for requirements). Ineligible crop years do not require verification, and as such, do not count against the number of months included in a given verification period (see options below). Verifiers shall review N rate records for any interim ineligible year(s) as a component of verifying eligibility in the subsequent eligible crop year (see Section 3.5.1.1).

If a field joins a project, that field will immediately be subject to the verification schedule of the project moving forward (e.g., for the first reporting period that field is enrolled in the new project). If a field or fields exits a project to become a separate project, that new project is subject to the reporting and verification requirements of an initial reporting and verification period. In other words, that new project's first verification may not take advantage of Options 2 or 3, below.

7.4.1.1 Initial Reporting and Verification Period

The reporting period for projects undergoing their initial verification and registration cannot exceed two complete eligible crop cultivation years (with a maximum of one year in between where no CRTs are being sought). Once a project is registered and has had at least one complete reporting period of emission reductions verified, the project developer may choose one of the verification options below.

7.4.1.2 Option 1: Verification Period Equaling One Reporting Period

Under this option, the verification period may not exceed one reporting period, which may be slightly greater or less than 365 days. Verification with a site visit is required for CRT issuance.

7.4.1.3 Option 2: Verification Period Equaling Two Reporting Periods

Under this option, the verification period cannot exceed two reporting periods and the PMP and PMR must be submitted to the Reserve for each reporting period. The PMP and PMR must be submitted for projects that choose Option 2 in order to meet the annual documentation requirement of the Reserve program. They are meant to provide the Reserve with information and documentation on project operations and performance. They also demonstrate how the project monitoring plan was met over the course of the first half of the verification period. They are submitted via the Reserve online registry, but are not publicly available documents. The monitoring plan and report shall be submitted within 30 days of the end of the reporting period. In the case of a multi-crop rotation, a 24-month verification period that consists of two non-consecutive eligible crop years is allowable, with no more than one interim ineligible crop year (e.g., verification could cover 24 months of data within a 36-month timeframe).

Under this option, CRTs may be issued upon successful completion of a site visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of PMPS or PMRs. Project developers may choose to have a verification period shorter than 24 months.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the project activity. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to nitrogen management projects.

Verification bodies trained to verify nitrogen management projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Nitrogen Management Project Protocol (NMPP)

The Reserve Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only ANSI-accredited verification bodies with lead verifiers trained by the Reserve for this project type are eligible to verify NMPP reports. Verification bodies approved under other project protocol types are not permitted to verify nitrogen management projects.[81]

In addition, each verification team must include an agronomist with at least 5 years' experience, or a local or state agricultural cooperative advisor. The agronomist or crop advisor will provide additional support and expertise with interpreting information, assessing field conditions, reviewing, and interviewing project developers and any relevant staff onsite.

8.1 Preparing for Verification

The project developer is responsible for coordinating all aspects of the verification process, coordinating with the verification body, Project Owners, Field Managers, and the Reserve, and submitting all necessary documentation to the verification body and the Reserve.

The project developer is responsible for selecting a single verification body for the project for each reporting period. The same verification body may be used up to six consecutive years (the number of consecutive years allowed, according to the Reserve Verification Program Manual[82]). Verification bodies, including the agronomist, must pass a conflict of interest (COI) review against the project developer, and all Project Owners. Consequently, the submitted List of Enrolled Fields in a project and the submitted List of Enrolled Projects in a cooperative must be updated by the project developer prior to the COI review.

Each year, project developers must make the PMPs and PMRs available to the verification body. These documents must meet the requirements in Sections 6 and 7. In all cases, the above documentation should be made available to the verification body after the NOVS/COI process is complete. Project Owners must sign all attestations and may assist the project developer in other aspects of project development, but ultimate responsibility for project monitoring reports and verification compliance is assigned to the project developer. For all

[81] Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/.
[82] Available at http://www.climateactionreserve.org/how/verification/verification-program-manual/.

projects, a field is considered verified if it is in the pool of fields under consideration for site visits and/or desktop verifications, even if not selected for either a site visit or desktop verification (see Section 8.2 for details on sampling for verification).

As a preliminary step in preparing for verification, the project developers may choose to exclude fields from the pool of fields that may be selected for verification activities. Project developers must report to the verification body all instances of field exclusion. The excluded fields shall be removed from the acreage totals and from field numbers used to determine field eligibility and verification sampling methodologies (in Section 8.3) and are therefore not considered verified.

8.2 Verification Sampling and Schedule for Projects and Cooperatives

Guidelines for verification sampling and verification schedules are the same for individual projects and projects joined together in cooperatives. This approach allows a consistent application of verification requirements at the project level, regardless of size or number of fields in the project, or whether the projects are combined into a cooperative or not.

In all cases, the verification schedule shall be established by the verification body using a combination of risk-based and random sampling, according to the verification schedule and sampling methodologies outlined in Section 8.2.1. These sampling methodologies establish a minimum and a range of verification frequencies, as well as guidance on circumstances in which the verification body is encouraged to add fields beyond the minimum percentage of fields required for site visit and/or desktop verification. The verifier may use professional judgment to determine the number of additional fields and method for selecting fields if a risk-based review indicates a high probability of non-compliance. The verification sampling requirements are mandatory regardless of the mix of entry dates represented by the group of fields in the project (and by the group of projects in the cooperative).

The initial site visit verification schedule for a given year shall be established after the completion of the NOVS/COI process. The schedule should be established as soon as possible after the commencement of verification activities, at a minimum, so as to include both risk-based and random sampling for the selection of site visited fields. This is meant to allow for the project developer or cooperative developer and verification body to work together to develop a cost-effective and efficient site visit schedule. Specifically, once the sample fields designated for a site visit have been determined, the verification body shall document all fields selected for planned site visit verification and provide a list of fields receiving a visit to the project developer or cooperative developer and the Reserve. The project developer or cooperative developer shall be responsible for all site visit planning. Following this notification, the project developer or cooperative developer shall supply the verification body with all the required documentation to demonstrate field-level conformance to the protocol. When a verification body determines that additional sampling is necessary due to suspected non-compliance, however, a similar level of advance notice may not be possible.

Though significant advance notice of a field's selection for a site visit is required, project and cooperative developers shall not be given advance notice of which fields' data will be subject to desktop verification in a given year. A field shall be prepared for desktop verification during every reporting period, so long as the field's Monitoring Plan is implemented and up-to-date in accord with the PMP, the Field Report submitted to the project developer, and all record-keeping requirements of this protocol are followed.

Regardless of the size of a project or cooperative, if the project or cooperative contains any fields that did not pass site visit verification the year before and wish to re-enter the project or cooperative, those fields must have a full verification with site visit for the subsequent reporting period. These fields must be site visited *in addition* to the verification sampling methodology and requirements outlined below in Section 8.2.1.

In all cases, when determining the sample size for site visits and desktop verifications, the verification body shall round up to the nearest whole number.

The actual requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any reporting period if the verification body determines that the risks for that field warrant a site visit.

8.2.1 Verification Schedule

It is possible that a field in a large project or cooperative never receives a site-visit during its entire crediting period. Therefore, a combination of risk-based and random sampling is a particularly important component of the enforcement mechanism. The sampling methodology for projects shall take place in three steps. Site visit sampling shall be informed in step one by a risk-based sampling approach and in step two by random sampling. The third step shall inform desktop verification based on random sampling.

A minimum of 5 percent of the total number of eligible fields in each project (e.g., only fields growing eligible crops in the reporting period to be verified) must be site visited. The verification body shall be allowed to vary the number of site visits performed based on levels of perceived risk identified during verification. Specific risks identified during the verification could include: fields generating large proportions of the emission reductions of the project, lack of historical records, and/or demonstrated poor communication of N-reduction strategies and implementation between Project Owners, Field Managers and project developers.

Each verification report must contain a description of the sampling methodology, number of site visits, and justification for higher levels of sampling (e.g., due to higher levels of risk).

8.2.1.1 Sampling for Site Visit Verification

1. Verifiers shall select fields for site visits first through a risk-based approach
2. Once the verifier has selected fields for site visits through the risk-based approach, additional fields shall be selected at random. The verification body shall randomly select additional fields until the number of site visits meets this minimum requirement of at least 5 percent (or the verifier's chosen percentage, based on higher risk)

8.2.1.2 Sampling for Desktop Verification

In addition to site visit verifications, each year verification bodies shall also randomly select fields to undergo a desktop verification of their field data. Verification bodies shall randomly select a sample of fields to undergo a desktop verification equal to two times the square root of the total number of fields in the project (rounded up to the next whole number).

Fields shall not be selected for a desktop only verification in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected

for a desktop verification reaches two times the square root of the total number of fields in the project.

8.3 Standard of Verification

The Reserve's standard of verification for nitrogen management projects is the Nitrogen Management Project Protocol (this document) and the Reserve Program Manual and Verification Program Manual. To verify a nitrogen management project, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide project definitions, eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.4 Monitoring Plan

The PMP serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and recordkeeping is ongoing by the project and/or cooperative developer and all enrolled fields. Verification bodies shall confirm that the PMP or CMP cover all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Section 6.3 are collected and recorded.

8.4.1 Annual Reports

The project developer must annually submit field data for projects to the Reserve. The PMR will consist of a *.csv file and attachments, as described in Section 7.2.1. Verification bodies must review the PMR to confirm project information and data collected according to the PMP. The project developer or cooperative developer must annually submit a PMR or CMR to the Reserve. The report will consist of a *.csv file and attachments. Verification bodies must review the PMR or CMR to confirm project information and data collected according to the PMP or CMP. The verification body will need to review field data during desktop verifications of randomly selected fields in a project. The field data must be made available to the verification body in order to confirm field-level information collected according to the PMP or CMP.

8.5 Verifying Eligibility at the Field Level

Verification bodies must affirm each project field's eligibility during site visit and/or desktop verifications according to the rules described in this protocol. The table below outlines the eligibility criteria for each project field. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items listed in Table 8.3.

Table 8.1. Summary of Field-Level Eligibility Criteria for a Nitrogen Management Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Each field will have a unique start date. One or more fields will be chosen to trigger the project start date. The start date for each field / project will be the first day of the cultivation year, which begins immediately after completion of the previous crop's harvest, in which the approved project activity is adopted at the field. Projects must be submitted for listing before the end of the cultivation year representing the project start date. All subsequent fields must be submitted for listing before the end of the second cultivation year following the field's start date.	Every verification verifier must confirm for each new field
Location and Crop Type	The field is located in an approved area of the U.S. and U.S. tribal areas and contains a corresponding eligible crop, according to Section 2.2 and Section 3.1.	Every verification
Performance Standard	The field passes the performance standard test for its respective county-crop combination according to Section 3.5.1.1). Fields previously in an ineligible year must also demonstrate that N loading has not occurred since the last verification to pass the performance standard test.	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the legal requirement test.	Every verification
Legal Title to CRTs	Signed Attestation of Title and monitoring procedures for ascertaining and demonstrating legal title to the CRTs.	Every verification
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all legal violations to verification body; project activities and project fields must not cause material violations of applicable laws. In particular, no violations to the Safe Drinking Water Act or Clean Water Act, due to agricultural discharges.	Every verification
HEL classification	If the project area includes land classified as HEL, that land must meet the Highly Erodible Land Conservation provisions to be eligible.	Once during first verification
Wetland classification	If the project area includes land classified as wetlands that land must meet the Wetlands Conservation provisions to be eligible.	Once during first verification

8.6 Core Verification Activities

The NMPP provides explicit requirements and guidance for quantifying the GHG reductions associated with the implementation of approved nitrogen management project activities on project fields. The Verification Program Manual describes the core verification activities that

shall be performed by verification bodies for all project verifications. They are summarized below in the context of a nitrogen management project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs for each field
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, ensuring that all relevant secondary effect SSRs for each field are identified.

Reviewing GHG management systems and estimation methodologies at the field level
The verification body reviews and assesses the appropriateness of the methodologies and management systems that are used to gather data and calculate baseline and project emissions for each field.

Reviewing GHG management systems and estimation methodologies at the project level
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the project uses to gather data and calculate baseline and project emissions on the project level.

Verifying emission reduction estimates at the field level
The verification body further investigates areas that have the greatest potential for material misstatements and confirms whether or not material misstatements have occurred for all fields undergoing verification. This involves site visits to a random sample of project fields, according to the sampling methodology outlined in Section 8.2.1.1, to ensure systems on the ground correspond to and are consistent with data provided to the verification body, combined with a random sample of desktop verifications of remaining project fields according to Section 8.2.1.2. In addition, the verification body recalculates a representative sample of the performance or emissions data from fields for comparison with data reported by the project developer in order to confirm calculations of GHG emission reductions.

Verifying emission reduction estimates at the project level
The verification body further investigates areas that have the greatest potential for material misstatements at the project level, including whether yield-loss statistical tests (Section 5.1.3.2) have been performed for the project.

8.7 Nitrogen Management Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a nitrogen management project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. Supplemental monitoring data and records (noted in Section 6.4) are not

included in the tables below. However, any supplemental information made available to the verifier by the project developer may be used to raise the verifier's level of assurance that the project activity occurred.

For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to nitrogen management projects that must be addressed during verification.

8.7.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for nitrogen management projects. These requirements determine if the project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any single requirement is not met on any given field, then that field will be ineligible for issuance of CRTs.[83] Ineligibility of one or more fields may make the entire project ineligible or the GHG reductions from the reporting period may be ineligible for issuance of CRTs, as specified in Section 3.3.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that all verified fields meet the definition of a nitrogen management project	No
2.2	Verify that all fields are comprised of eligible crop-region combinations	No
2.2.3	Verify that all verified fields meet the eligible project area definition	Yes
2.2.1.1	Verify that the total annual N rate decreased below baseline levels	No
2.3	Verify that all verified fields meet the definition of cultivation year	No
2.4	Verify that an appropriate indemnification and GHG reductions rights agreement or agreements have been executed	No
2.4	Verify the project and/or cooperative structure is appropriate	No
2.4	Verify ownership of the reductions by reviewing Attestation of Title, and contracts between Field Managers, and Project Owners	No
2.4	Verify that no fields within the project are simultaneously enrolled in another project	No
2.4	Verify that any fields previously enrolled in another project have followed the proper procedures to enter the new project and leave the old project	Yes
3.2	Verify accuracy of project start date for all verified fields based on operational records	Yes
3.4	Verify that each field is within the 10-year crediting period	No
3.5.1	Verify that each field meets the performance standard test	No

[83] This protocol allows for fields to be removed from a project for any given reporting period, due to ineligibility (or indeed voluntarily for unspecified reasons) and for such fields to be considered potentially eligible to return to the same project or any other project, for future reporting periods. The ability to bring such fields back into the same project, or any other project, may not be reflected in any future compliance nutrient management protocol.

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
3.5.1.1	Verify that each field previously in a year for which CRTs are not being sought applied no more than the permissible N rate range over the cultivation year	Yes
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to support demonstration of eligibility under the legal requirement test	No
3.5.3	Verify that any ecosystem service payment or credit received for activities on a project field has been disclosed and is allowed to be stacked	No
3.6	Verify that the project activities at all verified fields comply with applicable laws, particularly water quality laws, by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
3.6	Verify whether the project is located on fields that are classified as Highly Erodible Land or wetlands. If HEL or wetlands are included, verify that the required conservation compliance standards are being met	No
5.1.3.1, 5.1.4.4.1	Verify increases in N rates during cultivation years where CRTs are not being sought are appropriately accounted for	No
6.1, 6.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that all fields pass the legal requirement test at all times	No
6.3	Verify that field-level and project-level monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No

8.7.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
5.1	For each field, and the project as a whole, ensure that the emission reductions associated with reductions in synthetic N rates have been calculated correctly, using the NMQuanTool	No
5.1.3.1, 5.1.4.4.1	For each cultivation year for which CRTs are not being sought, ensure any increases in N rate are properly accounted for	No
5.1.3, 5.1.4.4	For each field, verify that the synthetic and organic N rate changes have been properly quantified	No
5.1.2, 5.1.3	For each field, verify that input parameters for both the baseline and the project are represented by the appropriate data and the calculations are accurate	Yes

Protocol Section	Quantification Item	Apply Professional Judgment?
5.2.2	For the project, verify that emissions from any increased consumption of fossil fuel and electricity are calculated correctly	Yes
5.1.3.2	For the project, verify that the emissions from crop production leakage are properly accounted for	No

8.7.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
1, 7	Verify that all contractors and employees are qualified to perform the duties expected. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6.1, 6.2	Verify that the project has documented and implemented the Project Monitoring Plan and, where appropriate, the Cooperative Monitoring Plan	No
6.1, 6.2	Verify that the project monitoring plans are sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6.3	Verify that appropriate monitoring data are measured or referenced accurately	No
6, 7, 8	Verify properly informed risk-based sampling for site visit selection	Yes
7.2	Verify that the Project Monitoring Report and any Cooperative Monitoring Report was uploaded to the Reserve software	No
7.2, 7.3	Verify that field data has been gathered and made available to project developers	No
7.3	Verify that all required records have been retained by the project developer	No

8.8 Successful and Unsuccessful Verifications

Successful verification of each field in the sample of fields selected for site visit and desktop verifications results in the crediting of all fields participating in the entire project, as calculated by the project developer according to the quantification methodology in Section 5.

Verification may uncover any number of material and immaterial errors at the field, project or cooperative level, and the extent to which an error was propagated through the project can affect whether a verification is determined to be "unsuccessful." A successful verification will result in the issuance of CRTs for the given field, project or cooperative, whereas any field receiving an "unsuccessful" verification will not be issued CRTs. A project receiving an "unsuccessful" verification for one or more fields, will still be issued CRTs for any fields that receive a "successful" verification.

8.8.1 Field-Level and Project-Level Errors

If material issues arise during verification of a participating field, verification bodies shall issue Corrective Action Requests, as needed. The project developer will need to independently

address the issues and required corrective actions. These are described in the verification guidance of this protocol and the Reserve Verification Program Manual. If the error can be corrected at the field level and is the type of error that will not be propagated across an individual's fields or the entire project, then the error shall be corrected and the field verification shall be considered successful. Errors shall be considered immaterial at the field level if they result in a discrepancy that is less than 5 percent of the total emission reductions quantified for that field.

If verification of a field reveals material non-compliance with the protocol, and no corrective action is possible, that field shall receive a negative verification and no CRTs shall be issued for that field, effectively removing the field from the project for that year. When verification is unsuccessful for a participating field, the verification body must verify additional fields until the total number of successful verifications reaches the required number (as described in Section 8.2), starting with fields managed by the same Field Manager, as follows. If the Field Manager managing the unsuccessfully verified field also manages other fields enrolled in the project, the verification body shall site visit a minimum of two additional fields or 5 percent of the remaining unverified fields, whichever is larger, that are managed by that project developer or Field Manager. If the verification of the additional fields is also unsuccessful, no CRTs shall be issued for any of the fields managed by the Field Manager.

Deliberate non-compliance may result in disqualification of the Field Manager including all of their enrolled fields. Additionally, if the Field Manager failing verification and their negatively verified fields re-enter the project the following year, each of the fields that failed verification the previous year shall be required to undergo a site visit, in addition to the minimum sampling requirements in Section 8.2.

Whenever a Field Manager receives a negative verification for all of their enrolled fields, the verification body shall use their professional judgment and a risk-based assessment to determine whether sampling additional fields for site visit verification, beyond the minimum requirements of this protocol, is necessary to verify the entire project to a reasonable level of assurance.

8.8.1.1 Cumulative Field-Level Error of Sampled Fields

Total errors and/or non-compliance shall be determined for the sampled fields and the offset issuance for those fields corrected, as required, by the Verification Program Manual. Should the aggregated error and/or non-compliance rate for the sampled fields be less than 5 percent, CRT issuance for fields not subjected to site visit or desktop verification shall be equal to the amount reported by the project. However, if the aggregated percent error and/or non-compliance rate (i.e., the percentage of verified fields failing verification) for sampled fields is greater than 5 percent, CRT issuance for fields not subjected to site visit or desktop verification shall be reduced by the total amount of aggregated percent error or non-compliance rate.

8.8.2 Project-Level Errors

If verification reveals a potential systemic error, which may be propagated out to the project level (e.g., a qualitative error with regard to the input parameters or a quantitative error repeated in multiple field-level calculations), the verification body shall use their professional judgment to sample additional fields, as necessary, to determine whether the error is truly systemic. Systemic errors must be corrected at the project level.

8.9 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Project activities that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e., fossil fuel destruction, deforestation, etc.).
Baseline look-back period	The baseline look-back period is defined as the three most recent cultivation years of that given crop on that given field, prior to the field's start date.
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the carbon cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
Conventional till	Tillage practice that includes one or more passes with tillage implements (e.g., moldboard plow, disk plow, chisel plow, etc.).
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Cooperative	Two or more individual NMPP projects that report and verify jointly, under a structure known formally as a 'cooperative'. A cooperative may consist of NMPP projects involving multiple Project Owners.
Cooperative Developer	The entity that takes on the role of project developer for cooperatives. The Cooperative Developer manages submittals, reporting and verification for a cooperative. A Cooperative Developer must have a Project Developer account on the Reserve.
Cooperative participant	A Project Owner whose project is being managed as a part of a cooperative, with a separate Cooperative Developer.
Cover crop	Crop planted for seasonal vegetative cover during non-crop production periods in a primary crop rotation, that is not harvested and is instead returned to the soil.
Crediting period	The period of time during which a project can generate CRTs. In this protocol, defined as five eligible crop years, which may occur over a period of up to ten years. See Section 3.4 for further definition.
Cultivation year	The period starting immediately after harvest of one primary crop and ending after the next primary planted crop is harvested the following calendar year. See Section 2.3 for further definition.
Effective date	The date of adoption of NMPP Version 2.0 by the Reserve Board.
Eligible crop year	One complete cultivation year in which an eligible crop (see Section 2.2.2) is grown. Eligible crop years are not required to be consecutive.

Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Enhanced efficiency fertilizer (EEF)	Fertilizer products that can reduce nutrient losses to the environment while increasing nutrient availability for the crop by either slowing the release of nutrients for uptake or altering the conversion of nutrients to other forms that may be less susceptible to losses. Nitrification inhibitors and slow release fertilizers are the two eligible EEFs in this protocol.
Field	A delineated contiguous cropland area, utilized to produce, or physically capable to produce, a single crop or rotation of crops, for which the basic management practices are all similar. See Section 2.2.3 for additional specifications.
Field Manager	Any entity that has the ability to control decision making on project fields, including farmers, their employees, or even entities that have legal ownership or control, such as landlords, state agencies etc. A Field Manager could include an individual, corporation, or other legally constituted entity, city, county, state agency, or combination thereof that has fee ownership and/or legal control of the land within the project area. Field Managers may or may not be directly involved in project development.
Fossil fuel	A fuel such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Highly erodible land (HEL)	Land that has an erodibility index of eight, as defined in Title 7 of the Code of Federal Regulations, Subpart A, Part 12.2. Part 12.21 further outlines how HEL is identified and how the erodibility index is calculated. Must implement HEL Conservation provisions to be eligible. See Section 3.6 for details.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Landowner	The entity listed on the deed to the property as the landowner.
Methane (CH_4)	A potent GHG with a GWP of 25, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Nitrification inhibitor	Substance that when applied in addition to the use of an ammonia (NH_3) or ammonium (NH_4^+) fertilizer, delay the conversion of NH_3 or NH_4^+ to nitrate

	(NO_3^-) (i.e., the nitrification process) by depressing the activity of *Nitrosomonas* bacteria, until the NO_3^- can be readily used by crops. Must be defined by AAPFCO as such and accepted for use by a state's fertilizer control agency or similar authority. Optional project activity. See Table 2.1.
Nitrogen Use Efficiency (NUE)	A measure of productivity per unit of N application typically defined as the proportion of all nitrogen inputs that are removed in harvested crop biomass.
Nitrous Oxide (N_2O)	A potent GHG with a GWP of 298, consisting of two nitrogen atoms and one oxygen atom.
No till	Tillage practice characterized by the use of seed drills and fertilizer applications with no additional tillage events or implements; surface residues are not incorporated into the soil and there is limited disturbance to the soil profile.
Primary crop	Defined as the main production crop grown on a field in a given year (e.g., corn is a primary crop and may be grown on its own or with a cover crop).
Project baseline	A "business as usual" GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	The term '*project developer'* will be used throughout this document to refer to both the responsible management entity for each project, and, in the case of cooperatives, the entity responsible for managing the cooperative.
Project Owner	Any entity which holds rights to the CRTs from the project at the time of issuance.
Slow release fertilizer	Fertilizers that slow or control the release of soluble nitrogen (NH_4^+ and NO_3^-) to the soil compared to conventional fertilizers, extending N availability to the crop and improving the synchronization between crop uptake and N availability; encompasses controlled release fertilizers. Must be defined by AAPFCO as such and accepted for use by a state's fertilizer control agency or similar authority. Optional project activity. See Table 2.1.
Synthetic N rate reduction	Reduction in the annual synthetic nitrogen application rate (i.e., the amount applied per acre for the cultivation year of an eligible crop) compared to baseline levels, without going below N demand. Mandatory project activity. See Table 2.1.
Technical Service Provider (TSP)	Technical Service Providers are individuals or businesses that have technical expertise in conservation planning and design for a variety of conservation activities. TSPs may be hired by farmers, ranchers, private businesses, nonprofit organizations, or public agencies to provide these services on behalf of the NRCS. TSPs must be certified by NRCS.
Verification	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification statement and provide verification services for operators subject to reporting under this protocol.
Wetland	Wetlands generally have a predominance of hydric soil and are inundated or saturated by surface or groundwater for various durations over the year. See Title 7 of the Code of Federal Regulations, Subpart A, Part 12.2 for the definition of wetlands. Must implement the Wetland Conservation provisions to be eligible. See Section 2.2.3 for details.

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Appendix A Nitrogen Management Review

The Climate Action Reserve (Reserve) has conducted a significant revision to its Nitrogen Management Project Protocol (NMPP) to expand applicability to additional practices, regions, and crops, while enhancing usability, simplifying quantification, and maintaining scientific accuracy.[84] NMPP V1.1 was limited to quantifying, monitoring, and verifying reductions in greenhouse gas (GHG) emissions, namely nitrous oxide (N_2O) emissions, from reductions in synthetic nitrogen application rate (N rate) on corn fields in the U.S. North Central Region (i.e., the Midwest). This appendix details the steps taken by the Reserve to prioritize the practices, crops, and regions for inclusion in the update to NMPP V2.0.

A.1 Nitrogen Management Stakeholder Survey

As a first step, the Reserve developed and issued a survey in Fall 2016 to stakeholders for their recommendations on what future revisions and expansions (i.e., additional practices, crops, regions and quantification methodologies) for the Reserve to prioritize for possible inclusion in the update from V1.1 to V2.0. The specific nutrient management practice options given in the survey included N-rate reduction (for additional crops and regions than in the current NMPP), the 4Rs (Right Rate, Right Time, Right Source, Right Place), cover crops, manure management, the use of Enhanced Efficiency Fertilizers[85] (EEFs), and precision agriculture. Participants included members from the original NMPP Workgroup and Science Advisory Committee (SAC), project developers, aggregators, agricultural science professionals, and methodology developers. After publishing an assessment of the survey results,[86] the Reserve discussed the outcomes and our biggest takeaways in a public meeting in the start of 2017. These consisted of the following:

1. California needs to be a priority region for inclusion (based on number of recently completed studies and for any future consideration by California Air Resources Board (ARB)), in addition to other regions with large emissions reduction potential.
2. Maintain flexibility when prioritizing crops for inclusion, with a focus on the major field crops and California specialty crops, and incorporate multi-year crop rotations.
3. The 4Rs and the use of EEFs were the priority practices recommended for inclusion.
4. When it comes to quantification, simple and easy-to-use emission factor-based models are critical and preferable over the more-complicated process-based models.

Equally worth mentioning here is the stakeholders' feedback on the surveyed practices not prioritized for inclusion, summarized as follows:

- Manure Management – difficulty in determining N_2O emissions resulting strictly from manure when both varying amounts of manure and synthetic fertilizer are applied and how a changing balance of manure to synthetic fertilizer ratio affects N_2O emissions
- Cover Crops – the full effects on N_2O emissions remain inconclusive; additional challenge of distinguishing between different species of cover crops

[84] The revision was made possible thanks to the support of the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Conservation Innovation Grant (CIG) program, as part of the "Demonstration of a Scalable Nutrient Management Project to Reduce Nitrous Oxide Emissions and Generate Voluntary or Compliance Greenhouse Gas Credits" CIG led by Environmental Defense Fund (EDF).
[85] Slow and controlled release N fertilizer (coated or encapsulated), nitrification inhibitor-treated, urease inhibitor-treated N fertilizer, or products treated with both nitrification and urease inhibitors are considered EEF products.
[86] See Nitrogen Management Survey Results Memo. Available at: http://www.climateactionreserve.org/how/protocols/nitrogen-management/revision/.

- Precision Agriculture – associated emission reductions may already be accounted for as a function of the N rate reduction practice, questioned data availability, and stressed the importance of capturing spatial heterogeneity

A.2 Literature Review

The Reserve then conducted an expansive literature review to assess whether there were enough published studies and statistics supporting the N_2O reductions benefits of the stakeholder survey priority practices. The results of this review, as found below in Table A.1, signified a growing scientific literature on the effects of the 4Rs and EEFs on N_2O emissions. Note, only resources demonstrating a consistent decrease in N_2O emissions from the implementation of the priority practice are listed. For example, Omonode et al. (2017) found that neither N source nor placement influenced the relationship between N_2O and net recovery efficiency (of nitrogen by the crop), and Burzaco et al. (2013) found that the optimal timing (i.e., side-dress timing) actually increased N_2O emissions. As such, neither of the studies are listed in Table A.1 next to the respective priority practices.

Table A.1. Priority Practices and Resources Supporting Consistent N_2O Emission Reductions

Stakeholder Survey Priority Practice	Resource/Reference
4Rs	
Right Rate	Eagle et al. (2017); Omonode et al. (2017); Pape et al. (2016); Venterea et al. (2016); Vyn et al. (2016); Wade et al. (2015); Culman et al. (2014); Eve et al. (2014); Shcherbak et al. (2014); Biggar et al. (2013); Burzaco et al. (2013); Burger and Horwath (2012); Eagle et al. (2012); Hoben et al. (2011); Ribaudo et al. (2011); Millar (2010)
Right Time	Eagle et al. (2017); Omonode et al. (2017); Pape et al. (2016); Venterea et al. (2016); Vyn et al. (2016); Wade et al. (2015); Biggar et al. (2013); Eagle et al. (2012); Ribaudo et al. (2011)
Right Source	Eagle et al. (2017); Eagle et al. (2012)
Right Place	Eagle et al. (2017); Biggar et al. (2013); Wade et al. (2015); Eagle et al. (2012); Ribaudo et al. (2011)
EEFs	
Use of Nitrification Inhibitor	Eagle et al. (2017); Lam et al. (2017); Burger et al. (2016); Snyder (2016); Eve et al. (2014); Burzaco et al. (2013); Eagle et al. (2012)
Use of Nitrification Inhibitor and Urease Inhibitor	Lam et al. (2017); Snyder (2016); Venterea et al. (2016); Pape et al. (2016); Decock (2014); Biggar et al. (2013);
Switch to Slow Release / Controlled Release Fertilizer	Snyder (2016); Eve et al. (2014); Biggar et al. (2013); Eagle et al. (2012)

A.2.1 NMPP V1.0 Science Advisory Committee Findings

The Reserve also revisited the previous materials and findings from the Science Advisory Committee (SAC)[87] adjourned during the development of NMPP V1.0 for further support on practices to prioritize in NMPP V2.0. The SAC refined and rated a list of potential nitrogen management practices for inclusion in the NMPP using criteria such as the available number of side-by-side comparisons showing measured N_2O reductions in the field, whether these studies showed consistent results, and whether N_2O emission reductions were direct or indirect, to denote in a general sense which ones were ready for inclusion in the NMPP based on the best

[87] The Reserve together with the Nicholas Institute of Duke University assembled a group of leading scientific experts to form a Science Advisory Committee (SAC). The purpose of the SAC was to help the Reserve interpret and apply the best available science into the NMPP. Committee membership was by invitation from the Reserve and the Nicholas Institute.

available science. Resources reaffirming the science related to the practices were discussed. Of importance to note here, the following practices were the only ones acknowledged as ready for inclusion in the protocol based on the best available science:

- Reducing amount of N applied, without going below N uptake demand
- Use of nitrification inhibitors or nitrification inhibitors combined with urease inhibitors
- Changing fertilizer composition (source) [specifically, switch from anhydrous ammonia to urea][88]
- Changing to use slow release fertilizer

A copy of the complete SAC findings can be found in the Appendices of NMPP V1.1, and can also be made available by the Reserve upon request.

A.2.2 Results

The updated literature review and review of the SAC findings solidified the Reserve's initial takeaways from the stakeholder survey. Accordingly, the 4Rs and use of EEFs received the highest priority for inclusion in NMPP V2.0, in terms of developing performance standards for additionality (see Appendix B) and methods for quantifying GHG emission reductions (see Appendix F) that occur as a result of adopting the practice(s) for different crops in different regions.

As detailed in Appendix F, the Reserve contracted with Mark Easter Consulting, LLC to develop the new quantification methodology for NMPP V2.0. While the Reserve presented our technical contractor with the complete list of priority practices (and left the inclusion of other practices open for consideration) only the practices included as eligible project activities in NMPP V2.0 were shown to have statistically significant N_2O reduction benefits in the USDA GHG Methods Document[89] (i.e., the "Blue Book"), of which the new quantification methodology is based on.[90]

A.3 Assessment of Excess Nitrogen Use

In addition to an updated literature review on nitrogen management practices' N_2O reduction benefits, the Reserve also conducted an analysis to assess where nitrogen is being applied in excess amounts (i.e., above agronomic events), and where there is greater potential for nitrogen management project implementation. The following details our findings.

A.3.1 CEAP Cropland Survey Reports

As detailed in Appendix F, the new quantification methodology for NMPP V2.0 has been stratified by 12 Conservation Effects Assessment Project (CEAP) regions.[91] CEAP Cropland

[88] For certain fertilizer sources.

[89] Eve et al. 2014.

[90] If practices' N_2O reduction benefits or potential benefits could be shown to be statistically significant based on analyses of flux measurements in field studies across the U.S., practice scalars were developed in the Blue Book. When the USDA GHG Methods were originally produced, and in the forthcoming update, time was spent examining various practices, including right time, place, and source, to see which were supported by reliable field measurements and which were not. Where certain 4Rs could not be shown to have a statistically significant effect, practice scalars could not be developed. This could change as new data become available and the USDA methods are further updated.

[91] The Conservation Effects Assessment Project (CEAP) was initiated by USDA NRCS to estimate conservation benefits for reporting at the national and regional levels and to establish the scientific understanding of the effects and benefits of conservation practices at the watershed scale. As CEAP evolved, the scope was expanded to provide research and assessment on how to best use conservation practices in managing agricultural landscapes to protect

Surveys were conducted to quantify the effects of conservation practices commonly used on cultivated cropland in the 12 regions shown in yellow in Figure A.1 during 2003–06[92]. The surveys included collecting information on the application of commercial fertilizers (rate, timing, method, and form) for crops grown the previous 3 years. The following criteria were used to identify the *appropriate* rate of nutrient application for each crop or crop rotation:

- The rate of nitrogen application, including the sum of both commercial fertilizer and manure nitrogen available for crops in the year of application, is
    - less than 1.4 times the amount of nitrogen removed in the crop yield at harvest for *each* crop,[93] except for wheat and other small grain crops
    - less than 1.6 times the amount of nitrogen removed in the crop yield at harvest for small grain crops (wheat, barley, oats, rice, rye, buckwheat, emmer, spelt, and triticale); and
    - less than 60 pounds of nitrogen per bale of cotton harvested

The CEAP findings have been prepared in a series of 12 reports.[94] The results on the percent of all cropped acres, for all crops in rotation, meeting the N rate criteria can be found in Table A.2.

and enhance environmental quality. CEAP regions transcend State borders and represent broad geographic regions with similar climate, physiography, and land use.

[92] A follow-up survey to assess progress was also conducted in 2011 in the Chesapeake Bay Region.

[93] The 1.4 ratio of application rate to yield represents 70-percent use efficiency for applied nitrogen, which has traditionally been accepted as good nitrogen management practice. The 30 percent "lost" includes plant biomass left in the field, volatilization during and following application, immobilization by soil and soil microbes, and surface runoff and leaching losses. A slightly higher ratio is used for small grain crops to maintain yields at current levels. See CEAP Cropland Reports in Reference Section.

[94] A list of CEAP regions and corresponding reports are available at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/?cid=nrcs143_014144

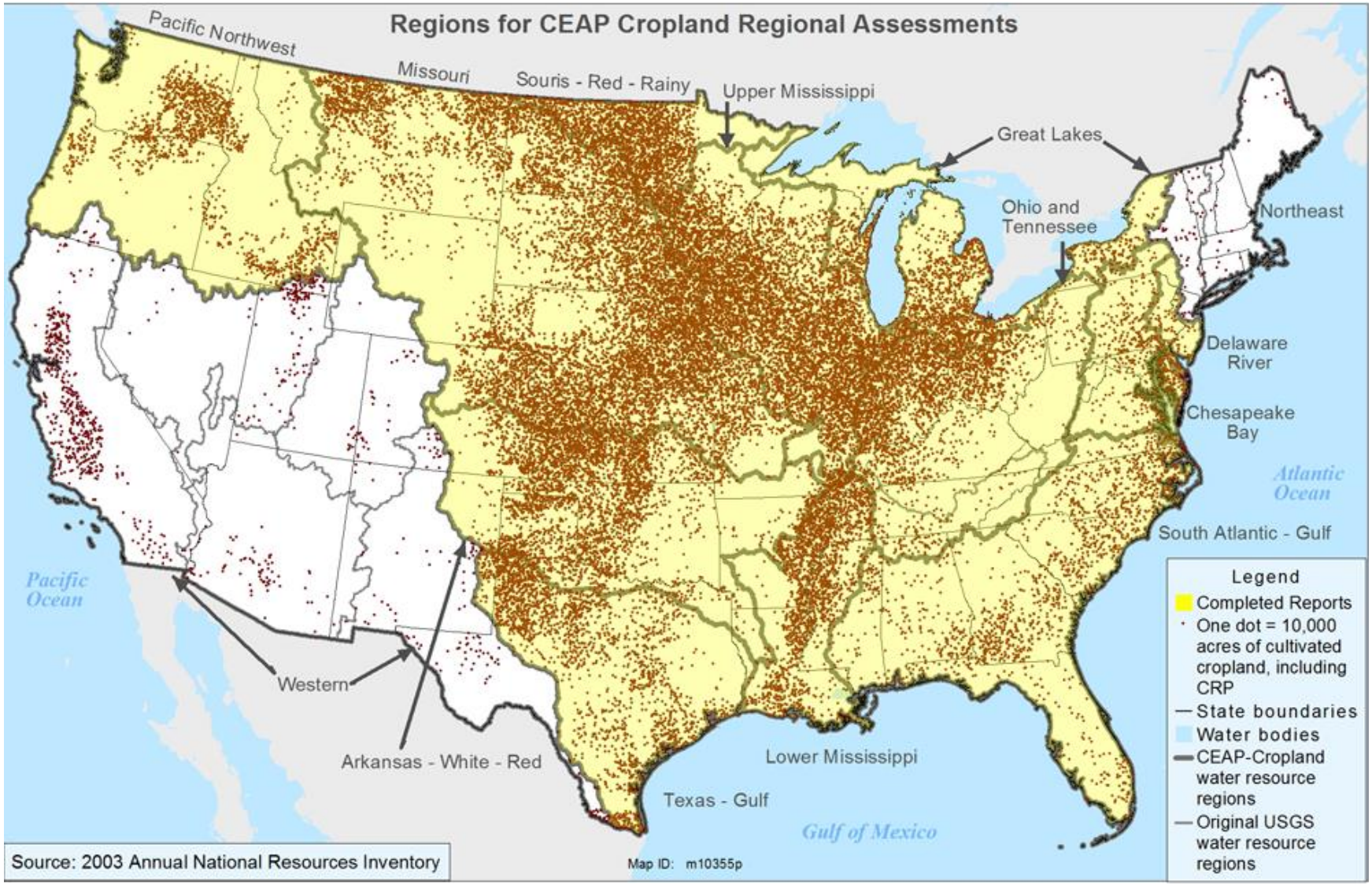

Figure A.1. 12 Watersheds (in yellow) for CEAP Cropland Regional Assessments

Table A.2. Findings from CEAP Cropland Reports on Regions Applying Appropriate N Rates

CEAP Cropland Report / Region	Eligible Crops Grown	Cropland Acres Meeting Appropriate N Rate Criteria[95] (%)
Arkansas White Red Basin	Corn Cotton Sorghum Wheat	59
Chesapeake Bay Region	Corn	23[96].
Delaware River Basin	Corn	43
Great Lakes Region	Corn Wheat	40
Lower Mississippi River Basin	Corn Cotton Sorghum Wheat	23
Missouri River Basin	Corn Wheat	63
Ohio-Tennessee River Basin	Corn Wheat	39
Pacific Northwest Basin	Barley Wheat	64
Souris-Red-Rainy Basin	Barley Corn Wheat	71
South Atlantic Gulf Basin	Corn Cotton Wheat	45
Texas Gulf Basin	Cotton (Upland) Sorghum Wheat	51
Upper Mississippi River Basin	Corn Wheat	39

A.3.2 USDA ERS Reports

Two recent studies conducted by the USDA Economic Research Service (ERS) provide a snapshot on the adoption of nutrient management practices that are supported by USDA conservation programs. All the data presented in both studies are derived from the Agricultural Resource Management Survey (ARMS).

[95] Based on all crops in rotation meeting the nitrogen rate criteria. For example, if corn and soybeans were on a 2-year rotation and that corn was grown during the year the CEAP surveys were conducted, then the N rate on both the corn and the previous year's soybean crops were assessed. If the application rate on corn met the rate criterion but excess nitrogen was applied to soybeans, then the rotation was identified as not meeting the criterion. This leads to the CEAP assessment reporting a smaller percentage of crop acres meeting the rate criterion than others (e.g., USDA ERS) may report.

[96] Note, the CEAP Cropland Conservation Progress Report for the Chesapeake Bay Region found the percent of cropped acres applying the appropriate nitrogen application rate on all crops in rotation declined by 9 percent from 32 percent in 2003-2006 to 23 percent in 2011.

A.3.2.1 *Conservation-Practice Adoption Rates Vary Widely by Crop and Region*

This analysis by Wade et al. (2015) evaluated the number of farmers applying nitrogen at rates greater than, equal to, or less than agronomic rates, and focused only on the application of commercial nitrogen on acres that do not receive manure[97] and on land planted to corn, soybean, wheat, and cotton.

The report defined a maximum agronomic or "benchmark" rate based on procedures outlined in the USDA/NRCS CEAP Cropland Reports (See Section A.3.1): for corn and wheat, the benchmark nitrogen application rate was 1.4 and 1.6 times expected removal, respectively, less a nitrogen credit of 40 pounds per acre for fields where soybeans were grown in the previous year, and for cotton, the benchmark rate was equal to 60 pounds of nitrogen per bale of expected yield, less a nitrogen credit of 40 pounds per acre for fields where soybeans were grown in the previous crop year.

The study compared their benchmarks to reported N rates at the field level, and found that nitrogen is applied at more than the benchmark rate on:

- 36 percent of corn acres (2010 data) by an average rate of 39 pounds per acre;
- 19 percent of cotton acres (2007 data) by an average rate of 40 pounds per acre;
- 22 percent of spring wheat acres (2009 data) by an average rate of 30 pounds per acre; and
- 25 percent of winter wheat acres (2009 data) by an average rate of 24 pounds per acre.

The study also found that farmers spent approximately $965 million on corn, cotton, and wheat nitrogen applications over benchmarks.[98]

A.3.2.2 *Nitrogen in Agricultural Systems: Implications for Conservation Policy*

This report by Ribaudo et al. (2011) explored the use of nitrogen in U.S. agriculture for producers of barley, corn, cotton, oats, peanuts, sorghum, and wheat during the survey year covered by ARMS data, and assessed changes in nutrient management by farmers that may improve nitrogen use efficiency. It defined the agronomic application N rate as applying no more nitrogen (commercial and manure) than 40 percent more than that removed with the crop at harvest, based on the stated yield goal, including any carryover from the previous crop. This definition is also consistent with CEAP.

Because the crops covered in the analysis were surveyed in different years, 2006 was specified as a reference year to examine the extent to which best nitrogen management practices are being followed. The report's findings revealed the application rate criterion was not met on over 53 million acres treated with nitrogen (32 percent). Cotton had the highest percentage of treated acres not meeting the rate criterion (47 percent), followed by corn (35 percent). However, corn accounted for 50 percent of all treated crop acres not meeting the rate criterion. The complete results on U.S. treated acres per crop *not* meeting the rate criterion can be found in Table A.3.

[97] The application of commercial fertilizer can be more carefully calibrated than the application of manure, which can vary in terms of nutrient content and is more difficult to precisely apply.
[98] Cost estimates were based on over-application quantities and annual ammonia nitrate prices.

Table A.3. Shares of Treated Acres that Did Not Meet the Rate Criterion, by Crop, in 2006

Crop	Did Not Meet N Rate Criteria	
	Treated Acres (%)	Treated Acres (Acres)
Barley	14	444,650
Corn	35	26,618,235
Cotton	47	5,906,020
Oats	33	906,840
Peanuts	1	7,370
Sorghum	24	1,288,800
Soybeans	3	505,820
Wheat	34	16,934,720
TOTAL	32	53,531,200

From a regional standpoint, in terms of nitrogen application in excess of the criterion rate, the study found that the USDA Farm Production Regions[99] of the Corn Belt and Lake States received the greatest amounts of excess nitrogen, as seen in Table A.4.

Table A.4. Total Nitrogen Applications Above Criterion Rate by Farm Production Region, 2006

USDA Farm Production Region	States Included	Excess N (1,000 tons N)
Appalachia	NC, KY, TN, VA, WV	36
Corn Belt	IL, IN, IA, MO, OH	298
Delta	AR, LA, MI	1
Lake States	MI, MN, WI	185
Mountain	AZ, CO, ID, MT, NE, NM, UT, WY	7
Northeast	CT, DE, MA, MD, NE, NH, NJ, NY, PA, RI, PA	44
Northern Plains	KS, ND, NE, SD	84
Pacific	CA, OR, WA	1
Southeast	AB, FL, GA, SC	5
Southern Plains	OK, TX	18

A.3.3 IPNI Nutrient Use Geographic Information System (NuGIS)

The International Plant Nutrition Institute (IPNI) Nutrient Use Geographic Information System (NuGIS) integrates multiple spatial datasets to create county-level estimates of nutrients (N, P and K) applied to the soil in fertilizer and livestock manure, nutrients removed by harvested agricultural crops, and remaining nutrient balances per total cropland acre across the lower 48 states.

The basic NuGIS model is a very simple field based partial nutrient balance algorithm:

> Balance = Farm fertilizer nutrient used + Recoverable manure nutrient use + Biological fixation – Nutrient in harvested crops[100]

[99] In terms of crop production. the Corn Belt has the largest number of farms with crops (i.e., 283,975 farms) and the most harvested acres (i.e., 81.5 million acres) of all USDA production regions. Collectively, the Corn Belt, Lake States, and the Great Plains account for 53 percent of all farms with crops and 71 percent of all harvested acres. Crop production in the Eastern United States is characterized by mostly smaller farms. Collectively, the Northeast, Appalachia, and Southeast regions have about 28 percent of farms with crops, but account for less than 12 percent of all harvested acres.

[100] Fixen et al., 2012

The most up-to-date results on N balance and N use are viewable through the color maps in Figure A.2 and Figure A.3, respectively. The analysis on N balance reveals areas of both highly positive (where more N is available than taken up by crops) and highly negative (where not enough N is available for crop needs) balances. The counties with positive N balances are in shades of green in Figure A.2. The counties using greater amounts of N are in darker shades of blue in Figure A.3.

See Appendix B for more information on IPNI NuGIS.

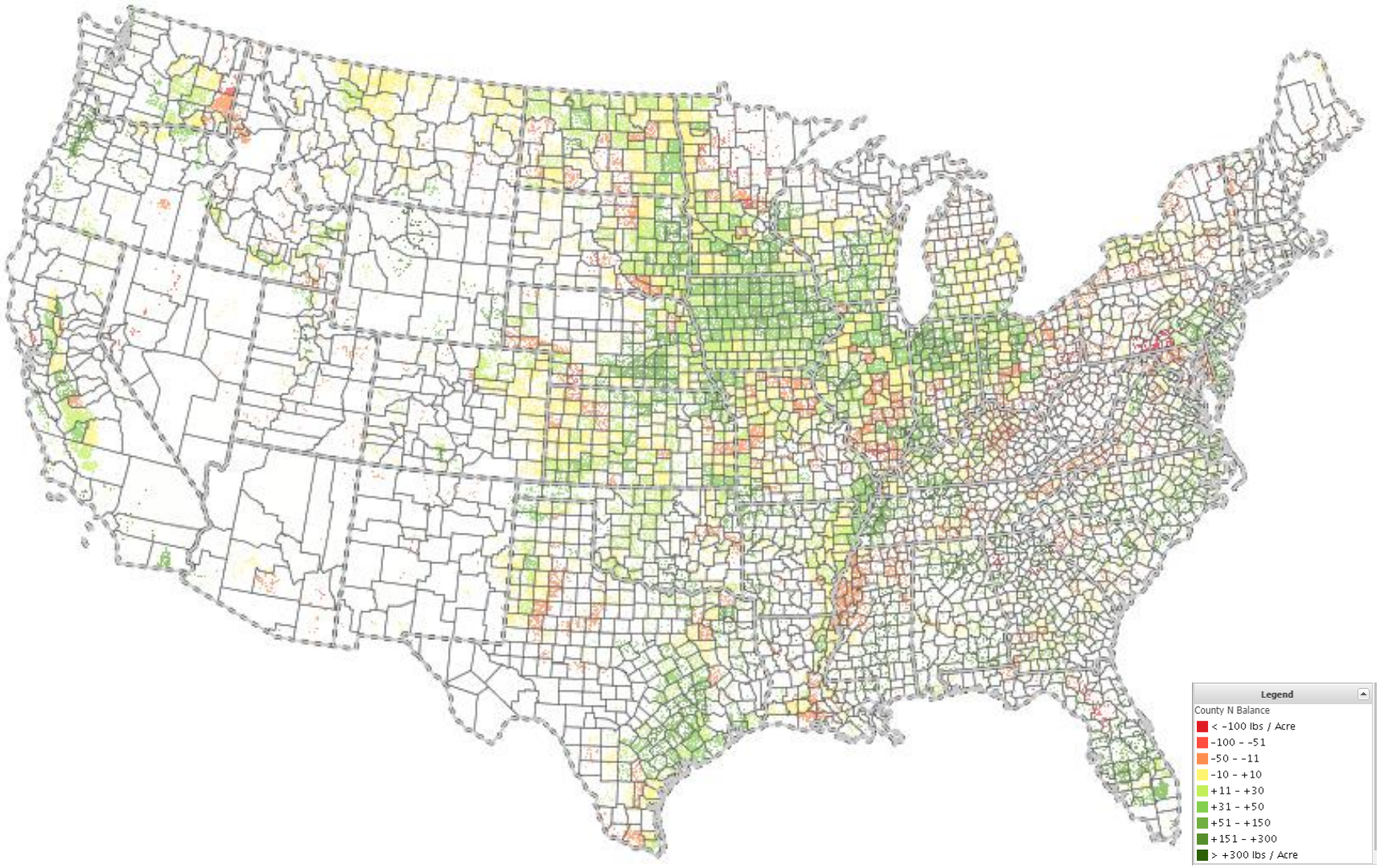

Figure A.2. 2014 IPNI NuGIS County-Level N Balance Data

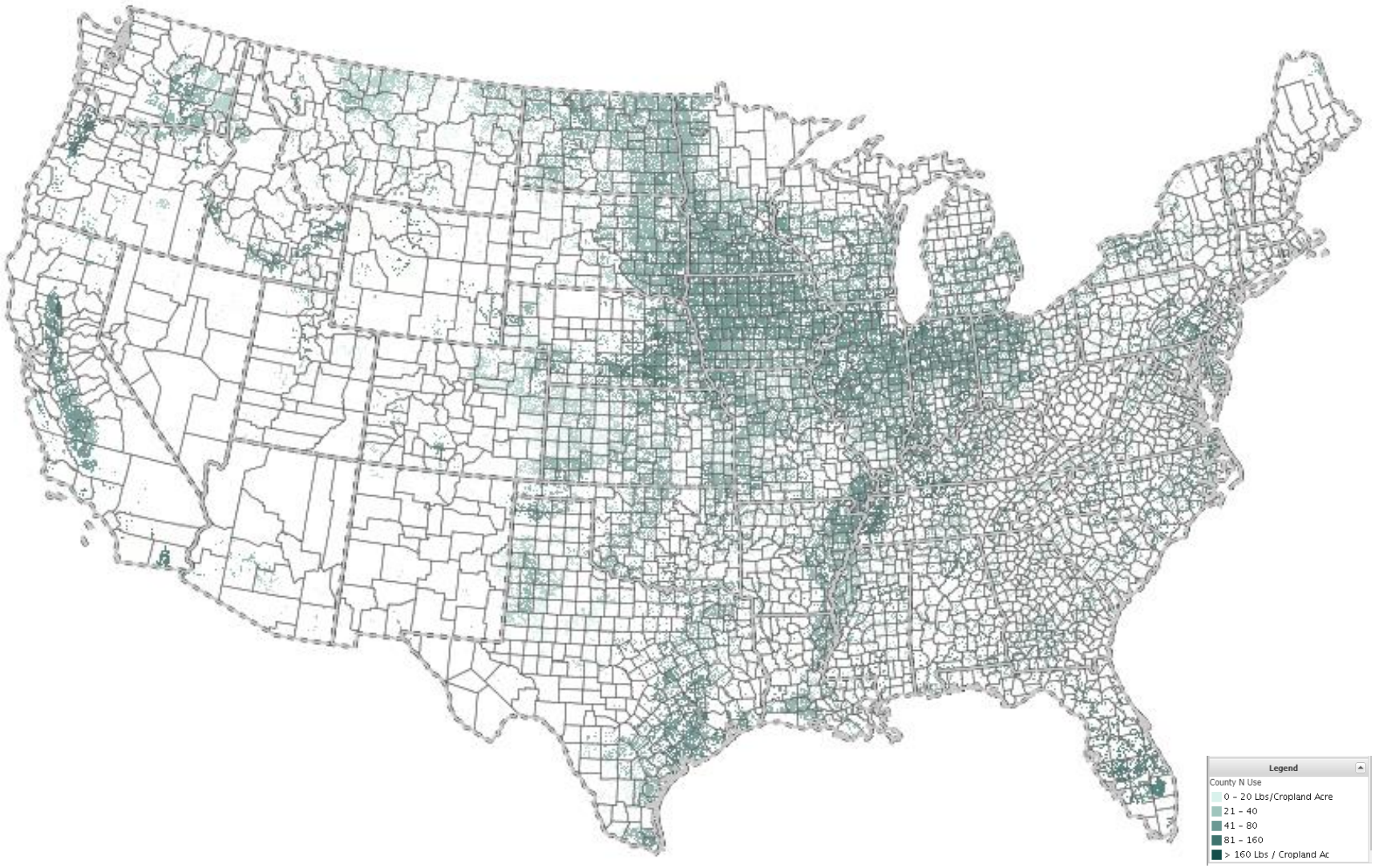

Figure A.3. 2014 IPNI NuGIS County-Level N Use Data

A.4 Summary of Findings

While it's challenging to assess whether, where, and how much excess nitrogen is being used at the farm or field level, the results from the CEAP Cropland Reports, USDA ERS Reports, and IPNI NuGIS help shed light on regions with greater potential for nitrogen management projects. For example, based on the findings of the CEAP surveys, counties in the Ohio-Tennessee River Basin[101] and the Upper Mississippi River Basin,[102] where only 39 percent of cropland acres were meeting the CEAP N rate criteria, may have more potential for nitrogen management projects than counties in the Souris-Red-Rainy Basin,[103] where 71 percent of cropland acres were meeting the CEAP N rate criteria. The results from the USDA ERS reports, which upheld similar criteria to the CEAP reports, reinforce the takeaways of the greater potential for projects in these regions, as do the more recent county-level N balance and N use assessments completed by IPNI as part of the NuGIS project. Note, the NuGIS results also indicate positive N balance and project potential in the California Central Valley.

[101] The Ohio-Tennessee River Basin includes a significant portion of seven states— Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia—and small parts of seven additional states. See Figure A.1.
[102] The Upper Mississippi River Basin includes large parts of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, and small areas in Indiana, Michigan, and South Dakota. See Figure A.1.
[103] The Souris-Red-Rainy Basin consists of parts of North Dakota and Minnesota, and a small part of the northeast corner of South Dakota. See Figure A.1.

Appendix B Summary of Performance Standard Test Development and Additionality Assessment

This appendix summarizes performance standard development and research into industry trends in nitrogen management practices in crop cultivation that have the potential to reduce nitrous oxide (N_2O) emissions. This appendix primarily lays out the background, rationale, and development of the performance standard test for the approved project activities of reducing synthetic nitrogen application rate (N rate) and using nitrification inhibitors or switching to a slow release fertilizers, which were identified in the Reserve's literary review (see Appendix A), Fall 2016 Stakeholder Survey, other methodologies,[104] and by the NMPP V1.0 Science Advisory Committee (SAC) [105] as practices with consistent N_2O emission reduction potential *and* for which there is an applicable quantification approach (see Appendix F).

B.1 Practices and Data Availability

While the complete 4R nutrient stewardship principles (right rate, right time, right source, and right place) and Enhanced Efficiency Fertilizers (EEFs) were prioritized for consideration in the NMPP V2.0 (see Appendix A), the lack of comprehensive datasets[106] on "business as usual" nitrogen management practices hindered the development of performance standards for a number of these practices, as shown in Table B.1.

The USDA Agricultural Resource Management Survey (ARMS) and National Agricultural Statistical Service (NASS) datasets, as well as the International Plant Nutrition Institute (IPNI) Nutrient Use Geographic Information System (NuGIS) dataset, discussed further below, were used to analyze common practice nitrogen management, and where sufficient data were available, research outcomes informed development of a performance standard. The only complete performance standards currently included in the NMPP are for 1) N rate reduction projects, and 2) N rate reduction projects and the use of a nitrification inhibitor or the switch to a slow release fertilizer.

[104] Millar et al., 2010.

[105] The SAC findings are contained in NMPP V1.1 available at: http://www.climateactionreserve.org/how/protocols/nitrogen-management/

[106] The Background Paper on Quantification of N_2O Mitigation Options, prepared by Terra Global Capital for the Reserve provides an extensive review of datasets considered for use in developing the performance standard (available at http://www.climateactionreserve.org/how/protocols/nitrogen-management/dev/). Only the most promising and comprehensive of datasets are discussed here.

Table B.1. List of Priority Practices and Data Availability

Priority List of Practices to Include in NMPP (Based on Stakeholder Survey Results)	Are comprehensive data available to develop performance standard?			Is a standardized quantification methodology for N_2O emissions currently available that meets Reserve criteria?[107]
	USDA ARMS	USDA NASS	IPNI NuGIS	
Right Rate[108] - Reduce N Applied without Going Below N Demand	Yes	Yes	Yes	Yes
Right Time - Switch from Fall to Spring N Application[109]	Yes	No	No	No
- Split N Applications	No	No	No	No
Right Source - Switch from Anhydrous Ammonia to Urea	No	No	No	No
Right Place - Apply N Below Soil Surface[110] (i.e., Closer to Roots)	No	No	No	No
Use of Enhanced Efficiency Fertilizers (EEFs) - Nitrification and Urease Inhibitors - Nitrification Inhibitors (only) - Urease Inhibitors (only) - Slow Release Fertilizers / Controlled Release Fertilizers	Yes[111]	No	No	Yes

[107] See Appendix F.
[108] Note, average N rate from ARMS and NASS is crop-specific and based on synthetic and manure N; average N rate from IPNI NuGIS does not include manure and is per all cropland.
[109] Not applicable to Winter Wheat.
[110] That is, fertilizer is injected or incorporated at time of application.
[111] It should be noted that 'N inhibitor' as defined in the USDA ARMS dataset includes nitrification inhibitors, urease inhibitors and chemical coated (slow release or controlled release) fertilizers. Only aggregated data on penetration rates for 'N inhibitors' are publicly available. The exact ARMS survey question has varied over the years, and has generally been broadly phrased. In the 2010 corn survey, for example, producers were asked to select among three specific types, other, or none: 1 Nitrification inhibitors (such as N-Serve); 2 Urease inhibitors (such as Agrotain); 3 Chemical-coated fertilizers (such as sulfur-coated urea and polymer-coated urea); 4 Other inhibitors; 5 None.

B.2 Nitrogen Cycling and Nitrogen Use Efficiency

Metrics to set a performance standard threshold must be simple and consistent. Though the annual N fertilization rate may seem like a straightforward metric for setting a performance threshold, particularly for practices that reduce nitrogen rates, it is not a consistent metric. More specifically, fields that receive an equal amount of N fertilizer can vary drastically in terms of yield, how much N crops take up, how much N is lost, and how much residual N remains after crop uptake, all of which influence the quantity of N available for processes that lead to N_2O emissions. This difference in efficiency across sites can be understood if one considers the nitrogen cycle.

Nitrogen cycles through cropland systems in a way that is influenced by a wide range of site-specific variables such as soil type, climate, cropping system and previous and current nitrogen management. A simplified diagram of the N cycle is depicted in Figure B.1 below.

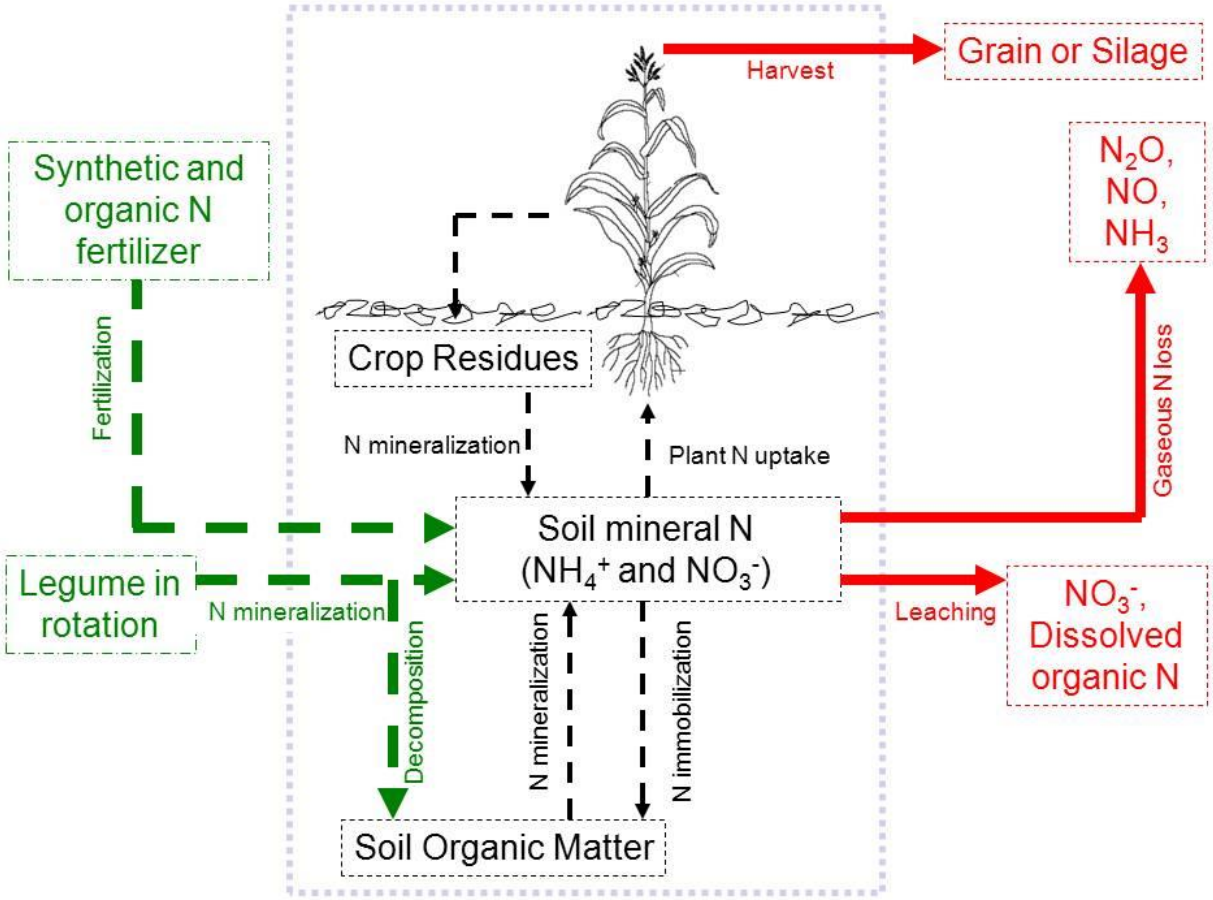

Figure B.1. Nitrogen Sources, Cycling, and Losses in Agricultural Systems[112]

Wide red arrows represent losses from the system, wide dashed green arrows external inputs and narrow dashed arrows internal recycling. The purple dotted line marks the accounting boundary.

N inputs in most agricultural systems consist of synthetic N fertilizer (e.g., anhydrous ammonia or urea), organic fertilizer (e.g., manure, compost, or sewage sludge), or carryover from legumes in the rotation. N can also become available through mineralization of organic matter or

[112] Drawing of corn plant was obtained from www.inra.fr with N Cycle added.

residual soil N carried over from one cultivation year to the next. Major N losses include leaching, ammonia (NH_3) volatilization or emission of nitrogen oxides (NO_x), N_2O, or nitrogen gas (N_2). Finally, N is also removed from the system through harvest, with the amount of N removed by harvest depending on the crop type and crop usage (e.g., corn for grain versus silage). As a consequence, the most appropriate N rate for a given field will vary drastically across and within cropping systems and regions.

The common best management practice for N rates is to apply nitrogen in amounts closer to the agronomic rate, where only as much nitrogen as crops can use is applied. Agronomic nitrogen rates depend on the crop, crop rotation, expected yield, weather, timing of application, soil, and other conditions, as detailed above. As seen in Appendix A, the maximum agronomic rate is frequently defined as applying no more nitrogen (commercial and manure) than 1.4 times the amount of nitrogen removed in the crop yield at harvest for corn, sorghum, and tomatoes, 1.6 times the amount of nitrogen removed in the crop yield at harvest for small grain crops (barley, oats, spring wheat, and winter wheat), and less than 60 pounds of nitrogen per bale of cotton harvested.

The most comprehensive evaluations of N budgets and N cycling in the system take into account all N inputs, losses and internal N cycling. A commonly used metric in the industry to characterize N budgets of cropland systems is nitrogen use efficiency (NUE). The NUE takes the form of a ratio that considers an output (e.g., crop biomass at harvest or economic yield) as the numerator and input (N supply) as the denominator.[113] The crop biomass at harvest (i.e., the "biological yield") can include either total aboveground plant dry matter or total plant N, whereas the economic yield includes either grain yield or total grain N.[114] The N supply can be from soil (N mineralization, carryover of residual N, N credit from legumes), fertilizer (organic or synthetic), or soil plus fertilizer.[115] Consequently, various working definitions and methodologies to measure and calculate NUE are in circulation, each of which finds their use in answering particular agronomic, ecological or economic questions. NUE can be used at various geographic scales, from studying and fine-tuning the N budget of a single field to evaluating nitrogen balances at a watershed or landscape scale.

At a landscape scale, NUE has been used by IPNI,[116] the Agricultural Sustainability Institute at UC Davis, and other entities as an important indicator to evaluate the sustainability and performance of various agricultural regions and cropping systems.[117] Regardless of the definition used for NUE, higher values for NUE generally reflect improved utilization of N by the crop, often decreasing the risk for harmful loss of N to the environment, such as N_2O emissions.

A performance standard threshold that is solely based on N fertilizer rates will be insufficient to deduce performance consistently across sites, due to the inability to account for site-specific factors. A high N rate threshold may be appropriate for high-yielding fields, but not for marginal fields within the same geographic region. Additionally, the inherent risk in a performance standard that is solely based on reductions in N fertilizer rates is overlooking potential reductions in yield. With increasing demand for food (due to increasing population and consumption), any shift in N management must sustain crop yield. If reductions in N fertilizer decrease crop yields, GHG emissions could actually increase, because production that

[113] Ladha, J.K., Pathak, H., Krupnik, T.J., et al., 2005.
[114] Ibid.
[115] Ibid.
[116] NuGIS, Fixen, 2010.
[117] Fixen, 2010; Ladha et al., 2005; Rosenstock et al., In Review.

compensates for yield losses could shift to less efficient regions or production systems (negative leakage). Incentives for GHG mitigation should therefore avoid reducing yield by much in highly efficient systems.[118] Furthermore, a performance standard test based on N fertilizer rates would be inequitably disadvantageous to early actors who have already begun applying N rates closer to agronomic amounts and advantageous to laggards who continue to apply N in excessive amounts.

A performance metric based on NUE (i.e., productivity per unit of N application) rather than absolute N rate can overcome these issues. NUE-based performance metrics reflect nitrogen management that limits N losses to the environment and maximizes N use by crops to maintain and enhance yield.

B.3 Partial Factor Productivity (PFP) as N Rate Reduction Performance Standard Threshold

In the previous section, it was explained how a performance threshold for reducing N rates shall be based on some measure of NUE. Ideally, all inputs, losses (including N removed by harvest), and internal recycling should be considered when characterizing cropland NUE. However, in practice, such data are lacking, both in terms of regional data sets needed to set a threshold, as well as site-specific data that would be needed to compare a field's performance against the threshold. The only data readily available to assess these respective NUE values and set NUE thresholds is limited to synthetic and organic fertilizer N inputs and cropping yields. Though more comprehensive NUE metrics, which include many additional variables, may approximate NUE more accurately in theory, these more comprehensive metrics can become rather complicated and opaque, making their use less desirable in the context of an offset protocol. For testing additionality, the focus should be on metrics for which sufficient data are available to define the common practice and that can be calculated for individual fields using historic and project data that is readily available to the grower. Metrics that reflect the system's N budget to its fullest extent will require additional data gathering and field sampling that are likely prohibitive to conduct at a field scale due to practical and financial constraints.

One of the goals with the update to Version 2.0 was to make the NMPP easier to use while upholding scientific integrity. As such, NMPP V2.0 uses the simplest form of crop production efficiency (i.e., where the output is the harvested crop yield), termed the Partial Factor Productivity (PFP), as the NUE metric in its performance standard test for N rate reductions. The PFP demonstrates how productive the cropping system is in comparison to its nutrient input, and is calculated in Equation 3.1 in units of crop yield per unit of N fertilizer applied – both of which should be part of any practical record-keeping for growers and are required by this protocol. Because PFP is a ratio, it always increases when N rate decreases and/or yield increases[119]. This might lead one to falsely conclude that the lowest fertilizer rate would result in the most efficient cropping system. However, reducing rates significantly below the agronomic rate, would in turn compromise yield and reduce PFP. The more valuable increases in efficiency come from yield improvement. For example, the PFP for N applied to U.S. corn increased by 50 percent between 1975 and 2006. This increase did not result from a decrease in N application

[118] Eagle, A., L. Olander, L.R. Henry, K. Haugen-Kozyra, N. Millar, and G.P. Robertson. 2012. Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States: A Synthesis of the Literature. Report NI R 10-04, Third Edition. Durham, NC: Nicholas Institute for Environmental Policy Solutions, Duke University.
[119] Doberman, A., 2007. *Nutrient use efficiency – measurement and management*. In: Kraus, A., Isherwood, K. and Heffer, P., Eds., Fertilizers Best Management Practices. Proceeding of International Fertilizer Industry Association, Brussels, Belgium, 7-9 March 2007, 1-22

rates. In fact, rates applied rose by 24 percent, but better genetic and improved management boosted yields by no less than 86 percent.[120]

A similar reporting metric – a ratio of Nitrogen Applied divided by Yield (A/Y) – is required to be calculated and provided in Nitrogen Management Plans (NMPs) by all growers regulated under the California Central Valley Regional Water Quality Control Boards' Irrigated Lands Regulatory Program (ILRP). The A/Y metric was developed by the NMP Technical Advisory Work Group (Work Group), consisting of Central Valley agricultural coalitions, representatives from California Department of Food and Agriculture (CDFA) and University of California Cooperative Extension, and practicing agronomists and crop experts. Per this Work Group's recommendation, the advantages of using the A/Y ratio as a *nitrogen removal* reporting metric are rapid data collection, consistent reporting across all crops and across reporting years, ease of calculation, and a tangible meaning of the relationship between the Applied Nitrogen and the Yield (see Appendix C for more information).

The simplified PFP calculated in this protocol only considers applied N and does not take into account all available N sources. However, if a large number of producers in a specific region apply relatively low N rates to a given crop because they account for potential residual N at the beginning of the cultivation year or legume N credits, the region- and crop-specific average PFP will be relatively large. Vice versa, if the selection of an appropriate N rate to a given crop is not commonly discounted for residual N or N credit from legumes, the region- and crop-specific-average PFP will be relatively large. Therefore, simple region- and crop-specific -average PFP values implicitly take into account the adoption of best management practices with respect to N rate, and can be used as thresholds to ensure additionality and promote environmental integrity.

It should also be noted that while the NMPP determines the additionality of emission reductions based on a metric that normalizes N rates by using crop yield, quantification of N_2O emission reductions in the NMPP is based on synthetic N rate reductions (with or without the implementation of other eligible project activities) quantified for a given project.

B.4 Development of County- and Crop-Specific PFP Benchmarks

Importantly for the development of the performance standard test, simple indicators such as PFP scale more easily than complex forms, provided reliable statistics on input use and crop yields are available. In developing PFP metrics to set performance standard thresholds in NMPP V2.0, the Reserve looked to improve the spatial scale from the state to the county level, and the temporal scale from annual to multiple years to create performance benchmarks more relatable to a specific grower's conditions at the farm or field-level than the annual state average performance benchmarks used in NMPP V1.1. However, there is currently no database containing average fertilizer N application rates or amount of N applied to planted or treated acres for specific crops at the U.S. county level. The following details the methods employed by the Reserve to get around this data gap and estimate multi-year county- and crop-specific average fertilizer nitrogen rates with the best available data. Complete equations detailing the Reserve's methodology for developing county- and crop-specific benchmarks are available by request.

[120] Snyder, C.S. and T.W. Bruulsema, 2007. *Nutrient Use Efficiency and Effectiveness in North America: Indices of Agronomic and Environmental Benefit*. International Plant Nutrition Institute. North Cross, Georgia. June 2007

B.4.1 Database Overview

The data used in the development of multi-year county- and crop-specific average N rates were derived from the USDA ARMS and NASS datasets and the IPNI NuGIS dataset

B.4.1.1 USDA National Agricultural Statistics Service (NASS) Quick Stats

The USDA's National Agricultural Statistics Service (NASS) conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture, including production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use, and changes in the demographics of U.S. producers. Two are of particular importance to the NMPP: 1) the Agricultural Chemical Use Program and 2) the Agricultural Yield survey.

The NASS Agricultural Chemical Use Program[121] is USDA's official source of statistics about on-farm chemical use and pest management practices. Since 1990, NASS has surveyed U.S. farmers to collect information on the chemical ingredients they apply to agricultural commodities through fertilizers and pesticides. On a rotating basis, the program currently includes field crops (row crops and small grains), fruits, vegetables, and nursery and floriculture crops. Each survey focuses on the top-producing states that together account for the majority of U.S. acres or production of the surveyed commodity. Data are available at the state level for all surveyed states, and includes percentage acreage treated, number of applications, rates of application, and total amounts applied of nitrogen (available annually for field crops, intermittently for fruits and vegetables).

The NASS Agricultural Yield survey[122] provides farmer reported survey data of expected crop yields used to forecast and estimate crop production levels throughout the cultivation year. The survey is conducted monthly in all states (except AK and HI) running from May through November. Small grains (winter wheat, spring wheat, barley, oats) data are collected from May through August. Row crop (corn, cotton, sorghum) data are collected from August through November. Vegetable (tomato) data are collected from April through September. California tomato processors are surveyed separately. Data are available annually for all eligible crops. This dataset is robust and published on a regular, annual schedule.

NASS is also responsible for conduct the Census of Agriculture (COA) every five years, providing the only source of consistent, comparable, and detailed agricultural data for every county in America.

The results of chemical use and yield surveys and the Census of Agriculture are made readily available through the NASS Quick Stats Database.[123]

B.4.1.2 USDA Agricultural Resource Management Survey (ARMS) Crop Production Practices Tailored Reports

USDA's Agricultural Resource Management Survey (ARMS)[124] is an annual survey of farm and ranch operators administered by the USDA Economic Research Service (ERS) and NASS.

[121] Available at: https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Chemical_Use/index.php
[122] Available at: https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Agricultural_Yield/index.php
[123] The Quick Stats Database (searchable database) is the most comprehensive tool for accessing agricultural data published by NASS. It allows you to customize your query by commodity, location, or time period. Available at: https://quickstats.nass.usda.gov/.
[124] Available at: https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Ag_Resource_Management/index2.php.

ARMS gathers data on field-level production practices, farm business accounts, and farm households. The ARMS collects production practices and cost of production data on selected commodities (*field crops only* – barley, corn, cotton, oats, sorghum, spring wheat, winter wheat), and is conducted in three data collection phases:

- The initial phase, (Phase I), ARMS Screening survey, collects general farm data such as crops grown, livestock inventory, and value of sales.
- The second phase, (Phase II), collects data associated with agricultural production practices, resource use, and variable costs of production for specific commodities. Commodities are surveyed on a predetermined rotation with up to five commodities surveyed in a given year. Farm operators provide data on fertilizer and nutrient applications, pesticide applications, pest management practices, and irrigation.
- The final phase, (Phase III) collects whole farm finance, operator characteristics, and farm household information. Farm operators provide data on farm operating expenditures, capital improvements, assets, and debt for agricultural production. In addition, operators provide data on farm-related income, government payments, the source and amount of off-farm income, and characteristics of themselves and their household.

This approach helps link commodity production activities and conservation practices with the farm business and operator household. Each phase of ARMS contains multiple versions of the survey questionnaire. The commonality of questions across versions provides one facet of data integration. The target commodity distinguishes questionnaires.

Data on the nutrient management practices of U.S. producers of the select field crops are available through/derived from the ARMS Crop Production Practices Tailored Reports.[125]

B.4.1.3 International Plant Nutrition Institute (IPNI) Nutrient Use Geographic Information System (NuGIS)

The International Plant Nutrition Institute (IPNI) is a not-for-profit, science-based organization dedicated to the responsible management of plant nutrition for the benefit of the human family. The Nutrient Use Geographic Information System (NuGIS) project is sponsored and directed by IPNI. The two primary objectives of this project are to assess nutrient use efficiency (NUE) and balance in crop production and identify weaknesses in the balance estimation processes and the datasets used for these estimations. NuGIS integrates multiple tabular and spatial datasets to create ***county-level*** estimates of nutrients (N, P and K) applied to the soil in fertilizer and livestock manure, and nutrients removed by harvested agricultural crops, per ***total cropland acre*** across the lower 48-states. Nutrient balances, inputs and removal efficiencies were estimated at three-year averages in five-year increments, coinciding with the USDA Census of Agriculture, from 1987 – 2007, and annually for 2010, 2011, and 2012.[126] Geospatial techniques were used to estimate balances and efficiencies for 8-digit hydrologic units using the county-level data.[127] Results are viewable through an interactive color map or exportable as tabular data.

[125] ARMS Tailored Reports allow the public user to view and download a variety of statistics summarizing the ARMS data. The user can select from several menus to create custom reports on topics ranging from the farm balance sheet to pesticide application methods. The tailored reports tool is segmented in two broad sections: 1) Farm Structure and Finance and 2) Crop Production Practices. For the latter, data were last updated April 23, 2015, reflecting the 2013 survey. Available at: https://data.ers.usda.gov/reports.aspx?ID=17883.
[126] As of February 23, 2015, "2012" is the most recent year of analysis.
[127] Available at: http://nugis.ipni.net/About%20NuGIS/.

Data for estimating the nutrients from commercial fertilizers, including detailed information on the county the fertilizer was sold in, the formulation of fertilizer sold as well as the intended use of the fertilizer, were provided by the Association of American Plant Food Control Officials (AAPFCO).[128] A detailed report of the development, testing, and implementation of the methods used to import and analyze AAPFCO data and produce annual county-level nutrient input estimates is available by contacting nugis@ipni.net.

B.4.2 Estimating State Average N Rates for Non-Survey Years

The USDA ARMS and NASS databases each provide state- and crop-specific average fertilizer N rate data for the same field crops in the same survey year. However, ARMS does not provide data on non-field crops, namely tomatoes, nor does it provide any data on crop yield, or any data at the county level, all of which are needed to develop county-specific PFP benchmarks. NASS also contains N rate data from more recent survey years. As such, NASS fertilizer N rate data was ultimately chosen over ARMS for completeness and consistency.

Because the eligible crops in this protocol were surveyed in different years, we specified reference years of 2010, 2011, and 2012, to estimate three-year average N rate applications. The three years selected correspond to the most recently available annual county-level N rate data estimates from IPNI NuGIS.

We then adapted procedures described in the 2011 USDA Economic Research Service (ERS) Report, *Nitrogen in Agricultural Systems: Implications for Conservation Policy,*[129] to estimate annual N rates for crops in their non-survey years, under the assumption that the percentages of planted acres treated with N and N application rates remain stable between the three reference years.[130] Specifically, we calibrated weights based on the change in planted acres[131] from the NASS survey year to the survey year in question, using the USDA published estimates of planted acres for 2010, 2011, and 2012.[132] Note, if planted acreage data for a given crop is not available, it was assumed the crop is not cultivated in the given state or county, or at least not in the given year. The annual state average N rates from the NASS survey year were then multiplied by the respective weights to estimate state average N rates for the non-survey reference years.

Table B.2 displays the relevant NASS survey year per eligible crop. Note, with the exception of oats, N rate data was available for all eligible crops in one of the three reference years. For oats, the most recently available N rate data (from survey year 2015) was adjusted as described above to estimate average state N rates for oats for each one of the three reference years.

[128] AAPFCO provides commercial fertilizer sales data each year for fertilizer products sold as tons of fertilizers, state and county sold in, year sold, season sold, container sold in, fertilizer type code, formulation as percent N, P_2O_5, and K_2O and the intended use of the fertilizer sold. IPNI used these AAPFCO values as a basis for estimating the nutrients applied with farm use commercial fertilizers at the county level.
[129] Ribaudo et al., 2011.
[130] We maintain the assumption that the percentage of planted acres treated with N would remain constant from 2010 through 2012 throughout the analysis.
[131] Note, while fertilizer-related data is available intermittently depending on the crop-specific survey year, NASS provides data on crop-specific planted acres at the state and county levels on an annual basis. However, if planted acreage data is not available, it is assumed the crop is not planted in the given state or county in the given year.
[132] USDA NASS 2018

Table B.2. NASS Crop-Specific Chemical Usage Survey Years

Eligible Crop	NASS Chemical Use Survey Year[133]
Barley	2011
Corn (Grain + Silage)	2010
Cotton (Upland)	2012
Oats	2015
Sorghum	2011
Spring Wheat	2012
Tomatoes (Processing)	2010
Winter Wheat	2012

B.4.3 Estimating County- and Crop-Specific Average N Rates

NASS provides state-and crop-specific average N rates for all crop-specific treated acres and IPNI NuGIS provides state- and county-specific N rates for all cropland acres. To arrive at estimates for three-year county- and crop-specific average N rates, the following steps were followed:

1. Adjusted the IPNI NuGIS-derived state- and county-specific farm nitrogen fertilizer inputs from per cropland acre to per *treated* cropland acre
    a. Divided the nitrogen inputs per cropland acre by the percentage of cropland acres in the state or county treated with fertilizer
    b. Obtained cropland acreage and treated cropland acreage from the 2012 Census of Agriculture (CoA) via NASS Quick Stats
        i. Removed pastured acreage from total cropland acreage when calculating the percentage of cropland acres treated with fertilizer
    c. Maintained the assumption that the percentage of treated acres remains constant from year to year over the reference years 2010-2012
2. Calculated the percentage change between the adjusted IPNI NuGIS-derived annual state-specific N input and the NASS-reported annual state- and crop-specific average N rate for each eligible state and crop and each reference year
3. Multiplied the state-and crop-specific percentage changes to the applicable adjusted IPNI NuGIS-derived annual county-specific N inputs to arrive at estimates for annual county- and crop-specific N rates for each eligible county and crop and each reference year
    a. That is, the adjusted annual county N inputs from NuGIS were multiplied by the same amount (i.e., percentage change) as the adjusted annual state N inputs from NuGIS were to match the state- and crop-specific N rates from NASS
    b. Put simply, cropland county data were adjusted by the same proportional change between cropland state data and crop-specific state data to estimate crop-specific county data
4. Averaged the annual county- and crop-specific N rate data for each reference year to derive three-year county- and crop-specific average N rates

All average N rate estimates can be found in the Nitrogen Management Project Eligibility Lookup Tool, as discussed in Section B.5.

[133] The NASS crop-specific survey years correspond to the same crop-specific years of the ARMS.

B.4.4 Calculating County- and Crop-Specific Yields

Annual county- and crop-specific yields were derived from NASS for each reference year.[134] To compute PFPs, crop yields and N rates must both be in the same units. NMPP V2.0 used N rates reported in pounds per acre. As such, crop yields had to be converted from the units reported in NASS to pounds per acre. See Table B.3 for the conversion factors used in this assessment.

Table B.3. Yield Conversion Factors

Eligible Crop	NASS Reported Yield Units	lb/bu[135]	lb/ton
Barley	bushels/ac	48	
Corn	bushels/ac	56	
Corn Silage	tons/ac		2000
Cotton (Upland)	lb/ac	32	
Oats	bushels/ac	32	
Sorghum	bushels/ac	56	
Spring Wheat	bushels/ac	60	
Tomatoes (Processing)	tons/ac		2000
Winter Wheat	bushels/ac	60	

B.4.5 Estimating County- and Crop-Specific PFP Benchmarks

The same PFP equation[136] is used to calculate the three-year county- and crop-specific average PFPs for developing performance standard thresholds as well as to determine project PFPs, based on projects' crop yield and fertilizer application records per eligible crop year, as described in Section 3.5.1.1.

B.5 Nitrogen Management Project Eligibility Lookup Tool

PFP benchmarks could only be developed for N rate-crop-county combinations where data were available. Specifically, if crop-specific state-level average N rate or county-level yield records were unavailable in NASS and/or county-level N rates per cropland were unavailable in NuGIS, PFP benchmarks could not be developed, for the reasons discussed in Section B.4.Without this data, the additionality of emission reductions resulting from nitrogen management projects cannot be assessed.

As a result, the practice-crop-region combinations eligible in NMPP V2.0 are restricted by the results of this assessment (and by the capabilities of the quantification approach – see Appendix F). To help project developers to both identify the eligible combinations and find the relevant county- and crop-specific PFP benchmarks and average N rates for their project, the Reserve developed the Nitrogen Management Project Eligibility Lookup Tool.

[134] If crop yield data is not available at the county level from NASS, county level PFP benchmarks could not be developed for the specific crop. This is the case for Cotton and is why data for Upland Cotton is used in its place, where available. County level yield data is also unavailable for Sorghum Silage and Fresh Tomatoes.
[135] Yield Conversion Factors were obtained from University of North Carolina at Chapel Hill. See https://www.unc.edu/~rowlett/units/scales/bushels.html
[136] The equation used to calculate the three-year county- and crop-specific average PFPs found in the Nitrogen Management Project Eligibility Lookup Tool is identical to Equation 3.1, with the exception that the PFP benchmarks are multi-year averages as opposed to annual metrics calculated each reporting period.

All resulting eligible practice-crop-region combinations can be easily found in the Reserve's Nitrogen Management Project Eligibility Lookup Tool. The Nitrogen Management Project Eligibility Lookup Tool is an easy-to-use Microsoft Excel© workbook that allow users to quickly determine if their project practice-crop-region combination is eligible and to identify the average PFP, N Rate and Yield for their specific crop and county.

B.6 Use of Nitrification Inhibitor or Switch to Slow Release Fertilizer Performance Standard

The performance standard for the switch to a slow release fertilizer (SRF) or the use of a nitrification inhibitor (NI) is based on 1) an evaluation of the adoption rates of each practice in an eligible region for an eligible crop and on 2) a financial barrier test.

B.6.1 Adoption Rate of Enhanced Efficiency Fertilizers

Data on adoption of "Nitrogen inhibitor used" in eligible cropping systems was obtained from USDA ARMS. The USDA ARMS question on Nitrogen inhibitors varies depending on the crop[137] and survey year, and has been broadly phrased to include a variety of types, including nitrification inhibitors, urease inhibitors, and chemical-coated (controlled or slow release) fertilizers, with the presented uptake data grouped to include all possible types. Furthermore, much collected data are statistically unreliable due to a low sample size, most noticeably, including the largest observed penetration rates at the state level for corn and cotton below.

Nationally,[138] USDA ARMS data for various years suggests that Nitrogen inhibitors are currently used on about:

- 12.46 percent of U.S. corn acreage (2010);
- 5.21 percent of U.S. cotton (2007);
- 0.71 percent of U.S. winter wheat acreage (2009);
- 0.54 percent of U.S. oats acreage (2005);
- 0.39 percent of U.S. sorghum acreage (2003); and
- 0.31 percent of U.S. spring wheat acreage (2004)

For a large number of crops, not enough data are available nationally for trend analysis. For where enough data were available, the following trends over time were observed:

- Increase from 10.4 percent to 12.5 percent for corn from 2000 to 2010
- Increase from 1.4 percent to 5.2 percent for cotton[139] from 2000 to 2007; and
- Decrease from 1.1 percent to 0.7 percent for winter wheat from 2000 to 2009

Across all states,[140] the smallest observed penetration rates in the most recent crop survey year were as follows:

- 3.1 percent of corn acreage in Nebraska (2010)
- 2.0 percent of cotton acreage in Texas (2007)
- 5.1 percent of sorghum acreage in Missouri (2003);[141] and

[137] Note, ARMS only contains data for field crops and does not contain data for tomatoes.
[138] No data on nitrification inhibitors is available for Barley on the national level.
[139] Unclear if this includes the subset of "upland" cotton.
[140] No data on nitrification inhibitors is available for Oats or Spring Wheat at the state level.
[141] Missouri is the only state for which there is data available on nitrification inhibitors for Sorghum.

- 3.0 percent of winter wheat acreage in Illinois (2009)[142]

Across all states, the largest observed penetration rates in the most recent crop survey year were as follows:

- 43.8 percent of corn acreage in Indiana (2010)
- 24.1 percent of cotton acreage in Arkansas (2007)
- 5.1 percent of sorghum acreage in Missouri (2003); and
- 3.0 percent of winter wheat acreage in Illinois (2009)

Because of the aggregation and low sample sizes, the above penetration rates should be interpreted with caution. As a result of the aggregation, it can at least be inferred though that the estimated individual adoption rates of nitrification inhibitors or slow release fertilizers are lower than the rates above.

Additionally, in their *Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States: A Synthesis of the Literature*, the Technical Working Group on Agricultural Greenhouse Gases (T-AGG), as coordinated by a team at the Nicholas Institute for Environmental Policy Solutions at Duke University, found that Nitrification inhibitors are currently utilized on only 3.4 megahectares (Mha) of U.S. cropland, and because 90 percent of commercial fertilizer is urea or ammonium based, a total area of 92 megahectares (Mha) is available for nitrification inhibitor application.[143]

B.6.2. Financial Barriers

At present, the use of Nitrification inhibitors and slow release fertilizers is also low due to their high cost relative to conventional fertilizers. Nitrification inhibitors have been found to increase the cost of fertilizer by roughly 9 percent[144] or by $8 - $20 per acre,[145] while slow release fertilizers can be 10 to 15 times as expensive per pound of nitrogen, compared to soluble, granular forms.[146]

B.6.3 Additionality Assessment

After evaluating the data available data from USDA ARMS, and considering that their high costs relative to conventional fertilizers continues to be a constraint to adoption and use, the Reserve has determined that these levels of practice uptake are sufficiently low that the use of a Nitrification inhibitor or slow release fertilizer is not common practice, and the implementation of either activity is therefore considered additional, *when* applied in combination with N rate reduction. All growers using an eligible nitrification inhibitor or switching to an eligible slow release fertilizer pass this performance standard test, so long as they pass the performance standard test for N rate reductions and demonstrate an N rate reduction in the project from the baseline look-back period.

B.7 Assessing Additionality in California

Concerns have been raised to the Climate Action Reserve about the additionality of any emission reductions from the NMPP in California due to the uptake of drip irrigation and

[142] Illinois is the only state for which there is data available on nitrification inhibitors for Winter Wheat in the most recent survey year.
[143] Eagle et al., 2012
[144] Eagle et al., 2012; Biggar et al., 2013
[145] Burger et al., 2016; U.S. EPA 2013
[146] Neal (undated); McKenzie-Mohr & Associates (undated)

consequential reductions in fertilizer application. Recent surveys of irrigation methods in California indicate that an increasing number of growers are using drip and micro-sprinkler irrigation, particularly for higher-value perennial and annual vegetable crops (Tindula, Orang, and Snyder 2013; Orang, Matyac, and Snyder 2008). For example, as of 2010, either drip or micro-sprinkler irrigation was used on more than 70 percent of almond, vineyard, and subtropical orchard crop acreage in California. These low-volume irrigation technologies are used on about 40 percent of existing acreage planted in deciduous trees such as walnuts (Tindula, Orang, and Snyder 2013) and are also increasingly used in processing tomatoes (63 percent), fresh market tomatoes (45 percent), onions (42 percent), cucurbits (39 percent), and other truck crops (35 percent). In some circumstances, drip and micro-sprinklers can be used to irrigate various grain and field crops; however, the cost of these technologies limits their feasibility in these lower-value crops (e.g., drip or micro-sprinklers are used on only 0–15 percent of current acreage planted in field crops).[147]

The Reserve is unaware of any public program mandating drip irrigation for cropping in California. As the studies indicate, this adoption has been driven almost entirely by market forces related to higher yields and more efficient water and fertilizer use; possible reductions in N_2O emissions are one of several important (albeit unintended) environmental co-benefits. Furthermore, while the capital investment required to install drip irrigation on processing tomato fields is partially compensated for by way of yield increases, installing drip for lower value crops (e.g., many forage crops) precludes use, or inapplicable, for example on fields receiving liquid manure, which cannot be applied through drip or sprinkler irrigation systems.[148]

As there are no mandated N use improvements, project developers may use drip irrigation on their fields and be eligible for a nitrogen management project. However, depending on when the practice was adopted, and its impact on N use efficiency, it may be difficult to reduce N rates any further in the project than from what was applied in the baseline look-back period (See Section 5.3.1.1). Encouragingly, other studies point to additional N_2O emission reductions that could be realized from applying nitrification inhibitors in addition to employing drip irrigation.[149]

[147] Culman et al., 2014.
[148] Harter et al., 2017.
[149] Burger et al., 2016.

Appendix C Overview of Water Quality Regulations: Impacts on Legal Requirements and Regulatory Compliance

No federal laws exist that regulate the composition or efficacy of fertilizers. State-level laws addressing composition and/or efficacy are discussed further below. Numerous regulations exist, including at the federal level, concerning the production of fertilizer. However, as fertilizer production is outside the GHG project boundary of this protocol, regulations on fertilizer production are not addressed here. Regulations concerning the use and disposal of hazardous materials, such as fertilizer, and regulations protecting against the contamination of drinking and surface water and air pollution (related indirectly to the land application of fertilizers) are addressed further discussed below.

C.1 Clean Water Act

Though the Reserve could identify no existing federal regulation that explicitly requires implementation of the approved project activity, state or local implementation of the federal Clean Water Act may result in direct and indirect requirements for nutrient management.

The Clean Water Act (CWA) is the federal law regulating water quality for surface waters in the United States. It establishes a comprehensive federal system for regulating the discharge of pollutants into navigable water bodies, while restoring and maintaining the health of the nation's surface waters.[150] The CWA meets these objectives by authorizing water quality standards, requiring and issuing permits for point source discharges (the National Pollution Discharge Elimination System (NPDES)), assisting with the funding of municipal sewage treatment plant construction, and helping with planning to manage nonpoint source pollution. The CWA authorizes EPA as the primary agency tasked with implementation and enforcement, but in practice, most implementation is through state environmental agencies and state-level regulations, and as such state-level implementation can be highly variable. States have the authority to set their own water quality standards, so long as they meet or exceed EPA's minimum requirements.

Though the CWA explicitly defines "point sources" (e.g., industrial or sewage treatment plants, Concentrated Animal Feeding Operations (CAFOs)), it defines nonpoint sources (e.g., agricultural runoff, urban runoff) as anything not considered a point source by the CWA or EPA regulation. The CWA makes it unlawful for point sources to discharge any pollutant into navigable waters without a permit (specifically an NPDES permit). Nonpoint source (NPS) pollution, however, comes from many diffuse sources and is caused by runoff from rainfall or snowmelt moving over and through the ground, picking up pollutants and eventually depositing them in water bodies. When watersheds are successfully meeting the CWA's water quality standards, nonpoint sources are generally unregulated and, in fact, agricultural stormwater discharges and return flows from irrigated agriculture are specifically exempt under the CWA.[151] However, in polluted watersheds that are not attaining the proper water quality standards (i.e.,

[150] The Clean Water Act (CWA) was formerly known as the Federal Water Pollution Control Act (FWPCA), which was first enacted in 1948. Following its significant reorganization and amendments in 1972 and 1977, the FWPCA came to be known by its current name, the CWA. The CWA can be found in 33 U.S.C. §§ 1251-1387.

[151] King, Ephraim, "Nutrients: A National Overview Need for Strong Partnerships & Joint Accountability," U.S. EPA, Office of Science and Technology, Presented at "Nutrient Summit" Springfield, Illinois, 13 September 2010. Available at: http://www.epa.state.il.us/water/nutrient/presentations/ephraim_king.pdf.

"impaired" waters), nonpoint sources may come under regulation as part of efforts to restore water quality.

States are responsible for monitoring water quality of surface waters within their jurisdiction, and biennially, states are required to provide an inventory of the condition of state water bodies and progress toward CWA goals (305(b)) as well as to identify which waters are "impaired" (i.e., not currently meeting water quality standards) or "threatened" (i.e., believed likely to become "impaired" by the time the next "303(d) List" is due).[152] Subsequent to listing waters on the 303(d) List, states are required to prioritize restoration of these waters based on the severity of pollution and begin developing Total Maximum Daily Loads (TMDLs)[153] for these waters. In practice, once a TMDL is established, the state implements a concrete plan to reach this limit through a combination of regulations and voluntary incentives that reduce NPS pollution. EPA funding is typically available to help states implement their nonpoint source management programs.[154] If runoff from agricultural sources is determined to be contributing to the impairment, the TMDL implementation plan typically will include some degree of agricultural best management practices (BMPs). Typically, voluntary incentive payments are the preferred policy mechanism for agricultural sources, as has been the strategy for Maryland, where the state is working towards its Chesapeake Bay TMDL goals through incentive payments which have significantly increased the acres of farmland voluntarily planting cover crops. However, states may also chose to legally require conservation or nutrient management plans, as has recently become the case in California, where the Central Valley Regional Water Quality Control Board (Central Valley Water Board or Water Board) of the State Water Resources Control Board has adopted two key water quality regulations regarding nutrient management: 1) the Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies (Dairy General Order) (See Appendix C.2) and the Irrigated Lands Regulatory Program (ILRP) (See Appendix C.3). Particularly relevant to the NMPP, if agriculture is determined to be the source of impairment, and the water body is impaired by high levels of nitrogen (in any of its forms, e.g., nitrate, nitrite, etc.), agricultural BMPs related to nitrogen management are likely to become part of the TMDL.

Circumstances exist where the agricultural producer has significant flexibility for meeting its TMDL obligations. Once a watershed is identified as "impaired," if any agricultural NPS pollution is identified as contributing to a watershed's impairment, agricultural nonpoint sources in that watershed may become limited by a NPS pollution obligation (e.g., a field- or region-specific obligation to help meet a TMDL or other policy mechanism chosen to meet that obligation). Producers often self-select what best management practices will become part of their legally required pollution reduction strategy, typically in the form of Conservation Management Plans, which address a variety of conservation management practices, or in the form of Nutrient Management Plans (NMPs), which focus more on nutrient management practices. As noted in Section 3.5.2, once a practice is self-selected as part of an NPS pollution obligation, the

[152]These reports contribute to the "National Water Quality Inventory" (Part 305(b) of CWA) and the "Impaired or Threatened Waters List" or the "303(d) List" (Part 303(d) of the CWA), respectively. Once identified as impaired or threatened, these waters will appear on the "303(d) List." As this list is updated frequently, project developers and verifiers should refer to the U.S. EPA website for the most up-to-date list of impaired watersheds: http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T.

[153] Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a pollutant, such as nitrate, that a given water body can receive without violating water quality standards. The term TMDL, however, is often used to refer to the whole process of establishing a TMDL, including all aspects of TMDL implementation and monitoring.

[154] Specifically, EPA funding is available through CWA Section 319(h) grants specifically for nonpoint source management, while states can also participate in the Clean Water State Revolving Fund (CWSRF) program, in which EPA to provide grants to states to establish loan funds which then provides low-cost financing to third parties (municipalities, non-profits, businesses) to implement water quality infrastructure projects.

Reserve considers that practice non-voluntary, as continued implementation of that practice is required by law, and that practice is no longer considered an eligible project activity for that farm.

Due to localized implementation of the CWA and TMDL strategies, the extent to which NMPs become effectively required by law may vary greatly in terms of flexibility and what is explicitly required (e.g., a project participant may be allowed to self-select practices to include in an NMP for their field, while elsewhere an explicit N rate reduction may be required).

C.2 California Dairy General Order

The California Central Valley Water Board's Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies (Dairy General Order or Order) requires owners and operators of dairy farms (Dischargers) in the Central Valley to protect water quality from pollution from nitrates and salts. Farmers must keep records to ensure they are managing manure waste properly, managing nutrient application to cropland to prevent excess runoff, and performing general housekeeping of the dairy facility to reduce threats to water quality.

All dairies receiving coverage under the Dairy General Order are required to develop and implement a Nutrient Management Plan (NMP) for all land application areas. The purpose of the NMP is to budget and manage the nutrients applied to the land application area(s) considering all sources of nutrients, crop requirements, soil types, climate, and local conditions in order to prevent adverse impacts to surface water and groundwater quality. NMPs must be developed by a certified specialist, including a Professional Soil Scientist, Professional Agronomist, or Crop Advisor certified by the American Society of Agronomy or a Technical Service Provider certified in nutrient management in California by the Natural Resources Conservation Service (NRCS). NMPs shall specify the form, source, amount, timing, and method of application of nutrients on each land application area to minimize nitrogen and/or phosphorus movement to surface and/or ground waters to the extent necessary to meet the provisions of the Order. Manure and/or process wastewater will be applied to the land application area for use by the first crop covered by the NMP only to the extent that soil tests indicate a need for nitrogen application. Supplementary commercial fertilizer(s) and/or soil amendments may be added when the application of nutrients contained in manure and/or process wastewater alone is not sufficient to meet the crop needs, as long as these applications do not exceed provisions of the Order. The NMP must take the site-specific conditions into consideration in identifying steps that will minimize nutrient movement through surface runoff or leaching past the root zone.

The Discharger shall develop a nutrient budget for each land application area. The nutrient budget shall establish planned rates of nutrient applications for each crop based on soil test results, manure and process wastewater analyses, irrigation water analyses, crop nutrient requirements and patterns, seasonal and climatic conditions, and the use and timing of irrigation water, and important nutrient application restrictions listed below:

- The rate of application of manure and process wastewater for each crop in each land application area to meet each crop's needs without total nitrogen application rates exceeding 1.4 times[155] the nitrogen that will be removed from the field in the harvested portion of the crop.

[155] The University of California Committee of Experts in Dairy Manure Management (UCCE) review of dairy waste states that based on field experiments and computer models, the appropriate nitrogen loading rate that minimizes nitrogen leaching and maximizes nitrogen harvest is between 140 to 165 percent of the nitrogen harvested.

- Additional applications of nitrogen are allowable if the following conditions are met:
  - Plant tissue testing has been conducted and it indicates that additional nitrogen is required to obtain a crop yield typical for the soils and other local conditions;
  - The amount of additional nitrogen applied is based on the plant tissue testing and is consistent with University of California Cooperative Extension written guidelines or written recommendations from a professional agronomist;
  - The form, timing, and method of application facilitates timely nitrogen availability to the crop; and
  - Records are maintained documenting the need for additional applications.
- If total nitrogen application exceeds 1.65 times total the nitrogen removed from the land application area through the harvest and removal of the previous crop, the Discharger shall either revise the NMP to immediately prevent such exceedance or submit a report demonstrating that the application rates have not and will not pollute surface or ground water

Due to these crop-specific restrictions on nitrogen rate, the Dairy General Order poses a concern regarding the regulatory additionality of offsets generated under the NMPP. Any field subject to the Order will only be eligible for emission reductions associated with reductions in N rates below this 40 percent residual N threshold. However, it is important to note that the Order is only applicable to farms applying manure; farms only applying synthetic N fertilizer are not subject to the Order.

C.3 California Irrigated Lands Regulatory Program

The California Central Valley Water Board's Irrigated Lands Regulatory Program (ILRP) regulates the waste discharge requirements (WDRs) adopted by the Water Board for agricultural discharges from commercial irrigated lands[156] to protect both surface and groundwater and reduce impacts of irrigated agricultural discharges to waters of the State. All growers regulated by the ILRP are required to prepare and implement Nitrogen Management Plans (NMPs) and submit NMP Summary Reports to the Water Board to help evaluate potential nitrogen impacts to groundwater and/or surface waters.

The NMP Summary Report collects information on Total Available Nitrogen Applied, and a ratio of Total Available Nitrogen Applied to Total Yield (A/Y Ratio) for each crop grown. The Total Available Nitrogen Applied includes the nitrogen from synthetic fertilizers and organic materials (manure and compost) applied, residual soil nitrogen, and nitrogen in irrigation water. Like the PFP metric used in the NMPP's performance standard test for additionality, the advantages of using the A/Y Ratio as a nitrogen *removal* reporting metric are rapid data collection, consistent reporting across all crops and across reporting years, ease of calculation, and a tangible meaning of the relationship between the Applied Nitrogen and the Yield. The A/Y Ratio provides the Water Board with data for analyzing and reporting nitrogen removal, and for developing outreach material for feedback to growers on nitrogen use compared to commonly recommended application rates and to other growers of the same crop in their area. Farm evaluations then allow the Water Board to determine if additional practices are needed to protect water quality.

[156] Land that is irrigated (regardless of water supply source) to produce crops or pasture for commercial purposes must be enrolled in the ILRP. Regulatory coverage is not required only if the property is not used for commercial purposes or if the irrigated land is covered under the Dairy Program.

As the ILRP mandates nitrogen management reporting and not practices, the program poses little concern to regulatory additionality. However, additional practices may be required at individual farms pending the results of evaluations, and as such, could pose a regulatory additionality concern in the future.

C.4 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) encourages states/tribes to preserve, protect, restore or enhance natural coastal areas, including wetlands, floodplains, estuaries, beaches, and dunes. Eligible areas border the Atlantic, Pacific, and Arctic Oceans, Gulf of Mexico, Long Island Sound, and Great Lakes. Participation is completely voluntary. To encourage states/tribes to participate, the act makes federal financial assistance available to develop and implement a comprehensive coastal management program. Most eligible states/tribes participate in the program. Section 6217 of the CZMA, administered jointly by EPA and the National Oceanic and Atmospheric Administration (NOAA), specifically supports states to develop and implement nonpoint pollution control programs for coastal areas.[157] Within a guiding document specifying typical measures to control nonpoint source pollution published by the EPA[158] in 1993, commercial N fertilizer is identified as a pollutant to coastal areas. Management measures to reduce pollution include development and implementation of a nutrient management plan focusing on (1) applying nutrients at rates necessary to achieve realistic crop yields, (2) improving the timing of nutrient application, and (3) using agronomic crop production technology to increase nutrient use efficiency. In 2003, EPA updated and expanded the 1993 coastal nonpoint source manual to address the control of agricultural nonpoint source pollution for the entire United States.[159] *National Management Measures to Control Nonpoint Source Pollution from Agriculture* highlights best available, economically achievable means of combating nonpoint source pollution, and discusses monitoring techniques, load estimation techniques, and watershed approaches.

As participation is voluntary, assistance received through CZMA does not affect field eligibility. Any financial assistance received by projects shall be disclosed to the project verifier and Reserve per Section 3.5.3.

C.5 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA), the main federal law to ensure drinking water quality, requires actions to prevent the contamination of surface and ground sources of drinking water (e.g., rivers, lakes, reservoirs, springs, ground water wells, but not private wells, serving less than 25 people). Although EPA is primarily responsible for enforcement of the federal SDWA, states may apply to EPA for the authority to implement the SDWA and its enforcement within their jurisdictions (e.g., “primacy”), so long as they can demonstrate that state standards will be at least as stringent as the national standards and that state water systems meet these standards.

The SDWA authorizes EPA to set national health-based standards limiting the amount of contaminants, such as nitrates and nitrites, in drinking water. In practice, these health-based standards are legally enforceable limits, called maximum contaminant levels (MCLs). The SDWA includes MCLs for both nitrates and nitrites, for which fertilizer runoff and leaching from

[157] See https://coast.noaa.gov/czm/act/
[158] Available at http://water.epa.gov/polwaste/nps/czara/MMGI_index.cfm
[159] Available at http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm

agriculture is the major source in drinking water. The MCL for nitrate is set at 10 mg/L or 10 ppm, while the MCL for nitrite is set at 1 mg/L or 1 ppm, both of which are measured in nitrogen.

The SDWA requires states and water suppliers to conduct assessments of potential contamination of water sources, and states are required to implement measures to protect water sources through voluntary incentive programs (to encourage agricultural BMPs) or legal enforcement actions, such as Notices of Violations (NOVs). Any individual discharger could, in theory, be found to be causing levels of nitrate or nitrite to exceed the MCL and receive a Notice of Violation. However, due to the nonpoint source nature of agricultural discharges, it is relatively difficult to identify one agricultural discharger as the source of an impairment and, as such, NOVs are typically only issued against agricultural discharges when the discharge is particularly egregious.

Though one of the main tools to limit agriculture's effect on drinking water quality are agricultural BMPs, to our knowledge, there is no legal requirement within the context of the SDWA to require best nitrogen management practices. However, any case of regulatory non-compliance, such as a NOV due to a violation of the SDWA, must be reported to the verifier, who will determine if the violation is material to the project.

C.6 Fertilizer Content Labeling Laws

There are no federal laws regulating the composition or efficacy of fertilizer in the U.S., but most states have developed their own fertilizer regulatory programs, which are generally administered by their respective departments of agriculture. These regulatory programs typically address efficacy claims and composition statements of the active ingredients displayed on labels for commercially available fertilizer.

The Association of American Plant Food Control Officials (AAPFCO), tasked with making regulation among states uniform, stated that metals in N fertilizer generally do not pose harm to the environment as long as the metal concentration in fertilizer is below a specific threshold.[160] In addition to trace metal composition testing, state fertilizer laws generally require product registration, licensing and efficacy testing to assure that statements made on the label are correct. Also, at the state level, fertilizer is primarily regulated for quality, as for any manufactured good. These regulations are usually administered through the state's department of agriculture.

With the exception of California's Dairy General Order, none of these laws should impact additionality or the eligibility of particular fertilizers in the NMPP.

[160] See http://www.aapfco.org/rules.html.

Appendix D Methodology for Determining $Frac_{LEACH}$ Values

As discussed in Section 5.1.4.3, $Frac_{LEACH}$ refers to the fraction of N inputs that is lost through leaching and runoff. This parameter is relevant to calculating N_2O emissions associated with LVRO in the project if there are increases in organic N rates from the baseline scenario (see Equation 5.22). This appendix contains the methodology for determining $Frac_{LEACH}$ values. As noted in Box 5.1, the $Frac_{LEACH}$ value calculated from project year climatological data shall be used for both the baseline and project emissions equations to conservatively quantify the emission reductions due to the project activity in a given year. The methodology for determination of $Frac_{LEACH}$ values is adapted from the IPCC and MSU-EPRI methodologies.[161]

The project developer shall calculate the $Frac_{LEACH}$ value for their project field on an annual basis, based on the USGS hydrologic year of October 1 to September 30.[162] Project developers shall calculate their $Frac_{LEACH}$ value using precipitation and evaporation data from the closest weather station available (preferably within 20 miles). If no weather station within 100 miles has both precipitation and evaporation data available, the project developer may use the monthly U.S. Evaporation and Precipitation maps published by the Climate Prediction Center at NOAA.[163] The project developer shall then convert evaporation data to evapotranspiration, by multiplying each month of data by the following conversion factors from Shaw, R.H. (1982).[164]

Table D.1. Evapotranspiration Conversion Factors

Month	Conversion Factor
January	1
February	1
March	1
April	1
May	1.375
June	1.475
July	1.725
August	1.75
September	1.55
October	1
November	1
December	1

Once all monthly precipitation and evapotranspiration data have been collected, monthly data should be totaled for the hydrological year, *t*, October 1 to September 30, and $Frac_{LEACH}$ calculated according to the following equations:

[161] The most significant difference is with regards to the time period over which $Frac_{LEACH}$ is calculated. The IPCC methodology uses the time period of the "rainy season," defined as "the period(s) when rainfall > (0.5*PanEvaporation)", while the MSU-EPRI methodology considers the growing season. However, as the dates of the rainy season, and the growing seasons will vary greatly across the NCR, as well as from year to year, and for the purposes of standardizing this methodology for project implementation, the hydrological year is used here. Additionally, the MSU-EPRI methodology uses the FAO Penman-Monteith equation for estimating potential evapotranspiration and calculating $Frac_{LEACH}$, while the IPCC uses potential evaporation for the calculation.
[162] This time period also corresponds with a typical corn cultivation year in the NCR and is expected to match the reporting period for most projects.
[163] Monthly evaporation available at: http://www.cpc.ncep.noaa.gov/cgi-bin/US_Evaporation-Monthly.sh and Monthly precipitation available at: http://www.cpc.ncep.noaa.gov/cgi-bin/US_Precipitation-Monthly.sh
[164] Available at http://www.ipm.iastate.edu/ipm/icm/2000/5-29-2000/wateruse.html.

If $\frac{Annual\ Precipitation}{Annual\ Potential\ Evapotranspiration} \geq 1.00$,	$Frac_{LEACH}$ = 0.3
If $\frac{Annual\ Precipitation}{Annual\ Potential\ Evapotranspiration} < 1.00$,	$Frac_{LEACH}$ = 0

Appendix E Default Values for Average Fertilizer N Concentration and Fertilizer Weights

Synthetic Fertilizer N Contents and Weights			
Fertilizer Type	**Form**	**N** (%)	**Weight** (lb/gallon)
Ammonia	dry/liquid	80	NA
Ammonium superphosphate	dry	12-17	--
Ammonium metaphosphate	dry	12	--
Ammonium nitrate	dry	32-34	--
Ammonium phosphate	dry	11-18	--
Ammonium phosphate nitrate	dry	27-30	--
Ammonium phosphate sulfate (APS)	dry	13-16	--
Ammonium polyphosphate (APP)	liquid	10-11	11.65
Ammonium polysulfide (Ammonium sulfate)	liquid	20-21	NA
Ammonium sulfate nitrate	dry	20-30	
Ammonium thiosulfate solution	liquid	12	11.00
Anhydrous ammonia	liquid/gas	82	NA
Aqua ammonia (ammonium hydroixde)	liquid	16-25	NA
Bone meal	dry	0-2	--
Calcium nitrate	dry	15-16	--
Diammonium phosphate sulfur	dry	15-16	--
Diammonium phosphate (DAP)	dry	16-21	--
Monoammonium phosphate (MAP)	dry	11-13	--
Natralene	dry/liquid	40	NA
Nitrogen solutions	liquid	7-58	7-21-7: 11.00 9-18-9: 11.11 12-0-0: 11.00
Nitric phosphate	dry	12-17	--
Potassium nitrate	dry	13	--
Potassium sodium nitrate	dry	15	--
Sodium nitrate (nitrate of soda)	dry	15-16	--
Urea	dry	45-46	--
Urea, sulfur coated	dry	36-38	--
Urea ammonium phosphate	dry	25-58	--
Urea ammonium nitrate (UAN)	liquid	28-32	28%: 11.66 32%: 11.06
Urea phosphate	dry	17	--

Organic Fertilizer N Contents and Weights		
Manure Type	**NC** (lb N/ton)	**Weight** (ton/gallon)
Beef cattle	8.5	8.5
Dairy cattle	6.1	8.4
Hog	11.3	8.4
Poultry	26.9	8.3

Source: Synthetic fertilizer N contents, fertilizer weights, and unit conversion factors are adopted from USDA NRCS Minnesota, Planning – Nutrient Management, Conversion Factors and Tables, Factors and Tables Useful When Planning. Organic fertilizer weights per unit of volume are adopted from: Lorimor, J., Sutton, A., & Powers, W. (2004). Manure Characteristics. *MWPS-18*. Section 1. Second Edition. Ames, IA: Midwest Plan Service. Default manure N contents are consistent with Edmonds et al. (2003) cited in U.S. Environmental Protection Agency. (2011). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. EPA 430-R-11-005*. Washington, D.C.

Appendix F Modeling to Develop Nitrogen Management Quantification Tool (NMQuanTool)

A major focus of the Climate Action Reserve's (Reserve's) update to NMPP V2.0 was to improve the usability and expand the applicability of the protocol to incorporate additional regions, crops and nitrogen management practices, while simplifying the quantification process. After thorough evaluation of existing methods and tools (e.g., COMET-Farm, DeNitrification-DeComposition (DNDC), MSU-EPRI, USDA GHG Methods (the "Blue Book"), IPCC), the Reserve determined the best approach for updating the NMPP quantification methodology was to engage an expert third party, technical contractor, Mark Easter Consulting LLC, to develop a new quantification methodology based on Tier 2-style standardized parameters and emission factors. The approach outlined in this appendix was developed and executed by Mark Easter Consulting, LLC. The team consisted of Dr. Keith Paustian, Mark Easter, Amy Swan, Ernest Marx, and Stephen Williams at Colorado State University (CSU). The effort summarized here resulted in the development of the NMQuanTool. A complete background document on the development and application of the NMQuanTool is available as a separate resource on the Reserve's webpage.

F.1 Overview

This appendix describes the standardized assumptions used by the Reserve's technical contractor in modeling baseline GHG emission reductions associated with reducing fertilizer amounts, utilizing enhanced efficiency fertilizers (EEF – slow release fertilizers or nitrification inhibitors), or converting from intensive tillage to no tillage systems. It also describes the modeling approach used by the technical contractor to estimate the baseline emissions from soil processes using the DAYCENT model (Parton *et al.* 1998) with a combination of national data sources. The methodology and standardized baselines are intended to provide accurate estimates of baseline emissions, give certainty over expected project outcomes, minimize project setup and monitoring costs, and reduce verification costs. The resulting emission rates, applied in the protocol as per acre emission factors, preclude the need for project-level modeling by project developers.

Modeling was performed using the same build of the DAYCENT model that was used for estimation of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013 (U.S. EPA 2016) (U.S. Inventory) compiled by the EPA, and which is incorporated in USDA's entity level GHG quantification tool, COMET-Farm. The DAYCENT model (i.e., daily time-step version of the Century model) is an ecosystem model that simulates plant production and cycling of carbon, nitrogen, and other nutrients in cropland, grassland, forest, and savanna ecosystems on a daily time step. The data were derived from national level soils and weather data sources, the USDA National Agricultural Statistics Service (NASS) Cropland Data Layer (CDL),[165] the USDA national database of crop planting and harvesting dates, the USDA Economic Research Service (ERS) Agricultural Resource Management Survey (ARMS) and the NREL Carbon Sequestration Rural Appraisal (CSRA).[166]

The approach to baseline determination and baseline modeling relied almost exclusively on geographic, historic, physical characteristics of project parcels, and current cropping practices – most of which are publicly available in national geospatial databases – in assigning a baseline

[165]The USDA-NASS Cropland Data Layer (CDL) is an annual raster, geo-referenced, crop-specific land cover data layer. Available at: https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php.
[166] (Paustian Group, unpublished data).

and associated emissions for any given project parcel. The modeled management practices were generated based on survey data from land within the same eco-climatic region and soil type as the project parcel, based on related data sources defined below.

Through this exercise, a minimum of 500 and up to 750 long-term cropland year-point samples were modeled in each of the12 CEAP regions (see Section F.2) in the U.S. lower 48 states for each crop type (corn for grain, corn for silage, sorghum for grain, sorghum for silage, cotton, processing tomatoes, spring grains – barley, oats, spring wheat – and winter wheat). The resulting emission rates for each crop stratum represent an average of the potential N_2O reduction practices at the points modeled within each region. This approach to baseline determination eliminates subjectivity by standardizing the baseline determination based exclusively on stratification (see Section F.2). Similarly, the methodology does not require project developers to execute complex biogeochemical process models. Instead, the methodology provides composite emission rates derived from these same biogeochemical process models utilizing geographic, soil, and cropping system assumptions representative of the project parcel. Compared to the alternative in which project developers would be responsible for asserting and documenting their baseline assumptions, and then conducting modeling themselves.

F.2 Stratification: Geography and Associated Climate

The N_2O emissions analyses and results were stratified by 12 Conservation Effects Assessment Program (CEAP) regions, which were rectified to county boundaries.[167] CEAP regions represent broad geographic regions with similar climate, physiography, and land use. CEAP regions were further stratified by USDA Major Land Resource Areas (MLRA)[168] for the purpose of random point sampling. Using the USDA NASS CDL for years 2010-2016, random point selection was limited to areas within an MLRA in which, 1) at least one year of corn, cotton, sorghum, soybeans, spring grains (barley, oats, spring wheat), tomatoes, or winter wheat was grown, and 2) all crops in rotation from 2010-2016 could be modeled in the COMET-Farm system which includes 33 common U.S. crops. The resulting cropland areas evaluated in this analysis are mapped in Figure F.1. Within each MLRA, a random point sample of 100 points was created within defined cropland areas, and randomly sampled at least 500 and up to 750 point-year data records from within this dataset. A point-year record is the occurrence of a crop growing for a single year within the CDL-predicted crop rotation found at this point. For example, a corn-soybean rotation grown for 10 years at this point would have five point-year occurrences of corn and five point-year occurrences of soybeans. This large point sample (approximately 15 million points) was then subsampled at the CEAP region scale to meet requirements for the uncertainty methods, but also improve efficiency of processing model runs in the COMET-Farm application programming interface (API) system.

[167] A lookup table for CEAP-region to county can be made available by the Reserve per request, and will be available at the Climate Action Reserve's Nitrogen Management webpage.

[168] Major land resource areas (MLRAs) are USDA-defined geographically associated land resource units (LRUs). The 278 major land resource areas are designated by Arabic numbers and identified by a descriptive geographic name in Agriculture Handbook 296. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053624.

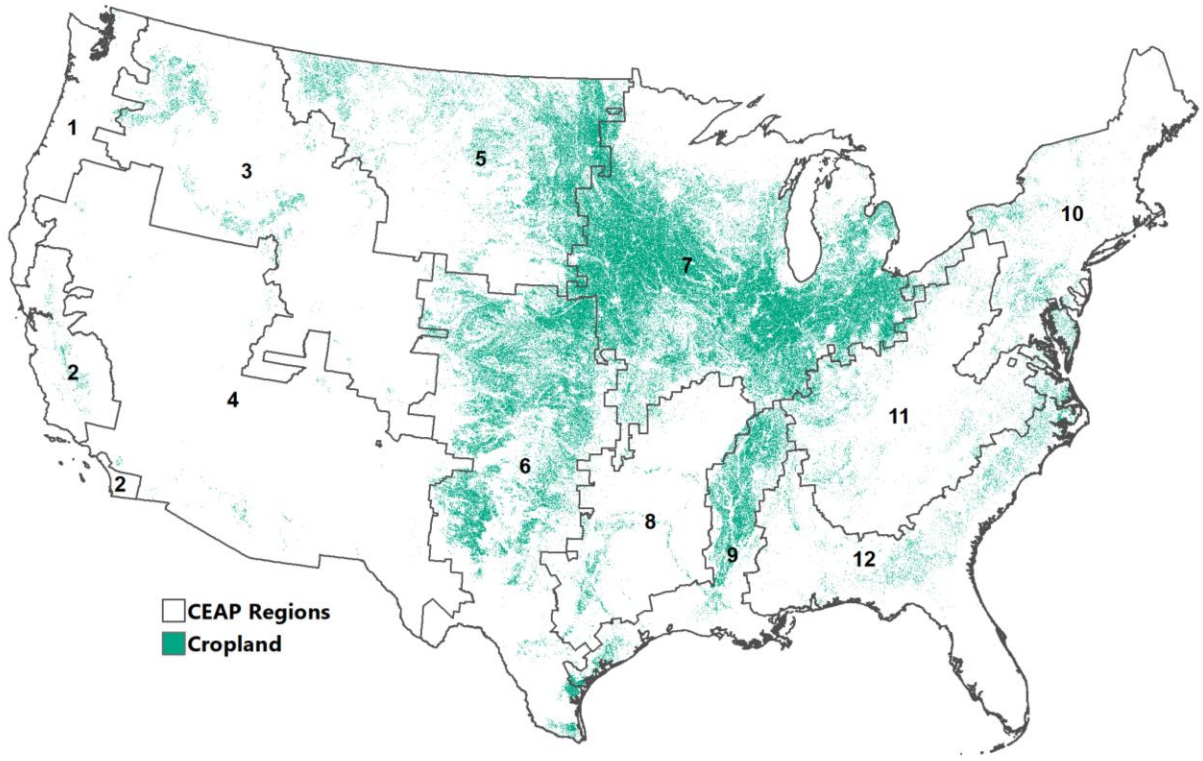

Figure F.1. Cropland areas included in the analysis, overlaid with county-rectified CEAP regions.

F.3 Baseline Determination

The baseline for any given project parcel is defined probabilistically as a composite of the likely crop rotation that might occur on that parcel were a user to implement practices that reduced soil N_2O emissions. The stratification regime defined above in Section F.2 plays a fundamental role in establishing the range of practices and relative probabilities for baseline practice. Based on the stratification element – the CEAP region – the U.S. was first broken into individual super-strata. By first stratifying by CEAP region, the U.S. is effectively subdivided into land areas based on suitability to certain cropping systems and the practices associated with those systems in those geographies. Because CEAP regions are based on agroecological classification, they define areas of similar climate, geomorphology, native vegetation and land management systems – all of which are the fundamental drivers of the biogeochemical processes involved in greenhouse gas emissions. Thus, CEAP regions are better-suited as stratification variables than other land area designations that are politically-based (e.g., states) or defined by a more limited set of criteria (e.g., NRCS Crop Management Zones (CMZ)[169] based on farm management practices).

For each unique super-strata, baseline practices were collected and estimated based on the real-world practices on agricultural land within the same CEAP region, as derived from the CDL, Economic Research Service (ERS) Agricultural Resource Management Survey (ARMS), National Agricultural Statistics Service (NASS), and CSRA. These resources represent the best available data sources for agricultural practice in the U.S. A brief description of the relevant data sources is included below:

[169] Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/tools/rusle2/?cid=stelprdb1247555

- Carbon Sequestration Rural Appraisal (CSRA): Developed by Colorado State University as input data for the COMET tools, the CSRA is derived from a survey instrument filled out by NRCS field staff, and describes historic land use and management (European Settlement to 2000) at the NRCS Land Resource Region (LRR)[170] level.

- Conservation Effects Assessment Project Region (CEAP): Agroecological classification developed by NRCS that defines areas of similar climate, geomorphology, native vegetation, and land management systems across the U.S.

- Soil Survey Geographic Database (SSURGO)[171]: Developed and managed by NRCS, the SSURGO database contains geographically linked information on soil properties including texture. SSURGO data were collected by the USDA National Cooperative Soil Survey, covering the states, commonwealths and territories of the U.S. It was generated from soil samples and laboratory analysis, and represents the finest resolution soil map data available in the U.S.

- Economic Research Service (ERS): Housed within the USDA, ERS gathers a variety of data on crop and livestock practices through its annual Agricultural Resource Management Survey (ARMS). ERS provides both annual and trend data, illustrating shifts in agricultural practice. ERS contains data on nutrient management, irrigation practices, and conservation practices.

- National Agricultural Statistics Service (NASS) Cropland Data Layer (CDL): Data on annual county-average crop area and yields from NASS are used as a secondary data source for availability control of model outputs.

- USDA NASS Agricultural Surveys of planting and harvest dates and Usual Planting and Harvesting Dates for U.S. Field Crops handbook that identifies the usual planting and harvesting dates for United States field crops.

For each CEAP region, relevant variables about baseline conditions were established using these data sources. In many cases, these variables were linked using spatial attributes. For example, CDL data were used to establish the various cropping sequences, and then each crop was assigned nitrogen application rate distributions based on regional ERS ARMS data and crop planting and harvest date reported by the USDA. The following three baseline practices were modeled for across all 12 CEAP regions, for each crop type (corn for grain, corn for silage, sorghum for grain, sorghum for silage, cotton, processing tomatoes, spring grains – barley, oats, spring wheat – and winter wheat) grown in the respective CEAP region, and for both irrigated and non-irrigated lands:

- No N rate reduction (i.e., the default state-level, crop-specific fertilizer rates from the ARMS survey)
- No use of an EEF (slow release fertilizers or nitrification inhibitors)
- No switch to no till (i.e., intensive tillage)

[170] USDA-defined Land Resource Regions (LRRs) are geographically associated MLRAs which approximate broad agricultural market regions. There are 28 land resource regions, and A through U, with the exception of Q, are found in the conterminous 48 states, as found in Agriculture Handbook 296. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053624.
[171] Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627.

In addition to the cropping and management variables extracted from these data sources, the methodology applied the same area-weight (10 acres) to each point sampled. Therefore, each random point sample is equally represented in the results. A description of the plant management details implemented in the model runs follows:

- Default planting and harvest dates were determined from state-level data, by crop, provided by the USDA NASS.
- Default fertilizer rates were derived from state-level data, by crop, from the ARMS survey. Fertilizer was applied at the time of planting.
- Tillage occurred in the week before planting.
- The effects of EEF practices on soil N_2O emissions were implemented on the model results derived from the DayCent model, as the plant growth effects of slow release fertilizers and nitrification inhibitors are under development for use in the Daycent model.
- Irrigation was simulated so that crops received irrigation water to full water holding capacity in the rooting zone when soil water holding capacity dropped below 55 percent.
- The baseline and conservation scenarios were run for 10 years, using the same weather and soils data for each.
- Crop rotations were built from the cropping sequence identified in the USDA CDL. A crop rotation was built using the sequence of crops predicted by CDL for the period of 2010-2016. This crop rotation was repeated in serial sequence through the modeling period.

F.4 Modeling Approach

In order to model baseline emissions for use in quantifying emission reductions, the composite baseline practices defined in above in Section F.3 were combined with climatic and initial condition inputs. Local weather data inputs were based on values from the PRISM database for 1979-2016 (PRISM Data Group 2017). Weather for each year in the future was modeled based on actual weather from a year in the past (within the last 30 years). Thus, inputs such as temperature and precipitation should reflect recent trends. All modeling was performed using stochastic modeling techniques and the DAYCENT model to evaluate the change in dependent carbon and nitrogen emissions sources across multiple scenarios. More specifically, this was done by modeling the actual rotation at randomly selected points that are currently categorized as cropland. The analysis incorporates composite baselines defined in Section F.3 in a manner consistent with the compilation in the COMET-Farm tool.

Modeling was conducted based on the strata delineated in Section F.2, which include previous land use in addition to the variables used to define the super strata. For each CEAP region, the following methodology was employed by utilizing the Colorado State University parallel computing capability, which includes dedicated database servers and a circa 200 central processing unit (CPU) computing cluster:

1. Cropland points were randomly sampled at the MLRA level within each CEAP region so that points were geographically distributed. At least 500 and up to 750 points containing the crops of interest for this project within each CEAP region were modeled.
2. Initial soil carbon and nitrogen pools at project start were predicted for each data point based on equilibrium ecosystem conditions prior to conversion to cropland, soil data, crop management, and a long-term spinup the DAYCENT model using practices defined in the preceding step.
3. For the cropland baseline scenario, each point was modeled forward applying the baseline crop management practices through the DAYCENT model for 10 years.

4. For the project scenario, each cropland point was modeled forward applying each of the conservation scenarios:
    a. 5 percent to 30 percent fertilizer reductions, modeled in DayCent at 5 percent increments. These were performed in discussion with the Climate Action Reserve and the steering committee.
    b. 40 percent and 50 percent fertilizer reduction, modeled in DayCent, to assess model performance beyond the likely practice levels, so that CSU could examine results for potential spurious model performance in the boundaries of the likely practices. No unusual results were found beyond the likely practices (e.g., 30 percent fertilizer reduction).
    c. Conversion from intensive tillage to no tillage, modeled utilizing N_2O change factors described in the USDA GHG Methods Document to modify the DayCent-predicted N_2O emissions.
    d. Use of slow release fertilizers, modeled utilizing N_2O change factors to described in the USDA GHG Methods Document to modify the DayCent-predicted N_2O emissions.
    e. Use of nitrification inhibitors, modeled utilizing N_2O change factors to described in the USDA GHG Methods Document to modify the DayCent-predicted N_2O emissions.
    f. Combinations of practices a-c above with practices d-f.
5. DAYCENT model results for soil N_2O emissions, modified using N_2O change factors in the USDA GHG Methods Document (described in item 4 above) were summarized as average annual change or emission rates in the ten-year increment following the conversion to a conservation practice.
6. The impact of tillage and EEF use was modeled against DayCent model runs, using the method described for direct soil N_2O emissions in chapter 3, section 3.5.4 of the USDA GHG Methods Document. Emissions factors for conversion to no tillage and/or use of nitrification inhibitors or slow release fertilizes were applied to the emissions predicted by the DayCent model against crops grown under default conditions for planting and harvest dates, fertilizer amounts, irrigation systems and intensive tillage. Fertilizer reductions were used in the fertilizer amounts used to run the DayCent model. For example, a 10 percent fertilizer reduction meant that a corn crop normally receiving 180 pounds of nitrogen per year in the DayCent model run would receive 162 pounds of nitrogen per year, or 18 pounds less in the DayCent model run. The DayCent model, rather than predicting base emissions from the base emission factors described in the USDA GHG Methods Document, was used for two main reasons: 1) The DayCent model predicted direct soil N_2O emissions better than did using the base emission factors described in the USDA GHG Methods Document; and 2) the base emission factors had not been calculated for tomatoes, and was missing for key regions of the country for other crops like oats and barley, meaning a mixed model approach would have to be reported in the final results (using the IPCC base emission factor for some crops, and the DayCent/DNDC-calculated base emission factor for others).
7. The average emissions reduction and 95 percent confidence intervals were calculated for each crop and CEAP region using Monte Carlo simulation techniques as described in the USDA GHG Methods Document, section 8.1. The IPCC good practice Guidance recommends using Monte Carlo simulation as the preferred method for predicting uncertainty in both dynamic and empirical greenhouse gas models, and is recommended when combining uncertainty effects of multiple factors and when the expected uncertainty is near or higher than 30 percent. Using Monte Carlo simulation allowed us to effectively combine the effects of multiple factors across different soil, crop rotation, and climatic conditions present in the geographically rich CEAP regions. The resulting

emission rates are provided by stratum in a tabular form and included as lookup in the Excel tool provided as part of this contract.

8. After well into this effort, the modeling team recommended certain portions of the analysis that were originally proposed be modified or dropped, as follows:
    a. Modeling fertilizer reductions in soybeans was not useful, as soybeans either do not receive nitrogen fertilizers, or when they do, it is in small amounts applied as starter fertilizer and the reductions would yield soil nitrous oxide emissions that were very small.
    b. Oats, barley, and spring wheat were combined into a single category of "spring grains" because the management for these crops was very similar and the emission reductions were nearly identical across the three crop types.
    c. Fresh tomatoes were dropped from the analysis because default fertilizer applications rates were not available, and crop management techniques were highly variable.
    d. Modeling cover crops became highly impractical for a number of reasons, including the regional variation in cover crops systems, the lack of comprehensive information related to how fertilizer application rates were adjusted to account for use of cover crops, and the lack of response of the indirect soil nitrous oxide model to the use of cover crops.
9. Indirect soil N_2O emissions were estimated using the IPCC Tier 1 methods described in the USDA GHG Methods Document, section 3.5.4. This method utilizes emission factors with uniform distributions. The uncertainty of these factors are large (for example, +167 percent/-67 percent for the leaching and runoff fraction), and because the distributions are uniform, the upper bounds of the emissions reduction estimate are often close to zero. As a result, reductions in indirect soil nitrous oxide emissions have a relatively small contribution to the overall emission reductions.

F.5 Results

Over 480,000 point-year model runs were completed on more than 13,900 randomly-sampled cropland points to complete this effort. Emission rate reductions were calculated for only those points where data passed quality control analysis. The full model results have been incorporated into the NMQuanTool and can be made available by the Reserve per request.

F.6 Tillage Practice and Increased N_2O Emissions

Regional climate has been identified as a major driver for the change in N_2O emissions with adoption of no tillage practices, and depending on the region, the potential to mitigate emissions with no tillage management has been found to only be realized when it's practiced in the long term. Further, the research on the switch to no-till indicates that in some ecoregions, particularly arid/semi regions, there is an increase in N_2O emissions in the short term (i.e., within the first 10 years) after conversion from conventional tillage. As described above in Section F.1, the impact of tillage use was modeled against DayCent model runs, applying emission factors for the conversion to no tillage from the USDA GHG Methods Document to the emissions predicted by the DayCent model against crops grown in different regions under different conditions for fertilizer amounts, irrigation systems and intensive tillage. The modeling effort found that certain activity-crop-region scenarios in combination with a switch to no-till in the short-term result in an increase in N_2O emissions, and a significant increase in uncertainty. All such scenarios have been identified and are ineligible to earn CRTs under this protocol. The results have been incorporated into the Nitrogen Management Project Eligibility Lookup Tool. A separate spreadsheet containing all ineligible activity-crop-region scenarios may be made available upon request to the Reserve.

All activity-crop-region scenarios in combination with the maintenance of till (i.e., no switch to no-till) or the switch to long term no-till (at least 10 consistent years) are eligible.

F.7 Uncertainty

Monte Carlo simulation techniques were utilized to calculated mean emission reductions and 95 percent confidence intervals, with 10,000 iterations utilized for each point. Uncertainty for direct soil N_2O was modeled using the methods utilized in the U.S. Inventory. Uncertainty for indirect soil N_2O were calculated using DayCent-predicted values for leaching and volatilization, which were utilized with emission factors described in the indirect soil N_2O method described in the USDA GHG Methods Document.

CLIMATE ACTION RESERVE

Version 1.1 | July 29, 2013

Organic Waste Composting

Project Protocol

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Released July 29, 2013

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
2 The GHG Reduction Project 3
2.1 Background 3
2.2 Project Definition 3
2.2.1 Project Activities 5
2.3 The Project Developer 5
3 Eligibility Rules 6
3.1 Location 6
3.2 Project Start Date 6
3.3 Project Crediting Period 6
3.4 Additionality 7
3.4.1 The Performance Standard Test 7
3.4.2 The Legal Requirement Test 8
3.5 Regulatory Compliance 10
4 The GHG Assessment Boundary 11
5 Quantifying GHG Emission Reductions 16
5.1 Quantifying Baseline Emissions 16
5.1.1 Determining the Weight of Eligible Wastes 22
5.2 Quantifying Project Emissions 27
5.2.1 Project Emissions from Onsite Fossil Fuel Combustion and Grid Delivered Electricity 28
5.2.2 Project Emissions from the Food Waste Composting Process 29
6 Project Monitoring 33
6.1 Monitoring Incoming Eligible Waste Streams 33
6.2 Monitoring and Documenting Pre-Project Waste Disposal for Grocery Store Waste Streams 34
6.3 Required Compost BMP Monitoring 34
6.3.1 Time, Temperature, and Turning Frequency BMP Monitoring 34
6.3.2 Waste Handling BMP Monitoring 36
6.4 Monitoring Requirements for Optional Process Controls 36
6.4.1 Monitoring Requirements for Application of Finished Compost to Pile/Windrow Surface and Synthetic Covers 36
6.4.2 Monitoring Requirements for Documenting Use of Biofilter Exhaust Gas Control Systems 37
6.5 Monitoring Parameters 38
7 Reporting Parameters 44
7.1 Project Submittal Documentation 44
7.2 Record Keeping 44
7.3 Reporting Period and Verification Cycle 45
8 Verification Guidance 46
8.1 Standard of Verification 46
8.2 Monitoring Plan 46
8.3 Verifying Project Eligibility 46
8.4 Core Verification Activities 47
8.5 OWC Verification Items 48
8.5.1 Project Eligibility and CRT Issuance 48
8.5.2 Quantification 49

8.5.3 Risk Assessment 51
8.6 Completing Verification 51
9 Glossary of Terms 52
10 References 55
Appendix A Data Lookup Tables 58
Appendix B Summary of Performance Standard and Regulatory Research 64
Appendix C Sample Project Diagram 73

List of Tables

Table 4.1. Description of All Sources, Sinks, and Reservoirs 12
Table 5.1. Waste Generator Categories and Default Food and Soiled Paper Fractions by Weight 27
Table 5.2. Methane and Nitrous Oxide Emission Factors 31
Table 6.1. Organic Waste Composting Project Monitoring Parameters 38
Table 8.1. Summary of Eligibility Criteria for an Organic Waste Composting Project 47
Table 8.2. Eligibility Verification Items 49
Table 8.3. Quantification Verification Items 50
Table 8.4. Risk Assessment Verification Items 51
Table A.1. Composting System Descriptions 58
Table A.2. Decay Rates (k) by Waste Type and Climate 59
Table A.3. Gas Collection Fractions by State 61
Table A.4. Fraction of Waste Sent to Waste to Energy Facilities, by State 61
Table A.5. CO_2 Emission Factors for Fossil Fuel Use 62
Table B.1. Selected Organic Waste Source Industries Studied 65
Table B.2. Summary of Waste Regulations by State 68
Table B.3. Landfill Organic Waste Diversion Regulations 70

List of Figures

Figure 4.1. General Illustration of the GHG Assessment Boundary 11
Figure A.1. K-Value Categories in the U.S., by County 63

List of Equations

Equation 5.1. Calculating GHG Emission Reductions 16
Equation 5.2. Calculating Baseline Methane Emissions for Food Waste Streams 17
Equation 5.3. Baseline Methane Emissions from Eligible Food Waste, by Waste Stream 18
Equation 5.4. Baseline Methane Emissions from Eligible Soiled Paper Waste, by Waste Stream 20
Equation 5.5. Determining Weight of Eligible Food and Soiled Paper Waste 23
Equation 5.6. Determining the Fraction of Eligible Waste in a Mixed-MSW MRF Fines Waste Stream 25
Equation 5.7. Determining the Fraction of Eligible Waste in a Mixed-MSW Waste Stream from a Single MRF 26
Equation 5.8. Total Project Emissions 28
Equation 5.9. Project Carbon Dioxide Emissions from Fossil Fuel and Grid Electricity 29
Equation 5.10. Methane Emissions from Composting 30
Equation 5.11. N_2O Emissions from Composting 32

Abbreviations and Acronyms

ASP	Aerated static pile
BMP	Best management practice
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
EPA	Environmental Protection Agency
FOD	First Order Decay
FOG	Fats, oils, and greases
GHG	Greenhouse gas
ISO	International Organization for Standardization
lb	Pound
MRF	Materials Recovery Facility
MSW	Municipal solid waste
MT	Metric ton (or tonne)
N_2O	Nitrous oxide
OPC	Optional process control
OWC	Organic waste composting
OWD	Organic waste digestion
Reserve	Climate Action Reserve
SSO	Source separated organics
SSRs	Sources, sinks, and reservoirs
UNFCCC	United Nations Framework Convention on Climate Change
WTE	Waste to Energy

1 Introduction

The Climate Action Reserve (Reserve) Organic Waste Composting Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the diversion of eligible organic wastes away from anaerobic landfill disposal systems and to composting operations where the material degrades in a controlled aerobic process.

The Climate Action Reserve is the most experienced, trusted and efficient offset registry to serve the California cap-and-trade program and the voluntary carbon market. With deep roots in California and a reach across North America, the Reserve encourages actions to reduce greenhouse gas emissions and works to ensure environmental benefit, integrity and transparency in market-based solutions to address global climate change. It operates the largest accredited registry for the California compliance market and has played an integral role in the development and administration of the state's cap-and-trade program. For the voluntary market, the Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies and issues and tracks the transaction of carbon credits (Climate Reserve Tonnes) generated from such projects in a transparent, publicly-accessible system. The Reserve program promotes immediate environmental and health benefits to local communities and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California.

Project developers that initiate composting projects use this document to register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with organic waste composting (OWC) projects.[1]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Methane (CH_4), a potent greenhouse gas (GHG), can be formed as a by-product of microbial respiration reactions that occur when organic materials decompose in the absence of oxygen (i.e. under anaerobic conditions). Organic waste deposited in municipal solid waste (MSW) landfills will decompose primarily under anaerobic conditions, producing significant quantities of methane gas and biogenic carbon dioxide (CO_2), as well as other trace gases. The resulting CH_4 component of the landfill gas, if not oxidized by landfill cover material or captured and destroyed by a gas collection system, will eventually be released to the atmosphere.

The rate at which CH_4 production occurs in a landfill is governed by the decay rates of the specific types of waste that are deposited in the landfill. Although many landfills actively control LFG through gas collection and combustion systems, recent research indicates that typical landfill gas collection system efficiencies increase with time after initial waste burial as the collection system is installed and subsequently expanded.[2] Therefore, the fraction of CH_4 that is collected from the decay of a certain type of waste will be inversely proportional to the decay rate of the waste type. For rapidly decaying organic waste streams such as food waste, a greater fraction of the CH_4 produced from decay will go un-captured as compared to slowly degrading waste types.

When organic waste is composted, the material decomposes under primarily aerobic conditions. By diverting rapidly degrading food waste away from landfills to aerobic composting operations, significant emissions of CH_4 to the atmosphere can be avoided. Biogenic CO_2 is the primary decomposition byproduct from aerobic composting, although composting systems also emit nitrous oxide (N_2O) and CH_4 to the atmosphere. The degree to which N_2O and CH_4 are released to the atmosphere depends on the environmental conditions under which the decomposition occurs at the composting facility.

CH_4 and N_2O formation primarily occurs when compost piles contain anaerobic pockets where oxygen levels are depleted. In order to achieve sufficient aeration and minimize the potential for anaerobic pockets within a composting system, wetter and denser composting feedstocks are generally mixed with drier materials that have some structural stability. This allows for airflow and allows aerobic conditions to be maintained. Commercial and municipal composting facilities in the U.S use a wide array of technologies from the relatively simple to the mechanically complex. The major classes of facilities are discussed in Table A.1 of Appendix A, however there are various iterations within and between the major classes of facilities. Because aerobic composting is a biologically mediated process, the fundamental biological principles are the same regardless of scale or technology. While technologies differ, commercial and municipal composting facilities are generally designed and operated in a manner that promotes aeration and minimizes the presence of anaerobic pockets, as anaerobic decomposition requires more time, results with lower temperatures inside the pile, and produces malodors.

2.2 Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the composting of one or more eligible waste streams at an aerobic composting operation where the waste is

[2] De la Cruz, F.B. and Barlaz, M. *Estimation of Waste Component Specific Landfill Decay Rates Using Laboratory-Scale Decomposition Data*. (2010).

processed in a system that complies with best management practices (BMPs), which ensure the composting process is operated under optimal conditions.[3] A "composting operation" is defined as a single facility, or a full complement of multiple facilities, necessary to process biodegradable organic solid waste components into a mature compost product. For the duration of the project, only a single composting operation may be utilized. In addition, any given composting operation may only be involved in a single project. A composting operation can be stand-alone, or may be incorporated into an existing landfill facility, Materials Recovery Facility (MRF) or other waste handling facility.

For the purposes of this protocol, a waste stream is defined as waste material originating from a specific facility (if commercial waste) or jurisdiction (if residential waste). An *eligible* waste stream is one that:

1. Consists of food waste and non-recyclable food soiled paper waste (referred to hereafter as food waste and soiled paper waste, respectively), as defined in Section 3.4.1; and

2. Continually passes the Legal Requirement Test criteria as outlined in Section 3.4.2.[4]

Fats, oils and greases (FOG) and any solids that are separated from FOG waste are not considered to be food waste and are not an eligible waste type.
To ensure optimal composting, the project composting operation must comply with the following BMPs:

1. Time, Temperature, and Turning Frequency BMP Requirements:
   - For Forced Aeration Systems (Aerated Static Pile (ASP) and/or enclosed, in-vessel, or in-building composting), the temperature of the compost is measured to be 55^{o}C or greater for 3 or more consecutive days, or
   - For Turned Windrow Systems (non-forced aeration), the temperature of the compost is measured to be 55^{o}C or greater for 15 or more days, during which time the windrow is turned a minimum of five times.[5]

2. Food Waste Handling BMP Requirements:
   - All waste stream deliveries containing food waste must be:
     a. Mixed and incorporated into the composting process no more than 24 hours after delivery of the waste to the facility, or
     b. Covered with a layer of high-carbon materials[6] or finished compost no more than 24 hours after delivery, and mixed and incorporated into the composting process no more than 72 hours after delivery, or
     c. Placed in a building under negative air pressure, with exhaust gas vented through a biofilter (or otherwise placed in an enclosed environment with emission controls that are equivalent to a biofilter in their control of methane and nitrous oxide) no more than 24 hours after delivery.

[3] BMPs in this protocol are largely taken from the EPA Time and Temperature standards for pathogen reduction, available at:
http://water.epa.gov/scitech/wastetech/biosolids/upload/2002_06_28_mtb_biosolids_503pe_503pe_5.pdf
[4] Each food waste stream must have documented the county or jurisdiction of origination in order to ensure the stream is eligible per the Legal Requirement Test.
[5] Project developers can use an alternative windrow turning frequency if it can be demonstrated that the frequency of turning complies with or conforms to state agency issued regulations or Best Management Practice guidelines.
[6] Wood chips, shredded yard waste, or similar high carbon organic materials.

Section 6.3 of this protocol provides the BMP monitoring requirements for a project operation per this protocol.

An operation that composts waste using non-aerated static or passive pile composting does not meet the BMP requirements per this protocol, and therefore does not meet the definition of an eligible project.

2.2.1 Project Activities

Project activities are those activities that are necessary for the composting process, beginning with the initial receipt of waste through to the production of finished compost. For the purposes of this protocol, the following activities are considered project activities as long as their execution is related to eligible waste streams processed by the project's aerobic composting operation:

- Receipt of waste
- Waste pre-processing, including storage, handling, and mixing
- Movement and handling of waste onsite
- Composting activities, including formation of piles, operation of aeration and leachate collection systems, turning of windrows, and other activities that are necessary for, or related to, the composting of eligible waste
- Movement, handling, and storage of finished compost onsite
- Movement, handling, and storage of leachate
- Measurement and documentation of project parameters, including BMPs
- Other operations at the compost facility/facilities that are necessary for the activities listed above

2.3 The Project Developer

The "project developer" is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be compost facility operators, GHG project developers, or other entities such as municipalities, institutions, or waste management companies.

In all cases, the project developer must attest to the Reserve that they have exclusive claim to the GHG reductions – including indirect emission reductions – resulting from the project. Indirect emission reductions are reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants. A composting project will result in indirect emission reductions if eligible waste feedstocks are diverted away from landfills that are not located at the project site or that are not owned or controlled by project participants. Each time a project is verified, the project developer must attest that no other entities are reporting or claiming (e.g. for voluntary reporting or regulatory compliance purposes) the GHG reductions caused by the project.[7] The Reserve will not issue CRTs for GHG reductions that are reported or claimed by entities other than the project developer (e.g. waste generators, landfills, or municipalities not designated as the project developer).

[7] This is done by signing the Reserve's Attestation of Title form, available at http://www.climateactionreserve.org/how/program/documents/.

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to register with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project (Section 2.2).

Eligibility Rule I:	Location	→	*U.S. and its territories*
Eligibility Rule II:	Project Start Date	→	*No more than six months prior to project submission*
Eligibility Rule III:	Additionality	→	*Meet performance standard*
		→	*Exceed regulatory requirements*
Eligibility Rule IV:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Only projects located in the United States, or on U.S. tribal lands, are eligible to register reductions with the Reserve under this protocol. All eligible food waste streams composted by a project must originate within the United States. Under this protocol, reductions from international projects are not eligible to register with the Reserve.

3.2 Project Start Date

The project start date for a composting project is to be chosen by the project developer, but must be on or subsequent to the date that the project developer has implemented and documented a Monitoring Plan ensuring compliance with the BMPs defined in Section 2.2 of this protocol, and has begun composting eligible waste.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date, except as specified below.[8] Projects may always be submitted for listing by the Reserve prior to their start date.

Projects may have a start date between June 30, 2008 and June 30, 2010 (inclusive) if the project was submitted no later than June 30, 2011.

3.3 Project Crediting Period

The crediting period for projects under this protocol is ten years. At the end of a project's first crediting period, project developers may apply for eligibility under a second crediting period. However, the Reserve will cease to issue CRTs for GHG reductions associated with eligible food and/or soiled paper waste streams if at any point in the future, the diversion of those waste streams becomes legally required, as defined by the terms of the Legal Requirement Test (see Section 3.4.2). Thus, the Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of two ten year crediting periods after the project start date, or until the project activity is required by law (based on the date that a legal mandate takes

[8] Projects are considered submitted when the project developer has fully completed and filed the appropriate Project Submittal Form, available on the Reserve's website.

effect), whichever comes first. Section 3.4.1 describes requirements for qualifying for a second crediting period.

3.4 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The Performance Standard Test
2. The Legal Requirement Test

3.4.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all composting projects, established by this protocol.

Compost facilities commonly process various feedstocks. The performance standard for this protocol defines compost feedstocks that the Reserve has determined are likely to be deposited in landfills under common practice or "business-as-usual" management practices.[9] Only projects that divert and compost eligible feedstocks are deemed to exceed common practice and are therefore eligible for registration under this protocol. Based upon the results of the performance standard research, food waste and co-mingled non-recyclable food soiled paper waste are the sole composting feedstocks deemed eligible per this protocol.[10] For the purposes of this protocol, food waste and food soiled paper are defined below:

- Food Waste: defined as non-industrial solid food waste commonly disposed of in a MSW system, consisting of uneaten food, food scraps, spoiled food and food preparation wastes from homes, restaurants, kitchens, grocery stores, campuses, cafeterias, or similar institutions. FOG and any solids that are separated from FOG waste, are not considered to be food waste and are not an eligible waste type.
- Food Soiled Paper Waste: non-recyclable paper items that are co-mingled with eligible food waste, consisting of paper napkins and tissues, paper plates, paper cups, fast food wrappers, used pizza boxes, wax-coated cardboard, and other similar paper or compostable packaging[11] items typically disposed of in an MSW system.

The Reserve's performance standard research indicates that approximately 2.5% of the food waste generated in the U.S. is composted annually as common practice, and that this is limited mostly to food waste from grocery stores and supermarket diversion programs.[12] Therefore, food waste and soiled paper waste streams are not eligible if they are sourced from grocery

[9] A summary of the study used to establish this list of feedstocks and define this protocol's performance standard is provided in Appendix B.

[10] Non-recyclable (soiled) paper as a category was not separately addressed in the performance standard research or through national waste characterization studies, however residential and commercial non-recyclable paper waste is co-mingled with food waste in the MSW waste stream and would be expected to have a diversion rate similar to or less than the diversion rate of food waste due to the fact that the waste is non-recyclable. Source separated compostable waste streams are likely to include food waste co-mingled with some amount of soiled paper.

[11] Non-paper compostable packaging products such as polyactide polymer (PLA) may replace paper or plastic packaging on some food products, and are assumed to have similar properties to soiled paper.

[12] Based on composting data supplied by the stakeholder work group that advised development of this protocol, and evidence from compost experts.

stores and/or supermarkets that have historically diverted these waste streams from landfills. Additionally, all grocery store waste streams composted by the project operation prior to the project start date are not eligible.

Projects must demonstrate the eligibility of each new grocery store waste stream composted by the project by documenting that the food and soiled paper component of the grocery store waste was being disposed of in a landfill for a period of at least 36 months prior to the date that the grocery store waste was first delivered to the project composting operation, or documenting that the grocery store waste stream was previously deemed to be an eligible waste stream at another OWC or organic waste digestion (OWD) project that is registered with the Reserve. If the grocery store has been in operation for less than 36 months prior to first delivery of organic waste to the project operation, then the project must demonstrate that the waste stream was being disposed of in a landfill for the entire history of the store.

Waste streams originating from new grocery store facilities are deemed eligible. Section 6.2 provides requirements for documenting the pre-project disposal of grocery store waste. All other food and soiled paper waste sources described above are eligible.

Eligible waste streams at the time a project is registered shall remain eligible throughout a project's first crediting period, regardless of changes in any future versions of this protocol. However, projects must demonstrate the eligibility of all new grocery store waste streams composted by the project operation according to the requirements above.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Performance Standard Test.

3.4.2 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. For composting projects, the Legal Requirement Test is applied to each eligible waste stream composted by the project. A food waste and/or soiled paper stream passes the Legal Requirement Test when:

1. There are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates that require the diversion of the eligible waste stream from landfills, and/or that require the aerobic treatment of the waste stream (see Sections 3.4.2.1 below, for further guidance on regulations affecting organic solid waste); or

2. A legally binding local mandate requiring diversion and aerobic treatment of the waste stream is enacted in conjunction with the project, as specified in Section 3.4.2.2.

To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[13] prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

[13] Form available at http://www.climateactionreserve.org/how/program/documents/.

If a project composts an eligible food waste stream that later becomes subject to a legal mandate requiring its diversion and/or aerobic treatment, the waste stream will remain eligible up until the date that the legal mandate takes effect. The project may continue to report GHG reductions to the Reserve associated with other eligible waste streams that are not subject to such mandates. The Reserve will continue to issue CRTs for the avoidance of methane associated with the composting of eligible waste streams that are not legally required to be diverted or aerobically treated.

3.4.2.1 Guidance on Solid Organic Waste Regulations

There are various state and local regulations, ordinances, and mandatory diversion targets that may obligate waste source producers or waste management entities to divert organic wastes away from landfills. An organic solid waste stream that is banned from landfilling, or for which a strong regulatory incentive exists to manage the waste stream in a system other than a landfill, fails the Legal Requirement Test.

State Regulations

States may have mandatory landfill diversion targets that require a percentage of waste generated be diverted from landfills to alternative management systems. Although waste diversion targets may not specify a reduction or percentage of diversion that must be met from *food* waste, these targets nevertheless provide strong regulatory incentives to divert all wastes (including food wastes) from landfills. Thus, food waste originating from a jurisdiction that is not in compliance with a mandated landfill diversion target does not pass the Legal Requirement Test until the date at which the jurisdiction comes into compliance with the mandated landfill diversion target.

Mandatory state diversion targets are not to be confused with state diversion goals. Should a state adopt a statewide waste diversion goal that does not impose penalties on jurisdictions for failing to meet diversion targets, then this state goal would not result in a failure of the Legal Requirement Test.

Local and Municipal Regulations and Ordinances

Local jurisdictions may have bans on certain types of waste going to landfill, or may have mandatory ordinances that require the diversion of organic solid wastes from landfills. If a local jurisdiction has established a mandatory ban on food waste disposal at landfills, or otherwise has enacted food waste diversion mandates, food waste streams originating from regulated sources within the jurisdiction fail the Legal Requirement Test.

3.4.2.2 Local Food Waste Diversion Mandates Enacted in Conjunction with a Composting Project

A food waste stream subject to a local food waste diversion mandate passes the Legal Requirement Test if (and only if):

1. The project composting the local food waste stream has an operational start date prior to, but no more than 5 years before, the date that the food waste diversion mandate is passed into law by the local jurisdiction; or

2. The project is *implemented* subsequent to, but no more than 6 months after, the date of passage into law of the local food waste mandate.

For the purposes of this protocol, the date of project implementation may be defined with respect to the date at which the project first broke ground, purchased food waste composting equipment, or began the permitting process to compost food waste at the facility/facilities.

All food waste streams must continue to pass the Legal Requirement Test on the state and federal level in order to be considered eligible per the Legal Requirement Test.

3.5 Regulatory Compliance

As a final eligibility requirement, project developers must attest that project activities do not cause material violations of applicable laws (e.g. air, water quality, safety, etc.). To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form[14] prior to the commencement of verification activities each time the project is verified. Project developers are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project activities.

A violation should be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the project developer shall disclose the violation to the verifier.

If a verifier finds that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurrent administrative violations directly related to project activities may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

[14] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project developers in order to determine the net change in emissions caused by a food waste composting project.[15] Figure 4.1 illustrates all relevant GHG SSRs associated with the management of eligible waste streams and delineates the GHG Assessment Boundary.

Table 4.1 provides greater detail on each SSR and justification for the inclusion or exclusion of certain SSRs and gases from the GHG Assessment Boundary.

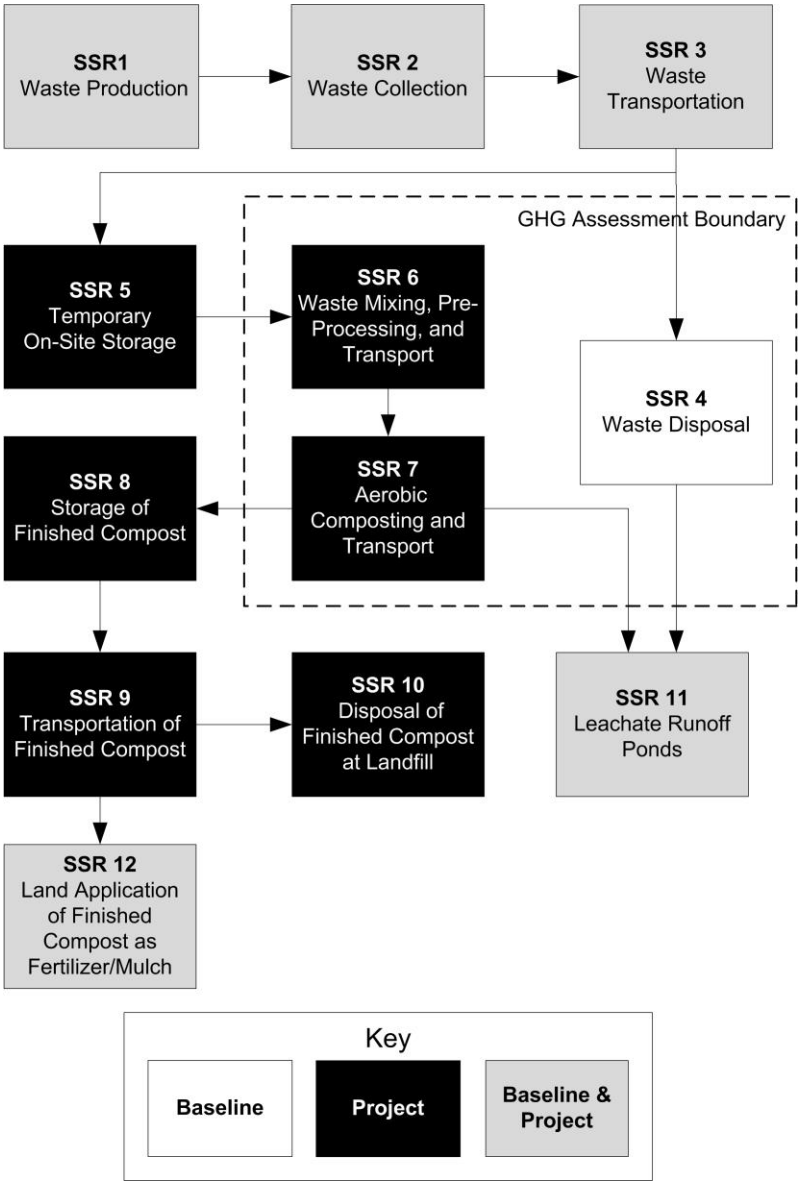

Figure 4.1. General Illustration of the GHG Assessment Boundary

[15] The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.

Table 4.1. Description of All Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
1. Waste Production	Fossil fuel emissions associated with the generation of waste	CO_2	E	N/A	Excluded. Project activity is unlikely to affect emissions relative to baseline activity.
		CH_4	E	N/A	Excluded. Project activity is unlikely to affect emissions relative to baseline activity.
		N_2O	E	N/A	Excluded. Project activity is unlikely to affect emissions relative to baseline activity.
2. Waste Collection	Fossil fuel emissions from mechanical systems used to collect, handle, and/or process waste prior to transportation	CO_2	E	N/A	Excluded. Project activity is unlikely to affect emissions relative to baseline activity.
		CH_4	E	N/A	Excluded. Project activity is unlikely to affect emissions relative to baseline activity.
		N_2O	E	N/A	Excluded. Project activity is unlikely to affect emissions relative to baseline activity.
3. Waste Transportation	Fossil Fuel emissions from transport of waste to final disposal/treatment system (e.g. garbage trucks, hauling trucks, etc.)	CO_2	E	N/A	Excluded. Emissions from project activity will in most instances be of comparable magnitude to baseline transportation emissions [16] The difference between project and baseline waste transportation distance can be large without significantly affecting a project's total net GHG reductions.
		CH_4	E	N/A	Excluded. Project activity is unlikely to affect emissions relative to baseline activity.
		N_2O	E	N/A	Excluded. Project activity is unlikely to affect emissions relative to baseline activity.
4. Waste Disposal at Landfill	Emissions resulting from landfill equipment, and anaerobic decay of food and food soiled paper waste disposed of at a landfill	CO_2	Fossil: E Biogenic: E	N/A	Fossil fuel emissions from landfill equipment excluded, as they are expected to decrease relative to baseline activity. Biogenic emissions are excluded.
		CH_4	I	Baseline: Modeled w/ FOD model based on site-specific measurement of quantity of food waste diverted, waste specific characteristic factors, and local climate Project: N/A	This is a primary source of GHG emissions that may be avoided by an OWC project.

[16] SAIC, Methane Avoidance from Composting Issue Paper (2009).

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		N_2O	E	N/A	Excluded for conservativeness.[17]
5. Temporary Onsite Storage	GHG emissions may result if waste is stored for long periods of time under anaerobic conditions prior to active composting	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	E	N/A	Excluded, as projects are required to utilize waste handling BMP requirements that minimize emissions from waste storage. Thus, CH_4 emissions are likely to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small. N_2O is unlikely to be produced until later stages of the active composting cycle.
6. Waste Mixing, Pre-Processing, and Transport	Emissions resulting from the use of fossil fuels or grid delivered electricity for pre-processing equipment used for processing/mixing eligible waste materials	CO_2	I	Baseline: N/A Project: Estimated using fossil fuel use or electricity use data and appropriate emission factors	Depending on the specifics of project waste pre-processing practices, increases in GHG emissions from this source could be significant. In cases where multiple facilities are engaged in a single compost process, fossil fuel emissions from transport between such facilities shall be included.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
7. Aerobic Composting and Transport	Emissions resulting from the composting process, including active composting and curing of eligible waste at project facilities	CO_2	Fossil: I Biogenic: E	Baseline: N/A Project: Estimated using fossil fuel use or electricity use data and appropriate emission factors	Project CO_2 emissions resulting from onsite fossil fuel use and/or grid delivered electricity may be significant. In cases where multiple facilities are engaged in a single compost process, fossil fuel emissions from transport between such facilities shall be included. Biogenic CO_2 emissions from aerobic processing are excluded.
		CH_4	I	Baseline: N/A Project: Estimated using emission factors adjusted for project-specific composting practices	Project CH_4 emissions depend on the type of composting as well as the management of the composting process. Projects are required to account for emissions based on project-specific composting practices.
		N_2O	I	Baseline: N/A Project: Estimated using emission factors adjusted for project-specific composting practices	Project N_2O emissions depend on the type of composting as well as the management of the composting process. Projects are required to account for potential emissions based on project-specific composting practices.

[17] The Reserve will continue to follow scientific research regarding N_2O emissions from landfills. It is conservative to exclude N_2O from the landfill baseline emissions quantification.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
8. Storage of Finished Compost	Emissions from the continued decay of stored finished compost	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	E	N/A	Excluded because the CH_4 potential of the waste is largely depleted within the first four weeks of the aerobic composting treatment, thus this emission source is assumed to be very small.[18]
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
9. Transportation of Finished Compost	Fossil fuel emissions from the transport of the finished compost to the site of end-use	CO_2	E	N/A	Excluded, as transportation distance can be large without significantly affecting a project's total net GHG reductions. It is expected that the majority of compost users are located in close proximity to the compost supplier.[18]
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
10. Disposal of Finished Compost at Landfill	Emissions from the disposal of finished compost at a landfill or other anaerobic disposal system	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	E	N/A	Excluded because this practice is not common, and the biodegradable components of the waste have largely decayed. Emissions are likely to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
11. Leachate Run-Off Ponds	Emissions from anaerobic storage and treatment of food and soiled paper leachate run-off	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	E	N/A	Excluded. This is a small source, and leachate from food and soiled paper waste is likely treated similarly at landfills and at composting facilities, therefore project activity is unlikely to affect emissions relative to baseline activity.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
12. Land Application	Emissions and sequestration related to the land application of fertilizers and finished compost.	CO_2	E	N/A	Excluded, as project activity is unlikely to increase emissions relative to baseline fertilizer application. Furthermore, the application of finished
		CH_4	E	N/A	

[18] SAIC, Methane Avoidance from Composting Issue Paper (2009).

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		N_2O	E	N/A	compost as soil amendment or mulch on agricultural lands has been shown to result in significant GHG benefits due to avoided fossil based fertilizer use, increased carbon sequestration, increased water retention in soils, and other impacts. This protocol does not address the GHG benefits of compost end-use, which is considered a complementary and separate activity.

5 Quantifying GHG Emission Reductions

GHG emission reductions from a composting project are quantified by comparing actual project emissions to the calculated baseline emissions. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary as a result of the project. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1). GHG emission reductions must be quantified and verified on at least an annual basis. Project developers may choose to quantify and verify GHG emission reductions on a more frequent basis if they desire. The length of time over which GHG emission reductions are periodically quantified and verified is called the "reporting period."

Equation 5.1. Calculating GHG Emission Reductions

$$\boldsymbol{ER = BE - PE}$$

Where,

			Units
ER	=	Total emission reductions for the reporting period	$MTCO_2e$
BE	=	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.1)	$MTCO_2e$
PE	=	Total project emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.2)	$MTCO_2e$

5.1 Quantifying Baseline Emissions

Total baseline emissions for the reporting period are estimated by calculating and summing the emissions from all relevant baseline SSRs that are included in the GHG assessment boundary. As indicated in Table 4.1, total baseline emissions are equivalent to the emissions of methane that would have occurred had eligible food and food soiled paper waste streams been disposed of at a MSW landfill (SSR 4).

The baseline calculation assumes that the quantity of eligible food and soiled paper waste that is composted by the project would otherwise have been disposed of at a landfill or waste incineration plant in the absence of the project.[19] While the majority of non-recovered organic MSW in the U.S. is disposed of at landfills, a small percentage of waste is also incinerated at Waste to Energy (WTE) facilities.[20] Organic wastes that are landfilled will degrade primarily under anaerobic conditions and will release methane to the atmosphere, whereas waste that is combusted will produce insignificant emissions of methane to the atmosphere. The baseline calculation for eligible food waste streams assumes that the food waste is landfilled, however the baseline methane emissions are adjusted to reflect that some of the waste would have gone to WTE facilities. The percentage of food and soiled paper waste that is assumed to be incinerated in the baseline is equal to the waste incineration rate for the U.S. state where the project is located, as specified in Table A.4 of Appendix A.

Equations 5.2, 5.3, and 5.4 below must be used to calculate the baseline methane emissions from the eligible food and soiled paper waste streams that are composted by the project during

[19] U.S. EPA, Municipal Solid Waste in the United States, 2007 Facts and Figures. (2007).
[20] Biocycle Magazine, State of Garbage (2006)

the reporting period. These equations are based on a First Order Decay (FOD) model.[21] The FOD model estimates the methane emissions that would have been emitted to the atmosphere over a period of ten years had the food and soiled paper waste been disposed of in a landfill instead of being composted by the project. The ten-year emission estimate is summed and applied to the total baseline emissions for the current reporting period.

Equations 5.3 and 5.4 represent the FOD model calculations that must be used to estimate baseline emissions for both the food waste component and the soiled paper component of the eligible waste that is composted by the project. For the calculation, the total weight of the food and soiled paper waste from each eligible waste stream must be aggregated over the reporting period. The inputs to the FOD model include:

- The State Waste Incineration (WTE) rate – the percentage of the waste that would have gone to a waste incineration plant instead of a landfill on a state-by-state basis
- The Landfill Gas Collection Efficiency (LCE) – the percentage of landfill gas that is captured and controlled due to the presence of a landfill gas collection and control system (see Box 5.1 for further information on the LCE parameter)
- The waste-specific fraction of total Degradable Organic Carbon (DOC_S), and fraction of DOC_S that is degradable under anaerobic conditions (DOC_f)
- The decay rate of the waste, k, which is a function of both the type of waste and external climate of the region where the waste would have been landfilled

Equation 5.2. Calculating Baseline Methane Emissions for Food Waste Streams

$$\boldsymbol{BE = \sum_{S} BE_{CH_4,S}}$$

Where,

			Units
BE	=	Total sum of the baseline emissions during the reporting period	$MTCO_2e$
$BE_{CH4,S}$	=	Baseline methane emissions from composted waste stream 'S' during the reporting period	$MTCO_2e$

$$\boldsymbol{BE_{CH_4,S} = BE_{FW,S} + BE_{SP,S}}$$

Where,

$BE_{FW,S}$	=	Baseline methane emissions from the food waste component of eligible waste stream 'S' that is composted during the reporting period	$MTCO_2e$
$BE_{SP,S}$	=	Baseline methane emissions from the soiled paper component of eligible waste stream 'S' that is composted during the reporting period	$MTCO_2e$

[21] The FOD model used in Equation 5.3 and 5.4 is referenced from the UNFCCC Clean Development Mechanism (CDM) approved methodology for calculating avoided methane emissions from waste diversion (Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0)). The model is adapted in order to quantify and sum the emissions over a ten year horizon of waste degradation rather than quantifying the annually distributed emissions. Due to model uncertainty, it is conservative to limit the calculation time frame to ten years, although waste would likely continue to break down in a landfill for a much longer period.

Equation 5.3. Baseline Methane Emissions from Eligible Food Waste, by Waste Stream

$$BE_{FW,S} = 0.9 \times W_{FW,S} \times (1 - WTE_S) \times 128 \times \rho \times FE_{FW,S} \times 21$$

Where,			Units
$BE_{FW,S}$	=	Baseline methane emissions from the food waste component of eligible waste stream 'S' that is composted during the reporting period	$MTCO_2e$
0.9	=	Model correction factor to account for model and waste composition uncertainties related to waste composition and waste characteristics[22]	fraction
$W_{FW,S}$	=	Aggregated weight of eligible food waste (measured on a wet basis) from eligible waste stream 'S' that is composted by the project during the reporting period. See Section 5.1.1 for guidance on determining the weight of eligible food waste	MT food waste (wet weight)
WTE_S	=	Fraction of waste from eligible waste stream 'S' that would have been incinerated at a Waste to Energy plant in lieu of being landfilled. This fraction is equal to the state-specific fraction of total generated waste that is incinerated. Referenced by waste origination State from Table A.4 in Appendix A	fraction
128	=	Methane potential of food waste (measured on a wet basis) from eligible waste stream 'S'. Projects must use this value for all food waste streams[23]	m^3CH_4/MT food waste (wet weight)
ρ	=	Density of methane, equal to **0.000674**	$MTCH_4/m^3$
$FE_{FW,S}$	=	Fraction of methane generated from eligible waste stream 'S' that is emitted to the atmosphere over a ten year time horizon, as calculated using the First Order Decay function. The fraction emitted to the atmosphere is a function of the decay rates of food waste, the landfill gas collection assumptions (see Box 5.1), and the amount of methane generated that is oxidized in the cover soil	fraction
21	=	Global warming potential of methane	$MTCO_2e$ / $MTCH_4$

[22] As per CDM Annex 10 – Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0) http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v4.pdf/history_view.
[23] U.S. EPA Inventory of Greenhouse Gas Emissions and Sinks, 1990-2008. Annex 3, Ch. 3.14, pg. A-295.

Equation 5.3. (Continued)

$$FE_{FW,S} = \sum_{x=1}^{10}\left[e^{-k_{FW,S}(x-1)} \times \left(1 - e^{-k_{FW,S}}\right) \times \left(1 - \left(GC_S \times LCE_x\right)\right)\right] \times (1 - 0.1)$$

Where,			Units
e	=	Mathematical constant, approximately equal to 2.71828	
$k_{FW,S}$	=	Decay rate for eligible food waste stream 'S'. The decay rate is a function of the climatological characteristics of the region where the waste is landfilled. Referenced from Table A.2 by waste origination county climate category, which is referenced from Figure A.2	yr^{-1}
x	=	Placeholder for the iterative calculation. The FOD equation calculates emissions out over a period of ten years (x = 1 to 10) following the year in which the waste is initially diverted to the compost operation. The ten year calculation is summed and applied to the total baseline emissions for the current reporting period	
GC_S	=	Gas collection factor for eligible waste stream 'S'. The gas collection factor is equal to the fraction of waste disposed at landfills utilizing gas collection for the state from which the waste stream 'S' originates. Referenced by state from Table A.3 in Appendix A	fraction
LCE_x	=	Fraction of methane that would be captured and destroyed by LFG collection systems in the year x, starting with the year that the waste is diverted to the project (x =1) and ending with year x = 10. All projects shall use a value of '**0.0**' for the first two years of calculated waste decay (x=1 to 2), a value of '**0.5**' for the third year (x=3), a value of '**0.75**' for years 4 to 7 (x=4 to 7), and a value of '**0.95**' for the remaining years of decay until the end of the calculation period (x =8 to 10). See Box 5.1 for a discussion of LCE assumptions[24]	fraction
0.1	=	Factor for the oxidation of methane by cover soil bacteria[25]	fraction

[24] The Reserve will periodically re-assess the LCE default parameters in order to ensure that landfill gas collection assumptions remain conservative and accurate.

[25] As per the Reserve Landfill Project Protocol V4.0, CDM Annex 10 – Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0), and U.S. EPA *Solid Waste Management and Greenhouse Gases: A Lifecycle Assessment of Emissions and Sinks,* Chapter 6, Pg. 87, ftnt27.

Equation 5.4. Baseline Methane Emissions from Eligible Soiled Paper Waste, by Waste Stream

$$BE_{SP,S} = 0.9 \times W_{SP,S} \times (1 - WTE_S) \times 310 \times \rho \times FE_{SP,S} \times 21$$

Where,			Units
$BE_{SP,S}$	=	Baseline methane emissions from the soiled paper component of eligible waste stream 'S' that is composted during the reporting period	$MTCO_2e$
0.9	=	Model correction factor to account for model and waste composition uncertainties related to waste composition and waste characteristics[26]	fraction
$W_{SP,S}$	=	Aggregated weight of eligible soiled paper waste (measured on a wet basis) from eligible waste stream 'S' that is composted by the project during the reporting period. See Section 5.1.1 for guidance on determining the weight of eligible food waste	MT soiled paper (wet weight)
WTE_S	=	Fraction of waste from eligible waste stream 'S' that would have been incinerated at a Waste to Energy plant in lieu of being landfilled. This fraction is equal to the state-specific fraction of total generated waste that is incinerated. Referenced by waste origination State from Table A.4 in Appendix A	fraction
310	=	Methane potential of soiled paper waste (measured on a wet basis) from eligible waste stream 'S'. Projects must use this value for all soiled paper waste streams[27]	m^3CH_4/MT food waste (wet weight)
ρ	=	Density of methane, equal to **0.000674**	$MTCH_4/m^3$
$FE_{SP,S}$	=	Fraction of methane generated from eligible waste stream 'S' that is emitted to the atmosphere over a ten year time horizon, as calculated using the First Order Decay function. The fraction emitted to the atmosphere is a function of the decay rates of soiled paper waste, the landfill gas collection assumptions (see Box 5.1), and the amount of methane generated that is oxidized in the cover soil	fraction
21	=	Global warming potential of methane	$MTCO_2e$ / $MTCH_4$

[26] As per CDM Annex 10 – Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0) http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v4.pdf/history_view.

[27] U.S. EPA *Solid Waste Management and Greenhouse Gases: A Lifecycle Assessment of Emissions and Sinks,* Chapter 6, Exhibit 6-3. The Value represents the methane potential of 'office paper'.

Equation 5.4. (Continued)

$$FE_{SP,S} = \sum_{x-1}^{10}\left[e^{-k_{SP,S}(x-1)} \times \left(1 - e^{-k_{SP,S}}\right) \times \left(1 - \left(GC_S \times LCE_x\right)\right)\right] \times (1 - 0.1)$$

Where,			Units
e	=	Mathematical constant, approximately equal to 2.71828	
$k_{SP,S}$	=	Decay rate for eligible soiled paper waste stream 'S'. The decay rate is a function of the climatological characteristics of the region where the waste is landfilled. Referenced from Table A.2 by waste origination county climate category, which is referenced from Figure A.2	yr^{-1}
x	=	Placeholder for the iterative calculation. The FOD equation calculates emissions out over a period of ten years (x = 1 to 10) following the year in which the waste is initially diverted to the compost operation. The ten year calculation is summed and applied to the total baseline emissions for the current reporting period	
GC_S	=	Gas collection factor for eligible waste stream 'S'. The gas collection factor is equal to the fraction of waste disposed at landfills utilizing gas collection for the state from which the waste stream 'S' originates. Referenced by state from Table A.3 in Appendix A	fraction
LCE_x	=	Fraction of methane that would be captured and destroyed by LFG collection systems in the year x, starting with the year that the waste is diverted to the project (x =1) and ending with year x = 10. All projects shall use a value of '**0.0**' for the first two years of calculated waste decay (x=1 to 2), a value of '**0.5**' for the third year (x=3), a value of **0.75** for years 4-7 (x=4 to 7), and a value of **0.95** for the remaining years of decay until the end of the calculation period (x =8 to 10). See Box 5.1 for a discussion on LCE assumptions[28]	fraction
0.1	=	Factor for the oxidation of methane by cover soil bacteria[29]	fraction

[28] The Reserve will periodically re-assess the LCE default parameters in order to ensure that landfill gas collection assumptions remain conservative and accurate.

[29] As per the Reserve Landfill Project Protocol V4.0, CDM Annex 10 – Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0), and U.S. EPA *Solid Waste Management and Greenhouse Gases: A Lifecycle Assessment of Emissions and Sinks,* Chapter 6, Pg. 87, ftnt27.

Box 5.1. Organic Waste Composting Protocol Treatment of Landfill Gas Collection Systems

Landfill Gas Collection System Assumptions

The baseline emission calculation excludes methane that would have otherwise been captured and controlled by an active landfill gas collection system. The Reserve acknowledges that many landfills have active gas collection and control systems in operation, of which the majority are in place due to federal, state, or local regulations.[30] Due to the uncertainty and difficulty associated with tracking and verifying pre-project waste disposal activities on a project-by-project basis, this protocol utilizes a conservative and highly standardized approach to determining the landfill gas collection efficiency (LCE) parameter for eligible waste baseline emission calculations that incorporates the most up-to-date scientific understanding of landfill gas collection efficiencies and state-specific landfill gas collection practices.

Specifically, the baseline calculation reflects the following assumptions:

1. The fraction of each eligible waste stream composted by the project that would have been disposed at a landfill with a collection system in the absence of the project is equal to the fraction of total disposed waste that is accepted at landfills with known or potential landfill gas collection systems on a state-specific basis. The state-specific gas collection fraction (GC_S), is referenced from Table A.3 in Appendix A based on where each eligible waste stream composted by the project originated.[31] The fraction of each eligible waste stream composted by the project that would have been disposed at a landfill without gas collection ($1\text{-}GC_S$) is assumed to have a landfill gas collection efficiency of 0%.

2. The Landfill Gas Collection Efficiency (LCE) parameter assumes landfills with gas collection will have a phased gas collection efficiency consistent with common landfill gas management.[32] The LCE_x parameter in Equations 5.3 and 5.4 shall be equal to zero for a period of two full years following the diversion and composting of the waste, followed by 50% collection efficiency in the third year, 75% collection in years 4 to 7, and 95% collection for years 8 to 10.

5.1.1 Determining the Weight of Eligible Wastes

Eligible waste is likely to be delivered to the project composting operation mixed with varying quantities and types of ineligible organic and/or inorganic materials. The type and quantity of eligible and ineligible waste contained in each delivery will depend primarily on the waste generation source where the material originates, and the methods by which organics are separated, or not, from the upstream waste. Depending on the operational design of the compost facility/facilities, the project might accept non-source separated MSW streams (mixed MSW) and/or various types of source separated organics (SSO) streams.

The project must track delivery of waste from each eligible waste stream and determine the percentages of food waste and soiled paper in each eligible waste stream according to Equation 5.5 below.

[30] Per the Performance Standard Analysis conducted for the Reserve's Landfill Project Protocol, V 2.0. See Appendix C of the Reserve's Landfill Project Protocol.
[31] The GC_S fraction was determined using data from the 2008 U.S. EPA Landfill Methane Outreach Program (LMOP) database.
[32] M.Barlaz et al. Memorandum to Jennifer Brady, Office of Resource Conservation and Recovery, US EPA: *WARM Component-Specific Decay Rate Methods.* (2009).

Equation 5.5. Determining Weight of Eligible Food and Soiled Paper Waste

$$W_{FW,S} = W_{T,S} \times FC_S \times F_{FW,S}$$

Where,

			Units
$W_{FW,S}$	=	Aggregated weight of eligible food waste (measured on a wet basis) from eligible waste stream 'S' that is composted by the project during the reporting period	MT food waste
$W_{T,S}$	=	Aggregated total weight of waste (measured on a wet basis) from eligible waste stream 'S' that is delivered to the operation during the reporting period	MT
FC_S	=	Fraction of eligible waste stream 'S' that is composted during the reporting period	fraction
$F_{FW,S}$	=	Food waste fraction of eligible waste stream 'S'. The fraction must be determined based on the corresponding methods described in Sections 5.1.1.1 and 5.1.1.2 below, according to the type of waste delivered to the site	fraction

$$W_{SP,S} = W_{T,S} \times FC_S \times F_{SP,S}$$

Where,

			Units
$W_{SP,S}$	=	Aggregated weight of eligible soiled paper waste (measured on a wet basis) from eligible waste stream 'S' that is composted by the project during the reporting period	MT soiled paper
$F_{SP,S}$	=	Soiled paper waste fraction of eligible waste stream 'S'. The fraction must be determined based on the corresponding methods described in Sections 5.1.1.1 and 5.1.1.2 and Equation 5.6 and Equation 5.7 below, according to the type of waste delivered to the site	fraction

5.1.1.1 Determining the Fraction of Eligible Waste in a Mixed MSW Waste Stream (Non-Source Separated)

If a composting project is receiving a mixed MSW stream, the weight of food waste must be determined using one of the four options detailed below. The first two options are applicable for all mixed MSW waste streams, the third is applicable only to MRF fines and the fourth is applicable only to non-SSO (mixed) organics-rich MSW from a single MRF.

Option 1:

The first option is to determine the weight of food waste using a national default factor of 20% of the total measured weight of the mixed MSW.[33]

Option 2:

The second option is to determine the weight of food waste using a food waste composition factor based on a published state, regional or municipal waste characterization study. If this option is chosen, the project must be sourcing a majority of the relevant waste stream from within the geographic boundaries of the study. The waste characterization study must have been conducted no more than 5 years prior to the current project reporting year.

[33] Based on the EPA's *Municipal Solid Waste Generation, Recycling, and Disposal in the United States, Tables and Figures for 2010*. Figure 13, pg. 45. (2011)

Option 3:

The third option, applicable only to MRF fines, allows project developers to conduct site-specific waste sampling for the MSW fines composted at the operation according to the following procedure:

- All sampling events shall use at least a 100 lb sample of the organic fine material that has recently passed through the final stage of the screening process
- Material particles larger than approximately two inches in diameter shall be physically sorted or screened, and weighed. The remaining fines fraction shall be collected and weighed in its entirety. The remaining fines must be mixed and shoveled into a radially symmetrical pile, and divided into quarters using perpendicular boards. One quarter of the remaining fines must be collected and chosen for hand sampling, and used as a basis for the composition of all fines in that sample
- The mixed waste quarter-sample shall be sorted into the following categories: food waste, soiled paper, other ineligible material

Each sampling event must quantify and record the proportional weight of food waste and of soiled paper as compared to the total weight of the sample:

- To determine the characterization for the 100 lb (or greater) sample, the project developer must recombine the composition result analytically and determine the weighted average based on the relative amounts of fines, as well as the larger (greater than two inch) particles sampled. Using Equation 5.6, the project developer shall quantify the mean food waste proportional weight ($F_{FW,S}$) and soiled paper proportional weight ($F_{SP,S}$). The $F_{FW,S}$ and $F_{SP,S}$ values shall then be used in Equation 5.5 for MRF fines waste streams
- Photo documentation and calculations must be recorded and retained for verification purposes, clearly showing the waste stream from which the sample is taken, the waste sample itself, the quartered sample pre-sorting, and the separated categories of waste following the hand-sorting

Each waste stream for which this procedure is applied shall have a minimum of eight sampling events (two per calendar quarter) for the first year that the stream is composted at the operation, followed by four sampling events every year thereafter (one per calendar quarter). The sampling events will produce single values for $F_{FW,S}$ and $F_{SP,S}$ for each calendar quarter. During a quarter with two sampling events, the values for that quarter shall be equal to an average of the respective values determined at each of the two events.

Option 4:

The fourth option is applicable only to organics-rich shipments of non-SSO (mixed) MSW that are sorted, but not processed (as opposed to MRF fines, which are a byproduct of waste processing activities), at a single MRF. This option allows project developers to conduct site-specific waste sampling for the waste stream according to the following procedure:

- A load of organics-rich mixed-MSW from a single MRF shall be divided into a grid of at least 8 cells, and then at least 4 of those cells shall be selected for sampling using a systematic, random sampling approach (e.g. construct a 4x2 grid and use a coin toss to

select one cell from each pair). The person undertaking the sampling has discretion as to the grid's design, for instance, by depositing the whole load onto the floor, after which a grid is superimposed onto the pile, or by drawing a grid on the floor before depositing the load onto the grid. The particular cells to be sampled shall be chosen anew with each sampling event

- All hand-sorting events shall use at least a 150 lb sample of the organic material from each cell that has been selected using the random sampling approach (i.e. at least four samples per event)
- Each sample shall be sorted into the following categories: food waste, soiled paper, other ineligible material
- Each sampling event must quantify and record the proportional weight of food waste and of soiled paper as compared to the total weight of the sample. The values for $F_{FW,S}$ and $F_{SP,S}$ shall be equal to the arithmetic mean of their respective sample results (Equation 5.7)
- Photo documentation and calculations must be recorded and retained for verification purposes, clearly showing the waste stream from which the sample is taken, the grid used for sampling (where possible) and the waste contained in each cell of the grid, the sample pre-sorting, and the separated categories of waste following the hand sorting

Each waste stream for which this procedure is applied shall have a minimum of eight sampling events (two per calendar quarter) for the first year that the stream is composted at the operation, followed by four sampling events every year thereafter (one per calendar quarter). The sampling events will produce single values for $F_{FW,S}$ and $F_{SP,S}$ for each calendar quarter. During a quarter with two sampling events, the values for that quarter shall be equal to an average of the respective values determined at each of the two events.

Equation 5.6. Determining the Fraction of Eligible Waste in a Mixed-MSW MRF Fines Waste Stream

$$F_{i,S} = \frac{(W_{HS} \times F_{i,HS}) + (W_{PR} \times F_{i,QS})}{W_{sample}}$$

Where,			Units
$F_{i,S}$	=	Fraction of waste category *i* (food waste or soiled paper waste) in eligible MRF fines waste stream 'S' (representing $F_{FW,S}$ for food waste and $F_{SP,S}$ for soiled paper waste)	fraction
W_{HS}	=	Weight of sample taken in large (>2") preliminary hand sort	lbs
$F_{i,HS}$	=	Fraction of waste category *i* in large (>2") preliminary hand sort	fraction
W_{PR}	=	Weight of total sample after large (>2") particles removed	lbs
$F_{i,QS}$	=	Fraction of waste category *i* in quarter sample	fraction
W_{sample}	=	Weight of total sample prior to hand sort (100 lb minimum) *(Note that $W_{sample} = W_{HS} + W_{PR}$)*	lbs

Equation 5.7. Determining the Fraction of Eligible Waste in a Mixed-MSW Waste Stream from a Single MRF

$$F_{i,S} = \frac{\sum W_{i,sample,y}}{\sum W_{sample,y}}$$

Where,			Units
$F_{i,S}$	=	Fraction of waste category *i* in the mixed MSW single-MRF eligible waste stream 'S'	fraction
$W_{i,sample,y}$	=	Weight of waste category *i* for sample *y*	fraction
$W_{sample,y}$	=	Total weight of sample *y* prior to hand sort (150 lb minimum)	lbs

5.1.1.2 Determining the Fraction of Eligible Waste in a Source Separated Organics Waste Stream

SSO waste is generated by both the commercial and residential sectors. Residential food waste collection programs are likely to produce a waste stream that is a combination of yard waste, food waste, and soiled paper. In certain regions and/or seasons, residential SSO may have limited yard waste material and may be primarily food and soiled paper. Commercial sector waste generators are broken down further into separate categories (Table 5.1). The types of commercial generators listed in Table 5.1 will primarily produce waste streams that consist of food waste and soiled paper in varying proportions.

5.1.1.2.1 Residential SSO Waste Stream Characterization

In order to determine the percent of food and soiled paper waste in a residential SSO waste stream, projects must use local or site-specific waste characterization data to determine the average fraction of food waste and soiled paper waste by weight collected by the residential diversion program. If available, projects may use local municipal waste characterization data provided by the local jurisdiction or a representative entity to quantify the proportion by weight of both food waste and soiled paper in the residential SSO waste stream. The project must be located within – or predominantly sourcing the waste stream being characterized from – the relevant municipality. If local data are not available, projects must conduct site-specific waste sampling for each residential waste stream composted at the operation.

The site-specific waste sampling shall be done according to the following requirements:

- All hand-sorting events shall use at least a 100 lb sample from a recent delivery of the residential SSO stream in question prior to mixing with other waste streams
- The SSO waste sample shall be sorted into the following categories: food waste, soiled paper, other ineligible material
- Each sampling event must quantify and record the proportional weight of food waste and of soiled paper as compared to the total weight of the sample
- The project must quantify the mean food waste proportional weight and soiled paper proportional weight ($F_{FW,S}$ and $F_{SP,s}$), respectively, for each quarter of the calendar year. For each waste category, the weight of the sorted material shall be divided by the weight of the total sample to determine the proportional weight
- Photo documentation must be recorded and retained for verification purposes, clearly showing the waste stream from which the sample is taken, the waste sample itself, and the separated categories of waste following the hand sorting

Each residential SSO stream shall have a minimum of eight sampling events (two per calendar quarter) for the first year that the stream is composted at the operation, followed by four sampling events every year thereafter for SSO stream (one per calendar quarter). The sampling events will produce single values for $F_{FW,S}$ and $F_{SP,S}$ for each calendar quarter. During a quarter with two sampling events, the values for that quarter shall be equal to an average of the respective values determined at each of the two events.

5.1.1.2.2 Commercial SSO Waste Stream Characterization

Commercial SSO waste is primarily food and food soiled paper waste (excluding corrugated cardboard, which would be an ineligible waste type). By volume, commercial waste streams would likely contain a high proportion of soiled paper wastes to food waste, however on a weight basis it would be expected that the paper component of the waste stream would constitute a much smaller proportion due to the fact that food waste is very high in moisture, whereas paper material would be much less dense with a much lower moisture content. In order to quantify the proportional weight of food waste and soiled paper waste in a commercial stream, projects may apply the default factors in Table 5.1 or may use a waste sampling approach that meets the requirements for site-specific waste sampling as described above in Section 5.1.1.2.1.[34] Waste sampling events may occur onsite or at the commercial waste generation facility.

Table 5.1. Waste Generator Categories and Default Food and Soiled Paper Fractions by Weight

Waste Generator Category	Fraction of Food Waste by Weight	Fraction of Soiled Paper by Weight
Restaurants/Cafeterias/Dining Halls/Other Food Service	0.80	0.10
Super Markets and Grocery Stores	0.80	0.10
Food Wholesale Distributors	0.70	0.20
Special Events and Public Venues	0.60	0.30
Other Commercial (hotels, office buildings, wholesale distributors)	0.50	0.40

5.2 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of the project activity. Project emissions must be quantified every reporting period on an *ex-post* basis.

As shown in Equation 5.8, project emissions equal:

- Carbon dioxide emissions from mobile and stationary combustion of fossil fuels and/or the use of grid delivered electricity (SSRs 6, 7), plus
- Methane emissions produced during the composting process (SSR 7), plus
- Nitrous oxide emissions produced during the composting process (SSR 7)

[34] Default values are developed by determining the ratio of Misc. Paper and Composite Paper to Food Waste generated within each waste generator category. Each category assumes 10% ineligible feedstock by weight as a conservativeness factor. The composition data is taken from California's Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry (Cascadia Consulting Group), 2006. The data is specific to California, however the types and proportions of material generated within a category would be expected to be relatively independent of region.

Equation 5.8. Total Project Emissions

$$PE = PE_{CO_2} + PE_{CH_4,C} + PE_{N_2O,C}$$

Where,			Units
PE	=	Total project emissions for the reporting period, from all SSRs within the GHG Assessment Boundary	$MTCO_2e$
PE_{CO2}	=	Project carbon dioxide emissions for the reporting period from fossil fuel and grid electricity sources included in the GHG Assessment Boundary (SSR 6, 7)	$MTCO_2e$
$PE_{CH4,C}$	=	Project methane emissions for the reporting period from the composting of eligible waste (SSR 7)	$MTCO_2e$
$PE_{N2O,C}$	=	Project nitrous oxide emissions for the reporting period from the composting of eligible waste (SSR 7)	$MTCO_2e$

5.2.1 Project Emissions from Onsite Fossil Fuel Combustion and Grid Delivered Electricity

Included in the GHG Assessment Boundary are carbon dioxide emissions resulting from fossil fuel combustion and/or the use of grid delivered electricity for onsite equipment that is used for:

- Sorting and pre-processing of eligible waste, including stationary and mobile emission sources (SSR 6)
- Composting eligible waste materials, including stationary and mobile emission sources (SSR 7)

If the project utilizes fossil fuel or grid electricity to power equipment necessary for performing the above processes, the resulting project carbon dioxide emissions shall be calculated per Equation 5.9 below. In cases where multiple facilities are engaged in a single compost process (see Section 2.2), fossil fuel emissions from the transport of waste or compost between such facilities must also be included.

Equation 5.9. Project Carbon Dioxide Emissions from Fossil Fuel and Grid Electricity

$$PE_{CO_2} = PE_{CO_2,FF} + PE_{CO_2,GE}$$

Where,			Units
PE_{CO2}	=	Total project carbon dioxide emissions from fossil fuel and electricity sources	$MTCO_2$
$PE_{CO2,FF}$	=	Carbon dioxide emissions from the destruction of fossil fuel during the reporting period	$MTCO_2$
$PE_{CO2,GE}$	=	Indirect carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	$MTCO_2$

$$PE_{CO_2,FF} = \frac{\sum_i (FF_{PR,i} \times EF_{FF,i})}{1000}$$

Where,			Units
$FF_{PR,i}$	=	Total fossil fuel consumed by project activities during the reporting period, by fuel type *i*	volume fossil fuel
$EF_{FF,i}$	=	Fuel specific emission factor, reference from Appendix A	$kgCO_2$/volume fossil fuel
1000	=	Kilograms per tonne	$kgCO_2/MTCO_2$

$$PE_{CO_2,GE} = (EL_{PR} \times EF_{EL})$$

Where,			Units
EL_{PR}	=	Total electricity consumed by project operations during the reporting period	MWh
EF_{EL}	=	Carbon emission factor for electricity used[35]	$MTCO_2$/MWh

5.2.2 Project Emissions from the Food Waste Composting Process

Project emissions from the aerobic composting process consist of both CH_4 and N_2O. Both gases are formed during the composting process largely as a result of depleted oxygen levels in the piles/windrows. The degree to which emissions of CH_4 and N_2O occur at a compost facility depend primarily on two controllable factors: the extent to which the composting system achieves and maintains sufficient aeration and promotes aerobic decomposition throughout the entire pile/windrow, and the extent to which the GHGs that may have formed in the pile/windrow are oxidized prior to venting to the atmosphere. Typically, adequate aeration can be ensured by controlling the moisture content and porosity of the compost, ensuring proper turning frequency in windrow systems, and/or utilizing forced aeration either with positive or negative pressure blower systems. Additionally, there are certain controls that can be implemented that result with higher oxidation rates in active compost systems. For turned windrow and static pile systems, applying a layer of finished compost to the windrow/pile during the initial composting phase has been shown to greatly increases the rate at which GHGs are oxidized, while venting air through a bio-filter system (such as wood chips) also results with higher oxidation rates.[36]

[35] To find the appropriate emission factor for grid-delivered electricity, refer to the version of the U.S. EPA eGRID most closely corresponding to the time period during which the electricity was used. Projects shall use the annual total output emission rates for the subregion where the project is located, not the annual non-baseload output emission rates. The eGRID tables are available from the U.S. EPA website: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

[36] Summary of compost GHG control options based off of information obtained from: Brown et al. *Greenhouse Gas Balance for Composting Operations* (2008).

Because different composting technologies utilize varying levels of operational controls, it is to be expected that emissions of both CH_4 and N_2O will vary depending on the technology used, as well as the various process controls utilized at the project facility/facilities. The project composting operation may use one or more of the classes of compost technologies described in Table A.1 in Appendix A, or may use hybrid systems that incorporate components from more than one composting class. The composting systems are grouped into two main categories for quantifying GHG emissions: turned (non-forced aeration) systems, and forced aeration systems. Should a composting operation utilize more than one category of composting technology, the project must quantify the emissions from each category based on the amount of eligible waste composted by each system. All composting projects must quantify the emissions for each reporting period in accordance with Section 5.2.2.1 and Section 5.2.2.2, respectively.

5.2.2.1 Methane Emissions from the Composting Treatment System

CH_4 emission factors are selected based on the site-specific composting technologies and controls implemented and monitored at the project facility/facilities to reflect the fact that some composting systems have a lower risk of emitting CH_4 to the atmosphere.

Projects must use Equation 5.10 to calculate the project CH_4 emissions from the composting of all eligible food and soiled paper waste at the project facility/facilities.

Project developers must use the emission factor in Table 5.2 corresponding to the category of composting technology implemented and monitored at the facility/facilities.

Equation 5.10. Methane Emissions from Composting

$$\boldsymbol{PE_{CH_4,C}} = \sum_{\boldsymbol{T}} \left[\boldsymbol{W_{C,T}} \times \boldsymbol{EF_{CH_4,T}} \right]$$

Where,			Units
$PE_{CH4,C}$	=	Total project emissions of CH_4 from the composting of eligible wastes at the project operation	$MTCO_2e$
$W_{C,T}$	=	Aggregated weight of eligible food and soiled paper waste from all eligible waste streams composted during the reporting period in composting system category 'T'	MT
$EF_{CH4,T}$	=	Methane emission factor for the composting treatment system category 'T', taken from Table 5.2	$MTCO_2e$/MT eligible waste

$$\boldsymbol{W_{C,T}} = \left(\boldsymbol{W_{FW}} + \boldsymbol{W_{SP}} \right) \times \boldsymbol{F_{EW,T}}$$

Where,			Units
W_{FW}	=	Aggregated weight of eligible food waste from all eligible waste streams composted during the reporting period at the operation (measured on a wet basis)	MT food waste
W_{SP}	=	Aggregated weight of eligible soiled paper waste from all eligible waste streams composted during the reporting period at the operation (measured on a wet basis)	MT soiled paper waste
$F_{EW,T}$	=	Fraction of eligible waste that is treated in each composting system category 'T' during the reporting period	fraction

Table 5.2. Methane and Nitrous Oxide Emission Factors

Composting Category 'T'	Optional Process Controls (OPCs)	OPC Monitoring Requirements	CH_4 Emission Factor ($MTCO_2e$/MT of eligible waste)*	N_2O Emission Factor ($MTCO_2e$/MT of eligible waste)*
Turned Systems (Non-forced aeration turned windrows or piles)	None	N/A	0.09	0.09
	Windrows covered with 15 cm or more of finished compost or other carbonaceous material for first 3 weeks of composting cycle	Section 6.4.1	0.06	
Forced Aeration Systems (ASP or other forced aeration system)	None	N/A	0.06	0.06
	ASP systems using synthetic covers	Section 6.4.1	0.03	
	Positive Aeration – piles covered with 15 cm or more of finished compost or other carbonaceous material for first 2 weeks of composting cycle	Section 6.4.1	0.03	
	Negative Aeration – exhaust gas directed through a control system consisting of wood chips or other biofilter	Section 6.4.2	0.03	

*Bounds for emissions of CH_4 were developed based upon estimates taken from the following sources: 2006 IPCC Guidelines for National GHG Inventories, U.S. EPA Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks (2006), CDM AM0025 V.10, and Brown et al. *Greenhouse Gas Balance for Composting Operations* (2008). All Emission Factors are within the range of emission factors prescribed by the IPCC. The default value for windrow systems (0.09 MT CO_2e/MT waste) is equivalent to the IPCC default emission factor for composting.

5.2.2.2 Nitrous Oxide Emissions from the Composting Treatment System

N_2O emission factors are selected based on the site-specific composting technologies used at the project facility/facilities to reflect the fact that some composting systems have a lower risk of emitting N_2O to the atmosphere.

Projects must use Equation 5.11 to calculate the project N_2O emissions from the composting of food waste at the project facility/facilities. Project developers must use the emission factor in

Table 5.2 above corresponding to the category or categories of composting technology used onsite.

Equation 5.11. N_2O Emissions from Composting

$$\boldsymbol{PE_{N_2O,C}} = \sum_{\boldsymbol{T}} \left[\boldsymbol{W_{C,T}} \times \boldsymbol{EF_{N_2O,T}}\right]$$

Where,			Units
$PE_{N2O,C}$	=	Project nitrous oxide emissions from the composting of eligible wastes	$MTCO_2e$
$W_{C,T}$	=	Aggregated weight of eligible food and soiled paper waste from all eligible waste streams composted during the reporting period in composting system category 'T'	MT
$EF_{N2O,T}$	=	Nitrous oxide emission factor for the composting treatment system 'T', taken from Table 5.2	$MTCO_2e$/MT eligible waste

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of instrument calibration activities; the role of individuals performing each specific monitoring activity; and a detailed project diagram. The Monitoring Plan should include QA/QC provisions to ensure that data acquisition is carried out consistently and with precision.

The Monitoring Plan must include detailed monitoring procedures that the project developer will follow to demonstrate that the project waste handling and composting methods continually comply with the BMPs outlined in Section 2.2.

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test and the Regulatory Compliance Test (Section 3.4.2 and 3.5, respectively).

Project developers are responsible for monitoring the performance of the project and ensuring that the operation of all project-related equipment is consistent with the manufacturer's recommendations.

6.1 Monitoring Incoming Eligible Waste Streams

In order to quantify the GHG reductions from a composting project, the project must accurately measure the quantity of incoming waste delivered to the composting operation, by waste stream. All projects must monitor and record each shipment of waste delivered to the operation using onsite scales and/or commercial receipts. The compost operation must keep a daily log showing:

- Date and time of all deliveries of material to the operation
- The weight of each delivered incoming waste stream
- The source of each delivered incoming waste stream

In addition, the project must retain all weigh scale receipts generated either on or offsite indicating the weight and source of all delivered material to the operation. This information is necessary to aggregate the weight of eligible food and soiled paper waste delivered to the site from each eligible waste stream according to the guidance provided in Section 5.1.1 and to verify eligibility of food waste from grocery store sources.

A QA/QC procedure for the inspection and calibration of weigh scales must be included in the Monitoring Plan. All weigh scales that are not used for commercial activities must be inspected and calibrated in accordance with manufacturer's specifications. The project may document incoming waste weight using commercial receipts from on or offsite scales.

6.2 Monitoring and Documenting Pre-Project Waste Disposal for Grocery Store Waste Streams

Waste streams originating from grocery stores or supermarkets are eligible if, and only if, the project developer can document that:

- For a continuous period of at least 36 months prior to the date that waste sourced from the grocery store was first composted at the project composting operation, food and soiled paper waste generated by the grocery store was sent to a landfill, or
- Food and/or soiled paper waste originating from the grocery store was deemed as eligible waste at an OWC project registered with the Reserve, or
- The grocery store from which the waste originated is a new facility

In order to document the eligibility of the grocery store waste stream, projects must monitor the following information for each grocery store waste stream:

- The initial date the waste stream is delivered to the project composting operation, for all new grocery store waste streams
- The origin of the new grocery store waste stream (by facility)
- The previous waste disposal methods used by the grocery store waste generator, for each new grocery store waste stream
- The opening date of any new grocery store facilities supplying waste to the project

Additionally, documentation demonstrating that grocery store waste was sent to landfill(s) prior to diversion to the project composting operation or that the grocery store is a new facility should be collected and retained by the project for verification purposes. Acceptable documentation includes, but is not limited to:

- Landfill tipping receipts from the grocery store and/or contracted waste haulers
- Waste hauler contracts
- Internal memoranda and/or employee training documents detailing waste handling and/or organics separation procedures, goals, and timelines
- Media or marketing campaigns detailing dates related to the grocery store waste diversion program
- Internal documentation, store leasing documents, or media or marketing campaigns announcing the opening date of the grocery store facility

6.3 Required Compost BMP Monitoring

Composting projects must include detailed monitoring procedures in the Monitoring Plan to monitor and document that the project waste handling and composting methods continually comply with the BMPs outlined in Section 2.2.

6.3.1 Time, Temperature, and Turning Frequency BMP Monitoring

To demonstrate compliance with the Time, Temperature, and Turning Frequency BMP requirements specified in Section 2.2, projects must monitor:

- Temperature: At a minimum, temperature shall be monitored and recorded at least once a day during the period that the temperature is required to be maintained at or above 55°C.[37] Temperature shall be measured as follows:
    - For Turned Windrow Systems: At a minimum, each operation shall monitor and record a temperature measurement for every 150 feet of windrow. The temperature shall be measured no more than 24 inches below the pile surface or below the point where the insulating layer meets the pile surface, if employing a layer of finished compost or other carbonaceous material.
    - For ASP or other Forced Aeration Systems: At a minimum, each operation shall monitor and record a temperature measurement for every 200 cubic yards of active compost. The temperature shall be measured no more than 18 inches below the surface, or below the point where the cover meets the active compost pile, if using a synthetic or insulating cover.
    - Alternative for Regulated Systems: If the operation where active composting occurs has obtained regulatory approval from a local, state, regional or federal agency for its composting system, as installed, and such approval includes written confirmation that it is sufficient to ensure aerobic activity of the compost, then that operation may implement the monitoring arrangement specified therein. The project must demonstrate compliance with the BMP requirements in Section 2.2. If regulatory records are insufficient to meet the requirements of this option, then one of the two above options must be employed, depending upon the type of system.
- Turning Frequency (Turned Windrow Systems only): At a minimum, each operation shall monitor and record all turning events for every 150 feet of windrow. The turning record must include, for each turning event, the calendar date and day of the composting cycle on which the turning event occurred. Turning event monitoring and recording shall commence at the start of the active composting cycle, and conclude when the temperature falls below 55°C upon completion of the time and temperature requirements.

The temperature and turning frequency records shall be used to establish the rate of compliance with the Time, Temperature, and Turning Frequency BMP requirements from Section 2.2. The project must have records to demonstrate the total number of 150 ft. windrow sections and/or 200 cubic yard piles that were formed over the reporting period, and must demonstrate that at least 90% of the windrow sections and/or piles were composted in compliance with the relevant Time, Temperature, and Turning Frequency requirements.

Should a project fail to achieve a 90% compliance rate due to missing or inadequate data, or due to failure of a portion of the system to meet Time, Temperature, and Turning Frequency BMP requirements, the project shall discount the baseline calculation by a percentage equal to the actual rate of compliance as demonstrated by the available data over the reporting period in question.

[37] Daily temperature readings may have gaps due to site closure. Data gaps not exceeding 3 days are permitted if the measurements prior to and subsequent to the data gap indicate that the pile/windrow reached and maintained 55°C or higher for the required length of time.

6.3.2 Waste Handling BMP Monitoring

To demonstrate compliance with the Waste Handling BMP requirements specified in Section 2.2, projects must record, as part of the daily log:

- The date and time that each delivered waste stream is mixed and incorporated into the composting process
- The type of carbonaceous material applied to the waste delivered to the operation (if any)
- The date and time that carbonaceous cover material is applied to the waste delivered to the operation (if applicable)

6.4 Monitoring Requirements for Optional Process Controls

For each Optional Process Control (OPC) implemented at the operation, all parameters must be monitored as specified in the corresponding monitoring section. For periods where monitoring is insufficient or is lacking data, the project developer must assume the OPC was not implemented and use default emission factors specified in Table 5.2.

6.4.1 Monitoring Requirements for Application of Finished Compost to Pile/Windrow Surface and Synthetic Covers

Composting projects that select CH_4 emission factors based on the practice of applying a layer of finished compost to the piles/windrows for the initial phase of the active composting cycle must monitor and record the following data:

- Turned Windrow Systems: For the first 3 weeks of the active composting cycle, the project must monitor and record for every150 feet of windrow (a) the days on which finished compost or other carbonaceous material is applied and (b) the depth of each application.
- Positive ASP Systems: For the first 2 weeks of the active compost cycle, the project must monitor and record for every 200 cubic yards of active compost (a) the days on which finished compost or other carbonaceous material is applied and (b) the depth of each application.

Composting projects that select CH_4 emission factors based on the utilization of ASP systems with synthetic breathable covers must demonstrate that the pile is appropriately covered during the first two weeks of the active composting phase by monitoring and recording the following data:

- All ASP systems: For the first 2 weeks of the active compost cycle, the project must monitor and record for every 200 cubic yards of active compost (a) the days on which the pile is covered with the synthetic cover (b) the days on which the cover is removed from the pile, and (c) the type of cover applied

Additionally, projects utilizing synthetic covers must do so in a manner consistent with manufacturer specifications.

6.4.2 Monitoring Requirements for Documenting Use of Biofilter Exhaust Gas Control Systems

Composting projects that select CH_4 emission factors based on the practice of venting exhaust gas from a negative ASP composting system through a biofilter gas control system must document and record the following data:

- The type of material or material mixture used as the biofilter media
- The area and depth of the biofilter media
- The ventilation rate of the designed system
- The designed residence time of the exhaust gas in the biofilter media[38]

The above documentation is used to provide evidence during verification that the biofilter system is designed and operated to ensure oxidation of the methane component of the exhaust gas. If the residence time of exhaust gas in the media is not known or is less than 4 seconds, the project may not assume methane oxidation and therefore must use an alternate emission factor from Table 5.2.

[38] Residence time is determined by dividing the volume of the biofilter bed by the airflow rate through the bed.

6.5 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Organic Waste Composting Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
General Project Parameters						
	Regulations	Project developer attestation of compliance with regulatory requirements relating to the composting project	Environmental regulations	n/a	Each verification cycle	Information used to: 1) To demonstrate ability to meet the Legal Requirement Test – where regulation would require the diversion of food waste from landfills. 2) To demonstrate compliance with associated environmental rules, e.g. criteria pollutant wastewater discharge, etc.
Baseline Calculation Parameters						
5.2	$BE_{CH4,S}$	Baseline methane emissions from composted waste stream 'S'	$MTCO_2e$	c	Each reporting period	
5.2	$BE_{FW,S}$	Baseline methane emissions from the food waste component of eligible waste stream 'S'	$MTCO_2e$	c	Each reporting period	
5.2	$BE_{SP,S}$	Baseline methane emissions from the soiled paper component of eligible waste stream 'S'	$MTCO_2e$	c	Each reporting period	
5.3	Origin of the Food Waste	The facility (if commercial) or jurisdiction where the food waste originates	Facility or jurisdiction (municipality or county)	n/a	For each shipment of inbound waste	This information is necessary to track eligible food waste streams and ineligible food waste streams that are composted by the project, as well as to determine appropriate decay rates (k values) to use in the calculation.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.3, 5.5	$W_{FW,S,}$	The wet weight of each eligible food waste stream composted by the project	MT of waste	m, c	For each shipment of inbound waste for each waste stream 'S'	Total weight must be measured for each delivery of waste, and the proportional weight of food waste determined for each source and aggregated over the reporting period.
5.3, 5.4	WTE_S	The fraction of waste from eligible waste stream 'S' that would have been incinerated in the absence of the project	Fraction by weight	r	Each reporting period	Referenced for each waste stream from Appendix A by state of origin of the waste stream.
5.3	$FE_{FW,S}$	Fraction of methane generated that is emitted to the atmosphere over a ten year time horizon	Fraction	c	Each reporting period	Calculated using the First Order Decay function.
5.3	$k_{FW,S}$	Decay rate of food waste, by waste stream 'S'	yr^{-1}	r	Each reporting period	Referenced from Appendix A, Figure A.2. The appropriate k value shall be chosen based on the k value applicable to the county-specific climate where the waste originated.
5.3, 5.4	GC_S	The state-specific gas collection fraction	Fraction	r	Each reporting period	Equal to the fraction of total waste that is disposed at open landfills with known or potential LFG collection systems. Referenced from Appendix A, Table A.3.
5.3	LCE_x	Fraction of methane that would be captured and destroyed by LFG collection systems in year x	Fraction	r	Each reporting period	All projects shall use a value of 0.0 for the first two years of calculated waste decay (x=1 to 2), a value of 0.5 for the third year (x=3), a value of 0.75 for years 4 to 7 (x=4 to 7), and a value of 0.95 for the remaining years of decay until the end of the calculation period (x =8 to 10). See Box 5.1 for a discussion of LCE assumptions.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.4, 5.5	$W_{SP,S}$	The wet weight of each eligible soiled paper waste stream composted by the project	MT of waste	m, c	For each shipment of inbound waste for each waste stream 'S'	Total weight must be measured for each delivery of waste, and the proportional weight of soiled paper waste determined for each source and aggregated over the reporting period.
5.4	$FE_{SP,S}$	Fraction of methane generated that is emitted to the atmosphere over a ten year time horizon	Fraction	c	Each reporting period	Calculated using the First Order Decay function.
5.4	$k_{SP,S}$	Decay rate of soiled paper waste, by waste stream 'S'	yr^{-1}	r	Each reporting period	Referenced from Appendix A, Figure A.2. The appropriate k value shall be chosen based on the k value applicable to the county-specific climate where the waste originated.
5.5	$W_{T,S}$	The aggregated total wet weight of waste delivered to the site from eligible waste stream 'S'	MT of waste	m	For each shipment of inbound waste for each waste stream 'S'	Total weight must be measured for each delivery of waste in order to determine the weight of eligible food and soiled paper waste from each waste stream that is composted by the operation during the reporting period.
5.5	FC_S	Fraction of eligible waste stream 'S' composted by the project	Fraction	c	Each reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.5, 5.6	$F_{FW,S}$	The food waste fraction by wet weight of eligible waste stream 'S'	Fraction by weight	m, c	Quarterly or each reporting period	The fraction of food waste must be determined for each waste stream 'S'. The fraction is determined according to Sections 5.1.1.1 or 5.1.1.2. For Residential SSO waste, measured quarterly or referenced from local data each reporting period. For Commercial SSO waste, referenced for each reporting period. For mixed MSW, measured quarterly or referenced for each reporting period.
5.5, 5.7	$F_{SP,S}$	The soiled paper waste fraction by wet weight of eligible waste stream 'S'	Fraction by weight	m, c	Quarterly or each reporting period	The fraction of soiled paper waste must be determined for each waste stream 'S'. The fraction is determined according to Sections 5.1.1.1 or 5.1.1.2. For Residential SSO waste, measured quarterly or referenced from local data each reporting period. For Commercial SSO waste, referenced for each reporting period. For mixed MSW, measured quarterly or referenced for each reporting period.
5.6, 5.7	$F_{i,S}$	Fraction of waste category *i* in MRF fines waste stream 'S'	Fraction	m, c	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The fraction of waste category *i* must be determined for each waste stream 'S'. The fraction is determined according to Section 5.1.1.1.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.6	W_{HS}	Weight of sample taken in large preliminary hand sort	lb	m	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The total weight of all fines larger than approximately two inches in diameter sorted and screened during preliminary screen of sample.
5.6	$F_{i,HS}$	Fraction of waste category *i* in large preliminary hand sort	Fraction	m, c	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The fraction of waste category *i* must be determined for each large preliminary hand sort. The fraction is determined according to Section 5.1.1.1.
5.6	W_{PR}	Weight of total sample after large particles removed	lb	m	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The total weight of all fines equal to or smaller than approximately two inches in diameter that remain following preliminary screen of sample.
5.6	$F_{i,QS}$	Fraction of waste category *i* in quarter sample	Fraction	m, c	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The fraction of waste category *i* must be determined for each quarter sample. The fraction is determined according to Section 5.1.1.1.
5.6, 5.7	W_{sample}	Weight of total sample prior to hand sort	lb	m	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	$W_{sample} = W_{HS} + W_{PR}$
Project Calculation Parameters						
5.8, 5.9	PE_{CO2}	Total project carbon dioxide emissions from fossil fuel and grid electricity	$MTCO_2e$	c	Each reporting period	
5.8, 5.10	$PE_{CH4,C}$	Project methane emissions from composting eligible waste	$MTCO_2e$	c	Each reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.8, 5.11	$PE_{N2O,C}$	Project nitrous oxide emissions from composting eligible waste	$MTCO_2e$	c	Each reporting period	
5.9	$FF_{PR,i}$	Total fossil fuel consumed by onsite combustion, by fuel type i	Volume	o	Each reporting period	Referenced from fuel use records or estimated based on miles traveled (for mobile combustion sources not owned or operated by the project developer).
5.9	$EF_{FF,i}$	Fuel-specific emission factor	$kgCO_2$ / volume	r	Each reporting period	Referenced from Appendix A.
5.9	EL_{PR}	Total electricity consumed by project operations	MWh	o	Each reporting period	From electricity use records.
5.9	EF_{EL}	Carbon emission factor for electricity used	$lbCO_2$ / MWh	r	Each reporting period	Referenced from Appendix A.
5.10, 5.11	$W_{C,T}$	The aggregated wet weight of all eligible food and soiled paper waste composted in composting system 'T'	MT of waste	m	Each reporting period	Aggregated from the weight of food and soiled paper waste from all eligible waste streams delivered to the site.
5.10	$EF_{CH4,T}$	The methane emission factor for composting system 'T'	$MTCO_2e$ / MT waste	r	Each reporting period	Referenced from Table 5.2 for each composting system.
5.10	W_{FW}	The aggregated wet weight of eligible food waste from all eligible waste streams delivered to the operation	MT of waste	m	Each reporting period	Aggregation of eligible waste streams only.
5.10	W_{SP}	The aggregated wet weight of eligible soiled paper waste from all eligible waste streams delivered to the operation	MT of waste	m	Each reporting period	Aggregation of eligible waste streams only.
5.10	$F_{EW,T}$	The fraction of eligible waste composted in system 'T'	Fraction by weight	o	Each reporting period	Based on the net volume of waste composted in each system 'T' at the operation.
5.11	$EF_{N2O,T}$	The nitrous oxide emission factor for composting system 'T'	$MTCO_2e$ / MT waste	r	Each reporting period	Referenced from Table 5.2 for each composting system.

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit verified emission reduction reports to the Reserve annually at a minimum.

7.1 Project Submittal Documentation

Project developers must provide the following documentation to the Reserve in order to register a composting project.

- Project Submittal form
- Project diagram (including information on each eligible waste stream category processed at that composting operation, project activities, and BMP monitoring – see Appendix C)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.

- Verification Report
- Verification Statement
- Project diagram (if changed from previous reporting period)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form

At a minimum, the above project documentation (except for the project diagram) will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Copies of all permits, Notices of Violations (NOVs), and any relevant administrative or legal consent orders dating back at least 3 years prior to the project start date
- Executed Attestation of Title forms, Attestation of Regulatory Compliance forms and Attestation of Voluntary Implementation forms

- Onsite weigh station calibration results
- Waste delivery receipts and records
- Daily logs detailing weight and source of all incoming waste streams
- Grocery store waste stream pre-project waste handling documentation and monitoring records
- Results of all residential waste stream hand-sorting events
- Compost BMP and OPC monitoring data
- Onsite fossil fuel use records
- Onsite grid electricity use records
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results
- All maintenance records relevant to the composting equipment and monitoring equipment

7.3 Reporting Period and Verification Cycle

Project developers must report GHG reductions resulting from project activities during each reporting period. Although projects must be verified annually at a minimum, the Reserve will accept verified emission reduction reports on a sub-annual basis, should the project developer choose to have a sub-annual reporting period and verification schedule (e.g. monthly, quarterly, or semi-annually).

To meet the annual verification deadline, the project developer must have the required verification documentation submitted within 12 months of the end of each reporting period (see Section 7.1). A reporting period cannot exceed 12 months, and no more than 12 months of emission reductions can be verified at once, except during a project's initial verification. Although there is some flexibility in the length of the initial reporting period, the project developer must still meet the 12-month verification deadline.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the diversion of organic waste away from landfills to aerobic composting systems. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to OWC projects.

Verification bodies trained to verify organic waste composting projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Organic Waste Composting Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify OWC project reports. Verification bodies approved under other project protocol types are not permitted to verify OWC projects. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at: http://www.climateactionreserve.org.

8.1 Standard of Verification

The Reserve's standard of verification for OWC projects is the OWC Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify an OWC project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, that consistent, rigorous monitoring and record-keeping is ongoing at the project site, and that the project has implemented and is monitoring the BMPs prescribed in Section 2.2 of this protocol. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm an OWC project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for OWC projects. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for an Organic Waste Composting Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing no more than 6 months after the project start date	Once during first verification
Location	United States and its territories, and U.S. tribal areas	Once during first verification
Performance Standard	The following eligible waste streams are aerobically composted at the project's composting operation: ▪ Food Waste: Food waste commonly disposed into a MSW system, consisting of uneaten food, food scraps, spoiled food and food preparation wastes ▪ Food Soiled Paper Waste: non-recyclable paper items that are co-mingled with food waste, consisting of paper napkins and tissues, paper plates, paper cups, fast food wrappers, used pizza boxes, and other similar paper items typically disposed of in an MSW system ▪ Food and soiled paper waste from grocery stores that historically sent food waste to landfills prior to sending food waste for composting at the project operation ▪ Food and soiled paper waste from new grocery store facilities	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of non-compliance to verifier; project must be in material compliance with all applicable laws	Every verification

8.4 Core Verification Activities

The Organic Waste Composting Project Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with the diversion of organic waste away from landfills to aerobic composting. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of an OWC project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emissions sources, sinks, and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as, *inter alia*, food and soiled paper waste disposal at landfills, and onsite aerobic composting of food and soiled paper waste.

Reviewing GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the methodologies and management systems that the OWC project operator uses to gather data and calculate baseline and project emissions.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project facility (or facilities if the project includes multiple facilities involved in a single compost process) to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.5 OWC Verification Items

The following tables provide lists of items that a verification body needs to address while verifying an OWC project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to OWC projects that must be addressed during verification.

8.5.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for OWC projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of an OWC project	No
2.2	Verify that the project composting facility (or multiple facilities engaged in a single compost process) has implemented the required BMPs for composting	No
2.3	Verify ownership of the reductions by reviewing Attestation of Title	No
3.2	Verify project start date	No
3.2	Verify that the project has documented and implemented a Monitoring Plan that contains a mechanism to ensure compliance with the BMPs defined in Section 2.2 of this protocol	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that project is within its 10 year crediting period	No
3.4.1	Verify that the project meets the Performance Standard Test	No
3.4.1	Verify that that the project has documentation showing that all eligible waste streams originating from grocery stores or super markets were previously landfilled prior to the date that the waste is first delivered to the composting operation	Yes
3.4.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.4.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	No
3.5	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that variance has been approved for monitoring variations	No

8.5.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
5.1	Verify that the baseline emissions from different eligible waste stream are properly aggregated	No
5.1.1	Verify that the correct k value is used for each food and soiled paper waste stream's baseline calculation	No
5.1	Verify that the FOD equation is used correctly for the food waste and soiled paper components of each eligible waste stream	No
5.1	Verify that baseline equation parameters, including referenced parameters, are applied correctly in the FOD equation	No
5.1.1	Verify that the proportional weight of food and soiled paper waste is determined for each eligible waste stream according to the requirements in Section 5.1.1.1 and/or 5.1.1.2	No
5.1.1.2.1	Verify that all Residential SSO waste streams have used either local jurisdiction waste characterization data or quarterly hand sorting to determine the proportion of food and soiled paper in the waste stream	No
5.1.1.2.2	Verify that all Commercial SSO waste streams have used either generator supplied waste characterization data or the sector-specific default values to determine the proportion of food and soiled paper in the waste stream	No
5.2	Verify that the project emissions calculations were calculated according to the protocol with the appropriate data	No
5.2.1	Verify that the project developer correctly monitored, quantified and aggregated electricity use	Yes
5.2.1	Verify that the project developer correctly monitored, quantified and aggregated fossil fuel use	Yes
5.2.1	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5.2.2	Verify that the project developer has correctly categorized the onsite composting treatment systems as either 'Turned Systems' or 'Forced – Aeration Systems'	Yes
5.2.2.1	Verify that the project developer has correctly applied methane emission factors	No
5.2.2.1	If default methane emission factors are not used, verify that project specific emission factors are based on official source tested emissions data or are from an accredited source test service provider	No
5.2.2.1	Verify that the project developer has correctly documented and monitored all Optional Process Controls	Yes
5.2.2.2	Verify that the project developer correctly applied nitrous oxide emission factors	No
5.2.2.2	If default methane emission factors are not used, verify that project specific emission factors are based on official source tested emissions data or are from an accredited source test service provider	No

8.5.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that the Composting system was operated and maintained according in a manner that would ensure that the BMPs in Section 2.2 are met	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
7.2	Verify that all required records have been retained by the project developer	No

8.6 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the California Registry to provide verification services for project developers.
Additionality	Organic waste management practices that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Aerobic	Requiring oxygen.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Composting process	The collection of steps required to prepare and convert raw organic waste into finished compost.
Composting operation	A single facility, or a full complement of multiple facilities, necessary to process biodegradable organic solid waste components into a mature compost product.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Effective Date	The date of initial adoption of this protocol by the Reserve Board: June 30, 2010.
Emission factor (EF)	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
First Order Decay model (FOD model)	A calculation developed to model the decay of waste under anaerobic conditions, based off of first-order kinetic equations.
Food waste	Non-industrial food waste commonly disposed into a MSW system, consisting of uneaten food, spoiled food and food preparation wastes from homes, restaurants, kitchens, grocery stores, campuses, cafeterias, and similar institutions.

Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
Grocery store or supermarket	A grocery store is a store established primarily for the retailing of food. Large grocery stores that stock products other than food, such as clothing or household items, are referred to as supermarkets.
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Landfill	A defined area of land or excavation that receives or has previously received waste that may include household waste, commercial solid waste, non-hazardous sludge and industrial solid waste.
Landfill gas (LFG)	Gas resulting from the decomposition of wastes placed in a landfill. Typically, landfill gas contains methane, carbon dioxide and other trace organic and inert gases.
Materials Recovery Facility (MRF)	A specialized plant that receives, sorts, and processes MSW in order to extract materials of value that would ordinarily otherwise go to landfill.
Metric ton or “tonne” (MT)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).

Mixed MSW	Non-source separated waste consisting of organic and inorganic components, reflecting waste typically disposed of at a landfill.
MRF fines	Residual material from the processing of mixed MSW at a materials recovery facility, characterized by small particle size and relatively high organics content as compared to typical mixed MSW loads. This material is not source-separated.
National Emission Standards for Hazardous Air Pollutants (NESHAP)	Federal emission control standards codified in 40 CFR 63. Subpart AAAA of Part 63 prescribes emission limitations for MSW landfills.
New Source Performance Standards (NSPS)	Federal emission control standards codified in 40 CFR 60. Subpart WWW of Part 60 prescribes emission limitations for MSW landfills.
Project baseline	A business as usual GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a GHG project.
Resource Conservation and Recovery Act (RCRA)	Federal legislation under which solid and hazardous waste disposal facilities are regulated.
Soiled paper waste	Non-recyclable paper items that are co-mingled with food waste, consisting of paper napkins and tissues, paper plates, paper cups, fast food wrappers, used pizza boxes, and other similar paper items typically disposed of in an MSW system.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
Verification	The process used to ensure that a given participant's greenhouse gas emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Waste stream	A supply of waste originating from a specific type of facility (if commercial waste) or jurisdiction (if residential waste). For the purpose of this protocol, eligible waste streams are further defined in Section 3.4.1.

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Appendix A Data Lookup Tables

Table A.1. Composting System Descriptions

Composting System	Description	% of Market	Likely to Meet BMP Requirements
Passive Piles	Passive piles rely predominantly on natural convection, a function of the porosity (or free air space) of the material or mix being composted. Passive piles are often turned very infrequently and may not be suitable for all feedstocks. Passive piles are likely to contain anaerobic pockets. Temperatures in these piles may not heat up to regulatory requirements for pathogen destruction, one of the hallmarks of commercial and municipal composting. For these reasons, passive piles do not meet the BMP requirements per this protocol.	<5%	No
Turned windrows	The predominant method of composting in the US. Windrow composting involves making elongated trapezoidal piles, which are turned with either a tractor, front-end loader, or specialized turning equipment. There can be significant variation in windrow size (which typically depends on the equipment used to turn the pile), windrow length, and management intensity. Some facilities can make quality compost in 8 to 9 weeks or longer from start to finish. Windrow operations can easily reach temperatures required for pathogen destruction. In these systems, any anaerobic regions are concentrated at the bottom of the windrow. Heat from decomposition dries these piles and in many cases, additional water is added to maintain sufficient moisture for microbial decomposition	90%	Yes
Aerated Static Piles (uncontained and contained)	These systems use a blower to introduce air into the composting mass, either with positive or negative pressure. ASPs can be uncontained or contained using membrane cover, or contained in an enclosed (in-vessel) or in-building system. The advantage of negatively aerating a static pile is that the exhaust can be directed to a point source and put through a control system such as a biofilter.	<5%	Yes

Table A.2. Decay Rates (k) by Waste Type and Climate

Climatic Category	Food Waste Decay Rates $k_{FW,S}$ (yr-1)	Soiled Paper Decay Rate $k_{SP,S}$ (yr-1)*
Temperate, Dry	0.06	0.04
Temperate, Wet	0.185	0.06
Tropical, Dry	0.085	0.045
Tropical, Wet	0.4	0.07

Source: UNFCCC Clean Development Mechanism: Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site.

* Soiled paper decay rate assumed to be equal to the decay rate of office paper, per communication with M. Barlaz.

Table A.3. Gas Collection Fractions, by State

Landfill State	Total Annual Waste Acceptance at Open Landfills (tons)				Fraction of Total Waste that is Accepted at Open Landfills with Known or Potential LFG Collection Systems	Gas Collection Fractions
	Landfills with No LFG Collection Systems	Landfills where LFG Collection Status is Unknown	Landfills with LFG Collection Systems	All Landfills		
AK	182,674	72,900	350,000	605,574	70%	0.70
AL	3,249,929	1,040,000	4,731,995	9,021,924	64%	0.64
AR	471,646		936,455	1,408,101	67%	0.67
AZ	387,105		4,064,059	4,451,164	91%	0.91
CA	1,397,403		35,968,060	37,365,463	96%	0.96
CO	1,474,132		4,810,118	6,284,250	77%	0.77
CT			158,164	158,164	100%	1.00
DE			830,741	830,741	100%	1.00
FL	2,132,545		14,359,416	16,491,961	87%	0.87
GA	1,170,878	166,567	10,390,734	11,728,179	90%	0.90
HI	249,249		578,335	827,584	70%	0.70
IA	1,152,713	71,272	1,491,316	2,715,301	58%	0.58
ID	548,261		763,791	1,312,052	58%	0.58
IL	434,737		13,667,105	14,101,842	97%	0.97
IN	1,831,127		8,889,583	10,720,710	83%	0.83
KS	1,401,161		2,548,150	3,949,311	65%	0.65
KY	1,124,893		5,238,221	6,363,114	82%	0.82
LA	473,833		4,368,346	4,842,179	90%	0.90
MA	900		2,184,392	2,185,292	100%	1.00
MD	453,344		1,785,180	2,238,524	80%	0.80
ME	26,355		851,679	878,034	97%	0.97
MI	456,335		16,258,806	16,715,141	97%	0.97
MN	139,398		1,631,572	1,770,970	92%	0.92
MO	255,400		2,424,101	2,679,501	90%	0.90
MS	842,731		2,402,865	3,245,596	74%	0.74
MT	179,576		603,515	783,091	77%	0.77
NC	1,527,569	50,802	5,380,169	6,958,540	78%	0.78
ND	197,579		140,000	337,579	41%	0.41

NE	438,116		1,715,057	2,153,173	80%	0.80
NH	153,449		1,783,857	1,937,306	92%	0.92
NJ			4,095,824	4,095,824	100%	1.00
NM	83,321		1,348,266	1,431,587	94%	0.94
NV	341,668		3,507,687	3,849,355	91%	0.91
NY	526,891		7,430,008	7,956,899	93%	0.93
OH	2,163,712		17,047,685	19,211,397	89%	0.89
OK	828,876		3,161,706	3,990,582	79%	0.79
OR	373,788		4,386,823	4,760,611	92%	0.92
PA	289,651		18,361,866	18,651,517	98%	0.98
PR	1,814,530		1,401,900	3,216,430	44%	0.44
RI	9,760		1,507,847	1,517,607	99%	0.99
SC	429,431		6,470,888	6,900,319	94%	0.94
SD	273,700		178,321	452,021	39%	0.39
TN	524,290		5,131,608	5,655,898	91%	0.91
TX	2,657,648	25,701	18,413,494	21,096,843	87%	0.87
UT	1,220,353		1,360,428	2,580,781	53%	0.53
VA	433,948	125,755	13,048,150	13,607,853	97%	0.97
VI			85,000	85,000	100%	1.00
VT	11,788		520,000	531,788	98%	0.98
WA	203,059		4,246,249	4,449,308	95%	0.95
WI	95,026		8,457,871	8,552,897	99%	0.99
WV	385,188	26,496	1,381,594	1,793,278	79%	0.79
WY	275,453			275,453	0%	0%
Grand Total	35,295,119	1,579,493	272,848,997	309,723,609	89%	N/A

Source: U.S. EPA Landfill Methane Outreach Program (LMOP) Database (2012).

Table A.4. Fraction of Waste Sent to Waste to Energy Facilities, by State

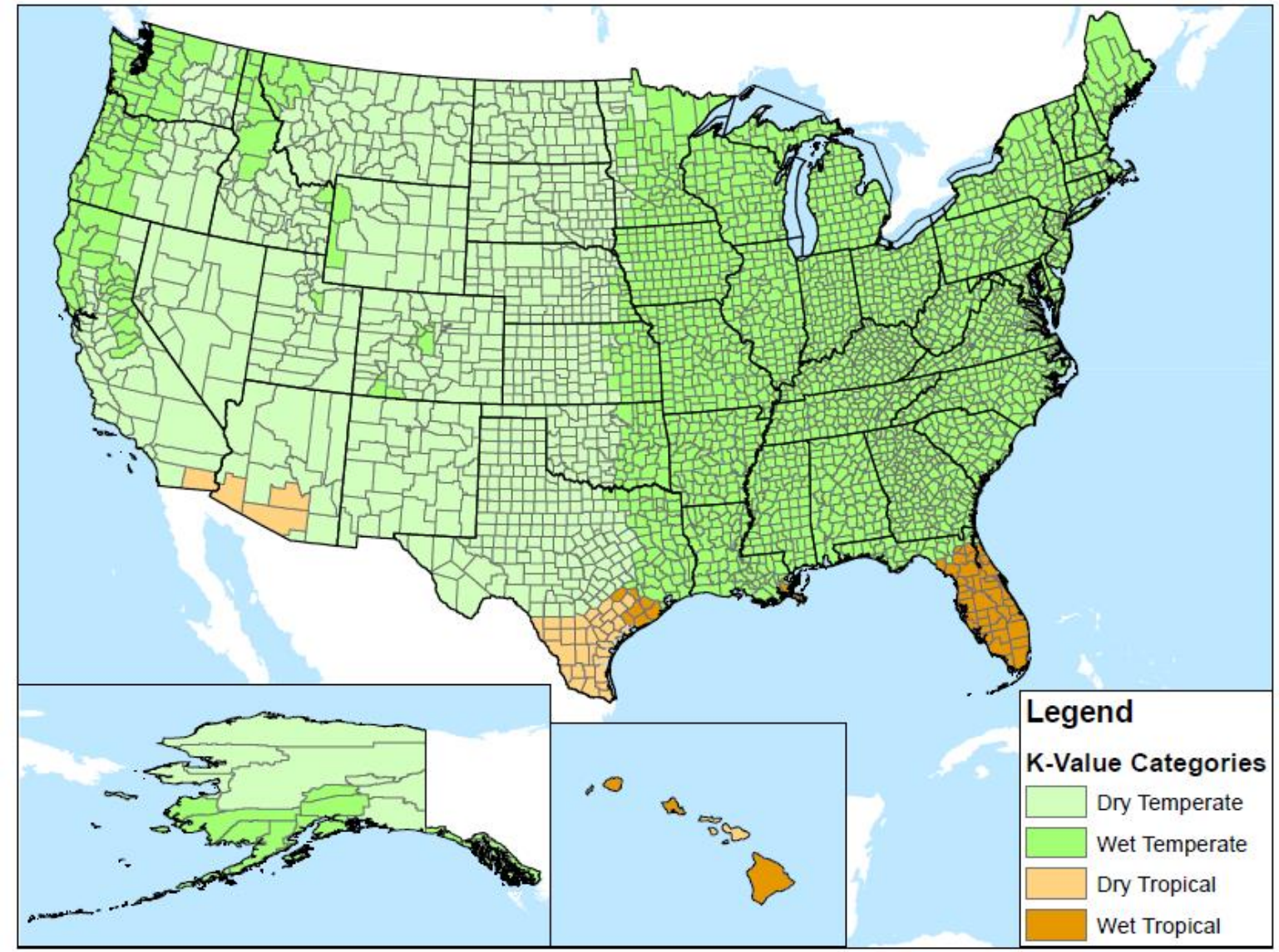
State	WTE_S (Fraction)
ALABAMA	0.03
ALASKA	0.03
ARIZONA	0.00
ARKANSAS	0.01
CALIFORNIA	0.02
COLORADO	0.00
CONNECTICUT	0.65
DELAWARE	0.00
FLORIDA	0.25
GEORGIA	0.01
HAWAII	0.28
IDAHO	0.00
ILLINOIS	0.00
INDIANA	0.05
IOWA	0.01
KANSAS	0.00
KENTUCKY	0.00
LOUISIANA	0.04
MAINE	0.19
MARYLAND	0.20
MASSACHUSETTS	0.37
MICHIGAN	0.07
MINNESOTA	0.21
MISSISSIPPI	0.00
MISSOURI	0.01
MONTANA	0.01
NEBRASKA	0.00
NEVADA	0.00
NEW HAMPSHIRE	0.16
NEW JERSEY	0.15
NEW MEXICO	0.00
NEW YORK	0.20
NORTH CAROLINA	0.01
NORTH DAKOTA	0.00
OHIO	0.00
OKLAHOMA	0.08
OREGON	0.04
PENNSYLVANIA	0.19
RHODE ISLAND	0.00
SOUTH CAROLINA	0.05
SOUTH DAKOTA	0.00
TENNESSEE	0.00
TEXAS	0.00
UTAH	0.04
VERMONT	0.09
VIRGINIA	0.13
WASHINGTON	0.04
WEST VIRGINIA	0.00
WISCONSIN	0.03
WYOMING	0.00

Source: Biocycle State of Garbage Report (2006). Table 3. (http://www.jgpress.com/images/art/0604/table3.gif)

Table A.5. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBtu / Short ton**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**Btu / Standard cubic foot**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Standard cub. ft.**
975 to 1,000 Btu / Std cubic foot	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Std cubic foot	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Std cubic foot	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Std cubic foot	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Std cubic foot	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Std cubic foot	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBtu / Barrel**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2 & 4)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 & 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401 deg. F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401 deg. F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable). Heat content factors are based on higher heating values (HHV).



Source: USGS, Hydrologic landscape regions of the United States (2003).

Figure A.1. K-Value Categories in the U.S., by County

Appendix B Summary of Performance Standard and Regulatory Research

The performance standard for the Organic Waste Composting Project Protocol was modified from the Organic Waste Digestion Project Protocol performance standard analysis and the Methane Avoidance from Composting issue paper completed by Science Applications International Corporation[39] (SAIC) in May 2009 and September 2009, respectively. The analysis culminated in two papers that provided performance standard options and recommendations to support the Reserve's protocol development process, which the Reserve has incorporated into the protocol's eligibility rules (see Section 3).

The purpose of a performance standard is to establish a threshold that is significantly better than common practice with regard to greenhouse gas (GHG) emissions for a specified service. If the threshold is voluntarily met or exceeded by a project developer, then the criterion for "additionality" is satisfied. The Reserve's project protocol focuses on the following emission reduction activity: the composting of organic food waste that was previously treated in MSW Landfills.

The analysis to establish the performance standard for the OWD protocol evaluated organic waste management practices in the specified categories of waste streams. The SAIC research for this study did not provide a detailed quantitative analysis of organic waste practices or volumes in the U.S. but rather provided a qualitative review of current practices and regulations for the identified waste categories. Ultimately, the analysis recommended for each waste category whether a performance standard to improve GHG emissions could be established. The Methane Avoidance from Composting issue paper completed subsequent to the OWD performance standard analysis largely confirmed the findings in regards to how the OWD protocol utilized the information in the OWD performance standard to define eligible vs. ineligible materials. The following sections summarize the methodology and key findings of the performance standard research.

B.1 Selected Waste Generating Industries

As organic waste sources span across a range of different point sources and disposal locations, an industry-based approach was utilized to inform the performance standard. A list of 82 industries was identified using the North American Industry Classification System (NAICS), the standard used by federal statistical agencies in classifying business establishments.[40] The list of 82 industries was then shortlisted based on their organic waste generation and greenhouse gas emissions potential. Thirty-one industries were shortlisted for detailed analysis. These were organized under the two categories of organic waste relevant to composting projects:

- Food and food-processing solid waste sources
- Agricultural solid waste sources

Table B.1 shows the major organic waste generating industries considered in the paper.

[39] http://www.climateactionreserve.org/wp-content/uploads/2009/11/Reserve_Composting_Issue_Paper_Final.pdf
[40] http://www.census.gov/eos/www/naics/

Table B.1. Selected Organic Waste Source Industries Studied

Category	Industry	Organic Waste Source Categories		Primary Manufacturing	Secondary Manufacturing
		Food & Food Processing Solid Waste	Agricultural Solid Waste		
Grain Manufacturing	1. Rice Milling 2. Malt Manufacturing 3. Wet Corn Milling		X	X	
Oilseed Processing	4. Soybean Processing 5. Other Oilseed Processing		X	X	
Sugar Manufacturing	6. Sugarcane Mills 7. Cane Sugar Refining 8. Beet Sugar Manufacturing	X	X	X	X
Fruit and Vegetable Manufacturing	9. Frozen Fruit, Juice, and Vegetable Manufacturing 10. Fruit and Vegetable Canning	X		X	X
Pre-Cooked Foods	11. Frozen Specialty Food Manufacturing 12. Specialty Canning 13. Commercial Bakeries	X			X
Dairies	14. Fluid Milk Manufacturing 15. Creamery Butter Manufacturing 16. Cheese Manufacturing	X			X
Animal/ Seafood Processing	17. Animal (except Poultry) Slaughtering 18. Meat Processed from Carcasses 19. Rendering and Meat Byproduct Processing 20. Poultry Processing 21. Seafood Canning	X		X	X
Beverage Manufacturing	22. Soft Drink Manufacturing 23. Breweries 24. Wineries	X			X
Paper Milling	25. Paper (except Newsprint) Mills 26. Paperboard Mills 27. Cellulosic Organic Fiber Manufacturing	X*			X
Fertilizer Manufacturing	28. Nitrogenous Fertilizer Manufacturing 29. Phosphatic Fertilizer Manufacturing 30. Fertilizer (Mixing Only) Manufacturing + Compost Manufacturing	X*	X		X
Medicinal Manufacturing	31. Medicinal and Botanical Manufacturing	X*			X

* Non-food industries that generate organic wastes (note, for the purposes of this study, these industries were grouped with the food processing for research, analysis and discussion).

Primary manufacturing is characterized by industries that process an agricultural or forestry product. These manufacturing plants or operations will generally be largest, and will produce the greatest quantities of waste per plant. Because of their large waste volumes and the producers' motivation to sell products to their highest use (and value), manufacturers will typically sell waste products to buyers who use them as feedstock for secondary products. Secondary manufacturing, on the other hand, is producing a more finished product from the primary manufacturing products.

In addition to these "pre-consumer" industries, SAIC also uncovered relevant information on "post-consumer" organic wastes from the Municipal Solid Waste streams in the U.S. such as food scraps and yard trimmings. Data was also obtained and analyzed for FOG wastes from pre and post-consumer sources.

B.2 Organic Waste Generation and Management and Composting Performance Standard Options

SAIC looked at two categories of organic waste relevant to composting projects: 1) solid food waste and 2) agricultural solid waste. They determined the types of waste and industries associated with each category, as well as waste quantities for each type of the waste and any seasonal and geographical variations. SAIC then looked at waste management practices in the U.S. for each of the two categories and provided an overview of how waste emissions arise, the methane potential of the waste, how it is managed in a "business as usual" setting and alternative management technologies.

The gathered evidence showed that for the two categories there is a strong economic incentive to extract and recover solids from waste streams and convert these into by-products or to burn wastes for energy.[41] Thus, the common practices of activity for these waste streams are already those with very low GHG emission potentials.

However, there are a few industrial solid food wastes that cannot be reused as byproducts and inevitably end up in landfill. Some examples of landfilled solid food waste identified in the research include milk solids, condemned animal carcasses, meat scraps, and pomace wastes from winery. Further studies should be conducted to determine if these niche pre-consumer waste streams can be better characterized and included into a food waste offset methodology.

Non-Industrial Food Waste

Studies by the U.S. EPA identified that 31.7 million tons of non-industrial food waste was generated in 2007, or 12.5% of total national MSW waste generated. In addition, studies by Biocycle Magazine estimate that just 0.8 million tons or 2.6% of this quantity was diverted from landfill to compost in 2007.[42] Since only 2.6% of this waste is currently being diverted, this would typically qualify as achieving significantly improved GHG performance and meeting a stringent performance threshold. Although not specifically addressed in the Biocycle Magazine estimate or EPA waste diversion estimates, the composting work group has supplied evidence that the majority of the non-industrial food waste that is currently composted in the U.S. is likely a result

[41] The burning of agricultural solids generates biogenic carbon in the form of CO_2 and is therefore considered carbon neutral. However, open burning of these wastes is an incomplete combustion process and can generate soot, carbon monoxide, and other pollutants of concern. There could be some GHG benefits from reducing open burning by reducing carbon black formation and some N_2O formed during incomplete combustion, since these would be considered anthropogenic. Further study would be needed to establish if GHG emissions from carbon black and N_2O resulting from open burning are significant.

[42] As of 2010, this figure has remained largely unchanged, having risen to 2.8%.

of waste diversion programs implemented at super markets and grocery stores, particularly supermarkets that are part of large regional chains.

FOG Wastes

FOG wastes (Fats, Oils, and Grease) were also studied for their generation and disposal practices. It was discovered that yellow grease is a valuable product which is almost always recycled into byproducts such as biofuels and rendered animal fats are also converted into valuable products such as soap and cosmetics. Brown grease (or grease trap grease) is mostly sent to Publicly Owned Treatment Works (POTWs) with some individual practices being identified which involve solids being separated and sent to landfill. However, this is estimated to be a very small amount and in leading states, reuse of brown grease as biofuel feedstock is becoming common, as well as hauling to rendering plants for extraction of valuable components for reuse. Common practice therefore recognizes FOG waste as a recyclable resource and only small quantities are being sent to landfill, so it is concluded that these waste types would not qualify as achieving significantly improved GHG performance through application in composting projects.

Yard Waste

Another organic waste category studied was yard waste. An estimated 32.6 million tons of yard trimmings were generated in 2007, or 12.8% of total national MSW generated. Unlike the low diversion rate of post-consumer food waste, the EPA estimated 20.9 million tons of yard trimmings, or 64.1% of the total quantity, was diverted from landfill for composting or mulching in 2007.[43] This is therefore the common practice and for the same reasons as were given for pre-consumer solid waste, a performance standard showing significantly improved performance above common practice cannot be established for yard waste.

B.3 Regulatory Conditions and Regulatory Additionality Recommendations

In order to properly credit emission reductions from organic waste composting projects, it is important to establish regulatory additionality that determines whether a project fulfills a regulatory obligation or if a project provides additional emission reductions beyond what is required by law. All GHG reduction projects are subject to a Legal Requirement Test to ensure that the emission reductions achieved by a project would not otherwise have occurred due to federal, state or local regulations.

In the study, SAIC found that there are no federal or state regulations currently in place that obligate waste source producers to divert waste to an aerobic composting facility. For landfills, Federal and State laws have long required methane collection systems. In California, starting in 2010, AB32 will also require any remaining uncontrolled MSW landfills to install emission control systems to manage methane emissions from the decomposition of organic matter.

Through AB939, California also calls for all municipalities to currently divert 50% of their waste stream from landfills. Thus, any municipality that has already achieved its landfill diversion goal would meet the Legal Requirement Test for additional landfill diversions of food wastes. Conversely, a municipality that has not yet met its landfill diversion target may not fulfill the Legal Requirement Test for additional landfill diversions (at least until the target is achieved). Other States such as North Carolina and Missouri have similar landfill diversion goals that are not mandated on the jurisdiction level, and therefore do not impact regulatory additionality.

[43] As of 2010, this figure has decreased slightly, to 57.4%. This modest change does not affect the original conclusion.

With a myriad of regulations that wholly or partly apply to activities involved with organic waste disposal (e.g. air quality, water quality, compost management) and with a wide variety of industries that generate organic wastes, compost project owners need to ensure their diversion of organics to an aerobic composting facility continues to meet relevant regulatory requirements for disposal. This will most likely need to be done on a case by case basis depending on the location, quantity of waste, and the operation that is generating the waste in order to properly account for any additional emission reductions that occur beyond what is required by law.

Relevant Regulations

SAIC conducted an evaluation of existing and pending state and national regulations related to composting activities to determine if they are or may be required by regulation. The following Table B.2 shows a summary of state recycling goals, landfill bans on yard trimmings, and the number of permitted composting facilities. Note that a goal implies a voluntary commitment, whereas a mandate requires a regulation in place.

Table B.2. Summary of Waste Regulations by State

State	State Recycling Goal/Mandate[44,45]	Yard Waste Ban[46] (Yes/No)	Estimated Number of Permitted Composting Facilities[47]
Alabama	25% goal in 1989 (the passing of HB 395 in '08 may up this rate)	No	Unknown
Alaska	25%	No	4
Arizona	No statewide recycling goal	No	10
Arkansas	50% goal by 2010	Yes	32
California	50% landfill diversion mandate	No	150
Colorado	Governor's challenge of 50% by 2000	No	29
Connecticut	40% goal by 2000	Yes	94
Delaware	70% goal by 2010	Yes (recent)	2
District of Columbia	45%		
Florida	75% goal by 2020	Yes	8
Georgia	25% goal by 1996	Yes	38
Hawaii	50% goal by 2000	No	5
Idaho	Non-binding resolution for 25% goal	No	5
Illinois	25% by 1996 (The Illinois Solid Waste Planning and Recycling Act (415 ILCS 15)	Yes	40
Indiana	50% by 2001	Yes	122[48]
Iowa	50% by 2000	Yes	93
Kansas	No statewide goal	No	123
Kentucky	25% by 1997	*YW banned from some landfills	34
Louisiana	30%	No	?

[44] "Appendix 1, State Recycling Goals and Mandates" in "Processing and Marketing Recyclables in New York City May 2004" (Original source www.afandpa.org), New York City Bureau of Waste Prevention, Reuse, & Recycling.
[45] Personal Communication, Justin Gast, Resource Recycling, 2009.
[46] BioCycle Magazine, State of Garbage in America 2008.
[47] Compiled from various site web sources and published reports including BioCycle (2008). The definition of what constitutes a "facility" varies state to state. Most states do not permit agricultural composting facilities.
[48] Indiana, Department of Environmental Management, Registered Yard Waste Composting Facilities, www.in.gov/idem/5077.htm#composting

State	State Recycling Goal/Mandate[44,45]	Yard Waste Ban[46] (Yes/No)	Estimated Number of Permitted Composting Facilities[47]
Maine	50% by 1998	No	80
Maryland	40% goal (1999)	Yes	5
Massachusetts	46% by 2000	Yes	223
Michigan	1998 policy encourages SWM percentages, 30%	Yes	155
Minnesota	50% (TC metro) 35% state (1989)	Yes	80
Mississippi	25% by 1996 (SN2984, 1991)	No	11
Missouri	40% by 1998 (SB530, 1990)	Yes	93
Montana	25% by 1996 (1991)	No	22
Nebraska	50% by 2002 (1992)	Yes/(Changed)	9
Nevada	25% goal by 1995 (AB 320, 1991)	No	4
New Hampshire	40% by 2000 goal	Yes	12
New Jersey	60% by 1996 (1992) 65% by 2000	Yes	172
New Mexico	50% by 2000 goal (SB 2, 1990)	No	29
New York	50% by 1997 (1987 SWMP)	No	35
North Carolina	40% by 2001 (1991)	Yes	120
North Dakota	40% by 2000 (1991)	No	8
Ohio	50% by 2000	*Some disposal restrictions on YW	444[49]
Oklahoma	Oklahoma State Recycling & Procurement Act	No	3
Oregon	50% by 2009 (1991)	No	44
Pennsylvania	35% goal by 2005	Yes	465
Rhode Island	70% (no deadline, 1989) SB 2797 (2008) sets municipal goals	No	13
South Carolina	35% by 1995(Bill 3927, 1999)	Yes	96
South Dakota	50% goal by 2001 (HB 1001	Yes	128
Tennessee	25% by 2003 (HB 1252, 1991)	No	2
Texas	40% goal by 1994 (SB 1340, 1991)	No	108
Utah	None	No	19[50]
Vermont	50% by 2005 Mandate?	No	12 BC
Virginia	25% by 1995 (1989)	No	30[51]
Washington	50% goal by 1995 (Mandatory)	No	41[52]
West Virginia	50% by 2010 (1991)	Yes	2
Wisconsin	40%	Yes	197[53]
Wyoming	None	No	3

[49] Ohio EPA, Licensed Class I, Class II, Class III and Class IV Composting Facilities, www.epa.ohio.gov/dsiwm/pages/comp_docs.aspx
[50] Utah Department of Environmental Quality, 2008 Utah Compost Facility Inventory (Calendar 2007 Data), www.hazardouswaste.utah.gov/SWBranch/SWSection/PermittedSolidWasteLandfills.htm
[51] Mid Atlantic Composting Directory, Virginia Cooperative Extension, Publication 452-230, www.pubs.ext.vt.edu/452/452-230/452-230.html
[52] Washington Department of Ecology, 2007 Compost Facilities, www.ecy.wa.gov/programs/swfa/compost/
[53] Wisconsin Department of Natural Resources, Licensed Yard Waste Composting Facilities, www.dnr.state.wi.us/org/aw/wm/recycle/issues/compost.htm

As shown in Table B.2, 23 out of 50 of the U.S. states (or 46%) ban some form of yard trimmings from landfills. Other states have high recycling goals that perhaps serve a similar purpose (California, Washington) and some states appear to have been more effective at implementing municipal and commercial composting programs. However, there is little data on the effectiveness of a given state's ban. It is fair to say that most of the state bans were put into effect as a means of preserving landfill capacity. One study[54] makes the argument that states with bans have greater yard waste diversion, but each state tracks facilities and volumes differently enough to introduce some uncertainty at developing good, comparable per capita yard trimmings diversion numbers (also yard trimmings generation variances are not well understood-some states may generate more yard trimmings than others). In recent years there have been several attempts to overturn state landfill bans on yard trimmings. For example, these have occurred in Iowa, Illinois, Nebraska, Missouri and Georgia. All of these to date with the exception of Nebraska (LB 776, 2006) have been unsuccessful.

Food waste bans have only been implemented in a limited number of jurisdictions, but several other governments are contemplating adding mandatory food waste bans to existing landfill bans. While the methods and responsible agencies for implementation vary, most bans involve outreach and coordination with residences and businesses (as applicable), haulers, and the ability to perform waste audits to ensure compliance and identify areas for program reinforcement.

Table B.3 contains a summary of key regulations related to diversion of organic waste from landfills to composting facilities.

Table B.3. Landfill Organic Waste Diversion Regulations

Regulation	Waste Applicability	Overview Summary / Goals	Implementation/ Enforcement
Mandatory Recycling and Composting - San Francisco Passed 6/9/2009 (San Francisco Supervisors, 2009)	Applies to all compostable waste generated within the City and County of San Francisco	100% segregation of trash, recyclables and compostable waste within the city. Specific requirements for multi-family and commercial properties, food/event managers, and haulers/processing facilities are established.	Specified containers must be provided at specific locations/events. Upon pickup, containers with contaminated material must be tagged with written notice following. Numerous tags/notices on the same container(s) result in administrative penalties for repeated violations not to exceed $100. Loads are available for inspection by the City.
Nova Scotia, effective 6/1/97 (Nova Scotia, 1996)	Compostable organic material - food waste, yard waste, soiled and non-recyclable paper	Nova Scotia is committed to achieving a national target of 50% waste diversion by the year 2000. Materials banned from landfill include beverage containers, corrugated cardboard, newsprint, scrap tires, used oil, lead-acid batteries, waste paint, automotive antifreeze, glass food containers, steel/tin cans,	Local municipalities given control over how to implement and enforce this regulation. Plans for each city must be provided to the Minister to ensure that the bans are implemented as described.

[54] DSM Environmental Services, 2004

Regulation	Waste Applicability	Overview Summary / Goals	Implementation/ Enforcement
		selected plastics and compostable organic materials.	
City of Seattle, WA table scrap recycling – effective April 2009 (City of Seattle, 2007 and Chan, 2007)	All single-family homes will be required to subscribe to food-waste recycling, a program that is now optional through the yard-waste collection program	Supporting the City of Seattle's Zero Waste Strategy and to help meet its goal of diverting 72% of its garbage from the landfill by 2025, all single-family homes in Seattle must sign up for table-scrap recycling. Recycling food waste will be voluntary for apartments, as well as for businesses. A future ban of all organics from single family garbage will be considered once the collection system has been fully established.	Single family home residents are required to obtain new containers for food waste and pay for service. The city will not check whether they are actually dumping food in the new separate bin. Recycling food waste is voluntary for apartments, as well as for businesses. If a ban is implemented, it will likely follow a similar structure to existing bans: violators are fined or their garbage doesn't get picked up.
Massachusetts – Pending (Commonwealth of Massachusetts, 2006 - 310 CMR 19.017, and Massachusetts Executive Office of Environmental Affairs. 2006)	Current landfill ban regulations apply to leaves, grass clippings, weeds, hedge clippings, and brush up to 1 inch in diameter from disposal	The 2006 Solid Waste Master Plan states they will consider amending the waste regulations to add food waste to the list of materials banned from disposal once an adequate in-state food waste diversion infrastructure is in place. Targeted sectors include: residential, supermarkets, hospitals and other health care facilities, hotels and convention centers, colleges and universities, and state institutions such as prisons.	Under development; Under existing waste bans, no person is allowed to dispose or contract for disposal of restricted materials. Where appropriate, Technical assistance and partnerships to stimulate market development are in place. Solid waste facilities, waste haulers and generators have a shared responsibility to comply with waste bans. MassDEP plans to conduct waste ban inspections at solid waste facilities. When haulers and generators of failed loads are identified, MassDEP will pursue enforcement against those entities.
Pennsylvania – Preliminary review (Hursh, 2007 and Pennsylvania Commodity Disposal Ban Review, 2008)	Source separated food waste only	Currently lack collection and management infrastructure to handle increased volume of food waste.	Under development.
Alameda County Ban on landfilling plant debris	All plant debris banned from landfill disposal within Alameda County (applies to two large landfills)	All plant debris.	Jurisdictions required to prepare compliance plans.

B.4 Barriers to Composting Project Implementation

There are several barriers that currently prevent the diversion of food wastes to aerobic composting facilities absent GHG reduction project incentives.

Population Density

In less populated areas there is less pressure to conserve landfill space and to separately collect recyclables and/or compostables.

Cost

Composting involves more processing steps such as receiving and processing the material, and thus more operating costs, than disposing of it in a landfill.

One barrier is that to attract the waste stream, composters often charge less than the standard disposal rate (with hauling being equal). This need to underprice in order to get materials when in fact taking these materials results in higher operating and permit costs for a facility is a major disincentive for compost operations to accept food waste.

Site Permitting

Composting facilities (like many solid waste handling sites) can be difficult to site. Odors, land use compatibility, and traffic impacts are the most difficult of the potential issues to overcome.

Food waste composting is most commonly done as an add-on to existing yard waste composting. However, many institutions (universities, correctional facilities, resorts) will start up a food waste composting only project, typically using some small-scale composting technology. However, the bulk of food waste composting is currently done at larger scale operations with food waste being one of the feedstocks that is composted. The primary feedstock at these facilities is likely to be yard waste although some sites will also accept municipal biosolids or other materials.

The first major barrier for food waste composting is getting permitted to take food waste at a yard waste site. Some states make it easier than others, e.g. by starting out with a quantity limitation, or by only allowing pre-consumer vegetative food waste (i.e. not meats, dairy). Very quickly, composters who want to take all types and quantity of food waste will require a solid waste facility permit. Pennsylvania has created a General Permit that makes this less onerous, but that process is still challenging. In Illinois, food waste was recently redefined so that it is no longer considered as solid waste. This was done to make it easier to establish composting facilities that accept food waste. In general, regulations and permitting are the largest hurdles to establishing a food waste composting site.

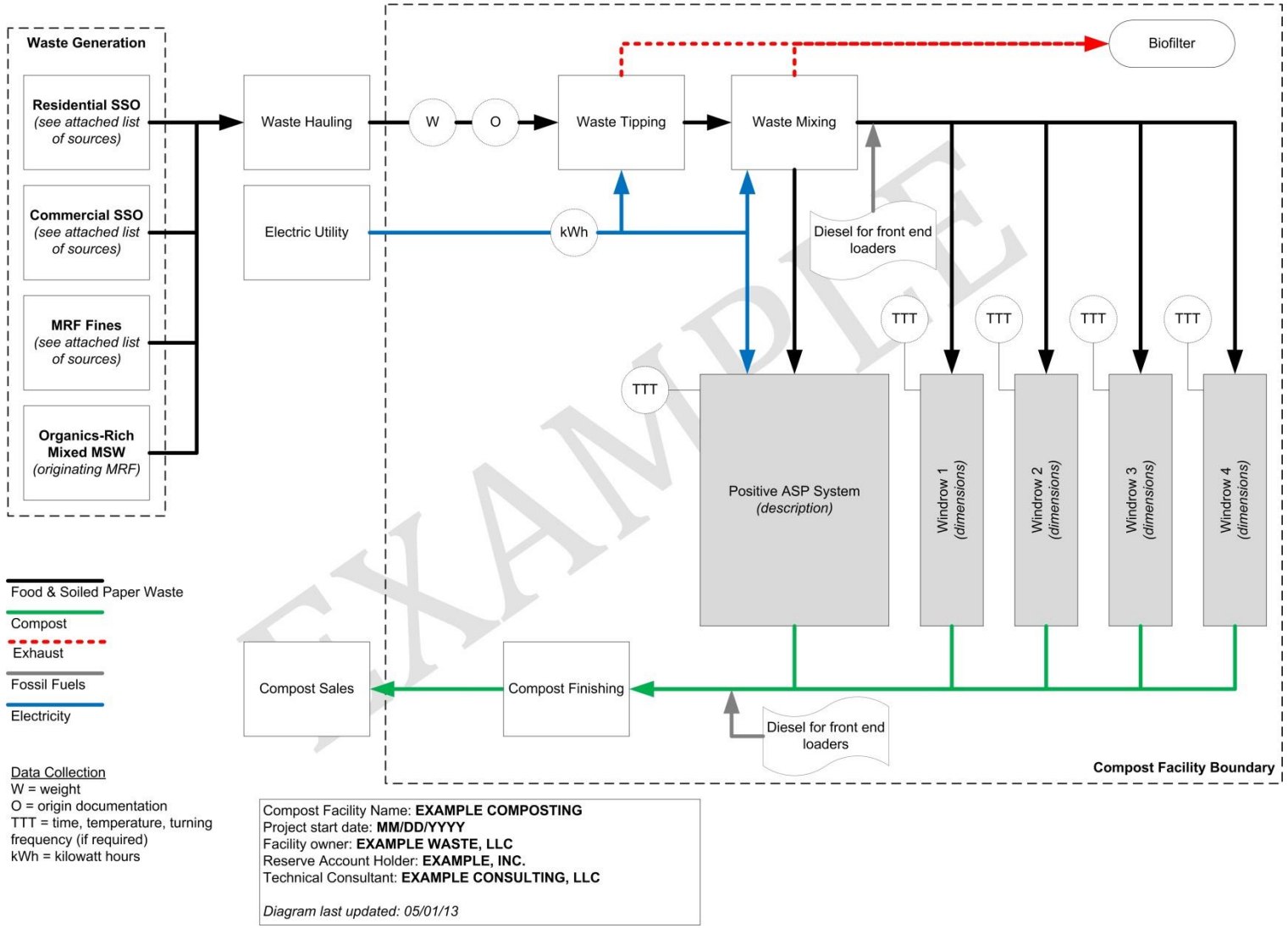
Accepting food waste will also increase operating costs for running the facility. As food waste requires near immediate processing, staff and equipment has to be onsite to accept and process materials when they are delivered. Appropriate process control and materials handling are critical to avoiding nuisance, odor, and vector problems.

Separate Collection

In some cases, separate collection (especially for food scraps) may be difficult to justify. In a few communities, particularly on the West Coast, food scraps are being added to the existing yard trimmings containers. This has proven to be a cost-effective tool in minimizing collection costs. This does not work out as well in states where yard trimmings generation is seasonal (the East Coast and Mid West), but food scraps generation is constant.

Appendix C Sample Project Diagram

Generalized Organic Waste Composting Project System Diagram



Organic Waste Composting Project Protocol Version 1.1

ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its Organic Waste Composting Project Protocol Version 1.1 (OWC V1.1) in July 2013. While the Reserve intends for the OWC V1.1 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the OWC V1.1.[1]

Per the Reserve's Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered OWC projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the OWC.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact Policy at: policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Climate Action Reserve Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications to the OWC are contained in this single document.

Errata and Clarifications (arranged by protocol section)

Section 3

1. Food Wholesalers and Food Distributors (CLARIFICATION – August 27, 2014).....3

Section 3

1. Food Wholesalers and Food Distributors (CLARIFICATION – August 27, 2014)

Section: 3.4.1 (The Performance Standard Test)

Context: This section defines eligible waste streams and a specific, additional set of requirements for food waste that is sourced from grocery stores. Food waste is only eligible if it is "non-industrial" in nature. Certain commercial facilities exist that do not process food but also do not provide it directly to consumers. It is not clear whether food waste from these facilities should be considered "industrial" and thus ineligible.

While not specifically addressed in the protocol, the Reserve believes that the intent is for food wholesalers and food distributors to be treated in the same manner as grocery stores. Food waste from food wholesalers and food distributors is therefore eligible, but must meet the documentation requirements applied to grocery stores.

If the activities of a particular food wholesaler or food distributor goes beyond the mere distribution of food products to the processing of food, and food that has undergone such processing then becomes waste, such waste is considered industrial in nature and ineligible. Facilities with multiple waste streams, some eligible and some ineligible, must be able to document the quantity of eligible waste separately from ineligible waste.

Clarification: Food waste originating from food wholesale and distribution facilities shall not necessarily be excluded as "industrial" per the first bullet of Section 3.4.1. The following text shall be added after the third paragraph on page 8:

> "Food waste originating at food wholesale and food distribution facilities shall not be considered 'industrial' for the purposes of eligibility as long as this facility does not process the food in any way (i.e. output a food product that is materially different from the input food product), but simply serves as a link in the distribution of food to commercial customers or consumers. Such facilities are considered akin to grocery stores and subject to the requirements of this protocol applicable to that source category."

Organic Waste Digestion Project Protocol Version 2.1

ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its Organic Waste Digestion Project Protocol Version 2.1 (OWDPP V2.1) in January 2014. While the Reserve intends for the OWDPP V2.1 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the OWDPP V2.1.[1]

Per the Reserve's Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered OWD projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the protocol.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact Policy at policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Climate Action Reserve Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications are contained in this single document.

Errata and Clarifications (arranged by protocol section)

Section 3

1. Food Wholesalers and Food Distributors (CLARIFICATION – November 1, 2018) 3
2. Regulatory Compliance at Centralized Digesters (CLARIFICATION – November 1, 2018) 3

Section 5

3. Calculating Metered Methane Destruction (ERRATUM – November 1, 2018)..... 4

Section 6

4. Methane Analyzer Factory Calibrations (CLARIFICATION – November 1, 2018) 5

Section 3

1. Food Wholesalers and Food Distributors (CLARIFICATION – November 1, 2018)

Section: 3.5.1 (The Performance Standard Test)

Context: This section defines eligible waste streams and a specific, additional set of requirements for food waste that is sourced from grocery stores. Food waste is only eligible if it is "non-industrial" in nature. Certain commercial facilities exist that do not process food but also do not provide it directly to consumers. It is not clear whether food waste from these facilities should be considered "industrial" and thus ineligible.

While not specifically addressed in the protocol, the Reserve believes that the intent is for food wholesalers and food distributors to be treated in the same manner as grocery stores. Food waste from food wholesalers and food distributors is therefore eligible, but must meet the documentation requirements applied to grocery stores.

If the activities of a particular food wholesaler or food distributor goes beyond the mere distribution of food products to the processing of food, and food that has undergone such processing then becomes waste, such waste is considered industrial in nature and ineligible. Facilities with multiple waste streams, some eligible and some ineligible, must be able to document the quantity of eligible waste separately from ineligible waste.

Clarification: Food waste originating from food wholesale and distribution facilities shall not necessarily be excluded as "industrial" per the first bullet of Section 3.5.1. The following text shall be added above the second to last paragraph on page 7:

> "Food waste originating at food wholesale and food distribution facilities shall not be considered 'industrial' for the purposes of eligibility as long as this facility does not process the food in any way (i.e. output a food product that is materially different from the input food product), but simply serves as a link in the distribution of food to commercial customers or consumers. Such facilities are considered akin to grocery stores and subject to the requirements of this protocol applicable to that source category."

2. Regulatory Compliance at Centralized Digesters (CLARIFICATION – November 1, 2018)

Section: 3.6 (Regulatory Compliance)

Context: This section states that, where a verifier determines that project activities have caused a material violation, no CRTs will be issued during the period(s) when the violation occurred. The guidance in this section does not specifically address:

- whether regulatory compliance issues arising prior to delivery of food and wastewater waste streams to the project facility, should be considered relevant for regulatory compliance requirements; or
- how to address regulatory compliance for projects where manure is received from multiple farms and managed in a centralized BCS.

With respect to manure waste streams, it is unclear whether a violation with respect to one manure source facility would jeopardize the ability of the project to receive credit from emission reductions related to manure from other source facilities. It may be possible for an offset project at a centralized digester to have CRTs issued to it for manure from compliant manure source facilities during a period of time when one or more manure source facilities are materially noncompliant with a regulation.

Clarification: The following text shall be inserted on page 10, at the end of Section 3.6:

> "With respect to projects that accept and manage manure from multiple, discrete source facilities (separate from the project BCS in both physical location and management), it may be possible for a project developer to demonstrate that a regulatory violation at one source facility does not affect the eligibility of the entire project under this section. Project developers should contact the Reserve to discuss potential regulatory non-compliance issues.
>
> With respect to projects that accept food waste streams, regulatory compliance violations occurring prior to delivery of such waste to the project site shall generally be considered unrelated to the project.
>
> With respect to projects that accept wastewater streams from offsite sources, regulatory compliance violations occurring prior to delivery of such waste to the project site shall generally be considered unrelated to the project."

Section 5

3. Calculating Metered Methane Destruction (ERRATUM – November 1, 2018)

Section: 5.3 (Calculating Metered Methane Destruction (Equation 5.21))

Context: The first equation in this protocol, Equation 5.1 provides guidance for calculating emission reductions, following the Reserve's standard methodology of subtracting project emissions from baseline emissions, to get emission reductions. For this protocol, project developers must calculate the baseline using two alternative approaches (metered vs modelled), and use the lower of these two baseline values in this first equation. Irrespective of which baseline value must be used, Equation 5.1 directs that project emissions (represented as PE), must then be subtracted from the baseline emissions. PE is then calculated in Section 5.2.1, in Equation 5.14, including by accounting for the Biogas Destruction Efficiency (BDE) of the given destruction devices used. BDE is also taken into account in Section 5.3, in Equation 5.21, when calculating the total volume of methane metered during the reporting period ($CH_{4\ destroyed}$). In effect, the incomplete combustion of methane is incorrectly taken into account twice, instead of just once, via the application of BDE in both of these two equations, when using the metered baseline approach, resulting in erroneously lower emission reductions.

Correction: A BDE value of 1 should be used in Equation 5.21 in Section 5.3, on page 46 of the protocol, when using the metered baseline approach.

Section 6

4. Methane Analyzer Factory Calibrations (CLARIFICATION – November 1, 2018)

Section: 6.2.1 (Biogas Measurement Instrument QA/QC)

Context: The third bullet in the list at the beginning of this section (page 53) states that "[all gas flow meters and continuous methane analyzers must be] calibrated by the manufacturer or a certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent."

The principle underlying this requirement is the need to ensure data integrity. More specifically, the intent of this requirement is that meters meet such requirement every time they are used to gather data that is used in project emission reduction quantification. If a meter was out of conformance with this calibration requirement during a portion of the reporting period when it is not in use, but is brought back into conformance with this requirement before again being used to gather data which is used for project emission reduction calculations, then the underlying intent of this requirement is met.

Clarification: The following text shall be inserted after the third bulleted point at the beginning of Section 6.2.1:

> "Conformance with this requirement is only required during periods of time where data gathered by the meter are used for emission reduction quantification. Periods where the meter did not meet this requirement will not cause the project to fail this requirement, provided the meter was not being used for project emission reduction quantification during such periods, and provided the meter was brought back into conformance before being employed to gather data which is used for project emission reduction quantification."

CLIMATE ACTION RESERVE

Version 2.1 | January 16, 2014

Organic Waste Digestion

Project Protocol

Climate Action Reserve
601 West 5th Street, Suite 650
Los Angeles, CA 90071
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Released January 16, 2014

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Table of Contents

Abbreviations and Acronyms 1

1 Introduction 1
2 The GHG Reduction Project 2
2.1 Background 2
2.2 Project Definition 2
2.3 The Project Developer 3
3 Eligibility Rules 4
3.1 Location 4
3.2 Project Start Date 4
3.3 Project Crediting Period 5
3.4 Anaerobic Baseline Conditions 5
3.4.1 Livestock Manure 5
3.4.2 Agro-Industrial Wastewater 5
3.4.3 Centralized Digesters 6
3.5 Additionality 6
3.5.1 The Performance Standard Test 6
3.5.2 The Legal Requirement Test 8
3.6 Regulatory Compliance 10
3.7 Ownership 10
4 The GHG Assessment Boundary 12
5 Quantifying GHG Emission Reductions 20
5.1 Quantifying Baseline Emissions 22
5.1.1 Baseline Emissions from Eligible Food and Food-Soiled Paper Waste Streams (SSR 4) 23
5.1.2 Baseline Emissions from Eligible Agro-Industrial Wastewater Streams (SSR 6) 34
5.1.3 Baseline Emissions from Manure Treatment Systems (SSR 5) 36
5.2 Quantifying Project Emissions 37
5.2.1 Project CO_2 Emissions from Fossil Fuel Combustion and Grid Delivered Electricity (SSRs 3, 8, 13, 15, 17) 38
5.2.2 Project Emissions from the Biogas Control System (SSRs 9, 10, 11, 12, 14) 39
5.2.3 Project Methane Emissions from Liquid Digester Effluent Storage and Treatment (SSR 16) 42
5.2.4 Project Emissions from Aerobic Treatment of Digestate (SSR 17) 42
5.2.5 Project Emissions from Anaerobic Disposal of Digestate Produced in the Digestion Process (SSR 18) 44
5.2.6 Project Emissions from Manure Treatment Systems (SSR 5) 44
5.3 Calculating the Total Quantity of Methane Destroyed by the Project 45
6 Project Monitoring 47
6.1 Organic Waste and Wastewater Monitoring Requirements 47
6.1.1 Food and Food-Soiled Paper Waste Monitoring 47
6.1.2 Monitoring and Documenting Pre-Project Waste Disposal for Grocery Store Waste Streams 48
6.1.3 Agro-Industrial Wastewater Monitoring 49
6.1.4 Digester Effluent and Digestate Monitoring 50
6.2 Biogas Control System Monitoring 51
6.2.1 Biogas Measurement Instrument QA/QC 53
6.2.2 Missing Data 55

6.3 Monitoring Parameters 55
7 Reporting Parameters 69
7.1 Project Submittal Documentation....69
7.2 Record Keeping....69
7.3 Reporting Period and Verification Cycle 70
8 Verification Guidance 71
8.1 Standard of Verification 71
8.2 Monitoring Plan 71
8.3 Verifying Project Eligibility....71
8.4 Core Verification Activities....72
8.5 OWD Verification Items 73
8.5.1 Project Eligibility and CRT Issuance 73
8.5.2 Quantification 75
8.5.3 Risk Assessment....76
8.6 Completing Verification....76
9 Glossary of Terms....77
10 References....81

Appendix A Associated Environmental Impacts 83
Appendix B Data Lookup Tables....84
Appendix C Development of the Performance Standard 91
Appendix D Data Substitution....99
Appendix E Example Project System Diagram....100

List of Tables

Table 4.1. Description of all Sources, Sinks, and Reservoirs....14
Table 5.1. Waste Generator Categories and Default Food and Soiled Paper Fractions by Weight 33
Table 5.2. Combined Methane and Nitrous Oxide Emission Factors for Aerobic Treatment of Digestate....43
Table 6.1. Organic Waste Digestion Project Monitoring Parameters 56
Table 8.1. Summary of Eligibility Criteria for an Organic Waste Digestion Project....72
Table 8.2. Eligibility Verification Items 74
Table 8.3. Quantification Verification Items 75
Table 8.4. Risk Assessment Verification Items....76
Table B.1. Decay Rates (k) by Waste Type and Climate....84
Table B.2. Fraction of Waste Sent to Waste-to-Energy (WTE) Facilities 84
Table B.3. Gas Collection Fractions, by State 85
Table B.4. Digestate Emission Factors by Climate Region....87
Table B.5. Methane Conversion Factor (MCF) for Wastewater Treatment Systems....87
Table B.6. Biogas Collection Efficiency by Digester Type 87
Table B.7. Biogas Destruction Efficiency Default Values by Destruction Device....88
Table B.8. CO_2 Emission Factors for Fossil Fuel Use 89
Table C.1. Selected Organic Waste Source Industries Studied....92
Table C.2. Economic Evaluation Guidelines for Digestion Feedstock....97
Table C.3. Example Digester Plant, Payback Economics....98

List of Figures

Figure 4.1. General illustration of the GHG Assessment Boundary 13
Figure 5.1. Organizational Chart of Equations in Section 5 21
Figure 6.1. Suggested Arrangement of Biogas Metering Equipment 52
Figure B.1. K-Value Categories in the U.S., by County....90

List of Equations

Equation 5.1. Calculating GHG Emission Reductions 22
Equation 5.2. Total Calculated Baseline Methane Emissions 23
Equation 5.3. Calculating Baseline Methane Emissions for Solid Waste Streams (SSR 4) 24
Equation 5.4. Baseline Methane Emissions from Eligible Food Waste, by Waste Stream 25
Equation 5.5. Baseline Methane Emissions from Eligible Soiled Paper Waste, by Waste Stream 27
Equation 5.6. Determining Weight of Eligible Food and Soiled Paper Waste 30
Equation 5.7. Determining the Fraction of Eligible Waste in a Mixed-MSW MRF Fines Waste Stream 32
Equation 5.8. Determining the Quarterly Fractional Weight of Food and Soiled Paper Waste 34
Equation 5.9. Total Baseline Emissions for Eligible Agro-Industrial Wastewater Streams (SSR 6) 35
Equation 5.10. Baseline Emissions for Each Eligible Wastewater Stream 36
Equation 5.11. Baseline Emissions for Eligible Manure Streams (SSR 5) 37
Equation 5.12. Total Project Emissions from All Sources 38
Equation 5.13. Project Carbon Dioxide Emissions from Fossil Fuel and Grid Electricity 39
Equation 5.14. Project Methane Emissions from the BCS (SSRs 9, 10, 11, 12, 14) 40
Equation 5.15. Adjusting the Biogas Flow for Temperature and Pressure 41
Equation 5.16. Methane Release from Venting Events 41
Equation 5.17. Project Methane Emissions from the BCS Effluent Pond (SSR 16) 42
Equation 5.18. Methane and Nitrous Oxide Emissions from Aerobic Treatment of Digestate (SSR 17) 44
Equation 5.19. Methane Emissions from Anaerobic Treatment of Digestate (SSR 18) 44
Equation 5.20. Project Emissions from Non-BCS Related Manure Treatment/Storage Systems 45
Equation 5.21. Metered Methane Destruction 46

Abbreviations and Acronyms

ACF	Actual cubic feet
BCS	Biogas control system
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
COD	Chemical oxygen demand
FOD	First Order Decay
GHG	Greenhouse gas
MSW	Municipal solid waste
MRF	Materials Recovery Facility
N_2O	Nitrous oxide
OWC	Organic Waste Composting
OWD	Organic Waste Digestion
POTW	Publicly owned treatment works
Reserve	Climate Action Reserve
SCF	Standard cubic feet
SSO	Source separated organics
SSRs	Sources, sinks, and reservoirs
t	Metric ton (or tonne)
UNFCCC	United Nations Framework Convention on Climate Change
WW	Wastewater
WWTP	Wastewater treatment plant

1 Introduction

The Climate Action Reserve (Reserve) Organic Waste Digestion (OWD) Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the diversion of organic waste and/or wastewater away from anaerobic treatment and disposal systems and to a biogas control system (BCS). For the purposes of this protocol, a biogas control system consists of an anaerobic digester, a biogas collection and monitoring system, and one or more biogas destruction devices.[1] Eligible organic waste and/or wastewater streams can be separately-digested, co-digested together, or co-digested in combination with livestock manure.[2] Project developers that co-digest eligible organic waste and/or wastewater sources together with livestock manure must use this protocol together with the most current version (as of the date of project listing) of the Climate Action Reserve's Livestock Project Protocol.

As the premier carbon offset registry for the North American carbon market, the Climate Action Reserve encourages action to reduce greenhouse gas (GHG) emissions by ensuring the environmental integrity and financial benefit of emissions reduction projects. The Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, issues carbon credits generated from such projects and tracks the transaction of credits over time in a transparent, publicly-accessible system. The Reserve offsets program demonstrates that high-quality carbon offsets foster real reductions in GHG pollution, support activities that reduce local air pollution, spur growth in new green technologies and allow emission reduction goals to be met at lower cost. The transparent processes, multi-stakeholder participation and rigorous standards of the Reserve help earn confidence that registered emissions reductions are real, additional, verifiable, enforceable and permanent. The Reserve's expertise and insight helped inform the development of the State of California's cap-and-trade program, which adopted four of the Reserve's protocols for use in its regulation. The Climate Action Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California .[3]

Project developers that initiate OWD projects use this document to quantify and register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive at least annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with an OWD project.[4]

[1] Eligible destruction options include both onsite destruction or offsite destruction
[2] Eligible organic waste streams are those that meet the "performance standard" threshold specified in Section 3.5.1 of this protocol
[3] For more information, please visit www.climateactionreserve.org.
[4] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Methane (CH_4), a potent GHG, can be formed as a by-product of microbial respiration reactions that occur when organic materials decompose in the absence of oxygen (i.e. under anaerobic conditions). This methane, if not captured, is emitted to the atmosphere. For manure and organic wastewater streams, this predominantly occurs when the waste is managed in uncontrolled anaerobic liquid-based systems (e.g. in lagoons, ponds, tanks, or pits)[5]. For solid organic waste, this predominantly occurs if the waste is disposed of at a landfill. The resulting CH_4 component of the landfill gas, if not oxidized by landfill cover material or captured and destroyed by a gas collection system, will eventually be released to the atmosphere.

A biogas control system is designed to capture and destroy methane gas produced from the anaerobic decomposition of organic wastes and manure. By diverting organic waste and manure away from landfills and anaerobic liquid-based management systems to a biogas control system, emissions of methane to the atmosphere can be prevented and avoided.

The rate at which CH_4 production occurs in a landfill is governed by the decay rates of the specific types of waste that are deposited in the landfill. Although many landfills actively control LFG through gas collection and combustion systems, recent research indicates that typical landfill gas collection system efficiencies increase with time after initial waste burial as the collection system is installed and subsequently expanded. [6] Therefore, the fraction of CH_4 that is collected from the decay of a certain type of waste will be inversely proportional to the decay rate of the waste type. For rapidly decaying organic waste streams such as food waste, a greater fraction of the CH_4 produced from decay will go un-captured as compared to slowly degrading waste types.

2.2 Project Definition

For the purpose of this protocol, a GHG reduction project ("project") is defined as the digestion of one or more eligible organic waste and/or agro-industrial wastewater streams in an operational biogas control system that captures and destroys methane gas that would otherwise have been emitted to the atmosphere in the absence of the project. For the purposes of this protocol, a BCS is considered *operational* on the date at which the BCS begins destroying methane gas upon completion of a start-up period.

Captured biogas can be destroyed onsite, or transported for offsite use (e.g. through a gas distribution or transmission pipeline), or used to power vehicles or fuel cells. Regardless of how project developers take advantage of the captured biogas, the ultimate fate of the methane must be destruction.

Projects that co-digest eligible organic waste streams together with manure also meet the definition of an OWD project. However, projects that digest manure without the addition of one or more eligible organic waste streams do not meet the definition of an OWD project and must use the Reserve's Livestock Project Protocol to register GHG reductions with the Reserve.

[5] Per IPCC Guidelines, if manure contains less than 20% dry matter it can be considered liquid.
[6] De la Cruz, F.B. and Barlaz, M. *Estimation of Waste Component Specific Landfill Decay Rates Using Laboratory-Scale Decomposition Data*. (2010).

Centralized digesters that digest eligible waste streams from more than one source also meet the definition of an OWD project. Similarly, existing digesters at municipal wastewater treatment plants that use excess capacity to co-digest or single-digest eligible organic waste streams also meet the definition of an OWD project. An *eligible* waste stream is one that:

1. Consists of municipal solid waste (MSW) food waste, non-recyclable MSW food-soiled paper waste, or agro-industrial wastewater streams as defined in Section 3.5.1; and
2. Continually passes the Legal Requirement Test criteria as outlined in Section 3.5.2.

2.3 The Project Developer

The "project developer" is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be agribusiness owners and operators, such as dairy or swine farmers, cheese producers, or food or agricultural processing plant operators. They may also be other entities, such as renewable power developers, municipalities, or waste management entities.

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to register with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project (Section 2.2).

Eligibility Rule I:	Location	→	*U.S. and U.S. tribal areas*
Eligibility Rule II:	Project Start Date	→	*No more than six months prior to project submission*
Eligibility Rule III:	Anaerobic Baseline	→	*Demonstrate anaerobic baseline conditions*
Eligibility Rule IV:	Additionality	→	*Meet performance standard*
		→	*Exceed regulatory requirements*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Only projects located in the United States and on U.S. tribal lands are eligible to register reductions with the Reserve under this protocol. All organic waste, wastewater, and manure waste sources that contribute waste to the OWD project must be located within the United States. Under this protocol, reductions from international projects are not eligible to register with the Reserve.

3.2 Project Start Date

As with the project definition for an OWD project (Section 2.2), the project start date for an OWD project is defined in relation to the eligible waste stream(s) rather than the physical BCS. The project start date is defined as the earliest date at which an eligible waste stream that the project developer wishes to include in the quantification of emission reductions is first digested in an *operational* biogas control system. For the purposes of this protocol, a BCS is considered *operational* on the date at which the BCS begins destroying methane gas, following an initial start-up period.[7] The start date can be selected by the project developer within a 6 month timeframe from the date at which an eligible waste stream (that the project developer wishes to include in the quantification of emission reductions) is first loaded into the BCS digester. Projects that digest manure without the addition of one or more eligible organic waste streams must use the Reserve's Livestock Project Protocol if seeking to register GHG reductions with the Reserve.

[7] In some instances, waste digestion projects may go through an initial piloting, demonstration, or testing phase where the intent is to perform research or testing on digester components and potential feedstocks. The piloting phase is generally prior to the financial commitment to implement a larger-scale (commercial scale) digestion project. If the first eligible waste stream that the project developer wishes to include in the quantification of emission reductions is the first waste to be digested in the project BCS, and the project has gone through a piloting phase and can demonstrate that less than 5,000 tonnes of food waste were digested per year during the piloting phase, the project developer may elect to begin the 10-year crediting period on the date corresponding to the operational start date of the commercial scale BCS system as opposed to the operational start date of the pilot-scale project.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date.[8] Projects may always be submitted for listing by the Reserve prior to their start date. Any BCS will be eligible to host a project, as there are no eligibility requirements pertaining to the BCS itself; however, only waste streams that were first digested in the project BCS no more than six months prior to the project start date will be eligible.

3.3 Project Crediting Period

The crediting period for OWD projects under this protocol is ten years. At the end of a project's first crediting period, project developers may apply for eligibility under a second crediting period. However, the Reserve will cease to issue Climate Reserve Tonnes (CRTs) for GHG reductions associated with eligible waste streams if at any point in the future, the diversion of those waste streams becomes legally required, as defined by the terms of the Legal Requirement Test (see Section 3.5.2), unless the waste stream passes the Legal Requirement Test for Local Waste Diversion Mandates, as specified in Section 3.5.2.1 below. Thus, the Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of two ten year crediting periods after the project start date, or until the project activity is required by law (based on the date that a legal mandate takes effect), whichever comes first. Section 3.5.1 describes requirements for qualifying for a second crediting period.

3.4 Anaerobic Baseline Conditions

Developers of projects that digest agro-industrial wastewater streams and/or manure streams must demonstrate that the depth of the anaerobic wastewater and/or manure treatment ponds and lagoons prior to the project's implementation were sufficient to prevent algal oxygen production and create an oxygen-free bottom layer; which means at least 1 meter depth.[9] In the event that the pre-project wastewater treatment system is located at a facility other than where the project is located, and is owned and/or operated by an entity other than the project developer, the project developer shall ensure that the verifier has access to all necessary data and has access to the site where the pre-project wastewater treatment system is located.

3.4.1 Livestock Manure

Projects accepting livestock manure shall refer to the most recent version of the Livestock Project Protocol[10] at the time of submittal. All manure streams must meet the additionality criteria of that version of the Livestock protocol to be eligible under the OWD protocol. Where there are any inconsistencies between requirements in this protocol and the relevant version of the Livestock protocol, this protocol shall prevail.

3.4.2 Agro-Industrial Wastewater

Agro-Industrial wastewater sourced from new agro-industrial facilities (i.e. facilities that have not previously generated wastewater) is not eligible. To be eligible, the project must be able to

[8] Projects are considered submitted when the project developer has fully completed, uploaded, and submitted the appropriate Project Submittal Form, available on the Reserve's website, through their account in the Climate Action Reserve.

[9] This is consistent with the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) methodologies ACM0010 and ACM0014 (available at http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html). For additional information on the design and maintenance of anaerobic wastewater treatment systems, see U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Storage Facility, No. 313; and U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Treatment Lagoon, No. 359.

[10] Available for download at: http://www.climateactionreserve.org/how/protocols/us-livestock/.

demonstrate that the agro-industrial wastewater stream was previously managed in an open, anaerobic lagoon as described in the first paragraph of Section 3.4 above. This requirement differs from the Livestock Protocol guidance for Greenfield projects due to differences in common practice management identified in the performance standard research described in Appendix C. Because use of open, anaerobic lagoons for wastewater management is less prevalent for agro-industrial wastewater streams, the test for additionality is more stringent.

3.4.3 Centralized Digesters

For projects that employ a centralized digester that will be accepting manure or wastewater from more than one source, each individual source of manure or wastewater (identified by the facility from which it is sourced) must meet the anaerobic baseline requirements as of the date that the particular waste stream was first delivered to the project, or demonstrate that the relevant waste stream was previously deemed to be an eligible waste stream at another project that is registered (i.e. has been successfully verified) with the Reserve. In other words, if a new facility begins sending manure or wastewater to the project digester after the project start date, the anaerobic baseline of that manure or wastewater must be assessed as of the date of initial delivery. For projects that employ a centralized digester that will be accepting eligible source separated organics (SSO) grocery store waste, each such waste stream must meet the additionality requirements set out in Section 3.5.1 below, at the time the waste was first delivered to the project.

3.5 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The Performance Standard Test
2. The Legal Requirement Test

3.5.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all organic waste digestion projects, established by this protocol.

OWD projects may digest numerous potential feedstocks. The performance standard for this protocol defines those feedstocks that the Reserve has determined are highly likely to result in methane emissions under common practice or "business as usual" management practices.[11] Only OWD projects that digest one of these feedstocks in a biogas control system are deemed to exceed common practice and are therefore eligible for registration under this protocol. An OWD project passes the Performance Standard Test only if one or more of the following eligible organic waste streams are consistently, periodically, or seasonally digested in the project's biogas control system:

- *Municipal Solid Waste (MSW) Food Waste*: Non-industrial food waste commonly disposed of in a MSW system, consisting of uneaten food, food scraps, spoiled food and

[11] A summary of the study used to establish this list of feedstocks and define this protocol's performance standard is provided in Appendix C.

food preparation wastes from homes, restaurants, kitchens, grocery stores, campuses, cafeterias, or similar institutions.

- *Food-Soiled Paper Waste*: Non-recyclable paper items that are co-mingled with eligible food waste, consisting of paper napkins and tissues, paper plates, paper cups, fast food wrappers, used pizza boxes, wax-coated cardboard, and other similar paper or compostable packaging[12] items typically disposed of in a MSW system.

- *Agro-industrial Wastewater*: Organic loaded wastewater from industrial or agricultural processing operations that, prior to the project, was treated in an uncontrolled anaerobic lagoon, pond, or tank at a privately owned treatment facility. Excluded from eligibility based on the Reserve's performance standard analysis are wastewaters produced at breweries, ethanol plants, pharmaceutical production facilities, and pulp and paper plants.

The Reserve's performance standard research indicates that approximately 2.8% of the MSW food waste generated in the U.S. is diverted from landfills annually as common practice, and that this is limited mostly to MSW food waste from grocery stores and supermarket diversion programs.[13] Therefore, MSW food waste and food-soiled paper waste streams are not eligible if they are sourced from grocery stores and/or supermarkets that have historically diverted these waste streams from landfills.

Projects must demonstrate the eligibility of each new grocery store waste stream digested by the project by documenting that the food and food-soiled paper component of the grocery store waste was being disposed of in a landfill for a period of at least 36 months prior to the date that the grocery store waste was first delivered to the project digester, or documenting that the grocery store waste stream was previously deemed to be an eligible waste stream at another OWD or OWC project that is registered with the Reserve. Waste streams originating from new grocery store facilities are deemed eligible. Section 6.1.2 provides requirements for documenting the pre-project disposal of grocery store waste. All other MSW food and food-soiled paper waste sources described above are eligible.

OWD projects may choose to digest multiple feedstocks, some of which may be ineligible per the Performance Standard Test. Ineligible waste streams, e.g. fats, oils, and greases (FOG) residues and municipal biosolids (sludge), may be co-digested alongside eligible organic waste streams. However, any methane produced by these waste streams and destroyed by the project will not be eligible for crediting with CRTs by the Reserve.

The Performance Standard Test is applied at the time a project applies for registration with the Reserve. Eligible waste streams at the time a project is registered shall remain eligible throughout a project's first crediting period, regardless of changes in any future versions of this protocol. However, projects must demonstrate the eligibility of all new grocery store waste streams digested by the project according to the requirements above.

[12] Non-paper compostable packaging products such as polyactide polymer (PLA) may replace paper or plastic packaging on some food products, and are assumed to have similar properties to soiled paper.

[13] Based on composting data supplied by the stakeholder work group that advised development of the Reserve's Organic Waste Composting protocol, and evidence from compost experts.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Performance Standard Test.

3.5.2 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. For OWD projects, the Legal Requirement Test is applied to each eligible waste stream digested by the project. A waste stream passes the Legal Requirement Test when:

1. There are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates that require the diversion of the eligible waste stream from landfills, and/or that require the aerobic treatment or anaerobic digestion of the waste stream (see Sections 3.5.2.2 and 3.5.2.3, below, for further guidance on regulations affecting organic solid waste and industrial wastewater streams); or
2. The waste stream passes the Legal Requirement Test for Local Waste Diversion Mandates, as specified in Section 3.5.2.1 below.

To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[14] prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project (and its associated waste streams) at all times passes the Legal Requirement Test.

If an OWD project digests an eligible organic waste stream that later becomes subject to a legal mandate requiring its diversion and/or aerobic treatment or anaerobic digestion, the organic waste stream will remain eligible up until the date that the legal mandate takes effect, unless the waste stream passes the Legal Requirement Test for Local Waste Diversion Mandates as specified in Section 3.5.2.1. Food and/or food-soiled paper waste streams that meet the requirements under Section 3.5.2.1 will remain eligible for the remainder of the crediting period, or until failure of the Legal Requirement Test with regards to state and/or federal regulations.

If an OWD project digests an eligible organic waste stream originating from a facility whose methane emissions are later included under an emissions cap (e.g. under a state or federal cap-and-trade program), the organic waste stream will remain eligible until the date that the emissions cap takes effect.

If an eligible organic waste stream digested by an OWD project becomes subject to a legally binding mandate requiring its diversion, anaerobic digestion, or aerobic treatment, the project may continue to report GHG reductions to the Reserve associated with other eligible waste streams that are not subject to such mandates. The Reserve will continue to issue CRTs for destruction of methane associated with the digestion of eligible waste streams that are not legally required to be diverted, anaerobically digested or aerobically treated.

[14] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

3.5.2.1 Legal Requirement Test for Local Waste Diversion Mandates

Local jurisdictions may have bans on certain types of waste going to landfill, or may have mandatory ordinances that require the diversion of organic solid wastes from landfills. If a local jurisdiction has established a mandatory ban on food waste and/or food-soiled paper disposal at landfills, or otherwise has enacted food and/or food-soiled paper waste diversion mandates, the food and/or food-soiled paper waste streams subject to the local diversion mandate passes the Legal Requirement Test if (and only if):

1. The project digesting the local food and/or food-soiled paper waste stream has an operational start date no later than 6 months after the date that the food waste diversion mandate is passed into law; and

2. The food and/or food-soiled paper waste stream continues to pass the Legal Requirement Test with regards to state and federal regulations.

3.5.2.2 Guidance on Solid Organic Waste Regulations

There are various state and local regulations, ordinances, and mandatory diversion targets that may obligate waste source producers or waste management entities to divert organic wastes away from landfills. An organic solid waste stream that is banned from landfilling, or is mandated to be managed in a system other than a landfill, fails the Legal Requirement Test.

State Regulations

States may have mandatory landfill diversion targets that require a percentage of waste generated to be diverted from landfills to alternative management systems. Although waste diversion targets may not specify a reduction or percentage of diversion that must be met from *organic* waste, these targets nevertheless provide strong regulatory incentives to divert all wastes (including organic) from landfills. Thus, organic waste originating from a jurisdiction that is not in compliance with a mandated landfill diversion target does not pass the Legal Requirement Test until the date at which the jurisdiction comes into compliance with the mandated landfill diversion target.

Mandatory state diversion targets are not to be confused with state diversion goals. Should a state adopt a statewide waste diversion goal that does not impose penalties on jurisdictions for failing to meet diversion targets, then this state goal would not result in a failure of the Legal Requirement Test.

Local and Municipal Regulations and Ordinances

Local jurisdictions may have bans on certain types of waste going to landfill, or may have mandatory ordinances that require the diversion of organic solid wastes from landfills. If a local jurisdiction has established a mandatory ban on food waste disposal at landfills, or otherwise has enacted food waste diversion mandates, food waste streams originating from the jurisdiction fail the Legal Requirement Test.

3.5.2.3 Guidance on Industrial Wastewater Regulations

Federal Regulations

There are several federal regulations and standards for industrial wastewater discharge and pre-treatment. For example, Title 40 of the Code of Federal Regulations establishes pre-treatment standards for 35 different categories of industrial facilities. As of the date of adoption of this protocol, however, no federal regulations or standards require the installation of a BCS at

industrial wastewater facilities, or the control of methane emissions to the atmosphere, so these regulations and standards do not affect application of the Legal Requirement Test.

State, Local, and Municipal Regulations

State regulations must be at least as stringent as any federal requirement, but states can adopt more stringent and additional requirements as well. Wastewater regulations vary between states and even between counties or cities within a single state. For example, the East Bay Municipal Utility District (EBMUD) in California sets Total Suspended Solids (TSS) limits between 30 and 3,500 mg/l depending on the industry while Sheboygan and Waukesha, Wisconsin set TSS limits at 234 and 340 mg/l, respectively. Each of these localities also sets different fees that are applied to discharges when wastewater pollution limits are exceeded. Limits and discharge fees range from a few thousand to a few million dollars, thereby encouraging reduction of wastewater discharges with a combination of prescriptive controls and economic motivation. Although certain regions may encourage reduction of wastewater discharge into public treatment systems through combination of lower discharge limits and higher fees, there are no regulations known as of the date of adoption of this protocol that specifically require the installation of a BCS at industrial wastewater facilities, or the control of methane emissions to the atmosphere.

3.6 Regulatory Compliance

As a final eligibility requirement, project developers must attest that project activities do not cause material violations of applicable laws (e.g. air, water quality, safety, etc.). To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form[15] prior to the commencement of verification activities each time the project is verified. Project developers are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project or project activities.

A violation should be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. The project developer shall disclose all instances of violations to the verifier and the verifier will then determine whether the requisite causality exists.

If a verifier finds that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurrent administrative violations directly related to project activities may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

3.7 Ownership

The project developer must attest to the Reserve that they have exclusive claim to the GHG reductions – including indirect emission reductions – resulting from the project. Indirect emission reductions are reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants. An OWD project may result in indirect emission reductions if it diverts organic waste streams away from landfills or wastewater treatment systems that are not located at the project site or that are not owned or controlled by project participants. Each time a project is verified, the project developer must attest that no other entities are reporting or claiming (e.g. for

[15] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

voluntary reporting or regulatory compliance purposes) the GHG reductions caused by the project.[16] The Reserve will not issue CRTs for GHG reductions that are reported or claimed by entities other than the project developer (e.g. waste generators, landfills, municipalities or others not designated as the project developer).

If an OWD project is receiving credits or incentive payments of any kind in addition to CRTs, the project developer needs to demonstrate that double claiming of emission reductions is not occurring. The project developer must demonstrate to the verifier that the party (or parties) providing those payments/credits are not directly or indirectly asserting any claim (legal or otherwise) to the project's emission reductions. The project developer should provide the verifier with any Terms of Reference, contracts, program rules, etc., associated with the granting of the payments/credits.

[16] This is done by signing the Reserve's Attestation of Title form, available at http://www.climateactionreserve.org/how/program/documents/.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project developers in order to determine the net change in emissions caused by an OWD project. [17]

CO_2 emissions associated with the destruction of biogas are considered biogenic emissions[18] (as opposed to anthropogenic) and are not included in the GHG Assessment Boundary. This is consistent with the Intergovernmental Panel on Climate Change's (IPCC) guidelines.[19]

This protocol does not account for carbon dioxide reductions associated with displacing grid-delivered electricity. Combusting biogas to produce electricity for the grid would be defined as a complementary and separate renewable energy project. Likewise, this protocol does not account for carbon dioxide reductions associated with the displacement of fossil fuels used for mobile or stationary combustion sources. Utilizing biogas as replacement fuel for boilers, vehicles, or other equipment would be defined as a complementary and separate activity.

Figure 4.1 below provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the boundary.

Table 4.1 provides justification for the inclusion or exclusion of certain SSRs and gases from the GHG Assessment Boundary.

[17] The definition and assessment of Sources, Sinks, and Reservoirs (SSRs) is consistent with ISO 14064-2 guidance.
[18] The rationale is that carbon dioxide emitted during combustion represents the carbon dioxide that would have been emitted during natural decomposition of the solid waste. Emissions from the landfill gas control system do not yield a net increase in atmospheric carbon dioxide because they are theoretically equivalent to the carbon dioxide absorbed during plant growth.
[19] *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; pg 5.10, ftnt 4. The rationale is that carbon dioxide emitted during combustion represents carbon dioxide that would have been emitted during the natural decomposition of the waste.

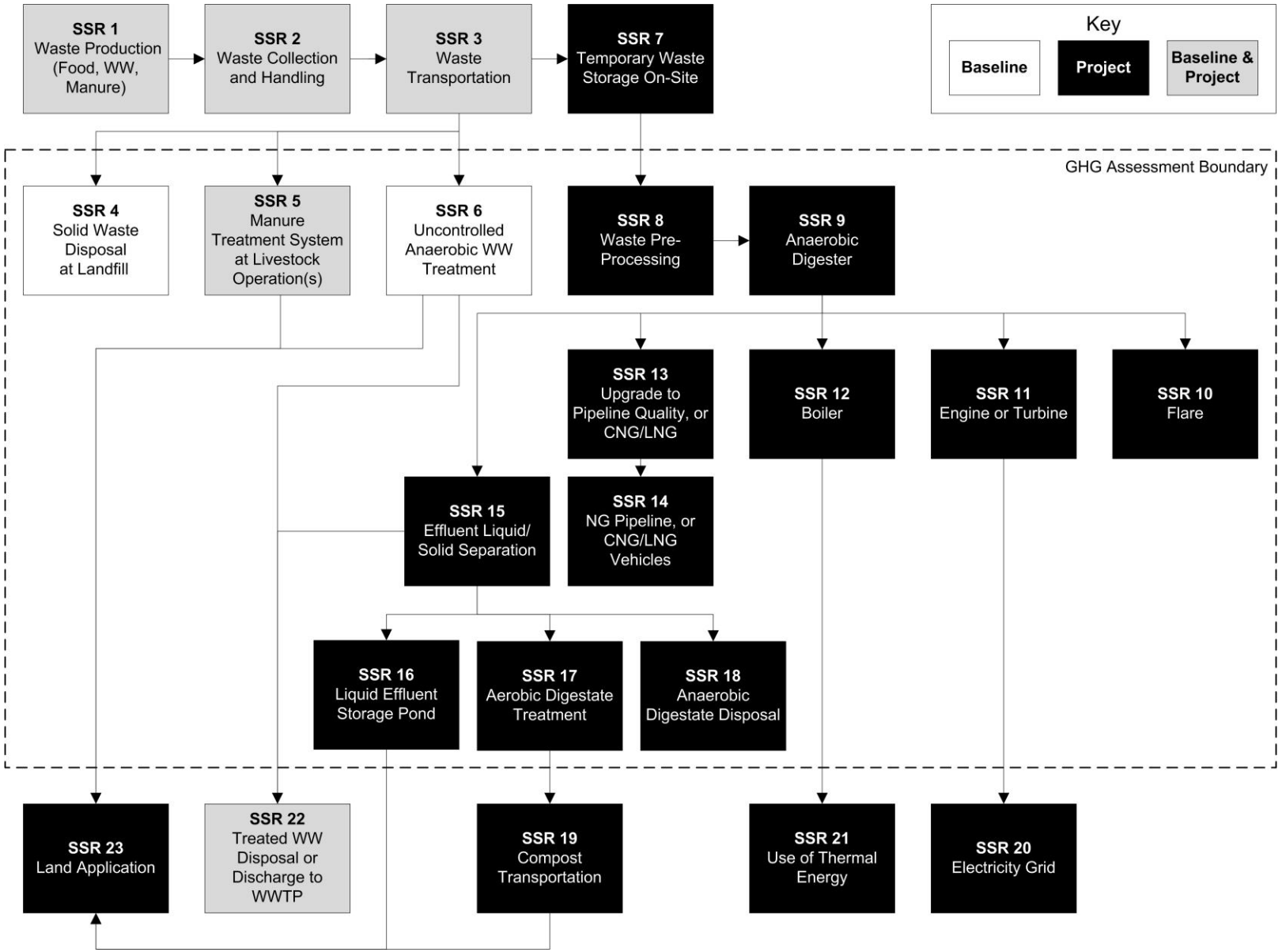

Figure 4.1. General Illustration of the GHG Assessment Boundary

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
1. Waste Production	Fossil fuel emissions associated with the generation of waste	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity.
		CH_4	E	N/A	Excluded, as project activity is unlikely to impact emissions relative to baseline activity.
		N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity.
2. Waste Collection and Handling	Fossil fuel emissions from mechanical systems used to collect, handle, and/or process waste prior to transportation, as well as GHG emissions resulting from the temporary storage of organic wastes.	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity.
		CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity.
		N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity.
3. Waste Transportation	Fossil fuel emissions from transport of waste to final disposal/treatment system (e.g. garbage trucks, hauling trucks, wastewater pumps, etc.)	CO_2	E	N/A	Excluded for simplicity, as emissions from project activity will in most instances be less than or of comparable magnitude to baseline transportation emissions due to the tendency to site digestion projects close to waste sources.[20] Also, the difference between project and baseline waste transportation distance can be large without significantly affecting a project's total net GHG reductions.
		CH_4	E	N/A	Excluded, as the net change in emissions from this source is assumed to be very small.
		N_2O	E	N/A	Excluded, as the net change in emissions from this source is assumed to be very small.
4. Solid Waste Disposal at Landfill	Emissions resulting from the anaerobic decay of food and food-soiled paper waste disposed of at a landfill	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** Modeled using FOD model based on site-specific measurement of the quantity of food waste diverted to the BCS, waste specific characteristic factors, and local climate **Project:** N/A	This is one of the primary sources of GHG emissions that may be affected by an OWD project.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.

[20] SAIC, Methane Avoidance from Composting Issue Paper (2009).

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
5. Manure Treatment System at Livestock Operation(s)	Emissions resulting from the uncontrolled anaerobic treatment of manure. Emissions from all treatment and storage systems at each livestock operation must be accounted for per the Reserve's Livestock Project Protocol	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** Modeled according to LS Protocol using site-specific information **Project:** Modeled according to LS Protocol using site-specific information	This is one of the primary sources of GHG emissions that may be affected by an OWD project, if the project is co-digesting manure with eligible organic waste streams.
		N_2O	E	N/A	Excluded; this is conservative as anaerobic digestion treatment of manure is likely to reduce emissions.
6. Uncontrolled Anaerobic Wastewater Treatment	Emissions resulting from the pre-project anaerobic treatment of organic loaded agro-industrial wastewater	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** Modeled using WW stream specific COD samples and default values **Project:** N/A	This is one of the primary sources of GHG emissions that may be affected by an OWD project.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
7. Temporary Waste Storage On-Site	If waste is temporarily stored onsite before digestion, GHG emissions may result if storage conditions are anaerobic	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small. Waste is unlikely to be stored in uncontrolled anaerobic conditions due to odor issues, and incentive to capture the highest energy value of the feedstock.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
8. Waste Pre-Processing	Emissions resulting from the use of fossil fuels or grid delivered electricity for waste pre-processing equipment	CO_2	I	**Baseline:** N/A **Project:** Estimated using fossil fuel use or electricity use data and appropriate emission factors	Depending on the specifics of project waste pre-processing practices, increases in GHG emissions from this source could be significant.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
9. Anaerobic Digester	Fugitive emissions from the anaerobic digester due to biogas collection inefficiency and unexpected biogas venting events	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** N/A **Project:** Metered, assuming default digester gas collection efficiencies. Emissions from venting events are estimated based on metered data and digester design	Fugitive CH_4 emissions in the project case may be significant depending on the BCS collection efficiency; venting events must be quantified.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
10. Flare	Emissions resulting from the destruction of biogas in flare	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** N/A **Project:** Metered, assuming a default methane destruction efficiency	Project CH_4 emissions may be significant, depending on destruction efficiency of flare.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
11. Engine or Turbine	Emissions resulting from the destruction of biogas in engine or turbine	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** N/A **Project:** Metered, assuming a default methane destruction efficiency	Project CH_4 emissions may be significant, depending on destruction efficiency of engine or turbine.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
12. Boiler	Emissions resulting from the destruction of biogas in boiler or other destruction device	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** N/A **Project:** Metered, assuming a default methane destruction efficiency	Project CH_4 emissions may be significant, depending on destruction efficiency of boiler or other device.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
13. Upgrade to Pipeline Quality or CNG/LNG	Emissions resulting from the use of fossil fuels or grid delivered electricity used to upgrade the quality of and transport the gas to the NG pipeline	CO_2	I	**Baseline:** N/A **Project:** Estimated using fossil fuel use or electricity use data and appropriate emission factors	Project CO_2 emissions resulting from onsite fossil fuel use and/or grid delivered electricity may be significant.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
14. NG Pipeline, or CNG/LNG Vehicles	Emissions from compressors and other equipment associated with transporting the natural gas through the pipeline	CO_2	E	N/A	Excluded, as the change in emissions from this source is assumed to be very small.
		CH_4	I	**Baseline:** N/A **Project:** Metered, assuming a default value representing the methane leakage in a NG pipeline and the end-use methane combustion efficiency	Project CH_4 emissions may be significant, depending on efficiency of end-user destruction, as well as processing, transmissions, and distribution losses.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
15. Effluent Liquid/Solid Separation	Emissions resulting from the burning of fossil fuels or use of grid delivered electricity for effluent solid separation equipment	CO_2	I	**Baseline:** N/A **Project:** Estimated using fossil fuel use or electricity use data and appropriate emission factors	Project CO_2 emissions resulting from onsite fossil fuel use and/or grid delivered electricity may be significant.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
16. Liquid Effluent Storage Pond	Emissions resulting from the open storage of the liquid component of digester effluent	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** Modeled using effluent stream specific COD samples and default values **Project:** N/A	A potentially significant source of GHG emissions depending on the specifics of the BCS system design.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
17. Aerobic Digestate Treatment	Emissions resulting from the active composting of digestate, either onsite or offsite	CO_2	Fossil: I Biogenic: E	**Baseline:** N/A **Project:** Estimated using fossil fuel use or electricity use data and appropriate emission factors	Project CO_2 emissions resulting from onsite fossil fuel use (and any offsite transport of digestate) and/or grid delivered electricity may be significant. Biogenic CO_2 emissions from aerobic treatment are excluded.
		CH_4	I	**Baseline:** N/A **Project:** Estimated using default emission factors based upon a tiered approach representing the risk of GHG emissions from the site-specific aerobic digestate treatment system	Project CH_4 emissions could be very small, but depend on the management of the composting process and feedstock, and are difficult to quantify on a standardized basis. Projects are required to account for potential emissions based on project-specific digestate management practices.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		N_2O	I	**Baseline:** N/A **Project:** Estimated using default emission factors based upon a tiered approach representing the risk of GHG emissions from the site-specific aerobic digestate treatment system	Project N_2O emissions could be very small, but depend on the management of the composting process and feedstock, and are difficult to quantify on a standardized basis. Projects are required to account for potential emissions based on project-specific digestate management practices.
18. Anaerobic Digestate Disposal	Emissions from the anaerobic disposal of digestate	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	**Baseline:** N/A **Project:** Modeled w/ FOD model based on site-specific measurement of the quantity of digestate material disposed anaerobically, conservative default digestate characteristic factors, and local climate	If digestate is disposed of anaerobically, fugitive emissions under the project could be significant.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
19. Compost Transport	Fossil fuel emissions from the transport of the finished compost to the site of end-use	CO_2	E	N/A	Excluded because the difference in baseline and project case emissions is expected to be insignificant, In the absence of compost, other fertilizer products would be transported to the site of application.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
20. Electricity Grid	Fossil fuel emissions from electricity generation displaced by the project	CO_2	E	N/A	This protocol does not cover displacement of GHG emissions from using biogas instead of fossil fuels in electrical generating equipment.
		CH_4	E	N/A	
		N_2O	E	N/A	
21. Use of Thermal Energy	Fossil fuel emissions from thermal energy generation displaced by the project	CO_2	E	N/A	This protocol does not cover displacement of GHG emissions from using biogas instead of fossil fuels in thermal energy generating equipment.
		CH_4	E	N/A	
		N_2O	E	N/A	
22. Treated Wastewater Disposal or Discharge to WWTP	Emissions from treated agro-industrial wastewater disposed of, or discharged into, the natural environment or a sewer system	CO_2	E	N/A	Excluded, as project activity is unlikely to increase emissions from wastewater disposal relative to baseline.
		CH_4	E	N/A	
		N_2O	E	N/A	

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
23. Land Application	Emissions and Sinks related to the land application of treated manure, organic wastewater, and finished compost	CO_2	E	N/A	Excluded, as project activity is unlikely to increase emissions relative to baseline. Furthermore, the application of finished compost as soil amendment or mulch on agricultural lands can result in significant GHG benefits due to avoided fossil based fertilizer use, increased carbon sequestration, increased water retention in soils, and other impacts. This protocol does not address the GHG benefits of compost end-use, which is considered a complementary and separate activity.
		CH_4	E	N/A	
		N_2O	E	N/A	

5 Quantifying GHG Emission Reductions

GHG emission reductions from an OWD project are quantified by comparing actual project emissions to baseline emissions from anaerobic waste management of the eligible waste streams. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the OWD project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1). GHG emission reductions must be quantified and verified at least every 12 months. Project developers may choose to quantify and verify GHG emission reductions on a more frequent basis if they desire. The length of time over which GHG emission reductions are quantified and verified is called the "reporting period."

The Reserve requires all projects to compare the calculated baseline emissions for the reporting period, as calculated in Section 5.1, to the ex-post metered quantity of methane that is destroyed in the biogas control system over the same period. The lesser of the two values must be used to estimate total baseline emissions for the reporting period. Equation 5.1 below provides the quantification approach that shall be used for calculating the emission reductions from OWD project activities. [21]

[21] The Reserve's GHG reduction calculation method for OWD projects is derived from the Kyoto Protocol's Clean Development Mechanism (AM0025 V.10, AM0073 V.1, ACM0014 V.2.1, AMS-III.E V.15.1, AMS-III.F V.6.0, and AMS-III.H V.9.0), and also draws from the Regional Greenhouse Gas Initiative (RGGI) Model Rule, the U.S. EPA Inventory of U.S. GHG Emissions and Sinks 1990-2006, and the 2006 IPCC Guidelines for National GHG Inventories

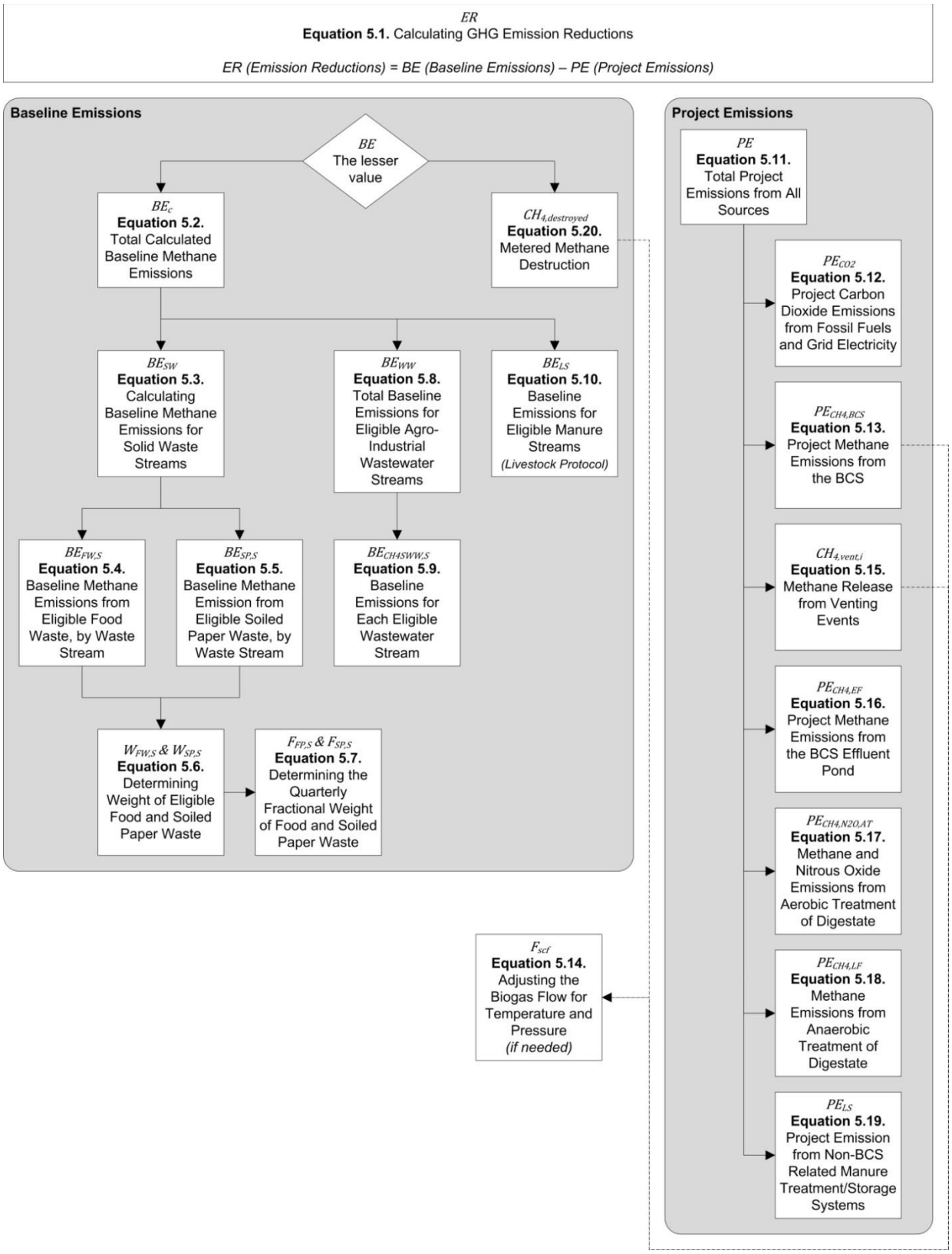

Figure 5.1. Organizational Chart of Equations in Section 5

Equation 5.1. Calculating GHG Emission Reductions

$$\boldsymbol{ER = BE - PE}$$

Where,

			Units
ER	=	Total emission reductions for the reporting period	tCO_2e
BE	=	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary	tCO_2e
PE	=	Total project emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.2)	tCO_2e

$$\boldsymbol{BE = min\left(BE_c, CH_{4,destroyed}\right)}$$

Where,

			Units
BE_c	=	Total calculated baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.1)	tCO_2e
$CH_{4,destroyed}$	=	Aggregated quantity of methane destroyed by the BCS during the reporting period (as calculated in Section 5.3)	tCO_2e

5.1 Quantifying Baseline Emissions

Total baseline emissions must be estimated by calculating and summing the expected baseline emissions for all relevant SSRs (as indicated in Table 4.1), during the reporting period.

The calculations used to estimate baseline emissions will depend on the management option(s) that would have been used to treat and/or dispose of eligible organic waste streams in the absence of an OWD project. Different baseline management options are assumed depending on the type of eligible waste stream involved:

- *MSW Food Waste and Food-Soiled Paper Waste*: Uneaten food, spoiled food, food preparation wastes, and non-recyclable food-soiled paper wastes from homes, restaurants, kitchens, grocery stores, campuses, cafeterias, and similar institutions is predominantly disposed of at managed landfills. Nation-wide, less than 3% of MSW food waste is currently diverted from landfills.[22] Thus, for the purposes of this protocol, the baseline emissions from MSW food waste streams are calculated based on the assumption that the waste would have been disposed of at a landfill in the absence of the project.[23] See Section 5.1.1 for the calculation procedure that must be used to quantify baseline emissions for eligible food and food-soiled paper waste streams.

- *Agro-industrial Wastewater*: Organic loaded wastewater from industrial or agricultural processing operations, if treated onsite at the facility, may be treated in uncontrolled anaerobic or semi-anaerobic lagoons, ponds, or tanks. Thus, for the purposes of this protocol, the baseline emissions from agro-industrial wastewater streams are calculated based on the wastewater treatment system in place prior to the installation of the BCS. The project developer must demonstrate that the pre-project wastewater treatment system utilized anaerobic treatment processes, and did not incorporate methane capture

[22] U.S. EPA, *Municipal Solid Waste Generation, Recycling, and Disposal in the United States – Tables and Figures for 2010.* Table 2.

[23] Food waste streams originating from grocery stores or supermarkets must have their pre-project disposal documented according to Section 6.1.2.

and control technologies. If this cannot be demonstrated for a particular wastewater stream, baseline emissions for the particular wastewater stream are assumed to be zero. See Section 5.1.2 for the calculation procedure that must be used to quantify baseline emissions for eligible wastewater streams.

- *Livestock manure*: For projects that co-digest eligible organic waste streams together with livestock manure, the baseline emissions for manure management draw from the Reserve's Livestock Project Protocol. Each livestock operation contributing manure waste to the digestion project shall account for baseline emissions from all sources within the GHG Assessment Boundary. See Section 5.1.3 of this protocol for requirements for calculating baseline emissions from manure management.

If the OWD project co-digests ineligible waste streams together with eligible organic waste streams, baseline emissions for all ineligible waste streams are assumed to be zero.

As shown in Equation 5.2, baseline emissions equal:

- The methane emissions from the decay of food and food-soiled paper waste deposited in a landfill (SSR 4), plus
- The methane emissions from anaerobic wastewater treatment of agro-industrial wastewaters (SSR 6), plus
- The methane generated by pre-project manure management systems (SSR 5)

Equation 5.2. Total Calculated Baseline Methane Emissions

$$\boldsymbol{BE_c = (BE_{SW} + BE_{WW} + BE_{LS})}$$

Where,

			Units
BE_c	=	Total calculated baseline emissions from all SSRs in the GHG Assessment Boundary during the reporting period	tCO_2e
BE_{SW}	=	Total baseline emissions during the reporting period, for eligible solid waste (food and food-soiled paper) streams (SSR 4)	tCO_2e
BE_{WW}	=	Total baseline emissions during the reporting period, for eligible agro-industrial wastewater streams (SSR 6)	tCO_2e
BE_{LS}	=	Total sum of the calculated baseline emissions during the reporting period, for all livestock operations contributing manure to the digester (SSR 5)	tCO_2e

5.1.1 Baseline Emissions from Eligible Food and Food-Soiled Paper Waste Streams (SSR 4)

Equations 5.3 and 5.4 represent the FOD model calculations that must be used to estimate baseline emissions for both the food waste component and the soiled paper component of the eligible waste that is digested by the project. For the calculation, the total weight of the food and soiled paper waste from each eligible waste stream must be aggregated over the reporting period. The inputs to the FOD model include:

- The state waste-to-energy (WTE) rate – the percentage of the waste that would have gone to a waste incineration plant instead of a landfill on a state-by-state basis

- The landfill gas collection efficiency (LCE) – the percentage of landfill gas that is captured and controlled due to the presence of a landfill gas collection and control system (see Box 5.1 for further information on the LCE parameter)
- The waste-specific fraction of total degradable organic carbon (DOC_S), and fraction of DOC_S that is degradable under anaerobic conditions (DOC_f)
- The decay rate of the waste, k, which is a function of both the type of waste and external climate of the region where the waste would have been landfilled

The FOD model estimates the methane emissions that would have been emitted to the atmosphere over a period of ten years following the year in which the waste is diverted to the project's BCS.[24]

Equation 5.3. Calculating Baseline Methane Emissions for Solid Waste Streams (SSR 4)

$$\boldsymbol{BE_{SW} = \sum_{S} BE_{CH_4,S}}$$

Where,

			Units
BE_{SW}	=	Total sum of the baseline emissions from solid waste (food waste and soiled paper waste) during the reporting period	tCO_2e
$BE_{CH4,S}$	=	Baseline methane emissions from digested waste stream 'S' during the reporting period	tCO_2e

$$\boldsymbol{BE_{CH_4,S} = BE_{FW,S} + BE_{SP,S}}$$

Where,

			Units
$BE_{FW,S}$	=	Baseline methane emissions from the food waste component of eligible waste stream 'S' that is digested during the reporting period	tCO_2e
$BE_{SP,S}$	=	Baseline methane emissions from the soiled paper component of eligible waste stream 'S' that is digested during the reporting period	tCO_2e

[24] The FOD model used in Equation 5.4 is referenced from the UNFCCC Clean Development Mechanism (CDM) approved methodology for calculating avoided methane emissions from waste diversion (CDM Annex 10 – Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0)). However, the model has been adapted in order to quantify emissions from a full ten years of waste degradation upfront rather than distributed on an annual basis. Due to modeling uncertainty, it is conservative to limit the calculation time frame to ten years, although waste would likely continue to break down in a landfill situation for much longer than ten years.

Equation 5.4. Baseline Methane Emissions from Eligible Food Waste, by Waste Stream

$$BE_{FW,S} = 0.9 \times W_{FW,S} \times (1 - WTE_S) \times 128 \times \rho \times FE_{FW,S} \times 21$$

Where,			Units
$BE_{FW,S}$	=	Baseline methane emissions from the food waste component of eligible waste stream 'S' that is digested during the reporting period	tCO_2e
0.9	=	Model correction factor to account for model and waste composition uncertainties related to waste composition and waste characteristics[25]	fraction
$W_{FW,S}$	=	Aggregated weight of eligible food waste (on a wet basis) from eligible waste stream 'S' that is digested by the project during the reporting period. See Section 5.1.1.1 for guidance on determining the weight of eligible food waste	t of food waste (wet weight)
WTE_S	=	Fraction of waste from eligible waste stream 'S' that would have been incinerated at a waste-to-energy plant in lieu of being landfilled. This fraction is equal to the state-specific fraction of total generated waste that is incinerated. Referenced by waste origination state from Table B.2 in Appendix B	fraction
128	=	Methane potential of food waste, measured on a wet basis[26]	m^3CH_4/t of food waste (wet weight)
ρ	=	Density of methane, equal to 0.000674	tCH_4/m^3
$FE_{FW,S}$	=	Fraction of methane generated that is emitted to the atmosphere over a ten year time horizon, as calculated using the First Order Decay function. The fraction emitted to the atmosphere is a function of the decay rates of food waste, the landfill gas collection assumptions (see Box 5.1), and the amount of methane generated that is oxidized in the cover soil	fraction
21	=	Global warming potential of methane	tCO_2e / tCH_4

[25] As per CDM Annex 10 – Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0) http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v4.pdf/history_view

[26] U.S. EPA Inventory of Greenhouse Gas Emissions and Sinks, 1990-2008. Annex 3, Ch. 3.14, pg. A-295.

Equation 5.4. (Continued)

$$FE_{FW,S} = \sum_{x=1}^{10}\left[e^{-k_{FW,S}(x-1)} \times \left(1 - e^{-k_{FW,S}}\right) \times \left(1 - (GC_S \times LCE_x)\right)\right] \times (1 - 0.1)$$

Where,			Units
e	=	Mathematical constant, approximately equal to 2.71828	
$k_{FW,S}$	=	Decay rate for food waste stream 'S'. The decay rate is a function of the climatological characteristics of the region where the waste is landfilled. Referenced from Table B.1 by waste type and climate category, which is referenced from Figure B.1	yr^{-1}
x	=	Placeholder for the iterative calculation. The FOD equation calculates emissions out over a period of ten years (x=1 to 10) following the year in which the waste is initially diverted to the digester. The ten year calculation is summed and applied to the total baseline emissions for the current reporting period	
GC_S	=	Gas collection factor for waste stream 'S'. The gas collection factor is equal to the fraction of waste disposed at landfills with gas collection systems in the state from which waste stream 'S' originates. Referenced by state from Table B.2 in Appendix B	fraction
LCE_x	=	Fraction of methane that would be captured and destroyed by LFG collection systems in the year x, starting with the year that the waste is diverted to the project (x=1) and ending with year x=10. All projects shall use a value of 0.0 for the first two years of calculated waste decay (x=1 to 2), a value of 0.5 for the third year (x=3), a value of 0.75 for years 4 to 7 (x=4 to 7), and a value of 0.95 for the remaining years of decay until the end of the calculation period (x=8 to 10). See Box 5.1 for a discussion on LCE assumptions[27]	fraction
0.1	=	Factor for the oxidation of methane by cover soil bacteria[28]	fraction

[27] The Reserve will periodically re-assess the LCE default parameters in order to ensure that landfill gas collection assumptions remain conservative and accurate.

[28] As per the Reserve Landfill Project Protocol V3.0, CDM Annex 10 – Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0), and U.S. EPA *Solid Waste Management and Greenhouse Gases: A Lifecycle Assessment of Emissions and Sinks,* Chapter 6, Pg. 87, ftnt27.

Equation 5.5. Baseline Methane Emissions from Eligible Soiled Paper Waste, by Waste Stream

$$BE_{SP,S} = 0.9 \times W_{SP,S} \times (1 - WTE_S) \times 310 \times \rho \times FE_{SP,S} \times 21$$

Where,			Units
$BE_{SP,S}$	=	Baseline methane emissions from the soiled paper component of eligible waste stream 'S' that is digested during the reporting period	tCO_2e
$W_{SP,S}$	=	Aggregated weight of eligible soiled paper waste (on a wet basis) from eligible waste stream 'S' that is digested by the project during the reporting period. See Section 5.1.1.1 for guidance on determining the weight of eligible soiled paper waste	t of soiled paper (wet weight)
WTE_S	=	Fraction of waste from eligible waste stream 'S' that would have been incinerated at a waste-to-energy plant in lieu of being landfilled. This fraction is equal to the state-specific fraction of total generated waste that is incinerated. Referenced by waste origination state from Table B.2 in Appendix B	fraction
310	=	Methane potential of soiled paper waste, measured on a wet basis. [29]	m^3CH_4/t of food waste (wet weight)
ρ	=	Density of methane, equal to 0.000674	tCH_4/m^3
$FE_{SP,S}$	=	Fraction of methane generated that is emitted to the atmosphere over a ten year time horizon, as calculated using the First Order Decay function. The fraction emitted to the atmosphere is a function of the decay rates of soiled paper waste, the landfill gas collection assumptions (see Box 5.1), and the amount of methane generated that is oxidized in the cover soil	fraction
21	=	Global warming potential of methane	tCO_2e / tCH_4

[29] U.S. EPA *Solid Waste Management and Greenhouse Gases: A Lifecycle Assessment of Emissions and Sinks,* Chapter 6, Exhibit 6-3. The Value represents the methane potential of 'office paper'.

Equation 5.5. (Continued)

$$FE_{SP,S} = \sum_{x=1}^{10}\left[e^{-k_{SP,S}(x-1)} \times \left(1 - e^{-k_{SP,S}}\right) \times \left(1 - \left(GC_S \times LCE_x\right)\right)\right] \times (1 - 0.1)$$

Where,			Units
e	=	Mathematical constant, approximately equal to 2.71828	
$k_{SP,S}$	=	Decay rate for soiled paper waste stream 'S'. The decay rate is a function of the climatological characteristics of the region where the waste is landfilled. Referenced from Table B.1 by waste type and climate category, which is referenced from Figure B.1	yr^{-1}
GC_S	=	Gas collection factor for waste stream 'S'. The gas collection factor is equal to the fraction of waste disposed at landfills with gas collection systems in the state from which waste stream 'S' originates. Referenced by state from Table B.2 in Appendix B	fraction
LCE_x	=	Fraction of methane that would be captured and destroyed by LFG collection systems in the year x, starting with the year that the waste is diverted to the project (x=1) and ending with year x=10. All projects shall use a value of 0.0 for the first two years of calculated waste decay (x=1 to 2), a value of 0.5 for the third year (x=3), a value of 0.75 for years 4 to 7 (x=4 to 7), and a value of 0.95 for the remaining years of decay until the end of the calculation period (x=8 to 10). See Box 5.1 for a discussion on LCE assumptions[30]	fraction
0.1	=	Factor for the oxidation of methane by cover soil bacteria[31]	fraction

[30] The Reserve will periodically re-assess the LCE default parameters in order to ensure that landfill gas collection assumptions remain conservative and accurate.

[31] As per the Reserve Landfill Project Protocol V3.0, CDM Annex 10 – Tool to determine methane emissions avoided from dumping waste at a SWDS (V4.0), and U.S. EPA *Solid Waste Management and Greenhouse Gases: A Lifecycle Assessment of Emissions and Sinks,* Chapter 6, Pg. 87, ftnt27.

Box 5.1. OWD Project Protocol Treatment of Landfill Gas Collection Systems

Landfill Gas Collection System Assumptions

The baseline emission calculation excludes methane that would have otherwise been captured and controlled by an active landfill gas collection system. The Reserve acknowledges that many landfills have active gas collection and control systems in operation, of which the majority are in place due to federal, state, or local regulations.[32] Due to the uncertainty and difficulty associated with tracking and verifying pre-project waste disposal activities on a project-by-project basis, this protocol utilizes a conservative and highly standardized approach to determining the landfill gas collection efficiency (LCE) parameter for eligible waste baseline emission calculations that incorporates the most up-to-date scientific understanding of landfill gas collection efficiencies and state-specific landfill gas collection practices.

Specifically, the baseline calculation reflects the following assumptions:

1. The fraction of each eligible waste stream digested by the project that would have been disposed at a landfill with a collection system in the absence of the project is equal to the fraction of total disposed waste that is accepted at landfills with known or potential landfill gas collection systems on a state-specific basis. The state-specific gas collection fraction (GC_S), is referenced from Table B.2 in Appendix B based on where each eligible waste stream originated.[33] The fraction of each eligible waste stream digested by the project that would have been disposed at a landfill without gas collection ($1\text{-}GC_S$) is assumed to have a landfill gas collection efficiency of 0%.

2. The landfill gas collection efficiency (LCE) parameter assumes landfills with gas collection will have a phased gas collection efficiency consistent with common landfill gas management.[34] The LCE_x parameter in Equations 5.3 and 5.4 shall be equal to zero for a period of two full years following the diversion and digestion of the waste, followed by 50% collection efficiency in the third year, 75% collection in years 4 to 7, and 95% collection for years 8 to 10.

5.1.1.1 Determining the Weight of Eligible Food Waste

Eligible waste is likely to be delivered to the OWD project mixed with varying quantities and types of ineligible organic and/or inorganic materials. The type and quantity of eligible and ineligible waste contained in each delivery will depend primarily on the waste generation source where the material originates, and the methods by which organics are separated, or not, from the upstream waste. Depending on the operational design of the OWD project, the project might accept non-source separated MSW streams (mixed MSW) and/or source separated organics (SSO) streams.

The project must track delivery of waste from each eligible waste stream and determine the percentages of MSW food waste and soiled paper in each eligible waste stream according to Equation 5.6 below. If the project is using quarterly food and soiled paper waste fractions, Equation 5.5 must be performed quarterly and summed over the entire reporting period to obtain the total weight of food and soiled paper waste digested by the project over the reporting period.

[32] Per the Performance Standard Analysis conducted for the Reserve's Landfill Project Protocol, V 2.0. See Appendix C of the Reserve's Landfill Project Protocol.

[33] The GC_S fraction was determined using data from the 2008 U.S. EPA Landfill Methane Outreach Program (LMOP) database.

[34] M.Barlaz et al. Memorandum to Jennifer Brady, Office of Resource Conservation and Recovery, U.S. EPA: *WARM Component-Specific Decay Rate Methods.* (2009).

Equation 5.6. Determining Weight of Eligible Food and Soiled Paper Waste

$$W_{FW,S} = W_{T,S} \times FD_S \times F_{FW,S}$$

Where,			Units
$W_{FW,S}$	=	Aggregated weight of eligible food waste (on a wet basis) from waste stream 'S' that is digested by the project during the reporting period	t food waste
$W_{T,S}$	=	Aggregated total weight of waste (on a wet basis) from waste stream 'S' that is delivered to the facility during the reporting period	t
FD_S	=	Fraction of waste stream 'S' that is digested during the reporting period	fraction
$F_{FW,S}$	=	Food waste fraction of waste stream 'S'. The fraction must be determined based on the corresponding methods described in Sections 5.1.1.2 and 5.1.1.3 below, according to the type of waste delivered to the site	fraction

$$W_{SP,S} = W_{T,S} \times FD_S \times F_{SP,S}$$

Where,			Units
$W_{SP,S}$	=	Aggregated weight of eligible soiled paper waste (on a wet basis) from waste stream 'S' that is digested by the project during the reporting period	t soiled paper
$F_{SP,S}$	=	Soiled paper waste fraction of waste stream 'S'. The fraction must be determined based on the corresponding methods described in Sections 5.1.1.2 and 5.1.1.3 below, according to the type of waste delivered to the site	fraction

5.1.1.2 Determining the Fraction of Eligible Waste in a Mixed MSW Waste Stream (Non-Source Separated)

If a composting project is receiving a mixed MSW stream, the weight of food waste must be determined using one of the four options detailed below. The first two options are applicable for all mixed MSW waste streams, the third is applicable only to Materials Recovery Facility (MRF) fines, and the fourth is applicable only to non-SSO (i.e. mixed) organics-rich MSW from a single source facility.

Option 1:

The first option is to determine the weight of food waste using a national default factor of 20% of the total measured weight of the mixed MSW.[35]

Option 2:

The second option is to determine the weight of food waste using a food waste composition factor based on a published state, regional, or municipal waste characterization study. If this option is chosen, the project must be sourcing a majority of the relevant waste stream from within the geographic boundaries of the study. The waste characterization study must have been conducted no more than 5 years prior to the current project reporting year.

[35] Based on the EPA's *Municipal Solid Waste Generation, Recycling, and Disposal in the United States, Tables and Figures for 2010*. Figure 13, pg. 45. (2011).

Option 3:

The third option, applicable only to MRF fines, allows project developers to conduct site-specific waste sampling for the MSW fines composted at the operation according to the following procedure:

- All sampling events shall use at least a 100 lb sample of the organic fine material that has recently passed through the final stage of the screening process
- Material particles larger than approximately two inches in diameter shall be physically sorted or screened, and weighed. The remaining fines fraction shall be collected and weighed in its entirety. The remaining fines must be mixed and shoveled into a radially symmetrical pile, and divided into quarters using perpendicular boards. One quarter of the remaining fines must be collected and chosen for hand sampling, and used as a basis for the composition of all fines in that sample
- The mixed waste quarter-sample shall be sorted into the following categories: food waste, soiled paper, other ineligible material

Each sampling event must quantify and record the proportional weight of food waste and of soiled paper as compared to the total weight of the sample:

- To determine the characterization for the 100 lb (or greater) sample, the project developer must recombine the composition result analytically and determine the weighted average based on the relative amounts of fines, as well as the larger (greater than two inch) particles sampled. Using Equation 5.7, the project developer shall quantify the mean food waste proportional weight ($F_{FW,S}$) and soiled paper proportional weight ($F_{SP,S}$). The $F_{FW,S}$ and $F_{SP,S}$ values shall then be used in Equation 5.5 for MRF fines waste streams
- Photo documentation and calculations must be recorded and retained for verification purposes, clearly showing the waste stream from which the sample is taken, the waste sample itself, the quartered sample pre-sorting, and the separated categories of waste following the hand-sorting

Each waste stream for which this procedure is applied shall have a minimum of eight sampling events (two per calendar quarter) for the first year that the stream is composted at the operation, followed by four sampling events every year thereafter (one per calendar quarter). The sampling events will produce single values for $F_{FW,S}$ and $F_{SP,S}$ for each calendar quarter. During a quarter with two sampling events, the values for that quarter shall be equal to an average of the respective values determined at each of the two events.

Option 4:

The fourth option is applicable only to organics-rich shipments of non-SSO (mixed) MSW that originate from a single source facility (either a single MRF or a single waste generator, such as a convention center or apartment complex). This option allows project developers to conduct site-specific waste sampling for the waste stream according to the following procedure:

- A single load shall be divided into a grid of at least 8 cells, and then at least 4 of those cells shall be selected for sampling using a systematic, random sampling approach (e.g. construct a 4x2 grid and use a coin toss to select one cell from each pair). The particular cells to be sampled shall be chosen anew with each sampling event

- All hand-sorting events shall use at least a 150 lb sample of the organic material from each cell that has been selected using the random sampling approach (i.e. at least four samples per event)
- Each sample shall be sorted into the following categories: food waste, soiled paper, other ineligible material
- Each sampling event must quantify and record the proportional weight of food waste and of soiled paper as compared to the total weight of the sample. The values for $F_{FW,S}$ and $F_{SP,S}$ shall be equal to the 90% lower confidence limit (LCL) of their respective sample results (Equation 5.7)
- Photo documentation and calculations must be recorded and retained for verification purposes, clearly showing the waste stream from which the sample is taken, the grid used for sampling (where possible) and the waste contained in each cell of the grid, the sample pre-sorting, and the separated categories of waste following the hand sorting

Each waste stream for which this procedure is applied shall have a minimum of eight sampling events (two per calendar quarter) for the first year that the stream is composted at the operation, followed by four sampling events every year thereafter (one per calendar quarter). The sampling events will produce single values for $F_{FW,S}$ and $F_{SP,S}$ for each calendar quarter.

Equation 5.7. Determining the Fraction of Eligible Waste in a Mixed-MSW MRF Fines Waste Stream

$$F_{i,S} = \frac{(W_{HS} \times F_{i,HS}) + (W_{PR} \times F_{i,QS})}{W_{sample}}$$

Where,

			Units
$F_{i,S}$	=	Fraction of waste category *i* (food waste or soiled paper waste) in eligible MRF fines waste stream 'S' (representing $F_{FW,S}$ for food waste and $F_{SP,S}$ for soiled paper waste)	fraction
W_{HS}	=	Weight of sample taken in large (>2") preliminary hand sort	lbs
$F_{i,HS}$	=	Fraction of waste category *i* in large (>2") preliminary hand sort	fraction
W_{PR}	=	Weight of total sample after large (>2") particles removed	lbs
$F_{i,QS}$	=	Fraction of waste category *i* in quarter sample	fraction
W_{sample}	=	Weight of total sample prior to hand sort (100 lb minimum) *(Note that $W_{sample} = W_{HS} + W_{PR}$)*	lbs

5.1.1.3 Determining the Fraction of Eligible Waste in a Source Separated Organics (SSO) Waste Stream

SSO waste is generated by both the commercial and residential sectors. Residential food waste collection programs are likely to produce a waste stream that is a combination of yard waste, food waste, and soiled paper. In certain regions and/or seasons, residential SSO may have limited yard waste material and may be primarily food and soiled paper. Commercial sector waste generators are broken down further into separate categories (see Table 5.1). The types of commercial generators listed in Table 5.1 will primarily produce waste streams that consist of food waste and soiled paper in varying proportions.

5.1.1.3.1 Residential SSO Waste Stream Characterization

In order to determine the percent of food and soiled paper waste in a residential SSO waste stream, projects must use local or site-specific waste characterization data to determine the

average fraction of food waste and soiled paper waste by weight collected by the residential diversion program. If available, projects may use local municipal waste characterization data provided by the local jurisdiction or a representative entity to quantify the proportion by weight of both food waste and soiled paper in the residential SSO waste stream. If local data are not available, projects must conduct site-specific waste sampling for each residential waste stream digested at the facility in accordance with the requirements in Section 5.1.1.4.

5.1.1.3.2 Commercial SSO Waste Stream Characterization

Commercial SSO waste is primarily food and food-soiled paper waste (excluding corrugated cardboard, which would be an ineligible waste type). By volume, commercial waste streams would likely contain a high proportion of soiled paper wastes to food waste, however on a weight basis it would be expected that the paper component of the waste stream would constitute a much smaller proportion due to the fact that food waste is very high in moisture, whereas paper material would be much less dense with a much lower moisture content.

If an SSO collection route delivers eligible SSO waste to the project that is collected from multiple commercial facilities across different categories, then the proportional weight of food waste and soiled paper waste in the mixed commercial SSO stream must be determined by conducting site-specific waste characterization in accordance with the requirements in Section 5.1.1.4. If a commercial SSO waste stream is delivered to the facility from a single facility, or an exclusive aggregate of facilities within the same category (e.g. a collection route servicing restaurants only), the project may apply the default factors rather than site-specific waste characterization.[36] The default values must be applied to the weight of the waste stream following initial removal of contaminants and/or ineligible SSO material (e.g. corrugated cardboard boxes).

Table 5.1. Waste Generator Categories and Default Food and Soiled Paper Fractions by Weight

Waste Generator Category	Fraction of Food Waste by Weight	Fraction of Soiled Paper by Weight
Restaurants/Cafeterias/Dining Halls/Other Food Service	0.80	0.10
Super Markets and Grocery Stores	0.80	0.10
Food Wholesale Distributors	0.70	0.20
Special Events and Public Venues	0.60	0.30
Other Commercial (Hotels, Office Buildings, Wholesale Distributors)	0.50	0.40

5.1.1.4 Site-Specific Waste Characterization Procedure

All site-specific waste characterization of SSO waste streams shall be done according to the following requirements[37]:

- Each waste stream shall have a minimum of 2 sampling runs per quarter, with each run consisting of at least 4 separate samples, for a total of 8 waste characterization samples per quarter

[36] Default values are developed by determining the ratio of Misc. Paper and Composite Paper to Food Waste generated within each waste generator category. Each category assumes 10% ineligible feedstock by weight as a conservativeness factor. The composition data is taken from California's Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry (Cascadia Consulting Group), 2006. The data is specific to California, however the types and proportions of material generated within a category would be expected to be relatively independent of region.

[37] It is recommended, but not required, that the waste characterization be performed by a qualified third party service provider.

- All waste characterization samples shall be at least 100 lb weight (wet) of mixed material drawn from a recent delivery of the SSO stream in question prior to mixing with other waste streams
- Each waste sample shall be sorted into the following categories: food waste, soiled paper, other ineligible material
- For each sample, the project developer must quantify and record the proportional weight of food waste and of soiled paper as compared to the total weight of the sample
- The project must quantify the food waste proportional weight and soiled paper proportional weight ($F_{FW,S}$ and $F_{SP,s}$) on a quarterly basis by using Equation 5.8 below to determine the 1-sided lower 90% confidence bound based on the 8 recorded proportional weight results

Written records and photo documentation must be retained for verification purposes. Section 6.1.1.1 provides requirements for site-specific waste characterization photo documentation and record keeping.

For commercial SSO waste streams delivered to the project from a single facility, the site-specific waste characterization events may occur on site or at the commercial waste generation facility.

Equation 5.8. Determining the Quarterly Fractional Weight of Food and Soiled Paper Waste

$$\boldsymbol{F_{FW,S}\ and\ F_{SP,S}} \;=\; \boldsymbol{90\%LCL = mean - t_{value} \times \left(\frac{SD}{\sqrt{n}}\right)}$$

Where,			Units
$F_{FW,S}$ and $F_{SP,S}$	=	Quarterly fractional weight of food and soiled paper waste (respectively) from waste stream 'S', equal to the 1-sided 90% lower confidence bound of the 8 quarterly fractional weights	fraction
mean	=	Quarterly fractional weight sample mean (of food or soiled paper waste) based on the number of sampling events	fraction
t_{value}	=	1-sided 90% t-value coefficient for a dataset with degrees of freedom *df*[38]	fraction
SD	=	Standard deviation of the quarterly fractional weight (of food or soiled paper waste)	fraction
n	=	Sample size	
df	=	Degrees of freedom (= n-1)	

5.1.2 Baseline Emissions from Eligible Agro-Industrial Wastewater Streams (SSR 6)

The calculations to determine the baseline methane emissions from agro-industrial wastewater streams that otherwise would have been treated in an anaerobic pond, lagoon, or tank are presented in Equation 5.9 and Equation 5.10 below. These equations shall be used to calculate the baseline emissions for each eligible wastewater stream that is digested in the project's BCS for each reporting period. Baseline emissions will be zero for any wastewater streams that, in

[38] For Microsoft Excel 2007 and earlier versions, use the formula "=TINV(0.2,*df*)". For version 2010 and later, use the formula "=T.INV.2T(0.2,*df*)".

the absence of the project, would have been treated at a wastewater treatment plant that collects and combusts methane gas.

The following equations calculate methane emissions that would have occurred during the reporting period from anaerobic decomposition of the waste in an anaerobic storage/treatment lagoon, pond, or tank by utilizing waste-specific inputs. The waste specific inputs include:

- The chemical cxygen demand (COD) of the wastewater as sampled – representing the organic load of the wastewater
- The methane conversion factor (MCF) – a function of the baseline storage/treatment system
- The methane producing capacity of the wastewater (B_0) – a function of the type of wastewater

Equation 5.9 and Equation 5.10 present the calculations that shall be used to quantify baseline emissions from all eligible wastewater streams during the reporting period. Each wastewater stream 'S' shall be sampled for COD content monthly according the guidance provided in Section 6.1.3.1.

Equation 5.9. Total Baseline Emissions for Eligible Agro-Industrial Wastewater Streams (SSR 6)

$$\boldsymbol{BE_{WW}} = \sum_{\boldsymbol{S}} \boldsymbol{BE_{CH_4,WW,S}}$$

Where,			Units
BE_{WW}	=	Total sum of the baseline emissions from each eligible wastewater stream entering the digester during the reporting period	tCO_2e
$BE_{CH4,WW,S}$	=	Baseline methane emissions from wastewater stream 'S', for the reporting period, calculated per Equation 5.10	tCO_2e

Equation 5.10. Baseline Emissions for Each Eligible Wastewater Stream

$$BE_{CH_4,WW,S} = B_{0,WW,S} \times MCF_{AT,S} \times 21 \times 0.89 \times \sum_i \left(Q_{WW,S,i} \times COD_{WW,S,i}\right)$$

Where,			Units
$BE_{CH4,WW,S}$	=	Baseline methane emissions from wastewater stream 'S', for the reporting period	tCO_2e
$B_{0,WW,S}$	=	Methane producing capacity of the wastewater stream 'S'. Project developers may use site-specific values that are determined based on the sampling approach provided in Section 6.1.3.2. The wastewater stream must be sampled prior to mixing with other residues. Alternatively, a conservative default value of 0.21 may be used[39]	tCH_4 / tCOD
$MCF_{AT,S}$	=	Methane conversion factor of the anaerobic treatment lagoon, pond, or tank where the waste was treated pre- project, equal to the lower bound value for the treatment system as provided in Table B.5 in Appendix B	fraction
21	=	Global warming potential for methane	tCO_2e/tCH_4
0.89	=	Baseline uncertainty factor to account for model uncertainties[40]	fraction
$Q_{WW,S,i}$	=	Volume of wastewater from stream 'S' in month *i*	m^3
$COD_{WW,S,i}$	=	Chemical oxygen demand of the untreated wastewater stream 'S' for month *i*. COD must be sampled prior to mixing with other residues, and must be sampled according to the guidance in Section 6.1.3.1 for each wastewater stream 'S' on a monthly basis	$tCOD/m^3$

5.1.3 Baseline Emissions from Manure Treatment Systems (SSR 5)

For projects that are co-digesting manure alongside eligible organic waste streams, project developers calculate the baseline emissions for the reporting period from all manure waste streams according to the pre-project manure management system in place at the livestock operation from which the manure is sourced. All livestock operations contributing waste to the digester must calculate baseline emissions from all manure management systems in accordance with the Reserve Livestock Project Protocol's baseline calculation approach (using the version of the Livestock Project Protocol that is current at the time of project submittal[41]). Projects co-digesting manure, whose reporting periods begin or end with incomplete calendar months, shall only quantify the baseline and project emissions for the portion of the month that is included within the reporting period. If a project developer can demonstrate that a particular manure management system is not affected by the project activity, then this system can be excluded from the baseline and project calculations. Baseline emissions from all livestock operations must be aggregated per Equation 5.11 below.

[39] Per CDM ACM0014 V.2.1 and CDM AMS III.F V.6

[40] Per Clean Development Mechanism (CDM) Methodology III.H, V.16.

[41] If a newer version of the Livestock Project Protocol is adopted subsequent to the project submittal, project developers have the option to upgrade to the newer version. However, reverting to a previous version is not allowed.

Equation 5.11. Baseline Emissions for Eligible Manure Streams (SSR 5)

$$BE_{LS} = \sum_{S} BE_{CH_4,LS,S}$$

Where,

			Units
BE_{LS}	=	Total sum of the calculated baseline emissions during the reporting period, for all livestock operations contributing manure to the digester (SSR 5)	tCO_2e
$BE_{CH4,LS,S}$	=	Baseline methane emissions from all affected manure management systems 'S', for the reporting period, calculated per the Livestock Project Protocol	tCO_2e

5.2 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of project activity. Project emissions must be quantified every reporting period on an *ex-post* basis.

As shown in Equation 5.12, project emissions equal:

- The carbon dioxide emissions from mobile and stationary combustion of fossil fuels and/or the use of grid delivered electricity (SSRs 3, 8, 13, 15, 17), plus
- The amount of methane created by the biogas control system that is not captured and destroyed by the control system (SSRs 9, 10, 11, 12, 14), plus
- The methane generated by the digester effluent storage pond (SSR 16), plus
- The methane and nitrous oxide produced by the aerobic treatment of the residual digestate produced in the digestion process (SSR 17), plus
- The methane generated by the anaerobic disposal of the residual digestate produced in the digestion process (SSR 18), plus
- The methane created by manure treatment and storage systems that were affected by project activity (SSR 5)

Equation 5.12. Total Project Emissions from All Sources

$$PE = \left(PE_{CO_2} + PE_{CH_4,BCS} + PE_{CH_4,EF} + PE_{CH_4,N_2O,AT} + PE_{CH_4,LF} + PE_{CH_4,LS}\right)$$

Where,			Units
PE	=	Total project emissions for the reporting period, from all SSRs within the GHG Assessment Boundary	tCO_2e
PE_{CO2}	=	Total project carbon dioxide emissions, for the reporting period, from fossil fuel and grid electricity sources included in the GHG Assessment Boundary (SSRs 3, 8, 13, 15, 17). See Section 5.2.1	tCO_2e
$PE_{CH4,BCS}$	=	Project methane emissions, for the reporting period, from the biogas control system (SSRs 9, 10, 11, 12, 14). See Section 5.2.2	tCO_2e
$PE_{CH4,EF}$	=	Project emissions for the reporting period, from the digester effluent pond (SSR 16) See section 5.2.3	tCO_2e
$PE_{CH4,N2O,AT}$	=	Project emissions of methane and nitrous oxide, for the reporting period, from the aerobic treatment of digestate material (SSR 17). See Section 5.2.4	tCO_2e
$PE_{CH4,LF}$	=	Project emissions, for the reporting period, from the anaerobic disposal of digestate material at a landfill (SSR 18). See Section 5.2.5	tCO_2e
$PE_{CH4,LS}$	=	Total sum of project emissions, for the reporting period, from manure management systems affected by the project (SSR 5)	tCO_2e

5.2.1 Project CO_2 Emissions from Fossil Fuel Combustion and Grid Delivered Electricity (SSRs 3, 8, 13, 15, 17)

Fossil Fuel Combustion and Grid Electricity

Included in the GHG Assessment Boundary are carbon dioxide emissions resulting from fossil fuel combustion and/or the use of grid delivered electricity for onsite equipment that is used for:

- The sorting and pre-processing of eligible waste (SSR 8)
- The upgrading of biogas to pipeline quality natural gas, compressed natural gas (CNG) or liquid natural gas (LNG) (SSR 13)
- The separation of liquid and solid components of the digestate (SSR 15)
- The aerobic treatment of digestate material (SSR 17)

If the project utilizes fossil fuel or grid electricity to power equipment necessary for performing the above processes, the resulting project carbon dioxide emissions shall be calculated per Equation 5.13 below.

If the project utilizes offsite pre-processing of eligible waste, then all CO_2 emissions from electricity used in the pre-processing and fossil fuel used in both the pre-processing and transport of waste from the pre-processing site to the project, must also be accounted for using Equation 5.13 below.

Equation 5.13. Project Carbon Dioxide Emissions from Fossil Fuel and Grid Electricity

$$PE_{CO_2} = \left(PE_{CO_2,FF} + PE_{CO_2,EL}\right)$$

Where,

			Units
PE_{CO2}	=	Total project carbon dioxide emissions, for the reporting period, from fossil fuel and grid electricity sources included in the GHG Assessment Boundary (SSRs 3, 8, 13, 15, 17)	tCO_2e
$PE_{CO2,FF}$	=	Total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	tCO_2
$PE_{CO2,EL}$	=	Total indirect carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	tCO_2

$$PE_{CO_2,FF} = \frac{\sum_i \left(FF_{PR,i} \times EF_{FF,i}\right)}{1000}$$

Where,

			Units
$FF_{PR,i}$	=	Total fossil fuel consumed by onsite combustion during the reporting period, by fuel type *i*	volume fossil fuel
$EF_{FF,i}$	=	Fuel-specific emission factor, reference from Appendix B	$kgCO_2$ / volume fossil fuel
1000	=	Kilograms per tonne	$kgCO_2/tCO_2$

$$PE_{CO_2,EL} = \left(EL_{PR} \times EF_{EL}\right)$$

Where,

			Units
EL_{PR}	=	Total electricity from the grid consumed by project operations over the reporting period	MWh
EF_{EL}	=	Carbon emission factor for electricity used, referenced from the most recent U.S. EPA eGRID emission factor publication. Projects shall use the annual total output emission rates for the subregion where the project is located	tCO_2/MWh

5.2.2 Project Emissions from the Biogas Control System (SSRs 9, 10, 11, 12, 14)

The biogas control system (consisting of the digester, the gas collection system, and the destruction devices) may be a significant source of methane emissions due to leakage of biogas from the digester and collection system (SSR 9) and incomplete destruction of methane in the various destruction devices (SSRs 10, 11, 12, 14). Methane emissions from the biogas control system must be calculated using Equation 5.14 below, using continuous biogas flow measurements and monthly methane concentration measurements. All flow measurement devices should internally correct to standard temperature and pressure (60°F and 1 atm). If the biogas flow metering equipment does not internally correct for temperature and pressure, both temperature and pressure must be measured continuously and the guidance provided in Equation 5.15 shall be used to adjust the flow for temperature and pressure.

Equation 5.14. Project Methane Emissions from the BCS (SSRs 9, 10, 11, 12, 14)

$$PE_{CH_4,BCS} = 21 \times \sum_i \left(CH_{4,meter,i} \times \left(\frac{1}{BCE} - BDE_{i,weighted} \right) + CH_{4,vent,i} \right)$$

Where,

			Units
$PE_{CH4,BCS}$	=	Methane emissions from the biogas control system during the reporting period	tCO_2e
21	=	Global warming potential for methane	tCO_2e/tCH_4
$CH_{4,meter,i}$	=	Total quantity of methane collected and metered in month *i*	tCH_4/month
BCE	=	Methane collection efficiency of the biogas control system, as referenced from Table B.6 in Appendix B	fraction
$BDE_{i,weighted}$	=	Monthly weighted methane destruction efficiency of the combustion device(s)	fraction
$CH_{4,vent,i}$	=	Monthly quantity of methane that is vented to the atmosphere due to BCS venting events, as quantified in Equation 5.16 below	tCH_4

$$CH_{4,meter,i} = F_i \times CH_{4,conc,i} \times 0.04230 \times 0.000454$$

Where,

			Units
F_i	=	Total monthly measured volumetric flow of biogas to all destruction devices. See Equation 5.15 for additional guidance on adjusting the biogas flow for temperature and pressure	scf/month
$CH_{4,conc,i}$	=	Monthly measured methane concentration of the biogas. If methane concentration is continuously measured, the value is equal to the monthly average	fraction
0.04230	=	Density of methane gas at STP (1 atm, 60°F)	lbs CH_4/scf
0.000454	=	Conversion factor, lbs to metric tons	t/lb

$$BDE_{i,weighted} = \frac{\sum_{DD}(BDE_{DD} \times F_{i,DD})}{F_i}$$

Where,

			Units
$BDE_{i,weighted}$	=	Monthly weighted average of all destruction devices used in month *i*	fraction
BDE_{DD}	=	Default methane destruction efficiency of a particular destruction device 'DD'. Referenced from Table B.7 in Appendix B	fraction
$F_{i,DD}$	=	Monthly flow of biogas to a particular destruction device 'DD'. See Equation 5.15 for additional guidance on adjusting the biogas flow for temperature and pressure	scf/month
F_i	=	Total monthly measured volumetric flow of biogas to all destruction devices. See Equation 5.15 for additional guidance on adjusting the biogas flow for temperature and pressure	scf/month

Equation 5.15. Adjusting the Biogas Flow for Temperature and Pressure

If the biogas flow metering equipment does not internally correct for the temperature and pressure of the biogas, separate pressure and temperature measurements must be used to correct the flow measurement. The temperature and pressure of the biogas must be measured continuously.

Important: Apply the following equation only if the biogas flow metering equipment does not internally correct for temperature and pressure.

$$F_{scf} = F_{unadjusted} \times \frac{520}{T} \times \frac{P}{1}$$

Where,			Units
F_{scf}	=	Volume of biogas collected for the given time interval, adjusted to 60°F and 1 atm	scf
$F_{unadjusted}$	=	Unadjusted volume of biogas collected for the given time interval	acf
T	=	Measured temperature of the biogas for the given time period (°R = °F + 459.67)	°R
P	=	Measured pressure of the biogas in for the given time interval	atm

5.2.2.1 Biogas Venting Events and Temporary Project Shutdowns

Although not common under normal digester operation, it is possible that a venting event may occur due to failure of digester cover materials, the digester vessel, or the gas collection system. In the event that a system failure results in the venting of biogas, the quantity of methane released to the atmosphere shall be estimated according to Equation 5.16 below.

Equation 5.16. Methane Release from Venting Events

$$CH_{4,vent,i} = \left(MS_{BCS} + \left(F_{pw} \times t\right)\right) \times CH_{4,conc,i} \times 0.04230 \times 0.000454$$

Where,			Units
$CH_{4,vent,i}$	=	Monthly quantity of methane that is vented to the atmosphere due to biogas control system venting events	tCH_4
MS_{BCS}	=	Maximum biogas storage of the biogas control system	scf
F_{pw}	=	Average total daily flow of biogas from the digester for the entire week prior to the venting event	scf/day
t	=	Number of days of the month that biogas is venting uncontrolled from the project's biogas control system	days
$CH_{4,conc,i}$	=	Methane concentration value relevant to the period of time of the venting event	
0.04230	=	Density of methane gas at STP (1 atm, 60°F)	lbs CH_4/scf
0.000454	=	Conversion factor, lbs to metric tons	t/lb

A temporary project shutdown is distinct from a venting event. In certain situations the project BCS may be shut down for an extended period of time to make significant repairs. These events are characterized by a venting event on the day of the shutdown, and then a cessation of project operations until the BCS is once again operable. In this case the project must quantify the release of stored biogas (MS_{BCS} in Equation 5.16) at the time the system is shut down, but not the subsequent daily release of biogas from the temporary storage system (i.e. by setting t = 0). The project will cease quantification of emission reductions until the BCS is once again operational. However, the project developer must be able to provide evidence to demonstrate

that project emissions did not exceed baseline emissions for this period. This is achieved by demonstrating that the management of waste during the shutdown is either the same as the baseline scenario for that waste stream (i.e. unheated lagoon for wastewater and manure or landfill for food waste) or is aerobic.

5.2.3 Project Methane Emissions from Liquid Digester Effluent Storage and Treatment (SSR 16)

Methane emissions from liquid digester effluent storage must be calculated using Equation 5.17 below. All projects sending the liquid portion of digester effluent to a storage pond shall use the following calculation approach to quantify project emissions from the effluent storage pond. If an OWD project recycles digester effluent, disposes of the effluent directly to a sewage system, or otherwise manages the effluent without the use of a liquid effluent storage pond, then this emission source is not applicable to the project.

Because of the variable nature of the waste entering the digester, it is necessary to base calculations on quarterly COD measurements taken from the effluent exiting the digester prior to entering the effluent storage pond. See Section 6.1.3.1 for additional guidance on performing COD sampling.

Equation 5.17. Project Methane Emissions from the BCS Effluent Pond (SSR 16)

$$PE_{CH_4,EF} = B_{0,EF} \times 0.3 \times 21 \times 1.12 \times \sum_i \left(Q_{EF,i} \times COD_{EF,i}\right)$$

Where,			Units
$PE_{CH4,EF}$	=	Total project methane emissions from the biogas control system effluent pond over the reporting period	tCO_2e
$B_{0,EF}$	=	Methane producing capacity of the effluent stream 'S'. Project developers may use site-specific values that are determined based on the sampling approach provided in Section 6.1.3.2. Alternatively, a value of 0.21 may be used for all effluent[42]	tCH_4 / tCOD
0.3	=	Methane conversion factor of the effluent storage pond[43]	fraction
21	=	Global warming potential for methane	tCO_2e/tCH_4
1.12	=	Project uncertainty factor to account for model uncertainties[44]	
$Q_{EF,i}$	=	Volume of effluent discharged into the effluent storage pond in month *i*	m^3
$COD_{EF,i}$	=	Chemical oxygen demand of the effluent discharged into the storage pond in month *i*. COD must be sampled quarterly according to the guidance provided in Section 6.1.3.1	$tCOD/m^3$

5.2.4 Project Emissions from Aerobic Treatment of Digestate (SSR 17)

The digestion of organic waste may produce residual waste (digestate) that, depending on how it is treated, could result in material emissions of methane and/or nitrous oxide. The degree to which aerobic treatment of organics releases methane and/or nitrous oxide to the atmosphere is highly uncertain due the complicated GHG emission pathways for methane and nitrous oxide, given various aerobic treatment methods. On a project-by-project basis, it is difficult to quantify

[42] Per CDM ACM0014 V.2.1 and CDM AMS III.F V.6.
[43] Equal to the higher bound MCF value for the anaerobic shallow lagoon system. 2006 IPCC Guidelines for National GHG Inventories, Vol. 5 Ch. 6 Table 6.3.
[44] Per CDM AMS III.H, V.16.

the emissions of methane and nitrous oxide that occur from the composting of digestate material, however it is possible to place bounds on the emissions based on peer reviewed literature and internationally accepted GHG accounting methodologies.[45] For the purposes of this protocol, a conservative approach is taken based on a range of possible emission factors and a range of potential composting techniques that either maximize or minimize the potential for GHG emissions.

Table 5.2 outlines the tiered approach that must be followed to estimate the combined emissions of methane and nitrous oxide as a function of the amount of digestate going into the composting process (measured on a wet basis).[46] The emission factors in Table 5.2 are applicable whether the digestate is treated at the project site or, in the case of centralized digesters, is returned to the source farms to be treated. If digestate is transported offsite for disposal, the CO_2 emissions related to transport fuels should be accounted for using Equation 5.13.

Table 5.2. Combined Methane and Nitrous Oxide Emission Factors for Aerobic Treatment of Digestate

Tier (GHG Emission Risk Level)	**CH_4 and N_2O Emission Factor** (tCO_2e / t (wet weight) of digestate aerobically treated*)
High: ▪ Digestate treated onsite in uncovered non-aerated static piles ▪ Material treated offsite at an undocumented facility	0.10
Medium: ▪ Digestate treated onsite in aerated systems (turned windrows or aerated static piles) ▪ Material treated offsite at a centralized composting facility	0.06
Low: ▪ Digestate treated onsite in an enclosed system (in-vessel) utilizing a bio-filter or biogas scrubber	0.02
Zero: ▪ Materials thermally dried upon separation from liquid effluent ▪ Materials used directly as animal bedding material ▪ Digestate immediately blended as soil amendment	0

* Project developers may use the site-specific weight of waste going to aerobic treatment, or may use a conservative default value equal to 20% of the wet weight of the waste entering the digester. [47]

OWD projects shall use Equation 5.18 to estimate the combined emissions of methane and nitrous oxide from aerobic digestate treatment, using the appropriate emission factor from Table 5.2 above.

[45] Bounds for potential emissions of N_2O and CH_4 were developed based upon estimates and empirical results of GHG emission from composting, taken from the following sources: 2006 IPCC Guidelines for National GHG Inventories, CDM AM0025 V10, U.S. EPA Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks (2006), and Brown et al. *Greenhouse Gas Balance for Composting Operations* (2008).

[46] The GHG risk level is assessed based off of information obtained from: Brown et al. *Greenhouse Gas Balance for Composting Operations* (2008)

[47] Default weight based conservatively on expert feedback

Equation 5.18. Methane and Nitrous Oxide Emissions from Aerobic Treatment of Digestate (SSR 17)

$$PE_{CH_4,N_2O,AT} = W_{D,AT} \times EF_{D,AT}$$

Where,			Units
$PE_{CH4,N2O,AT}$	=	Project emissions of methane and nitrous oxide, for the reporting period, from the aerobic treatment of digestate material	tCO_2e
$W_{D,AT}$	=	Total wet weight of digestate treated aerobically onsite, or sent offsite for aerobic treatment, over the reporting period. Project proponents may use site specific weights, or may use a default value of 20% of the wet weight of waste entering the digester	t
$EF_{D,AT}$	=	Emission factor for the appropriate aerobic treatment Tier, as provided in Table 5.2	tCO_2e / t digestate

Project carbon dioxide emissions from the use of fossil fuel or grid powered equipment during the aerobic digestate treatment process are calculated in Section 5.2.1.

5.2.5 Project Emissions from Anaerobic Disposal of Digestate Produced in the Digestion Process (SSR 18)

If residual waste (digestate) is disposed of anaerobically, all such waste will be treated as if it had been landfilled, and the resulting methane emissions will be accounted for using Equation 5.19. In order to quantify the emissions from the landfilling of digestate, the project developer must track the weight of digestate that is treated anaerobically during the reporting period ($W_{D,LF}$). Project developers should use the look-up table (Table B.1 in Appendix B) to find the appropriate emission factor for the project.

Equation 5.19. Methane Emissions from Anaerobic Treatment of Digestate (SSR 18)

$$PE_{CH_4,LF} = W_{D,LF} \times EF_{LF}$$

Where,			Units
$PE_{CH4,LF}$	=	Project emissions, for the reporting period, from the anaerobic disposal of digestate material at a landfill	tCO_2e
$W_{D,LF}$	=	Total wet weight of digestate treated anaerobically over the reporting period. Project proponents must monitor the weight of digestate being treated anaerobically according to guidance in Section 6.1.4.2	t
EF_{LF}	=	Emission factor for the appropriate climate region, as provided in Table B.4	tCO_2e / t digestate

5.2.6 Project Emissions from Manure Treatment Systems (SSR 5)

For projects that are co-digesting manure alongside eligible organic waste streams, it is necessary to account for the project emissions from all manure management systems that have been affected by project activity. This is necessary per the GHG accounting method used in the Reserve Livestock Project Protocol.[48] If the baseline anaerobic system still receives a percentage of the manure stream on an ongoing basis, the emissions from this source could be

[48] The Reserve Livestock Project Protocol sums the entire methane emissions from the baseline anaerobic lagoon, assuming that all the manure sent to the baseline anaerobic lagoon pre-project is sent to the BCS in the project scenario, however if a project is sending less than 100% of the manure stream to the BCS, then the remaining portion that is still going to the anaerobic lagoon after project implementation must be accounted for as project emissions.

significant. If a project developer can demonstrate that a particular manure management system has not been affected by project activity, then this system can be excluded from the project emissions calculation. The project emissions calculation must be performed in accordance with the Reserve Livestock Project Protocol's project emissions guidance for non-BCS related sources, and aggregated for each livestock operation according to Equation 5.20 below.

Equation 5.20. Project Emissions from Non-BCS Related Manure Treatment/Storage Systems

$$PE_{CH_4,LS} = \sum_{S} PE_{CH_4,LS,S}$$

Where,

			Units
$PE_{CH4,LS}$	=	Total sum for the reporting period of the project methane emission calculation results for all manure management systems affected by project activity	tCO_2e
$PE_{CH4,LS,S}$	=	Project methane emissions from manure management system 'S' for the reporting period, as calculated per the method described in the non-BCS project emissions section of the Livestock Project Protocol	tCO_2e

5.3 Calculating the Total Quantity of Methane Destroyed by the Project

The Reserve recognizes that there can be material differences between the calculated emission reductions and the actual quantity of methane that is captured and destroyed by the biogas control system. In most cases, the amount of metered methane that is destroyed by the project in any given reporting period should greatly exceed the sum of the baseline emissions over the same time period, due primarily to the incomplete degradation of waste as modeled in the FOD equation over a 10 year timeframe. In some instances, however, digester performance issues related to start-up periods, venting events, and other biogas control system operational issues may result in sub-optimal gas generation or destruction. These operational issues have the potential to result in substantially less methane destruction than is calculated, leading to an overestimation of emission reductions. To address this issue and maintain consistency with international best practice, the Reserve requires that calculated baseline emissions be compared to the ex-post metered quantity of methane that is captured and destroyed by the biogas control system. The lesser of the two values will represent the total baseline emissions for the reporting period.

Projects shall use Equation 5.21 to determine the total quantity of methane that is captured and destroyed by the project's BCS.

Equation 5.21. Metered Methane Destruction

$$\boldsymbol{CH_{4,destroyed} = \sum_{i} \left(CH_{4,meter,i} \times BDE_i\right) \times 21}$$

Where,			Units
$CH_{4,destroyed}$	=	Aggregated quantity of methane collected and destroyed during the reporting period	tCO_2e
$CH_{4,meter,i}$	=	Monthly quantity of methane collected and metered. See Equation 5.14 for calculation guidance	tCH_4/month
BDE_i	=	Monthly methane destruction efficiency of the combustion device. In the event that there is more than one destruction device in operation in any given month, the weighted average destruction efficiency from all combustion devices is to be used	fraction
21	=	Global warming potential for methane	tCO_2e/tCH_4

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of instrument cleaning, inspection, field check and calibration activities; and the role of individuals performing each specific monitoring activity, as well as QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision. The Monitoring Plan shall also contain a detailed project diagram – beginning when waste arrives at the project site – including the placement of all meters and equipment that affect SSRs within the GHG Assessment Boundary (see Figure 4.1).

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.5.2).

Project developers are responsible for monitoring the performance of the project and ensuring that the operation of all project-related equipment is consistent with the manufacturer's recommendations.

6.1 Organic Waste and Wastewater Monitoring Requirements

There are numerous parameters related to OWD project activities that must be monitored and tracked in order to accurately quantify the baseline and project emissions. Below are the requirements that shall be met for the monitoring of OWD projects.

6.1.1 Food and Food-Soiled Paper Waste Monitoring

In order to quantify the GHG reductions from an OWD project that is digesting food and food-soiled paper waste streams, the project must accurately measure the quantity of in-coming waste delivered to the digestion facility, by waste stream. All projects must monitor and record each shipment of waste delivered to the facility using onsite scales and/or commercial receipts. The facility must keep a daily log showing:

- Date and time of all deliveries of material to the facility
- The weight of each delivered in-coming waste stream
- The source of each delivered in-coming waste stream

In addition, the project must retain all weigh scale receipts generated either onsite or offsite indicating the weight and source of all delivered material to the facility. This information is necessary to aggregate the weight of eligible food and food-soiled paper waste delivered to the site from each eligible waste stream according to the guidance provided in Section 5.1.1 and to verify eligibility of MSW food waste from grocery store sources.

A QA/QC procedure for the inspection and calibration of weigh scales must be included in the Monitoring Plan. All weigh scales that are not used for commercial activities must be inspected and calibrated in accordance with manufacturer's specifications. The project may document incoming waste weight using commercial receipts from onsite or offsite scales.

6.1.1.1 Documenting Site-Specific Waste Characterization Events

For each site-specific waste characterization event performed, the following records and photo documentation must be retained in order to demonstrate compliance with the waste characterization requirements of Section 5.1.1.4.

The following data must be recorded and retained for each sampling event:

- Origination and description of the waste stream each sample is drawn from
- Empty weight for each container used in the waste sort
- Weight of each sample (subtracting container weight) for the pre-sort sample and post-sort waste components (food, paper, ineligible waste)
- Fractional weight of each component (food, paper, ineligible waste) as compared to the total weight of the original sample

Photo documentation must be recorded and retained for verification purposes. Photo documentation should clearly show:

- The weigh scale or scales used for the sampling event
- The containers used for the sampling event
- The waste stream from which the sample was taken
- The waste sample prior to sorting
- The separated categories post-sorting

6.1.2 Monitoring and Documenting Pre-Project Waste Disposal for Grocery Store Waste Streams

Source-separated waste streams originating from grocery stores or supermarkets are eligible if, and only if, the project developer can document that:

- For a continuous period of at least 36 months prior to the date that waste sourced from the grocery store was first digested at the project digester, food and food-soiled paper waste generated by the grocery store was sent to a landfill, or
- Food and/or food-soiled paper waste originating from the grocery store was deemed as eligible waste at an OWC or OWD project registered with the Reserve, or
- The grocery store from which the waste originated is a new facility

In order to document the eligibility of the grocery store waste stream, projects must monitor the following information for each grocery store waste stream:

- The initial date the waste stream is delivered to the project digester, for all new grocery store waste streams
- The origin of the new grocery store waste stream (by facility)
- The previous waste disposal methods used by the grocery store waste generator, for each new grocery store waste stream
- The opening date of any new grocery store facilities supplying waste to the project

Additionally, documentation demonstrating that grocery store waste was sent to landfill(s) prior to diversion to the project digester or that the grocery store is a new facility should be collected and retained by the project for verification purposes. Acceptable documentation includes, but is not limited to:

- Landfill tipping receipts from the grocery store and/or contracted waste haulers
- Waste hauler contracts
- Internal memos and/or employee training documents detailing waste handling and/or organics separation procedures, goals, and timelines
- Media or marketing campaigns detailing dates related to the grocery store waste diversion program
- Internal documentation, store leasing documents, or media or marketing campaigns announcing the opening date of the grocery store facility

6.1.3 Agro-Industrial Wastewater Monitoring

For OWD projects that pump eligible agro-industrial wastewater streams into the digester, the project developer shall monitor and record the following data for each wastewater stream:

- The daily volume of wastewater (m^3/day) entering the digester (aggregated monthly)
- The monthly COD of the wastewater (tCOD/m^3) prior to mixing with other residues

The monthly COD of the wastewater must be determined by sampling. All COD sampling must be performed in accordance with the requirements in Section 6.1.3.1.

A QA/QC procedure for the inspection, cleaning, and calibration of wastewater monitoring equipment must be included in the Monitoring Plan. Wastewater monitoring instruments must be inspected, cleaned, and calibrated in accordance with manufacturer's specifications.

6.1.3.1 Requirements for Chemical Oxygen Demand Sampling

The chemical oxygen demand (COD) must be sampled and analyzed in accordance with the COD sampling and analysis technique detailed in the *Standard Methods for the Examination of Water and Wastewater, 5220 – Chemical Oxygen Demand*.[49] COD sampling and analysis shall be done by professionals experienced with the procedures used to determine COD as described in the above mentioned Standard Method approach.

6.1.3.2 Requirements for Determining the Site-Specific Maximum Methane Potential (B_0)

For OWD projects that choose to determine a site-specific maximum methane potential value for one or more wastewater streams being digested in the project's BCS, the following criteria must be met in order to ensure accuracy and consistency of the site-specific B_0 values:

1. Wastewater samples for each eligible wastewater stream must be sampled prior to mixing with other residues.
2. For each eligible wastewater stream, a total of at least ten samples must be taken across the span of at least 1 week.
3. All samples must be analyzed using a Biochemical Methane Potential (BMP) Assay procedure at an independent, third-party laboratory that is familiar and experienced with

[49] http://www.standardmethods.org/store/ProductView.cfm?ProductID=37

this test and ISO 11734.[50] The laboratory must be able to document at least three years of experience with the BMP assay, and must have procedures in place to maintain a consistent inoculum. The laboratory must maintain and follow a standard operating procedure that outlines the process used in undertaking BMP analysis at that laboratory, and which can be made available to a verifier upon request.

4. At least ten samples must be analyzed by the chosen laboratory, the highest and lowest outlier results shall be discarded, and the site-specific B_0 value to be used for the sampled wastewater stream shall equal the 90% lower confidence limit of the remaining assay results. The laboratory shall conduct an assay on the seed inoculum itself in order to control for its contribution to the methane potential of the wastewater samples. The laboratory shall also conduct a control assay with a substrate of known methane potential (such as glucose or cellulose) to verify correct procedures were followed and that the inoculum was viable. If the control assay differs from its established expected value by greater than 15%, all results from that batch of assays shall be discarded. Measurement of gas flow shall be corrected to standard temperature and pressure (60°F and 1 atm). Devices used to measure gas flow and methane content shall be properly installed and calibrated, such that they can provide results within +/- 5% accuracy.

A site-specific B_0 value determined according to the requirements outlined above will be valid for the reporting period during which the sampling occurred. The verifier must confirm that sampling procedures conform to this section and that the personnel responsible for the sampling are trained and competent.

6.1.4 Digester Effluent and Digestate Monitoring

6.1.4.1 Liquid Effluent

For OWD projects that send the liquid portion of the digester effluent to a temporary storage pond, the project developer is responsible for monitoring the effluent that is discharged from the digester in order to quantify the methane emissions from the effluent storage pond for the reporting period in accordance with Equation 5.17. This requires that the project developer directly monitor and record:

- The daily volume of digester effluent wastewater (m^3/day) that is exiting the digester prior to entering the effluent storage pond (aggregated monthly)
- The quarterly COD (tCOD/m^3) of the effluent wastewater exiting the digester prior to entering the effluent storage pond

As an alternative to measuring the daily volume of digester effluent exiting the digester, the project developer may use the total daily measured influent volume of wastewater that enters the digester as a conservative approximation for daily digester effluent volume.

The quarterly COD of the effluent must be determined by sampling. All COD sampling must be performed in accordance with the requirements in Section 6.1.3.1. Samples must be taken prior to effluent entering the storage pond, and must be taken after solids are removed from the effluent stream.

[50] For more information on BMP Assay analysis and procedures, see: Moody et al. "Use of Biochemical Methane Potential (BMP) Assays for Predicting and Enhancing Anaerobic Digester Performance." (2009) http://sa.pfos.hr/sa2009/radovi/pdf/Radovi/r10-009.pdf

A QA/QC procedure for the inspection, cleaning, and calibration of wastewater monitoring equipment must be included in the Monitoring Plan. Effluent monitoring instruments shall be inspected, cleaned, and calibrated in accordance with manufacturer's specifications.

6.1.4.2 Digestate Material

For OWD projects that dispose of all or a portion of the project's digestate material at a landfill or using some other anaerobic treatment method, the project developer is responsible for monitoring the quantity of digestate that is disposed of in such manner. Emissions from the anaerobic disposal of digestate must be quantified in accordance with Section 5.2.5. This requires that the project developer directly monitor and record all vehicles delivering digestate to landfill systems or other anaerobic treatment locations/systems and record:

- The weight (metric tons) on a wet basis of digestate material that is disposed of using such a method (aggregated for the reporting period)

6.2 Biogas Control System Monitoring

Project developers are responsible for monitoring the performance of the project and for operating each component of the BCS in a manner consistent with the manufacturer's recommendations. The methane capture and control system must be monitored with measurement equipment that directly meters:

- The flow of biogas delivered to each destruction device (except as specified below), measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure
- The fraction of methane in the biogas, measured no less than once for every three month period (i.e. a 12 month reporting period should contain no less than 4 methane concentration measurements)

A single flow meter may be used to monitor the flow of gas to multiple destruction devices under certain conditions. If all destruction devices are of identical methane destruction efficiency (as described in Table B.7) and verified to be operational during all times when flow is recorded (i.e. there is recorded evidence of destruction), no additional steps are necessary for project registration. One example of this scenario would be a single meter used for a bank of multiple, identical engines that are always operated together. If the destruction devices are not of identical efficiency, then the destruction efficiency of the least efficient device shall be applied to the flow data for this meter. If there are any periods where the operational data show that one or more devices were not destroying methane, these periods are eligible for crediting, provided that the verifier can confirm all of the following conditions are met:

a. The destruction efficiency of the least efficient destruction device in operation is used as the destruction efficiency for all destruction devices monitored by this meter; and
b. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and
c. For any period where one or more destruction device(s) within this arrangement is not operational, it is documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period. For devices other than flares, it is shown that the output corresponds to the flow of gas.

Flow data must be corrected for temperature and pressure at 60°F and 1 atm, either internally or by using Equation 5.15.

Figure 6.1 represents the suggested arrangement of the biogas flow meters and methane concentration metering equipment. It is recommended that some level of gas conditioning occurs prior to the measurement of flow and methane concentration to prevent measurement error due to moisture and contaminant buildup.

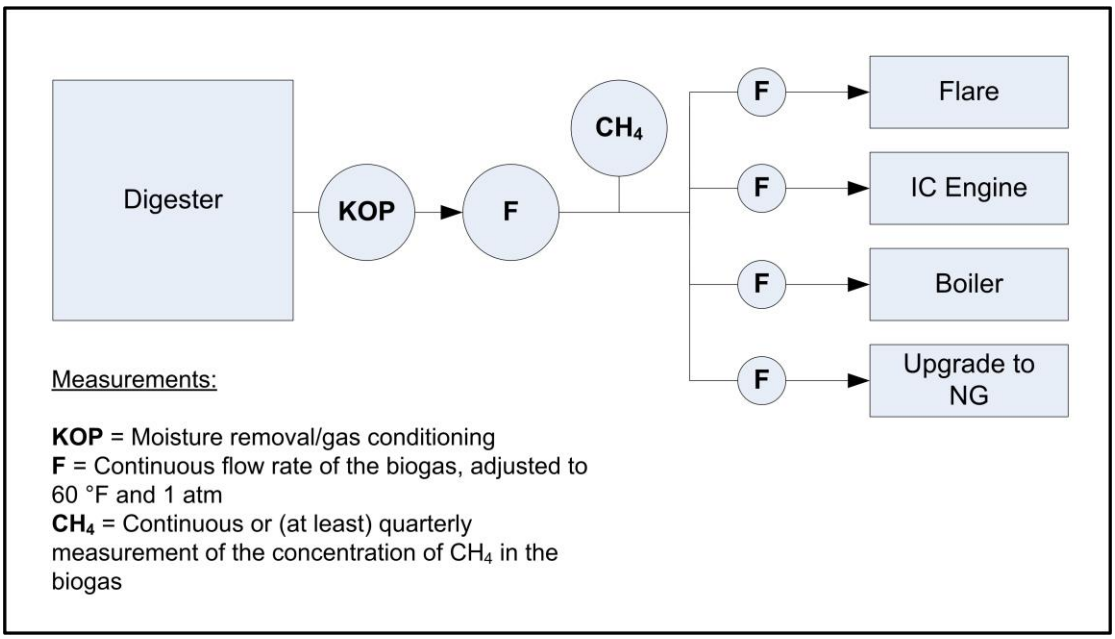

Figure 6.1. Suggested Arrangement of Biogas Metering Equipment

Note: The number of flow meters must be sufficient to track the total flow as well as the flow to each combustion device. The above example includes one more flow meter than would be necessary to achieve this objective.

Operational activity of the destruction devices shall be monitored and documented at least hourly to ensure actual methane destruction. GHG reductions will not be accounted for or credited during periods in which the destruction device is not operational. For flares, operation is defined as thermocouple readings above 500°F. For all other destruction devices, the means of demonstration shall be determined by the project developer and subject to verifier review. An exception to this requirement is made for destruction devices that receive less than 10% of the total biogas generated during the reporting period and that can be demonstrated to comply with condition (b) in the list above (in this Section). Those devices do not need to be monitored for operational status.

If for any reason the destruction device or the operational monitoring equipment (for example, the thermocouple on the flare) is inoperable, then all metered biogas going to the particular device shall be assumed to be released to atmosphere during the period of inoperability. In other words, for periods of missing “on/off” operational data, a value of “off” shall be used. During the period of inoperability, the destruction efficiency of the device must be assumed to be zero. In Equation 5.14, the monthly destruction efficiency (BDE) value shall be adjusted accordingly. See below for an example BDE adjustment.

Box 6.1. Example BDE Adjustment

As an example, consider a situation where the primary destruction device is an open flare with a BDE of 96%, and it is found to be inoperable for a period of 5 days of a 30 day month. Assume that the total flow of biogas to the flare for the month is 3,000,000 scf, and that the total flow recorded for the 5 day period of inoperability is 500,000 scf. In this case, the monthly BDE would be adjusted as follows:

BDE = {(0.96 x 2,500,000) + (0.0 x 500,000)} / 3,000,000 = 80%

6.2.1 Biogas Measurement Instrument QA/QC

All gas flow meters[51] must be:

- Cleaned and inspected according to a regular schedule as documented in the project's Monitoring Plan. Project developers and verifiers should consult with the manufacturer and installer of the metering equipment to determine the proper cleaning procedure and frequency to ensure that accuracy remains within the acceptable tolerance
- Field checked for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube) or manufacturer specified guidance, at the end of but no more than two months prior to or after the end date of the reporting period[52]
- Calibrated by the manufacturer or a certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent

All continuous methane analyzers must be:

- Cleaned and inspected according to a regular schedule as documented in the project's Monitoring Plan. Project developers and verifiers should consult with the manufacturer and installer of the equipment to determine the proper cleaning procedure and frequency to ensure that accuracy remains within the acceptable tolerance
- Field checked for calibration accuracy with the percent drift documented, using either a portable instrument (such as a portable methane analyzer) or manufacturer specified guidance, at the end of but no more than two months prior to or after the end date of the reporting period.[53] A field check procedure should be sufficient to confirm accuracy of the methane analyzer as it is installed, under typical site conditions (temperature, pressure, flow rate) and prior to any cleaning and inspection
- Calibrated by the manufacturer or a certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent

Alternative for regulated meters:

- Projects that export biogas through a pipeline may have installed a custody transfer meter – or similar commercial measurement device – for the measurement and analysis

[51] Field checks and calibrations of flow meters shall assess the volumetric output of the flow meter.
[52] Instead of performing field checks, the project developer may instead have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but no more than two months prior to the end date of the reporting period to meet this requirement.
[53] Instead of performing field checks, the project developer may instead have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but no more than two months prior to or after the end date of the reporting period to meet this requirement.

of biogas delivered to the pipeline. If the accuracy of this meter, and the maintenance and calibration necessary to maintain accuracy, are regulated by a government agency (including specific requirements for maintenance, inspection, and/or calibration), then the project may prove adherence to those regulatory requirements in lieu of the QA/QC requirements listed above. The standard of accuracy must be at least +/- 5%.

If the required calibration or calibration check is not performed and properly documented, no GHG credits may be generated for that reporting period. Flow meter calibrations shall be documented to show that the meter was calibrated to a range of flow rates consistent with the range of expected flow rates produced by the project BCS. Methane analyzer calibrations shall be documented to show that the calibration was carried out to the range of conditions (temperature and pressure) corresponding to the range of conditions that occur in the project BCS.

If the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment. However, if the field check indicates that the measurement accuracy of the meter has drifted, the project developer has the option to first record the as-found condition (percent drift) of the field check, then clean the equipment and conduct a second field check. If this second check indicates measurement accuracy within the acceptable threshold, no further calibration is required and the as-left condition of the meter shall be recorded to document calibration accuracy. This shall be considered a failed field check followed by a successful field check. If the second field check confirms accuracy outside of the +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment.

For the interval between the last successful field check and any calibration event confirming accuracy outside of the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time that the meter is shown to be measuring within the accuracy threshold (unless the last event occurred during the prior reporting period, in which case adjustment is made back to the beginning of the current reporting period).

- For calibrations or field checks that indicate the flow meter was outside the +/- 5% accuracy threshold, the project developer shall estimate total emission reductions using i) the metered values without correction, and ii) the metered values adjusted based on the greatest calibration drift recorded at the time of calibration. The lower of the two emission reduction estimates shall be reported as the scaled emission reduction estimate

For example, if a project conducts field checks quarterly during a year-long reporting period, then only three months of data will be subject at any one time to the penalties above. However, if the project developer feels confident that the meter does not require field checks or calibration on a greater than annual basis, then failed events will accordingly require the penalty to be applied to the entire year's data. Further, frequent calibration may minimize the total accrued drift (by zeroing out any error identified), and result in smaller overall deductions.

In order to provide flexibility in verification, data monitored up to two months after a field check may be verified for the reporting period. As such, the end date of the reporting period must be no more than two months after the latest successful field check.

If a portable calibration instrument is used (such as a pitot tube), the portable instrument shall be calibrated at least annually by the manufacturer or at an ISO 17025 accredited laboratory. The portable instrument also must be field calibrated to a known sample gas prior to each use.

6.2.2 Missing Data

In situations where the flow rate or methane concentration monitoring equipment is missing data, the project developer shall apply the data substitution methodology provided in Appendix D.

6.3 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1. Refer to the monitoring section of the Livestock Project Protocol for the prescribed monitoring parameters necessary for livestock manure baseline and project calculations.

Table 6.1. Organic Waste Digestion Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
General Project Parameters						
	Regulations	Project developer attestation of compliance with regulatory requirements relating to the digester project	Environmental regulations	N/A	Each verification cycle	Information used to: 1) Demonstrate ability to meet the Legal Requirement Test – where regulation would require the installation of a biogas control system. 2) Demonstrate compliance with associated environmental rules, e.g. criteria pollutant and effluent discharge limits.
Equation 5.1	ER	Total emission reductions for the reporting period	tCO_2e	c	Each reporting period	
Equation 5.1	BE	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary	tCO_2e	c	Each reporting period	BE is the lesser of the two values: BE_c or $CH_{4,destroyed}$.
Equation 5.1 Equation 5.12	PE	Total project emissions for the reporting period, from all SSRs in the GHG Assessment Boundary	tCO_2e	c	Each reporting period	
Equation 5.1 Equation 5.2	BE_c	Total calculated baseline emissions from all SSRs in the GHG Assessment Boundary during the reporting period	tCO_2e	c	Each reporting period	
Equation 5.1 Equation 5.21	$CH_{4,destroyed}$	Aggregated quantity of methane destroyed by the BCS during the reporting period	tCH_4	m, c	Monthly	Measured in order to compare to modeled reductions (see Section 5.3).

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.2 Equation 5.3	BE_{SW}	Total baseline emissions during the reporting period, for eligible solid waste (food and food-soiled paper) streams	tCO_2e	c	Each reporting period	
Equation 5.2 Equation 5.9	BE_{WW}	Total baseline emissions during the reporting period, for eligible agro-industrial wastewater streams	tCO_2e	c	Each reporting period	
Equation 5.2 Equation 5.11	BE_{LS}	Total sum of the calculated baseline emissions during the reporting period, for all livestock operations contributing manure to the digester	tCO_2e	c	Each reporting period	
Baseline Calculation Parameters for Food and Food-Soiled Paper Waste Streams						
	Origin of waste streams	The jurisdiction where the food waste and/or soiled paper waste originates	Jurisdiction (municipality or county)	N/A	For each truckload of waste	This information is necessary to track eligible food waste streams and ineligible food waste streams that are digested in the project's BCS, as well as to determine appropriate decay rates (k values) to use in the calculation.
Equation 5.3	$BE_{CH4,S}$	Baseline methane emissions from digested waste stream 'S' during the reporting period	tCO_2e	c	Each reporting period	
Equation 5.3 Equation 5.4	$BE_{FW,S}$	Baseline methane emissions from the food waste component of eligible waste stream 'S' that is digested during the reporting period	tCO_2e	c	Each reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.3 Equation 5.5	$BE_{SP,S}$	Baseline methane emissions from the soiled paper component of eligible waste stream 'S' that is digested during the reporting period	tCO_2e	c	Each reporting period	
Equation 5.4 Equation 5.6	$W_{FW,S}$	Aggregated weight of eligible food waste (on a wet basis) from eligible waste stream 'S' that is digested by the project during the reporting period	t of food waste (wet weight)	c	Each reporting period	
Equation 5.4 Equation 5.5	WTE_S	Fraction of waste from eligible waste stream 'S' that would have been incinerated at a waste-to-energy (WTE) plant in lieu of being landfilled	Fraction	r	N/A	Referenced by state of origination.
Equation 5.4	$FE_{FW,S}$	Fraction of methane generated that is emitted to the atmosphere over a ten year time horizon, as calculated using the First Order Decay function	Fraction	c	Each reporting period	The fraction emitted to the atmosphere is a function of the decay rates of food waste, the landfill gas collection assumptions (see Box 5.1), and the amount of methane generated that is oxidized in the cover soil.
Equation 5.4	$k_{FW,S}$	Decay rate for food waste stream 'S', by waste type and climate region	yr^{-1}	r	N/A	Referenced from Table B.1 in Appendix B. Figure B.1 is used to determine the climate region. The appropriate k value shall be chosen based on the k value applicable to the county where the waste originated.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.4 Equation 5.5	GC_S	Gas collection factor for waste stream 'S'	Fraction	r	N/A	Equal to the fraction of waste disposed at landfills with gas collection systems in the state from which the waste stream 'S' originates. Referenced by state from Table B.2 in Appendix B.
Equation 5.4 Equation 5.5	LCE_x	Fraction of methane that would be captured and destroyed by LFG collection systems in the year x, starting with the year that waste is diverted to the project (x=1) and ending with the year x=10	Fraction	r	N/A	All projects shall use a value of 0.0 for the first two years of calculated waste decay (x=1 to 2), a value of 0.5 for the third year (x=3), a value of 0.75 for years 4 to 7 (x=4 to 7), and a value of 0.95 for the remaining years of decay until the end of the calculation period (x=8 to 10). See Box 5.1 for a discussion on the LCE assumptions.
Equation 5.5 Equation 5.6	$W_{SP,S}$	Aggregated weight of eligible soiled paper waste (on a wet basis) from eligible waste stream 'S' that is digested by the project during the reporting period	t of soiled paper (wet weight)	c	Each reporting period	See Section 5.1.1.1 for guidance on determining the weight of eligible soiled paper waste.
Equation 5.5	$FE_{SP,S}$	Fraction of methane generated that is emitted to the atmosphere over a ten year time horizon, as calculated using the First Order Decay function	Fraction	c	Each reporting period	The fraction emitted to the atmosphere is a function of the decay rates of soiled paper waste, the landfill gas collection assumptions (see Box 5.1), and the amount of methane generated that is oxidized in the cover soil.
Equation 5.5	$k_{SP,S}$	Decay rate for soiled paper waste stream 'S', by waste type and climate region	yr^{-1}	r	N/A	Referenced from Table B.1 in Appendix B. Figure B.1 is used to determine the climate region. The appropriate k value shall be chosen based on the k value applicable to the county where the waste originated.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.6	$W_{T,S}$	Aggregated total weight of waste (on a wet basis) from waste stream 'S' that is delivered to the facility during the reporting period	t	m	Every delivery of waste stream 'S' to the facility	Measured using onsite or offsite weigh scales. All weigh receipts must be retained for verification and deliveries must be logged daily.
Equation 5.6	FD_S	Fraction of waste stream 'S' that is digested during the reporting period	Fraction	o	N/A	In the instance that less than 100% of a delivered waste stream is digested at the facility (e.g. if a portion of the waste is composted across the street at a neighboring compost facility). Equal to 1 if all eligible waste delivered is digested.
Equation 5.6 Equation 5.8	$F_{FW,S}$	Food waste fraction of waste stream 'S'	Fraction	m, r	Quarterly (if measured) or once during the reporting period (if referenced)	The fraction must be determined based on the corresponding methods described in Sections 5.1.1.2 and 5.1.1.3 according to the type of waste delivered to the site and the availability of local or state waste characterization data.
Equation 5.6 Equation 5.8	$F_{SP,S}$	Soiled paper waste fraction of waste stream 'S'	Fraction	m, r	Quarterly (if measured) or once during the reporting period (if referenced)	The fraction must be determined based on the corresponding methods described in Sections 5.1.1.2 and 5.1.1.3 according to the type of waste delivered to the site and the availability of local or state waste characterization data.
Equation 5.7	$F_{i,S}$	Fraction of waste category *i* (food waste or soiled paper waste) in eligible MRF fines waste stream 'S'	Fraction	m, c	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The fraction of waste category *i* must be determined for each waste stream 'S'. The fraction is determined according to Section 5.1.1.2. Represents $F_{FW,S}$ for food waste and $F_{SP,S}$ for soiled paper waste.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.7	W_{HS}	Weight of sample taken in large (>2") preliminary hand sort	lbs	m	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The total weight of all fines larger than approximately two inches in diameter sorted and screened during preliminary screen of sample.
Equation 5.7	$F_{i,HS}$	Fraction of waste category *i* in large (>2") preliminary hand sort	Fraction	m, c	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The fraction of waste category *i* must be determined for each large preliminary hand sort. The fraction is determined according to Section 5.1.1.2.
Equation 5.7	W_{PR}	Weight of total sample after large (>2") particles removed	lbs	m	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The total weight of all fines equal to or smaller than approximately two inches in diameter that remain following preliminary screen of sample.
Equation 5.7	$F_{i,QS}$	Fraction of waste category *i* in quarter sample	Fraction	m, c	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	The fraction of waste category *i* must be determined for each quarter sample. The fraction is determined according to Section 5.1.1.2.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.7	W_{sample}	Weight of total sample prior to hand sort (100 lb minimum)	lbs	m	Twice per quarter for the first year that the waste stream is composted by the project and quarterly thereafter	$W_{sample} = W_{HS} + W_{PR}$
Baseline Calculation Parameters for Agro-Industrial Wastewater Streams						
Equation 5.9 Equation 5.10	$BE_{CH4,WW,S}$	Baseline methane emissions from wastewater stream 'S', for the reporting period	tCO_2e	c	Each reporting period	
Equation 5.10	$B_{0,WW,S}$	Methane producing capacity of the wastewater stream 'S'	$tCH_4/tCOD$	m, r	Once per reporting period	A site-specific value may be used; alternatively, a value of 0.21 shall be used.[54] See guidance in Section 6.1.3.2.
Equation 5.10	$MCF_{AT,S}$	Methane conversion factor of the anaerobic treatment lagoon, pond, or tank where the wastewater was previously treated	Fraction	r	N/A	An MCF must be applied to each wastewater stream that would have been treated anaerobically. Referenced as the lower bound value from Table B.5 by treatment type.
Equation 5.10	$Q_{WW,S,i}$	Volume of wastewater from stream 'S' in month *i*	m^3	m	Continuously for each waste stream pumping wastewater to the digester facility, or by truckload if trucked into the digester facility (aggregated monthly)	The volume of wastewater entering the digester must be known for all wastewater streams. Must continuously measure wastewater that is pumped in, and measure each truckload and aggregate monthly for each wastewater stream. See Section 6.1 for guidance.

[54] Per CDM ACM0014 V.2.1, available at http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.10	$COD_{WW,S,i}$	Chemical oxygen demand of the untreated wastewater stream 'S' for month *i*	$tCOD/m^3$	m	Monthly for each wastewater stream	COD must be sampled according the guidance in Section 6.1.3.1 for each wastewater stream 'S'.
Equation 5.11	$BE_{CH4,LS,S}$	Baseline methane emissions from all affected manure management systems 'S', for the reporting period, calculated per the Reserve Livestock Project Protocol	tCO_2e	c	Each reporting period	
Project Calculation Parameters						
Equation 5.12 Equation 5.13	PE_{CO2}	Total project carbon dioxide emissions, for the reporting period	tCO_2e	c	Each reporting period	From fossil fuel and grid electricity sources included in the GHG Assessment Boundary (SSRs 3, 8, 13, 15, 17).
Equation 5.12 Equation 5.14	$PE_{CH4,BCS}$	Project methane emissions, for the reporting period, from the biogas control system	tCO_2e	c	Each reporting period	SSRs 9, 10, 11, 12, 14.
Equation 5.12 Equation 5.17	$PE_{CH4,EF}$	Project emissions, for the reporting period, from the digester effluent pond	tCO_2e	c	Each reporting period	SSR 16.
Equation 5.12 Equation 5.18	$PE_{CH4,N2O,AT}$	Project emissions of methane and nitrous oxide, for the reporting period, from the aerobic treatment of digestate material	tCO_2e	c	Each reporting period	SSR 17.
Equation 5.12 Equation 5.19	$PE_{CH4,LF}$	Project methane emissions, for the reporting period, from the anaerobic disposal of digestate material at a landfill	tCO_2e	c	Each reporting period	SSR 18.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.12 Equation 5.20	$PE_{CH4,LS}$	Total sum of project emissions, for the reporting period, from manure management systems affected by the project	tCO_2e	c	Each reporting period	SSR 5, quantified using the Reserve Livestock Project Protocol.
Equation 5.13	$PE_{CO2,FF}$	Total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	tCO_2	c	Each reporting period	
Equation 5.13	$PE_{CO2,EL}$	Total indirect carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	tCO_2	c	Each reporting period	
Equation 5.13	$FF_{PR,i}$	Total fossil fuel consumed by onsite combustion during the reporting period, by fuel type *i*	Volume	o	Each reporting period	Referenced from fuel use records or estimated based on miles traveled (for mobile combustion sources not owned or operated by the project developer).
Equation 5.13	$EF_{FF,i}$	Fuel-specific emission factor	$kgCO_2$ / volume	r	Each reporting period	Referenced from Table B.8 in Appendix B.
Equation 5.13	EL_{PR}	Total electricity from the grid consumed by project operations over the reporting period	MWh	o	Each reporting period	From electricity use records.
Equation 5.13	EF_{EL}	Carbon emission factor for electricity used	$lbCO_2$ / MWh	r	Each reporting period	Referenced from the most recent U.S. EPA eGRID emission factor publication. Projects use the annual total output emission rates for the subregion where the project is located.
Equation 5.14 Equation 5.21	$CH_{4,meter,i}$	Total quantity of methane collected and metered in month *i*	tCH_4/month	m, c	Continuously, aggregated monthly	Calculated from metered flow and methane concentration measurements.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.14	BCE	Biogas collection efficiency of the biogas control system	Fraction	r	Once per reporting period	A default factor that accounts for digester gas collection inefficiency. Referenced from Table B.6 by digester type and cover type.
Equation 5.14	$BDE_{i,weighted}$	Monthly weighted methane destruction efficiency of the combustion device(s)	Fraction	c	Monthly	
Equation 5.14 Equation 5.16	$CH_{4,vent,i}$	Monthly quantity of methane that is released to the atmosphere due to BCS venting events	tCH_4	c	Monthly	
Equation 5.14	F_i	Total monthly measured volumetric flow of biogas to all destruction devices	scf	m	Continuously, aggregated monthly	See Equation 5.15 for additional guidance on adjusting the biogas flow for temperature and pressure.
Equation 5.14 Equation 5.16	$CH_{4,conc,i}$	Monthly measured methane concentration of the biogas	Fraction	m	Quarterly or Continuously	If methane concentration is continuously measured, the value is equal to the monthly average. If quarterly measurements are used, the value is equal to the most recent methane concentration measurement.
Equation 5.14	BDE_{DD}	Default methane destruction efficiency of a particular destruction device	Fraction	r	Monthly	Referenced from Table B.7 in Appendix B.
Equation 5.14	$F_{i,DD}$	Monthly flow of biogas to a particular destruction device	scf	m	Continuously, aggregated monthly	The flow of biogas to each combustion device must be known.
Equation 5.15	F_{scf}	Volume of biogas collected for the given time interval, adjusted to 60°F and 1 atm	scf	c	Continuously	Calculated if gas flow meters do not internally correct for the temperature and pressure of the biogas.
Equation 5.15	$F_{unadjusted}$	Unadjusted volume of biogas collected for the given time interval	acf	m	Continuously	Measured if gas flow meters do not internally correct for the temperature and pressure of the biogas.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.15	T	Measured temperature of the biogas for the given time period	°R (°R = °F + 459.67)	m	Continuously	Measured to adjust the flow of biogas. No separate monitoring of temperature is necessary when using flow meters that automatically adjust flow volumes for temperature and pressure, expressing biogas volumes in normalized cubic feet.
Equation 5.15	P	Measured pressure of the biogas for the given time period	atm	m	Continuously	Measured to adjust the flow of biogas. No separate monitoring of pressure is necessary when using flow meters that automatically adjust flow volumes for temperature and pressure, expressing biogas volumes in normalized cubic feet.
Equation 5.16	MS_{BCS}	Maximum biogas storage of the BCS system	scf	r	Once per reporting period	Obtained from digester system design plans. Necessary to quantify the release of methane to the atmosphere due to an uncontrolled venting event.
Equation 5.16	F_{pw}	Average total daily flow of biogas from the digester for the entire week prior to the venting event	scf/day	m	Weekly	The average flow of biogas can be determined from the daily records from the previous week.
Equation 5.16	t	Number of days of the month that biogas is venting uncontrolled from the project's BCS	Days	m, o	Monthly	The approximate number of days that the BCS vented biogas to the atmosphere, down to the nearest 4 hours, as determined from metering evidence, personnel accounts, and energy production records.
Equation 5.17	$B_{0,EF}$	Methane producing capacity of the effluent stream 'S'	/	r	N/A	Project developers may use site-specific values that are determined based on the sampling approach provided in Section 6.1.3.2. Alternately, a value of 0.21 may be used for all effluent.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.17	$Q_{EF,i}$	Volume of effluent discharged into the effluent storage pond in month *i*	m^3	m	Continuously, aggregated monthly	The volume of effluent exiting the digester before entering the effluent storage pond or the wastewater treatment system. See Section 6.1.4 for guidance.
Equation 5.17	$COD_{EF,i}$	Chemical oxygen demand of the effluent discharged into the storage pond in month *i*	$tCOD/m^3$	m	Quarterly	COD of the digester effluent must be sampled quarterly; refer to the guidance provided in Section 6.1.3.1.
Equation 5.18	$W_{D,AT}$	Total wet weight of digestate treated aerobically onsite, or sent offsite for aerobic treatment during the reporting period	t	m, r	Measured by truckload and aggregated per reporting period (if using site-specific value)	From weigh station records or default value.
Equation 5.18	$EF_{D,AT}$	Combined methane and nitrous oxide emission factor for the appropriate aerobic treatment tier	tCO_2e / t of digestate	r	Each reporting period	Reference Table 5.2 for appropriate aerobic treatment category.
Equation 5.19	$W_{D,LF}$	Total wet weight of digestate treated anaerobically over the reporting period	t/year	m	Measured by truckload and aggregated for the reporting period	From weigh station records.
Equation 5.19	EF_{LF}	Emission factor for the anaerobic treatment of digestate at a landfill, per the appropriate climate region	tCO_2e/t digestate	r	Each reporting period	Referenced from Table B.4.
Equation 5.20	$PE_{CH4,LS,S}$	Project methane emissions from manure management system 'S', for the reporting period	tCO_2e	c	Each reporting period	Calculated per the method described in the non-BCS project emissions section of the Reserve Livestock Project Protocol.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.21	BDE_i	Monthly methane destruction efficiency of the combustion device(s)	Fraction	r, c	Monthly	In the event that there is more than one destruction device in operation in any given month, the weighted average destruction efficiency from all combustion devices is to be used.

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit verified emission reduction reports to the Reserve every 12 months at a minimum.

7.1 Project Submittal Documentation

Project developers must provide the following documentation to the Reserve in order to register an OWD project:

- Project Submittal form
- Project diagram from Monitoring Plan – see Appendix E (not public)
- Completed Reserve Livestock Calculation Tool, if used (not public)
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Project diagram from Monitoring Plan – see Appendix E (not public)
- Completed Reserve Livestock Calculation Tool, if used (not public)
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form

At a minimum, the above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of GHG reductions, including all required sampled data
- Copies of all solid waste, air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project activities dating back at least 3 years prior to the project start date, and for each subsequent year of project operation

- Project developer attestation of compliance with regulatory requirements relating to the OWD project
- Biogas flow meter information (model number, serial number, manufacturer's calibration procedures)
- Methane monitor information (model number, serial number, calibration procedures)
- Destruction device monitor information (model number, serial number, calibration procedures)
- Cleaning and inspection records for all biogas meters
- Field check results for all biogas meters
- Calibration results for all meters
- Destruction device monitoring data for each destruction device
- Biogas flow and methane concentration data
- Food and food-soiled paper waste weight data
- Food and food-soiled paper waste characterization data
- Wastewater and digester effluent flow meter information (model number, serial number, manufacturer's calibration procedures)
- Wastewater and digester effluent flow data
- Results of CO_2e reduction calculations
- Initial and subsequent verification records and results
- All maintenance records relevant to the biogas control system, monitoring equipment, and destruction devices

Calibrated portable gas analyzer information that the project developer should retain includes:

- Date, time, and location of methane measurement
- Methane content of biogas (% by volume) for each measurement
- Methane measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.3 Reporting Period and Verification Cycle

Project developers must report GHG reductions resulting from project activities during each reporting period. Although projects must be verified every 12 months at a minimum, the Reserve will accept verified emission reduction reports more frequently, should the project developer choose to have a reporting period and verification schedule of less than 12 months. A reporting period cannot exceed 12 months, and no more than 12 months of emission reductions can be verified at once, except during a project's first verification, which may include historical emission reductions from prior years.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the diversion of organic waste and/or wastewater away from anaerobic treatment and disposal systems and to a biogas control system (BCS). This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to OWD projects.

Verification bodies trained to verify organic waste digestion projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Livestock Project Protocol
- Climate Action Reserve Organic Waste Digestion Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only Reserve-approved verification bodies are eligible to verify OWD project reports. Verification bodies approved under other project protocol types are not permitted to verify OWD projects. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/.

8.1 Standard of Verification

The Reserve's standard of verification for OWD projects is the OWD Project Protocol (this document), the Livestock Project Protocol (for manure co-digestion projects), the Reserve Program Manual, and the Verification Program Manual. To verify an OWD project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm an OWD project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for OWD projects. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for an Organic Waste Digestion Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing within 6 months of the project start date	Once during first verification
Location	United States and U.S. tribal areas	Once during first verification
Anaerobic Baseline	Projects digesting agro-industrial wastewater streams and/or manure streams must demonstrate that the depth of the anaerobic wastewater and/or manure treatment ponds and lagoons prior to the project's implementation were sufficient to prevent algal oxygen production and create an oxygen-free bottom layer; which means at least 1 meter depth	Once during first verification
Performance Standard	One of the following eligible waste streams must be consistently, periodically or seasonally digested in the project's biogas control system: ▪ Municipal Solid Waste (MSW) Food Waste: Food waste commonly disposed into a MSW system, consisting of uneaten food, food scraps, spoiled food and food preparation wastes ▪ Food-Soiled Paper Waste: Non-recyclable paper items that are co-mingled with eligible food waste, consisting of paper napkins and tissues, paper plates, paper cups, fast food wrappers, used pizza boxes, wax-coated cardboard, and other similar paper or compostable packaging items typically disposed of in a MSW system ▪ MSW food and food-soiled paper waste from grocery stores that historically sent food waste to landfills prior to sending food waste to the project digester ▪ MSW food and food-soiled paper waste from new grocery store facilities ▪ Agro-Industrial Wastewater: Organic loaded wastewater from industrial or agricultural processing operations that, pre-project, was treated in an uncontrolled anaerobic lagoon, pond, or tank at a privately owned treatment facility	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws	Every verification
Exclusions	▪ Grid electricity and fossil fuel displacement ▪ Wastewater produced at breweries, ethanol plants, pharmaceutical production facilities, and pulp and paper plants	Every verification

8.4 Core Verification Activities

The Organic Waste Digestion Project Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with the diversion of organic waste and/or wastewater away from anaerobic treatment and disposal systems and to a BCS. The Verification Program Manual describes the core verification activities that shall be performed by

verification bodies for all project verifications. They are summarized below in the context of an OWD project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs (SSRs)
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as, *inter alia*, food waste disposal at landfills, anaerobic wastewater treatment, and/or manure treatment at livestock operations (if co-digesting manure with waste streams).

Reviewing GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the methodologies and management systems that the OWD project operator uses to gather data and calculate baseline and project emissions.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.5 OWD Verification Items

The following tables provide lists of items that a verification body needs to address while verifying an OWD project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to OWD projects that must be addressed during verification.

8.5.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for OWD projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met,

either the project may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3 and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of an OWD project	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that project is within its 10 year crediting period	No
3.4	Verify that all pre-project wastewater and/or manure treatment lagoons/ponds/tanks were of sufficient depth to ensure an oxygen-free bottom layer (> 1m)	Yes
3.4.1	If co-digesting manure with eligible organic waste, verify that all livestock operations contributing manure to the digestion project meet eligibility requirements per the most recent Livestock Project Protocol (as of the time of project submittal)	No
3.4.2	If one or more waste streams are sourced from Greenfield facilities (including, but not limited to, the project facility), verify that all wastewater was previously managed in an open anaerobic lagoon and the relevant Livestock Project Protocol Greenfield guidance is applied for all manure waste streams.	Yes
3.5.1	Verify that the project meets the Performance Standard Test	No
3.5.1	Verify that the project has documentation showing that all eligible waste streams originating from grocery stores or supermarkets were previously landfilled prior to the date that the waste is first delivered to the project digester	Yes
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.5.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	No
3.5.2.1	Verify that any food waste streams are eligible per Section 3.5.2 if the project is digesting food waste originating from a jurisdiction that has a mandatory food waste diversion ordinance or regulation	Yes
3.6	Verify that the project activities comply with applicable laws by reviewing any instances of material non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
3.7	Verify ownership of the reductions by reviewing the Attestation of Title	No
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that variance has been approved for monitoring variations	No
6	Verify that all gas flow meters and continuous methane analyzers adhered to the inspection, cleaning, and calibration schedule specified in the protocol. If they do not, verify that variance has been approved for monitoring variations or that adjustments have been made to data per the protocol requirements	No
6	Verify that adjustments for failed calibrations were properly applied	No
6,Appendix D	If used, verify that data substitution methodology was properly applied	No

8.5.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
5	Verify that the calculated baseline is compared with the total amount of methane metered and destroyed by the project, and the lesser of the two values is used as the baseline for the GHG reduction calculation	No
5.1	Verify that the baseline emissions from different eligible waste streams are properly aggregated	No
5.1.1	Verify that the correct k value is used for each food waste stream's baseline calculation	No
5.1.1	Verify that the FOD equation and/or the look-up table (Table B.3) is used correctly for each food waste stream	No
5.1.1	Verify that the weight of eligible food waste used for the baseline calculation is determined correctly	No
5.1.2	Verify that COD sampling of wastewater is performed monthly according to the guidance in Section 6.1.3.1	No
5.1.2	Verify that the correct MCF factor was used for the wastewater baseline calculation for each eligible wastewater stream	No
5.1.2	Verify that the B_0 value used for the wastewater baseline calculation is the default, or a site-specific value determined according to the guidance of Section 6.1.1.1	No
5.1.3, 5.2.6	Verify that the baseline and project emissions calculations for all manure waste streams digested by the OWD project are calculated according to the requirements of the most recent (as of the time of project submittal) Livestock Project Protocol	No
5.2	Verify that the project emissions calculations were calculated according to the protocol with the appropriate data	No
5.2.1	Verify that the project developer correctly monitored, quantified, and aggregated electricity use	Yes
5.2.1	Verify that the project developer correctly monitored, quantified, and aggregated fossil fuel use	Yes
5.2.1	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5.2.2	Verify that the project developer applied the correct methane destruction efficiencies	No
5.2.2	Verify that the project developer correctly quantified the amount of uncombusted methane	No
5.2.2.1	Verify that methane emissions resulting from any venting events or temporary project shutdowns are estimated correctly	Yes
5.2.3	Verify that COD sampling of liquid digester effluent is performed quarterly if the project stores liquid effluent in a storage pond	No
5.2.3	Verify that the correct MCF factor was used for the effluent storage pond	No
5.2.4	If the project aerobically treats (composts) digestate material either onsite or offsite, verify that the aerobic treatment tier from Table 5.2	Yes

Protocol Section	Quantification Item	Apply Professional Judgment?
	used for the calculation is consistent with the project-specific management of digestate material	
5.2.5	Verify that the weight of digestate disposed anaerobically is determined correctly based off of appropriate data	No
5.3	Verify that the project developer correctly monitored and quantified the amount of methane destroyed by the project	No

8.5.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Items that Inform Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that the BCS was operated and maintained according to manufacturer specifications	No
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6.1.3.1	Verify that the COD sampling and analysis was done by professionals experienced with the procedures used to determine COD as described in the Standard Method approach	Yes
6.1.3.2	Verify that all samples used to determine a site-specific B_0 factor are analyzed at an independent third-party laboratory that is experienced with the Biochemical Methane Potential (BMP) Assay procedure used to determine the maximum methane potential value of wastewaters	Yes
7.2	Verify that all required records have been retained by the project developer	No

8.6 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Projects that are digesting one or more eligible feedstocks in a biogas control system (BCS) are deemed to exceed common practice, and that are not mandated by regulation.
Agro-industrial wastewater	Organic loaded wastewater from industrial or agricultural processing operations that, pre-project, was treated in an uncontrolled anaerobic lagoon, pond, or tank at a privately owned treatment facility. Excluded from eligibility based on the Reserve's performance standard analysis are wastewaters produced at breweries, ethanol plants, pharmaceutical production facilities, and pulp and paper plants.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, de-forestation, etc.).
Biogas	Gas generated as a result of decomposition of organic materials under anaerobic conditions. Generally consists primarily of methane and carbon dioxide, with other trace gases.
Biogas control system (BCS)	A waste management system consisting of an anaerobic digester, biogas collection and metering equipment, and biogas destruction device(s).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Chemical oxygen demand (COD)	The chemical oxygen demand (COD) is the amount of oxygen consumed to completely chemically oxidize the organic water constituents to inorganic end products. COD is an important, rapidly measured variable for the approximate determination of the organic matter content of water samples.
Digester effluent	The largely decomposed residue material that has passed through the anaerobic digester system.
Digestate	The solid residue material separated from the liquid digester effluent stream.

Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Emission factor (EF)	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
First Order Decay model (FOD model)	A calculation developed to model the decay of waste under anaerobic conditions, based off of first-order kinetic equations.
Flare	A destruction device that uses an open flame to burn combustible gases with combustion air provided by uncontrolled ambient air around the flame.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenfield project	A project implemented at new industrial facilities that have no prior wastewater treatment system.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Landfill	A defined area of land or excavation that receives or has previously received waste that may include household waste, commercial solid waste, non-hazardous sludge, and industrial solid waste.
Landfill gas (LFG)	Gas resulting from the decomposition of wastes placed in a landfill. Typically, landfill gas contains methane, carbon dioxide and other trace organic and inert gases.
Materials Recovery Facility (MRF)	A specialized plant that receives, sorts, and processes MSW in order to extract materials of value that would ordinarily otherwise go to a landfill.

MRF fines	Residual material from the processing of mixed MSW at a Materials Recovery Facility, characterized by small particle size and relatively high organics content as compared to typical mixed MSW loads. This material is not source-separated.
Metric ton or "tonne" (t)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
Mixed MSW	Non-source separated waste consisting of organic and inorganic components, reflecting waste typically disposed of at a landfill.
MSW food waste	Non-industrial food waste commonly disposed into a MSW system, consisting of uneaten food, spoiled food and food preparation wastes from homes, restaurants, kitchens, grocery stores, campuses, cafeterias, and similar institutions.
National Emission Standards for Hazardous Air Pollutants (NESHAP)	Federal emission control standards codified in 40 CFR 63. Subpart AAAA of Part 63 prescribes emission limitations for MSW landfills.
New Source Performance Standards (NSPS)	Federal emission control standards codified in 40 CFR 60. Subpart WWW of Part 60 prescribes emission limitations for MSW landfills.
Project baseline	A "business as usual" GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a GHG project, as identified in the OWD Project Protocol, Section 2.
Resource Conservation and Recovery Act (RCRA)	Federal legislation under which solid and hazardous waste disposal facilities are regulated.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
Verification	The process used to ensure that a given participant's greenhouse gas emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.

Verification body	A Reserve-approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Waste stream	For the purpose of this protocol, an eligible waste stream is defined as an eligible waste type per the eligibility requirements in Section 3.5.1 (post-consumer food waste or agro-industrial wastewater), originating from a specific source or collection route. Examples: ▪ Residential SSO food and paper waste from a specific county or municipal jurisdiction ▪ Commercial SSO food and paper waste from a specific collection route ▪ Wastewater from a specific industrial plant

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Appendix A Associated Environmental Impacts

Organic waste and manure digestion projects have many documented environmental benefits, including air emission reductions, water quality protection, and electricity generation. These benefits are the result of practices and technologies that are well managed, well implemented, and well designed. However, in cases where practices or technologies are poorly or improperly designed, implemented, and/or managed, local air and water quality could be compromised.

With regard to air quality, there are a number of factors that must be considered and addressed to realize the environmental benefits of a biogas project and reduce or avoid potential negative impacts. Uncontrolled emissions from combustion of biogas may contain between 200 to 300 ppm NO_X. The anaerobic treatment process creates intermediates such as ammonia, hydrogen sulfide, orthophosphates, and various salts, all of which must be properly controlled or captured. In addition, atmospheric releases at locations offsite where bio-gas is shipped may negate or decrease the benefit of emissions controls onsite. Thus, while devices such as Selective Catalyst Reduction (SCR) units can reduce NO_X emissions and proper treatment system operation can control intermediates, improper design or operation may lead to violations of federal, state, and local air quality regulations as well as release of toxic air contaminants.

With regard to water quality, it is critical that project developers and managers ensure digester integrity and fully consider and address post-digestion management of the effluent in order to adequately manage nutrient loading and avoid contamination of local waterways and groundwater resources. Catastrophic digester failures; leakage from pipework and tanks; and lack of containment in waste storage areas are all examples of potential problems. Further, application of improperly treated digestate and/or improper application timing or rates of digestate to agricultural land may lead to increased nitrogen oxide emissions, soil contamination, and/or nutrient leaching, thus negating or reducing benefits of the project overall.

As specified in Section 3.6, Project developers must comply with all local, state, and national air and water quality regulations pertaining to project activity. Projects must be designed and implemented to mitigate potential releases of pollutants such as those described, and project managers must acquire the appropriate local permits prior to installation to prevent violation of the law.

The Reserve agrees that GHG emission reduction projects should not undermine air and water quality efforts and will work with stakeholders to establish initiatives to meet both climate-related and localized environmental objectives.

Appendix B Data Lookup Tables

Table B.1. Decay Rates (k) by Waste Type and Climate

Climatic Category (by Mean Annual Precipitation)	**Food Waste Decay Rate** $k_{FW,S}$ (yr^{-1})	**Soiled Paper Decay Rate** $k_{SP,S}$ (yr^{-1})*
Dry (0-25 inches)	0.072	0.031
Wet (25-50 inches)	0.144	0.063
Very Wet (50 + inches)	0.288	0.126

Source: Memorandum to Jennifer Brady, Office of Resource Conservation and Recovery, U.S. EPA: WARM Component-Specific Decay Rate Methods. ICF International, 2009.
* Soiled paper decay rate assumed to be equal to the decay rate of mixed office paper, per communication with M. Barlaz.

Table B.2. Fraction of Waste Sent to Waste-to-Energy (WTE) Facilities

State	**WTE_S (Fraction)**
ALABAMA	0.03
ALASKA	0.03
ARIZONA	0.00
ARKANSAS	0.01
CALIFORNIA	0.02
COLORADO	0.00
CONNECTICUT	0.65
DELAWARE	0.00
FLORIDA	0.25
GEORGIA	0.01
HAWAII	0.28
IDAHO	0.00
ILLINOIS	0.00
INDIANA	0.05
IOWA	0.01
KANSAS	0.00
KENTUCKY	0.00
LOUISIANA	0.04
MAINE	0.19
MARYLAND	0.20
MASSACHUSETTS	0.37
MICHIGAN	0.07
MINNESOTA	0.21
MISSISSIPPI	0.00
MISSOURI	0.01
MONTANA	0.01
NEBRASKA	0.00
NEVADA	0.00
NEW HAMPSHIRE	0.16
NEW JERSEY	0.15
NEW MEXICO	0.00

State	WTE_S (Fraction)
NEW YORK	0.20
NORTH CAROLINA	0.01
NORTH DAKOTA	0.00
OHIO	0.00
OKLAHOMA	0.08
OREGON	0.04
PENNSYLVANIA	0.19
RHODE ISLAND	0.00
SOUTH CAROLINA	0.05
SOUTH DAKOTA	0.00
TENNESSEE	0.00
TEXAS	0.00
UTAH	0.04
VERMONT	0.09
VIRGINIA	0.13
WASHINGTON	0.04
WEST VIRGINIA	0.00
WISCONSIN	0.03
WYOMING	0.00

Source: Biocycle State of Garbage Report (2006), Table 3. (http://www.jgpress.com/images/art/0604/table3.gif)

Table B.3. Gas Collection Fractions, by State

Landfill State	Total Annual Waste Acceptance at Open Landfills (tons)				Fraction of Total Waste Accepted at Open Landfills with Known or Potential LFG Collection Systems	Gas Collection Fractions
	Landfills with No LFG Collection Systems	Landfills where LFG Collection Status is Unknown	Landfills with LFG Collection Systems	All Landfills		
AK	182,674	72,900	350,000	605,574	70%	0.70
AL	3,249,929	1,040,000	4,731,995	9,021,924	64%	0.64
AR	471,646		936,455	1,408,101	67%	0.67
AZ	387,105		4,064,059	4,451,164	91%	0.91
CA	1,397,403		35,968,060	37,365,463	96%	0.96
CO	1,474,132		4,810,118	6,284,250	77%	0.77
CT			158,164	158,164	100%	1.00
DE			830,741	830,741	100%	1.00
FL	2,132,545		14,359,416	16,491,961	87%	0.87
GA	1,170,878	166,567	10,390,734	11,728,179	90%	0.90
HI	249,249		578,335	827,584	70%	0.70
IA	1,152,713	71,272	1,491,316	2,715,301	58%	0.58
ID	548,261		763,791	1,312,052	58%	0.58
IL	434,737		13,667,105	14,101,842	97%	0.97
IN	1,831,127		8,889,583	10,720,710	83%	0.83
KS	1,401,161		2,548,150	3,949,311	65%	0.65
KY	1,124,893		5,238,221	6,363,114	82%	0.82

Landfill State	Total Annual Waste Acceptance at Open Landfills (tons)				Fraction of Total Waste Accepted at Open Landfills with Known or Potential LFG Collection Systems	Gas Collection Fractions
	Landfills with No LFG Collection Systems	Landfills where LFG Collection Status is Unknown	Landfills with LFG Collection Systems	All Landfills		
LA	473,833		4,368,346	4,842,179	90%	0.90
MA	900		2,184,392	2,185,292	100%	1.00
MD	453,344		1,785,180	2,238,524	80%	0.80
ME	26,355		851,679	878,034	97%	0.97
MI	456,335		16,258,806	16,715,141	97%	0.97
MN	139,398		1,631,572	1,770,970	92%	0.92
MO	255,400		2,424,101	2,679,501	90%	0.90
MS	842,731		2,402,865	3,245,596	74%	0.74
MT	179,576		603,515	783,091	77%	0.77
NC	1,527,569	50,802	5,380,169	6,958,540	78%	0.78
ND	197,579		140,000	337,579	41%	0.41
NE	438,116		1,715,057	2,153,173	80%	0.80
NH	153,449		1,783,857	1,937,306	92%	0.92
NJ			4,095,824	4,095,824	100%	1.00
NM	83,321		1,348,266	1,431,587	94%	0.94
NV	341,668		3,507,687	3,849,355	91%	0.91
NY	526,891		7,430,008	7,956,899	93%	0.93
OH	2,163,712		17,047,685	19,211,397	89%	0.89
OK	828,876		3,161,706	3,990,582	79%	0.79
OR	373,788		4,386,823	4,760,611	92%	0.92
PA	289,651		18,361,866	18,651,517	98%	0.98
PR	1,814,530		1,401,900	3,216,430	44%	0.44
RI	9,760		1,507,847	1,517,607	99%	0.99
SC	429,431		6,470,888	6,900,319	94%	0.94
SD	273,700		178,321	452,021	39%	0.39
TN	524,290		5,131,608	5,655,898	91%	0.91
TX	2,657,648	25,701	18,413,494	21,096,843	87%	0.87
UT	1,220,353		1,360,428	2,580,781	53%	0.53
VA	433,948	125,755	13,048,150	13,607,853	97%	0.97
VI			85,000	85,000	100%	1.00
VT	11,788		520,000	531,788	98%	0.98
WA	203,059		4,246,249	4,449,308	95%	0.95
WI	95,026		8,457,871	8,552,897	99%	0.99
WV	385,188	26,496	1,381,594	1,793,278	79%	0.79
WY	275,453			275,453	0%	0%
Grand Total	35,295,119	1,579,493	272,848,997	309,723,609	89%	N/A

Source: U.S. EPA Landfill Methane Outreach Program (LMOP) Database (2012).

Table B.4. Digestate Emission Factors by Climate Region

Decay Rate (k Value)	Digestate Emission Factor* (tCO_2e/t waste)
Dry	0.067
Wet	0.150
Very Wet	0.218

*The digestate emission factor is calculated using an FOD model with IPCC default values for sludge waste.

Table B.5. Methane Conversion Factor (MCF) for Wastewater Treatment Systems

Type of Wastewater Treatment System	MCF Lower Bound
Anaerobic reactor without methane capture	0.8
Anaerobic shallow lagoon (depth < 2 m)	0.1*
Anaerobic deep lagoon (depth > 2m)	0.8

Source: *IPCC Guidelines for National GHG Inventories*, Volume 5, Chapter 6 (2006)
* A lower bound value of 0.1 is used instead of 0.0, the lower bound in the IPCC guidelines.

Table B.6. Biogas Collection Efficiency by Digester Type

Digester Type	Cover Type	Biogas Collection Efficiency (BCE) as a Decimal
Covered Anaerobic Lagoon	Bank-to-Bank, impermeable	0.95
	Partial area (modular), impermeable	(0.95) x (% area covered)
Complete mix, plug flow, or fixed film digester	Enclosed vessel	0.98
Two stages of differing types	With flow metered for each stage	$\frac{(BCE1) \times (Gasflow1) + (BCE2) \times (Gasflow2)}{Total\ biogas\ flow}$
	No separate flow metering	$(BCE1) \times 0.7 + (BCE2) \times 0.3$

Adapted from: U.S. EPA Climate Leaders, Offset Project Methodology for Managing Manure and Biogas Recovery Systems, 2008. Table IIf (original table has been expanded upon).

Table B.7. Biogas Destruction Efficiency Default Values by Destruction Device

Biogas Destruction Device	Biogas Destruction Efficiency (BDE)*
Open flare	0.96
Enclosed flare	0.995
Lean-burn internal combustion engine	0.936
Rich-burn internal combustion engine	0.995
Boiler	0.98
Microturbine or large gas turbine	0.995
Upgrade and use of gas as CNG/LNG fuel	0.95
Upgrade and injection into natural gas transmission and distribution pipeline	0.98**
Offsite use of gas under a direct-use agreement	*Per corresponding destruction device factor (not pipeline)*

Source: The default destruction efficiencies for enclosed flares and electricity generation devices are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data is made available to the Reserve.

* If available, the official source tested methane destruction efficiency shall be used in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for each of the combustion devices used in the project case. If neither the state or locality relevant to the project site offer accreditation for source testing service providers, projects may use an accredited service provider from another U.S. state or domestic locality. Alternatively, projects may choose a non-accredited service provider, under the following conditions: 1) the service provider must provide verifiable evidence of prior testing which was accepted for compliance by a domestic regulatory agency, and 2) the prior testing procedures must be substantially similar to the procedures used for determining methane destruction efficiency for the project destruction device(s).

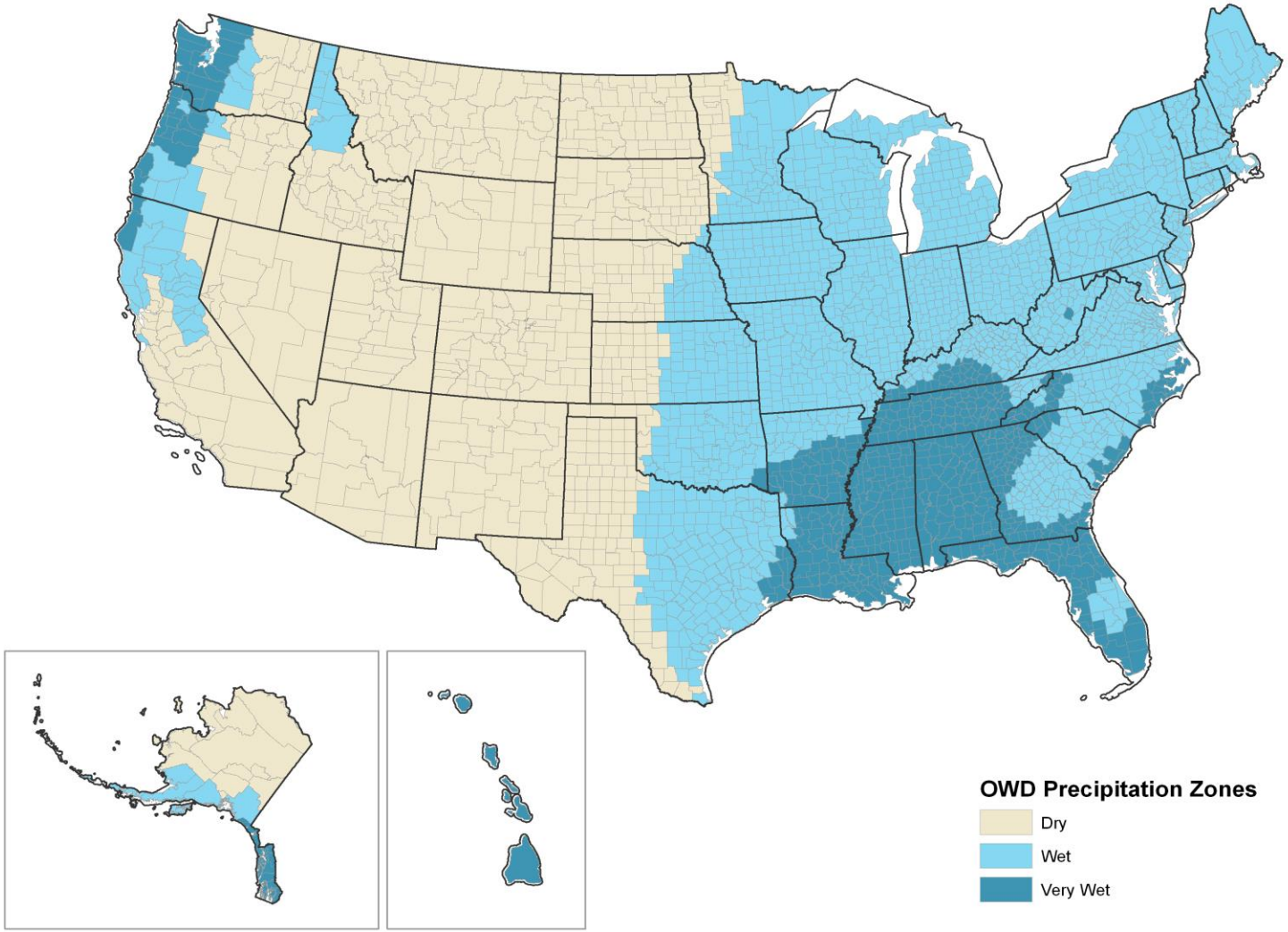
****** The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH4/PJ, which is 0.8%. These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations.[55]

[55] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

Table B.8. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBtu / Short ton**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**Btu / Standard cubic foot**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Standard cub. ft.**
975 to 1,000 Btu / Std cubic foot	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Std cubic foot	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Std cubic foot	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Std cubic foot	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Std cubic foot	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Std cubic foot	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBtu / Barrel**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2 & 4)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 & 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401 deg. F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401 deg. F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable). Heat content factors are based on higher heating values (HHV).



Source: USGS, Hydrologic landscape regions of the United States (2003)

Figure B.1. K-Value Categories in the U.S., by County

Appendix C Development of the Performance Standard

The analysis to establish a performance standard for the Organic Waste Digestion Project Protocol was undertaken by Science Applications International Corporation (SAIC). It took place in January to May of 2009. The analysis culminated in two papers that provided performance standard options and recommendations to support the Reserve's protocol development process, which the Reserve has incorporated into the protocol's eligibility rules (see Section 3).

The purpose of a performance standard is to establish a threshold that is significantly better than average greenhouse gas (GHG) production for a specified service, which, if met or exceeded by a project developer, satisfies the criterion of "additionality." The Reserve's project protocol focuses on the following emission reduction activity: the anaerobic digestion of organic wastes that were previously treated in uncontrolled anaerobic waste treatment systems.

The analysis to establish the performance standard evaluated organic waste management practices in the specified categories of waste streams. The paper did not provide a detailed quantitative analysis of organic waste practices or volumes in the U.S. but rather provides a qualitative review of current practices and regulations for the identified waste categories. It did not provide a performance "threshold" or baseline of GHG emissions from organic waste. Ultimately, it recommended for each waste category whether a performance standard to improve GHG emissions can be established. The paper had the following sections:

- Organic waste source industries in the U.S.
- The process for which organic wastes are generated from each identified waste stream; their respective "business as usual" and alternative (or better practice) management practices and potential GHG reductions for these management practices
- Current and anticipated federal and state regulations impacting organic waste management practices
- Recommendations for regulatory additionality
- Recommendations for OWD performance standard options
- Digestion economics

C.1. Selected Waste Generating Industries

As organic waste sources span across a range of different point sources and disposal locations, an industry-based approach was utilized to inform the performance standard. A list of 82 industries was identified using the North American Industry Classification System (NAICS), the standard used by Federal statistical agencies in classifying business establishments.[56] The list of 82 industries was then shortlisted based on their organic waste and greenhouse gas potential. Thirty-one industries were shortlisted for detailed analysis. These were organized under the three categories of organic waste:

- Food and food-processing solid waste sources
- Agricultural solid waste sources
- Industrial/agricultural wastewater sources (including wastewater coming from onsite agro-industrial and food processing industries)

Table C.1 shows the major organic waste generating industries considered in the paper.

[56] http://www.census.gov/eos/www/naics/

Table C.1. Selected Organic Waste Source Industries Studied

Category	Industry	Organic Waste Source Categories			Primary Manuf.	Secondary Manuf.
		Food & Food Processing Solid Waste	Agricultural Solid Waste	Industrial/ Agricultural Wastewater		
Grain Manufacturing	1. Rice Milling 2. Malt Manufacturing 3. Wet Corn Milling		X	X	X	
Oilseed Processing	4. Soybean Processing 5. Other Oilseed Processing		X	X	X	
Sugar Manufacturing	6. Sugarcane Mills 7. Cane Sugar Refining 8. Beet Sugar Manufacturing	X	X	X	X	X
Fruit and Vegetable Manufacturing	9. Frozen Fruit, Juice, and Vegetable Manufacturing 10. Fruit and Vegetable Canning	X		X	X	X
Pre-Cooked Foods	11. Frozen Specialty Food Manufacturing 12. Specialty Canning 13. Commercial Bakeries	X		X		X
Dairies	14. Fluid Milk Manufacturing 15. Creamery Butter Manufacturing 16. Cheese Manufacturing	X		X		X
Animal/ Seafood Processing	17. Animal (except Poultry) Slaughtering 18. Meat Processed from Carcasses 19. Rendering and Meat Byproduct Processing 20. Poultry Processing 21. Seafood Canning	X		X	X	X
Beverage Manufacturing	22. Soft Drink Manufacturing 23. Breweries 24. Wineries	X		X		X
Paper Milling	25. Paper (except Newsprint) Mills 26. Paperboard Mills 27. Cellulosic Organic Fiber Manufacturing	X*		X		X
Fertilizer Manufacturing	28. Nitrogenous Fertilizer Manufacturing 29. Phosphatic Fertilizer Manufacturing 30. Fertilizer (Mixing Only) Manufacturing + Compost Manufacturing	X*	X	X		X
Medicinal Manufacturing	31. Medicinal and Botanical Manufacturing	X*		X		X

* Non-food industries that generate organic wastes. (Note: for the purposes of this study, these industries were grouped with food processing for research, analysis, and discussion.)

Primary manufacturing is characterized by industries that process an agricultural or forestry product. These manufacturing plants or operations will generally be largest, and will produce the greatest quantities of waste per plant. Because of their large waste volumes and the producers' motivation to sell products to their highest use (and value), manufacturers will typically sell waste products to buyers who use them as feedstock for secondary products. Secondary manufacturing, on the other hand, is producing a more finished product from the primary manufacturing products.

In addition to these "pre-consumer" industries, SAIC also uncovered relevant information on "post-consumer" organic wastes from the municipal solid waste (MSW) streams in the U.S. such as food scraps and yard trimmings. Data was also obtained and analyzed for fats, oils, and grease (FOG) wastes from pre- and post-consumer sources.

C.2. Organic Waste Generation and Management and OWD Performance Standard Options

SAIC looked at three categories of organic wastes: 1) solid food waste, 2) agricultural solid waste, and 3) agro-industrial wastewater and determined the types of waste and industries associated with each category, as well as waste quantities for each type of the waste and any seasonal and geographical variations. SAIC then looked at waste management practices in the U.S. for each of these categories and provided an overview of how waste emissions arise, the methane potential of the waste, how it is managed in a "business as usual" setting and alternative management technologies.

The gathered evidence showed that for the first two categories (industrial food wastes and agricultural waste), there is a strong economic incentive to extract and recover solids from waste streams and convert these into by-products or to burn wastes for energy.[57] Thus, the common practices of activity for these waste streams are already those with very low GHG emission potentials.

However, there are a few solid food wastes that cannot be reused as byproducts and inevitably end up in landfill. Some examples of landfilled solid food waste identified in the research include milk solids, condemned animal carcasses, meat scraps and pomace wastes from winery. Further studies should be conducted to determine if these niche pre-consumer waste streams can be better characterized and included into a food waste offset methodology. The Reserve will continue to research this topic for future revisions to the protocol.

Post-Consumer Food Waste

Studies by the U.S. EPA identified that 31.7 million tons of post-consumer food waste was generated in 2007, or 12.5% of total national MSW waste generated. In addition, studies by Biocycle Magazine estimate that just 0.8 million tons or 2.6% of this quantity was diverted from landfill to compost in 2007. Since only 2.6% of this waste is currently being diverted, this would typically qualify as achieving significantly improved GHG performance and meeting a stringent performance threshold.

[57] The burning of agricultural solids generates biogenic carbon in the form of CO_2 and is therefore considered carbon neutral. However, open burning of these wastes is an incomplete combustion process and can generate soot, carbon monoxide, and other pollutants of concern. There could be some GHG benefits from reducing open burning by reducing carbon black formation and some N_20 formed during incomplete combustion, since these would be considered anthropogenic. Further study would be needed to establish if GHG emissions from carbon black and N_20 resulting from open burning are significant.

FOG Wastes

FOG wastes (fats, oils, and grease) were also studied for their generation and disposal practices. It was discovered that yellow grease is a valuable product which is almost all recycled into by-products such as biofuels and rendered animal fats are also converted into valuable products such as soap and cosmetics. Brown grease (or grease trap grease) is mostly sent to publicly owned treatment works (POTWs) with some individual practices being identified which involve solids being separated and sent to landfill. However, this is estimated to be a very small amount and in leading states, reuse of brown grease as biofuel feedstock is becoming common, as well as hauling to rendering plants for extraction of valuable components for reuse. Common practice therefore recognizes FOG waste as a recyclable resource and only small quantities are being sent to landfill, so it is concluded that these waste types would not typically qualify as achieving significantly improved GHG performance through application in digestion projects.

Yard Waste

Another organic waste category studied is yard waste. An estimated 32.6 million tons of yard trimmings were generated in 2007, or 12.8% of total national MSW generated. Unlike post-consumer food waste, an EPA estimate of 20.9 million tons or 64.1% of this quantity was diverted from landfill for composting or mulching in 2007. This is then the common practice and for the same reasons as were given for pre-consumer solid waste, there would appear to be no incentive to develop technologies to further reduce GHG emissions. Therefore, a performance standard showing significantly improved performance above common practice cannot be established for yard waste.

Composting

Composting of organic waste from the first two general categories is often considered a GHG reduction measure since aerobic degradation processes of the organic material tend to dominate over anaerobic processes. However, methane conversion potential (referred to as Methane Conversion Factors or MCFs, for which tables has been developed by the IPCC) of compost piles for manure are very low – ranging from zero to a maximum of 1.5% in a higher temperature setting. With such a low methane emission potential for the common practice case, there would appear to be no incentive to develop technologies to further reduce GHG emissions. Therefore, a performance standard showing significantly improved performance cannot be established for composted food and agricultural wastes.

Industrial and Agricultural Wastewater

The third category of waste studied was industrial/agricultural wastewater. SAIC found that residual wastewater was, in most cases, sent to a POTW after solids were reduced to a level acceptable to the POTW. The POTW, in turn, manages the residual wastewater in various ways. As noted earlier, the 2004 U.S. EPA identified that 59% of wastewater flow in the U.S. goes to facilities with anaerobic digestion and 20% of flow in the U.S. goes to facilities that have anaerobic digestion and utilize the off-gas. Facilities without gas utilization are typically equipped with flares to combust the methane. According to U.S. EPA and California Integrated Waste Management Board studies, 60% to 70% of biosolids from POTWs are either composted or land applied. Both of these practices involve predominantly aerobic decomposition processes, although in some cases the biosolids could be temporarily stored in an anaerobic condition prior to composting or land treatment. Overall, the statistics indicate that a majority of POTW sludges are already treated in a way that generates little or no methane from aerobic processes or from biodigestion. The overall GHG emission baseline is then very low for the POTW sludges and there is little incentive to develop a performance standard to further reduce emissions.

However, based on follow-up research, SAIC identified that agro-industrial wastewater treatment does occur onsite at many food and agricultural processing operations. There are many agro-industrial industries and facilities in the U.S. with varying onsite wastewater management practices in the U.S. The variations are largely a consequence of the industry segment as some will inherently have higher organic material loading such as those identified by EPA in current U.S. inventories as significant methane emitters – i.e. pulp and paper manufacturing, meat and poultry processing, vegetables, fruits, and juices processing, starch-based ethanol production, and petroleum refining. Additionally, variations will occur geographically in the U.S. depending on the allowable organic discharge limits (post treatment) in any specific area, and the feasibility of discharging wastewaters to a public treatment system. Even with these limitations, several important trends have emerged that will inform a performance standard for digestion in several industry segments. Meat and poultry processing are the best candidates at this time for an OWD performance standard to create additional GHG reductions. Onsite anaerobic wastewater management is a common practice in these industry segments and the market penetration data do not indicate any significant uptake of digesters and methane collection systems in these segments.

For the remaining industry segments reviewed, important questions remain. For fruit, vegetable, and juice processing, the market data indicate that some sub-categories (juice) have more AD system uptake than others (vegetable). In addition, EPA data indicate only 11% of these facilities have onsite wastewater systems. This appears to be attributable to a number of factors, including wide variations in the COD content of wastewater between different producer types within this diverse industry segment, and significant seasonal changes in wastewater composition and volume at individual facilities. This leads to a mixed conclusion that facilities in this segment, if they can demonstrate a sufficient history of past anaerobic lagoon operation and low market penetration (e.g. vegetable processing), could be eligible for inclusion in the performance threshold. These outstanding questions indicate that it appears to be preferable to further break this industry segment down into sub-categories rather than to apply a uniform performance standard across it.

For breweries and the emerging corn/biofuel ethanol industry segments, the market data suggest that AD systems are becoming more common place, although specific market penetration percentages could not be determined. This raises questions about the additionality of AD system projects in corn ethanol plants and breweries until a better understanding of the market penetration of AD systems in these segments is developed.

Pulp and paper was not studied in the initial research as it is a complex industry that involves some chemical processes. However, the data obtained from EPA in this current research (high methane emissions, no indication of significant penetration of AD systems) would indicate potential for further investigation of the applicability of a performance standard for reducing methane emissions from anaerobic degradation processes. Specifically a separate evaluation of their onsite wastewater practices and AD system penetration appears warranted. A similar conclusion can be made for the pharmaceutical industry in that it can involve a variety of processes not studied in the original research but appear to have low penetration of digesters.

There are several other industrial segments for which the market data indicate the plausibility as well as low penetration of anaerobic digestion projects, including dairy foods processing, candy, sugar, and yeast production. For each of these industries, more information on existing wastewater practices and the relative prevalence of AD systems is needed before determining

the applicability of a performance standard for reducing methane emissions from anaerobic degradation processes.

Based on the conclusions above, SAIC recommends categorizing the various industries examined according to their suitability for the development of an anaerobic digestion with methane recovery performance standard as follows:

Include as an Eligible Project Type

- Meat and poultry processing
- Vegetable processing

Exclude as an Eligible Project Type

- Breweries and ethanol industry segments

Promising: Needs Further Information to Ensure Consistency with Eligible Project Types

- Pulp and paper
- Dairy foods processing
- Sugar production
- Candy manufacturing
- Yeast production
- Fruit and juice processing
- Pharmaceuticals

C.3. Regulatory Conditions and Regulatory Additionality Recommendations

In order to properly credit emission reductions from digester projects, it is important to establish regulatory additionality that determines whether a project fulfills a regulatory obligation or if a project provides additional emission reductions beyond what is required by law. All GHG reduction projects are subject to a Legal Requirement Test to ensure that the emission reductions achieved by a project would not otherwise have occurred due to federal, state or local regulations.

In the study, SAIC found that there are no federal or state regulations currently in place that obligate waste source producers or wastewater management entities to invest in a biogas control system or a bio-digester. For landfills, Federal and State laws have long required methane collection systems. In California, starting in 2010, AB32 will also require any remaining uncontrolled MSW landfills to install emission control systems to manage methane emissions from the decomposition of organic matter.

Through AB939, California also calls for all municipalities to currently divert 50% of their waste stream from landfills, with an increase to a 75% diversion rate under consideration. Other states such as North Carolina and Missouri have similar landfill diversion laws. Thus, any municipality that has already achieved its landfill diversion goal would meet the Legal Requirement Test for additional landfill diversions of food wastes, for example. Conversely, a municipality that has not yet met its landfill diversion target may not fulfill the Legal Requirement Test for additional landfill diversions (at least until the target is achieved).

With a myriad of regulations that wholly or partly apply to activities involved with organic waste disposal (e.g. air quality, wastewater, compost management) and with a wide variety of

industries that generate organic wastes, digestion project owners need to ensure their diversion of organics to digestion continues to meet relevant regulatory requirements for disposal. This will most likely need to be done on a case by case basis depending on the location, quantity of waste, and the operation that is generating the waste in order to properly account for any additional emission reductions that occur beyond what is required by law.

C.4. Digestion Economics

The SAIC study found that the dominant economic factor regarding adoption of digestion technology is capital and operations and maintenance (O&M) costs for a digestion reactor, managing the solid, liquid and gaseous byproducts of digestion (e.g. send to landfill, land spreading, commodity byproduct, etc.).

Table C.2 outlines general guidelines to evaluate the capital and O&M costs of different types of feedstock for digestion.

Table C.2. Economic Evaluation Guidelines for Digestion Feedstock

Type of Feedstock	Capital Costs	Operation and Maintenance
Anaerobic digestion of liquids	$10-15/gal of wastewater treated	$0.005/gal treated (with energy recovery)
Anaerobic digestion of agricultural / animal waste	$60-75/gal of wastewater treated	O&M costs $0.006/gal treated net capital payback Net O&M Income $0.04/gal treated
Anaerobic digestion of MSW	$50,000/ton of daily volume	$15.00/ton net capital payback
Aerobic digestion of liquids	$8.75-13/gal of daily volume treated	$0.0075/gal treated

Economies of scale favor those facilities with higher throughput and an increased ability to effectively manage digestion conditions and byproducts. Waste generating industries, primary manufacturers or waste and wastewater management facilities that aggregate large quantities of materials will have the most favorable economics. However, large dairies, that could manage other wastes from nearby businesses, could also have the scale to achieve an economic payback. The payback time of investment in small- and medium scale digesters can be considerably high. Typical small-scale agricultural biogas plants (e.g. digester volume 235 m^3) can have payback times of over 10 years. Typical examples of large scale digestion plants (e.g. digester volumes 4,650 – 6,000m^3) have payback times between 3 to 10 years.[58]

Favorable economics may also exist at wastewater treatment plants that could install digesters or better yet have digesters that could be used or expanded to digest food waste. Due to increased biogas yields, the co-digestion of bio-wastes together with municipal sewage sludge in existing municipal sewage digesters can considerably reduce wastewater treatment costs. Therefore in many municipal sewage sludge digesters, organic wastes are co-digested on an occasional basis. Some successful examples from sewage treatment plants have been reported in Denmark and also in Germany. Typical co-substrate addition rates in sewage sludge digesters are between 5% to 20%. Adding co-substrates like flotation sludge, fat trap contents,

[58] R.Braun, R. "Potential of Co-Digestion – Limits and Merits" April 2002. Available at: http://www.novaenergie.ch/iea-bioenergy-task37/Dokumente/final.PDF

food leftovers, etc., can considerably raise the biogas productivity of sewage sludge digesters by 40% to 230%. Nevertheless, if co-digestion is to be implemented into existing sewage treatment plants, depending on the bio-waste concentration and other factors, additional pre- and post-treatment equipment must be taken into consideration for the final cost calculation. For example, the cost and the logistical feasibility of cleaning (e.g. of plastic and other impurities) and grinding the materials so that they are suitable for the digester at the POTWs may be a major constraint in many cases.

Table C.3 provides a general example of a dedicated MSW fed digester plant.

Table C.3. Example Digester Plant, Payback Economics

Parameters	Values
Digester volume	150,000 tons/year
Main substrate	MSW – Post-Consumer Food Waste
Investment costs	$15,000,000
Annual capital repayment costs	$3,500,000
Other operating costs (year)	$2,500,000
Total annual costs	$6,000,000
Total revenue	$9,056,000
Net income (before taxes)	$3,056,000

Source: SAIC.

The simple payback for this investment of $15 million is 4.9 years. If one considers the value of GHG credits (of avoided methane emissions from MSW being landfilled) estimated at between $1 and $1.5 million annually,[59] the simple payback ranges from 3.2 years to 3.7 years. However, if the landfill is required to have methane controls, this reduces the methane emitted and therefore the value of GHG credits to $450,000 annually,[60] increasing the payback to 4.3 years.

[59] Based on EPA emissions factors for methane emissions from MSW in landfill (sourced from AP 42, Fifth Edition, Volume I Chapter 2: Solid Waste Disposal http://www.epa.gov/ttn/chief/ap42/ch02/index.html) and estimating carbon credit value at $8/ton (sourced from New Carbon Finance, Voluntary Market Research Note 13th January 2008 at www.newcarbonfinance.com/download.php?n=NCF_Voluntary_VCI_01_091.pdf&f=fileName&t=NCF_downloads).

[60] Based on 70% methane control efficiency rate.

Appendix D Data Substitution

This appendix provides guidance on calculating emission reductions when data integrity has been compromised due to missing data points. The methodologies presented below are to be used only for the methane concentration and flow metering parameters.

The Reserve expects that projects will have continuous, uninterrupted data for the entire verification period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously. If data is missing for both parameters, no reductions can be credited.

Further, substitution may only occur when two other monitored parameters corroborate proper functioning of the destruction device and system operation within normal ranges. These two parameters must be demonstrated as follows:

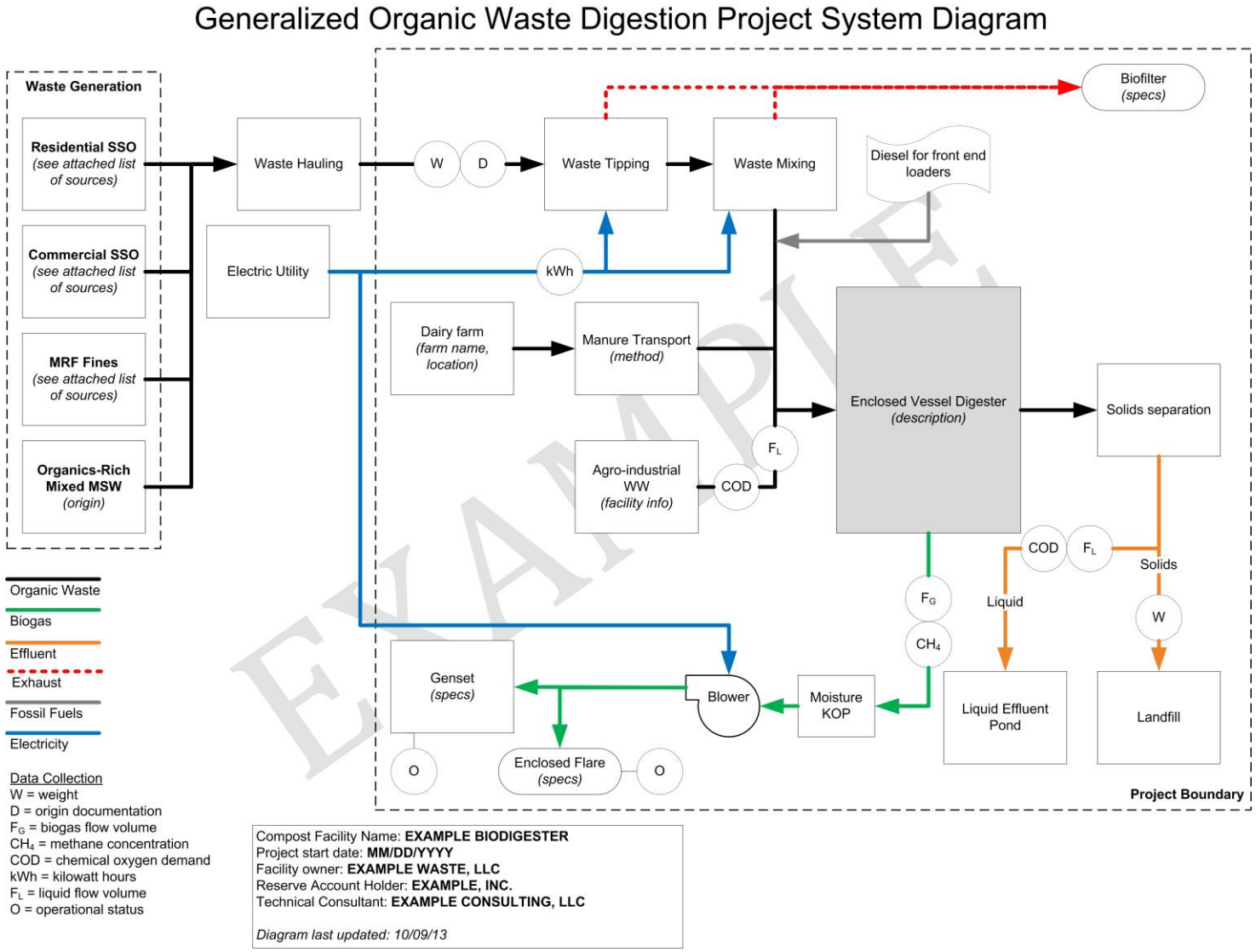
1. Proper functioning can be evidenced by thermocouple readings for flares, energy output for engines, etc.
2. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
3. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology may be applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours immediately before and following the outage
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness
Greater than one week	No data may be substituted and no credits may be generated

Note: It is conservative to use the upper confidence limit when calculating emissions from the BCS (Equation 5.14); however, it is conservative to use the lower confidence limit when calculating the total amount of methane that is destroyed in the BCS (Equation 5.21).

Appendix E Example Project System Diagram



CLIMATE ACTION RESERVE

United States | Version 2.0 | June 27, 2012

Ozone Depleting Substances

Project Protocol

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601 West 5th Street, Suite 650
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Released June 27, 2012

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Table of Contents

Abbreviations and Acronyms 1

1 Introduction 2
2 The GHG Reduction Project 3
2.1 Background 3
2.2 Project Definition 5
2.3 Eligible ODS 5
2.4 The Project Developer 7
3 Eligibility Rules 8
3.1 Location 8
3.2 Project Start Date 8
3.3 Project Crediting Period 8
3.4 Additionality 9
3.5 Regulatory Compliance 10
4 The GHG Assessment Boundary 11
5 Quantifying GHG Emission Reductions 18
5.1 Quantifying Baseline Emissions 18
5.2 Quantifying Project Emissions 25
5.3 Deduction for Vapor Composition Risk 31
6 Project Monitoring and Operation 33
6.1 Reserve ODS Tracking System 33
6.2 Point of Origin Documentation Requirements 34
6.3 Custody and Ownership Documentation Requirements 35
6.4 Building Foam Requirements 35
6.5 Appliance Foam Requirements 37
6.6 Concentrated ODS Composition and Quantity Analysis Requirements 37
6.7 Destruction Facility Requirements 40
6.8 Monitoring Parameters 42
7 Reporting Parameters 47
7.1 Project Documentation 47
7.2 Joint Verification 47
7.3 Record Keeping 48
7.4 Reporting Period and Verification Cycle 48
8 Verification Guidance 49
8.1 Joint Project Verification 49
8.2 Standard of Verification 50
8.3 Monitoring and Operations Plan 50
8.4 Verifying Project Eligibility 50
8.5 Core Verification Activities 51
8.6 Verification Site Visits 52
8.7 ODS Verification Items 53
8.8 Completing Verification 56
9 Glossary of Terms 57
10 References 59

Appendix A Summary of Legal Requirement Test Development 61
Appendix B Summary of Performance Standard Development 64
Appendix C Rules Governing ODS Destruction 69

Appendix D Development of Refrigerant Emissions Rates 75
Appendix E Foam Recovery Efficiency and Calculations....85
Appendix F Default Emission Factors for Calculating ODS Transportation and Destruction Emissions....88
Appendix G Emission Factor Tables....91
Appendix H ODS Project Diagram Sample....92

List of Tables

Table 2.1. Production Phase-Out Schedule of the Montreal Protocol 3
Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs 13
Table 5.1. Global Warming Potential of Eligible ODS....19
Table 5.2. Baseline Emission Rates for ODS Refrigerants....21
Table 5.3. 10-Year Emission Rates of Appliance and Building Foam at End-of-Life....24
Table 5.4. Emissions from Shredding and Landfilling ODS Foam Blowing Agents....25
Table 5.5. Refrigerant Substitute Emission Factors....26
Table 5.6. Eligible Low Pressure and High Pressure ODS 31
Table 5.7. Determining the Deduction for Vapor Composition Risk 31
Table 6.1. Identification of Point of Origin....34
Table 6.2. ODS Project Monitoring Parameters....43
Table 8.1. Summary of Eligibility Criteria....50
Table 8.2. Verification Site Visit Requirements....52
Table 8.3. Project Eligibility Verification Items 53
Table 8.4. Operational Requirement and ODS Eligibility Verification Items 54
Table 8.5. Quantification Verification Items 55
Table 8.6. Risk Assessment Verification Items....56
Table B.1. Destruction of ODS in the U.S....65
Table B.2. ODS Destroyed from Ineligible Imported Sources....65
Table B.3. Recoverable ODS from End-of-Life Refrigeration Equipment and Foam Appliances in the U.S., 2003-2004....66
Table B.4. Destruction of Recoverable, U.S. Sourced End-of-Life ODS 66
Table D.1. Weighted Average Annual Loss Rate Percent and Market Share for Class I ODS...79
Table D.2. Characterization of Categories from the EPA Vintaging Model 80
Table D.3. Calculation of Substitute Emissions for CFC-11....82
Table D.4. Calculation of Substitute Emissions for CFC-12....82
Table D.5. Calculation of Substitute Emissions for CFC-13....83
Table D.6. Calculation of Substitute Emissions for CFC-113....83
Table D.7. Calculation of Substitute Emissions for CFC-114....83
Table D.8. Calculation of Substitute Emissions for CFC-115....84
Table F.1. Project Emissions (Excluding Substitutes)....89
Table G.1. CO_2 Emission Factors for Fossil Fuel Use 91

List of Figures

Figure 4.1. Illustration of the GHG Assessment Boundary for Refrigerant Projects 11
Figure 4.2. Illustration of the GHG Assessment Boundary for Appliance Foam Projects 12
Figure 4.3. Illustration of the GHG Assessment Boundary for Building Foam Projects 12
Figure D.1. Illustration of Refrigerant Project Baseline Scenario and Project Scenario....76

List of Equations

Equation 5.1. Total Emission Reductions 18
Equation 5.2. Total Baseline Emissions 18
Equation 5.3. Baseline Emissions from Refrigerant ODS 21
Equation 5.4. Baseline Emissions from ODS Blowing Agent 23
Equation 5.5. Total Project Emissions 25
Equation 5.6. Project Emissions from the Use of Non-ODS Refrigerants 26
Equation 5.7. Calculating Project Emissions from the Release of ODS Blowing Agent during Processing 27
Equation 5.8. Project Emissions from Transportation and Destruction Using the Default Emission Factors 28
Equation 5.9. Project Emissions from the Destruction of ODS 28
Equation 5.10. Fossil Fuel Emissions from the Destruction of ODS 29
Equation 5.11. Electricity Emissions from the Destruction of ODS 29
Equation 5.12. Calculating Project Emissions from ODS Not Destroyed 29
Equation 5.13. Calculating Project Emissions of CO_2 from the Oxidation of ODS 30
Equation 5.14. Calculating Project Emissions from the Transportation of ODS 30
Equation 5.15. Determining Liquid Fill Level in Project Container 32

Abbreviations and Acronyms

A/C	Air conditioning
AHRI	Air-Conditioning, Heating and Refrigeration Institute
CAA	Clean Air Act
CEMS	Continuous emissions monitoring system
CFC	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon dioxide
CPT	Comprehensive Performance Test
CRT	Climate Reserve Tonne
DOT	United States Department of Transportation
DRE	Destruction and removal efficiency
EPA	United States Environmental Protection Agency
GWP	Global warming potential
HBFC	Hydrobromofluorocarbons
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HWC	Hazardous waste combustor
MACT	Maximum available control technology
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
ODS	Ozone depleting substances
PU	Polyurethane
RAL	RAL Quality Assurance Association
RCRA	Resource Conservation and Recovery Act
REFPROP	Reference Fluid Thermodynamic and Transport Properties Database
Reserve	Climate Action Reserve
TEAP	Technology and Economic Assessment Panel
WEEE	Waste Electrical and Electronic Equipment Directive

1 Introduction

The Climate Action Reserve U.S. Ozone Depleting Substances Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the destruction of high global warming potential ozone depleting substances (ODS) sourced from and destroyed within the U.S. that would have otherwise been released to the atmosphere. This project category includes ODS used in foam blowing agent and refrigerant applications. All destroyed ODS must be fully documented, chemically analyzed, and destroyed at a qualifying facility to be eligible for crediting under this protocol. All ODS must originate in the United States; potential project developers wishing to generate credits from the destruction of ODS originating outside of the United States must use the Climate Action Reserve's Article 5 Ozone Depleting Substances Project Protocol.

As the premier carbon offset registry for the North American carbon market, the Climate Action Reserve works to ensure environmental benefit, integrity and transparency in market-based solutions that reduce greenhouse gas emissions. It establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, issues carbon credits generated from such projects and tracks the transaction of credits over time in a transparent, publicly-accessible system. By facilitating and encouraging the creation of GHG emission reduction projects, the Climate Action Reserve program promotes immediate environmental and health benefits to local communities, allows project developers access to additional revenues and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501c(3) nonprofit organization based in Los Angeles, California.

ODS project developers must use this document to quantify, verify and report GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all projects must submit to annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve's Verification Program Manual and Section 8 of this protocol.

This project protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with an ODS destruction project.[1]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

The term "ozone depleting substances" refers to a large group of chemicals known to destroy the stratospheric ozone layer when released into the atmosphere. ODS were historically used in a wide variety of applications including refrigerants, foam blowing agents, solvents, and fire suppressants. In addition to their potency as ozone depleting substances, the ODS addressed by this protocol also exhibit high global warming potentials (GWP). The GWP of these ODS range from several hundred to several thousand times that of carbon dioxide (see Table 5.1).

The adoption of the Montreal Protocol on Substances that Deplete the Ozone Layer[2] in 1987 laid out a global framework for the phase-out of the production of certain known ODS. The Montreal Protocol differentiated two separate phase-out schedules: one for the developing Article 5 countries[3] and a more rapid phase-out for the developed Non-Article 5 countries[4], including the United States. The current phase-out schedule for Class I and Class II ODS for the United States, as dictated by the Montreal Protocol, is presented below in Table 2.1. The United States incorporated this phase-out schedule in domestic regulations and also applied a "worst first" approach to HCFC (i.e. prioritizing production phase-outs according to the destructive potential of HCFC in the ozone layer). The U.S. schedule is also presented below in Table 2.1.

Table 2.1. Production Phase-Out Schedule of the Montreal Protocol[5,6]

Ozone Depleting Substance	Non-Article 5 Countries	U.S.
CFC (chlorofluorocarbons)	January 1, 1996	January 1, 1996
Halons	January 1, 1994	January 1, 1994
Carbon tetrachloride	January 1, 1996	January 1, 1996
Methyl chloroform	January 1, 1996	January 1, 1996
Methyl bromide	January 1, 2005	January 1, 2005
HBFC (Hydrobromofluorocarbons)	January 1, 1996	January 1, 1996
HCFC (hydrochlorofluorocarbons)	January 1, 1996: Freeze at baseline	January 1, 1996: Freeze at baseline
	January 1, 2004: cut by 35%	January 1, 2003: No production and no importing of HCFC-141b
	January 1, 2010: cut by 75%	January 1, 2010: No production and no importing of HCFC-142b and HCFC-22, except for use in equipment manufactured before 1/1/2010

[2] http://ozone.unep.org/Ratification_status/montreal_protocol.shtml, and subsequent revisions and amendments.
[3] See http://ozone.unep.org/Ratification_status/list_of_article_5_parties.shtml for a list of countries operating under Article 5.
[4] See http://ozone.unep.org/Ratification_status/ for a list of all countries that have ratified the Montreal Protocol.
[5] U.S. EPA, Phase-out of Class I Ozone Depleting Substances, available at: http://www.epa.gov/ozone/title6/phaseout/classone.html.
[6] U.S. EPA, Phase-out of Class II Ozone Depleting Substances, available at: http://www.epa.gov/ozone/title6/phaseout/classtwo.html.

Ozone Depleting Substance	Non-Article 5 Countries	U.S.
	January 1, 2015: cut by 90%	January 1, 2015: No production and no importing of any HCFC, except for use as refrigerants in equipment manufactured before 1/1/2020
	January 1, 2020: cut by 99.5% (can only be used for refrigerator/AC servicing after this date)	January 1, 2020: No production and no importing of HCFC-142b and HCFC-22
	January 1, 2030: full phase-out	January 1, 2030: No production and no importing of any HCFC

The Montreal Protocol and the U.S. Clean Air Act[7] (CAA) control the production of ODS in the United States. However, neither framework requires the destruction of extant stocks of ODS. Rather, these stocks may leak to the atmosphere or may be recovered, recycled, reclaimed, and reused indefinitely, often in equipment with very high leak rates. Because the Montreal Protocol and Title VI of the CAA do not forbid the use of existing or recycled controlled substances beyond the phase-out dates, even properly managed ODS banks will eventually be released as fugitive emissions to the atmosphere.

Refrigerants

Prior to the 1996 production phase-out in the United States, equipment utilizing ODS refrigerants was preferred in a wide variety of applications. These applications include industrial and commercial refrigeration, cold storage, comfort cooling equipment (i.e. air conditioning), and various consumer applications. While the production of ODS refrigerants has been phased out (with the exception of certain HCFC), these substances are continually recovered, reclaimed and recycled to service old equipment. As such, use of these ODS is still widespread, and can be found everywhere from vehicle air conditioners to industrial chillers.

Despite regulations prohibiting their intentional release through servicing, use, and end of life, refrigerant ODS may be inadvertently released to the atmosphere at rates of up to 35 percent per year.[8]

Foams

The ODS CFC-11, CFC-12, HCFC-141b, and HCFC-22 were used as blowing agents in the production of foam prior to their mandated production phase-out in the United States. Many of the applications for which this foam was used, such as refrigeration or A/C units and building insulation, have extended lifetimes and these foams containing ODS will therefore be present in the waste stream for many years to come. When foam is disposed of, ODS blowing agent is released from the foam during shredding[9] and/or degradation in the landfill.[10]

[7] CAA, Title VI, Section 604(a).
[8] IPCC/TEAP. (2005). Special report: Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons.
[9] Scheutz et al. (2007). Release of fluorocarbons from insulation foam in home appliances during shredding. *Journal of the Air & Waste Management Association.*
[10] Scheutz et al. (2007). Attenuation of fluorocarbons released from foam insulation in landfills. *Environmental Science & Technology*, *41*: 7714-7722.

2.2 Project Definition

For the purposes of this protocol, a project is defined as any set of activities undertaken by a single project developer resulting in the destruction[11] of eligible ODS at a single qualifying destruction facility within a 12-month period. Destruction may take place under one or more Certificates of Destruction. Each Certificate of Destruction must document the ODS destroyed. The ODS destroyed may come from a single origin (e.g. one supermarket) or from numerous sources. However, the entire quantity of eligible ODS destroyed must be documented on one or more Certificates of Destruction issued by a qualifying destruction facility.

Although project developers may engage in ongoing recovery, aggregation and destruction activities, destruction events that fall outside of the 12-month window designated for a project may only be counted as part of a separately registered project. Project developers may choose a shorter time horizon for a single project (e.g. 3 months or 6 months), but no project may run longer than 12 months.

In order for multiple Certificates of Destruction to be included under a single project, all of the following conditions must be met:

- The project developer and owner of emission reductions are the same for all ODS destroyed
- The qualifying destruction facility is the same for all Certificates of Destruction
- Project activities span a timeframe of no more than 12 months from the project's start date to completion of the last ODS destruction event
- No Certificate of Destruction is included as part of another project

For all projects, the end fate of the ODS must be destruction at either an approved Hazardous Waste Combustor (HWC) subject to the Resource Conservation and Recovery Act (RCRA), CAA, and the National Emissions Standards for Hazardous Air Pollutants (NESHAP) standards, or any other transformation or destruction facility that meets or exceeds the Montreal Protocol's Technology and Economic Assessment Panel (TEAP) standards provided in the *Report of the Task Force on Destruction Technologies*.[12] Non-RCRA permitted facilities cannot receive and destroy ODS materials that are classified as hazardous waste and must demonstrate compliance with the Title VI requirements of the CAA for destruction of ODS, as well as demonstrate destruction and removal efficiency (DRE) of 99.99 percent and emission levels consistent with the guidelines set forth in the aforementioned TEAP report (see Appendix C).

2.3 Eligible ODS

This protocol provides requirements and guidance for the accounting of GHG reductions from two general sources of ODS eligible under the project definition:

- **Refrigerants:** A project may recover or aggregate eligible ODS refrigerant (see Section 2.3.1) from industrial, commercial or residential equipment, systems, and appliances or stockpiles, and destroy it at a qualifying destruction facility.

[11] In this protocol, the term "destruction" is used to describe any activity that results in the elimination of ODS with an efficiency of 99.99 percent or higher. This definition incorporates both destruction and transformation technologies as defined by the EPA and the Clean Air Act (40 CFC 82).
[12] TEAP. (2002). Report of the Task Force on Destruction Technologies. *Volume 3B*.

- **Foams:** A project may extract eligible ODS blowing agent (see Section 2.3.2) from appliance foams and destroy the concentrated ODS foam blowing agent at a qualifying destruction facility; or, a project may destroy intact foam sourced from building insulation at a qualified destruction facility.

A single project may incorporate ODS obtained from one or both of these ODS source categories. Tracking procedures and calculation methodologies differ depending on the source of ODS. ODS sources not in one of the above categories, such as ODS that were used as or produced for use as solvents, medical aerosols or other applications are not eligible under this protocol.

2.3.1 Refrigerant Sources

This source category consists of ODS material produced prior to the U.S. production phase-out that could legally be sold into the U.S. refrigerant market.[13] The ODS must originate from domestic U.S. supplies; imported refrigerant is not eligible under this protocol. Project developers seeking to register projects involving the domestic destruction of imported refrigerant must use the Reserve's Article 5 Ozone Depleting Substances Project Protocol.

In the absence of a GHG reduction project, this material may be illegally vented or recovered for re-sale into the refrigerant recharge market. As described in Section 5, for GHG reduction calculation purposes, this protocol conservatively assumes that the refrigerant would be reclaimed.

Only destruction of the following ODS refrigerants is eligible for crediting under this protocol:

- CFC-11
- CFC-12
- CFC-13
- CFC-113
- CFC-114
- CFC-115

ODS extracted from a foam source for use in refrigeration equipment is not considered part of this source category, and must instead be considered as a foam source.

ODS sourced from the federal government is eligible if it meets the point of origin requirements detailed in Section 6.2.

Additionally, all refrigerant recovery, handling, and destruction must be performed in accordance with the reporting and operation requirements of Section 6.

2.3.2 Foam Sources

This source category consists of ODS blowing agent entrained in foams that, absent a GHG reduction project, would have been released at end-of-life. The ODS blowing agent must originate from U.S. foam sources; imported foams are not eligible under this protocol.

[13] Any ODS produced in association with a critical use or as by-product is ineligible.

Only the following ODS foam blowing agents are eligible to generate reductions under this protocol:

- CFC-11
- CFC-12
- HCFC-22
- HCFC-141b

To be eligible for crediting, the ODS blowing agent must be destroyed in one of two ways:

1. **ODS blowing agent extracted from appliance foam and destroyed.** The ODS blowing agent must be extracted from the foam to a concentrated form prior to destruction. This must be done under negative pressure to ensure that fugitive release of ODS cannot occur. The recovered ODS blowing agent must be aggregated, stored, and transported in cylinders or other hermetically sealed containers.

2. **Intact foam containing ODS blowing agent from buildings destroyed intact.** When the intact foam is separated from building panels, it must be stored, transported, and destroyed in sealed containers.

All blowing agent and foam collection, handling, extraction, and destruction must be performed in accordance with the reporting and operation requirements of Section 6.

2.4 The Project Developer

The "project developer" may be any entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be ODS aggregators, facility owners, facility operators, or GHG project financiers. The project developer must have clear ownership of the project's GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership each time the project is verified by signing the Reserve's Attestation of Title form.[14]

Neither the federal government nor a federal government agency is eligible to be a project developer under this protocol, but material sourced from the federal government may be eligible if it meets all protocol requirements (see Section 6.2).

[14] Attestation of Title form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/. Verification activities not related to confirming the Attestation of Title (such as site visits or project material eligibility confirmation) may commence prior to this form being uploaded to the Reserve.

3 Eligibility Rules

Projects that meet the definition of a GHG reduction project in Section 2.2 must fully satisfy the following eligibility rules in order to register with the Reserve.

Eligibility Rule I:	Location	→	*U.S. and its territories*
Eligibility Rule II:	Project Start Date	→	*No more than six months prior to project submission*
Eligibility Rule III:	Additionality	→	*Exceed legal requirements*
		→	*Meet performance standard*
Eligibility Rule IV:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

For ODS destruction to be eligible as a project under this protocol, all ODS must be sourced from stocks in the United States or its territories and destroyed within the United States or its territories. Project developers seeking to register projects involving the domestic destruction of imported ODS must use the Reserve's Article 5 Ozone Depleting Substances Project Protocol.

3.2 Project Start Date

The project start date is defined according to the commencement of project activities.

- For concentrated (non-mixed) ODS projects[15] that are not aggregated at the destruction facility, the project start date is the day that the project ODS departs the final storage or aggregation facility for transportation to the destruction facility.
- For concentrated (non-mixed) ODS projects where eligible material is aggregated at the destruction facility, the project start date is the day when destruction commences, as documented by a Certificate of Destruction.
- For mixed ODS projects, the project start date is the day that mixing procedures begin.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date.[16] Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Project Crediting Period

An ODS project includes a discrete series of destruction events over a 12-month period, beginning on the project start date. No destruction events may occur more than 12 months after the project start date. For the purposes of this protocol, it is assumed that, absent the project, the avoided ODS emissions would have occurred over a longer time horizon.

Under this protocol, the project crediting period is the period of time over which avoided emissions are quantified for the purpose of determining creditable GHG reductions. Specifically,

[15] As defined in Section 6.6.

[16] Projects are considered submitted when the project developer has fully completed and filed the required documents, available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

ODS projects will be issued CRTs for the quantity of ODS that would have been released over a ten-year period following a destruction event. At the time the project is verified, CRTs are issued for all ODS emissions avoided by a project over the 10-year crediting period.

3.4 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have otherwise occurred in the absence of a GHG market.

Projects must satisfy both of the following tests to be considered additional:

1. The Legal Requirement Test
2. The Performance Standard Test

3.4.1 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to international, federal, state or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the destruction of ODS. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[17] each time the project is verified (see Section 8).[18] In addition, the project's Monitoring and Operations Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

3.4.2 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all ODS destruction projects, established on an *ex ante* basis by this protocol.[19]

For this protocol, the Reserve uses a Performance Standard Test based on an evaluation of U.S. "common practice" for privately managed ODS. Because the Reserve has determined that destruction of ODS is not common practice in the United States (see Appendix B), all ODS destruction activities that meet the project definitions and other eligibility requirements pass the Performance Standard Test.

The Reserve will periodically re-evaluate the appropriateness of the Performance Standard Test, and if necessary, amend this protocol accordingly. Projects that meet the Performance Standard Test and other requirements of the version of this protocol in effect at the time of their submission are eligible to generate CRTs.

[17] Attestation of Voluntary Implementation form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.
[18] Verification activities not related to confirming the Attestation of Voluntary Implementation (such as site visits or project material eligibility confirmation) may commence prior to this form being uploaded to the Reserve.
[19] A summary of the study to establish the Performance Standard Test is provided in Appendix B.

3.5 Regulatory Compliance

Projects must be in material compliance with all applicable laws (e.g. air, water quality, and safety) at all times during each reporting period, as defined in Section 5. The regulatory compliance requirement extends to the operation of destruction facilities where the ODS is destroyed, as well as the facilities where mixed ODS projects are mixed and sampled, and the transportation of the ODS to the destruction facility. These facilities and transportation events must meet applicable regulatory requirements during implementation of project activities. For example, any upsets or exceedances of permitted emission limits at a destruction facility must be managed in keeping with an authorized startup, shutdown, and malfunction plan.[20]

Project developers must attest that the project has met this requirement by signing the Reserve's Attestation of Regulatory Compliance[21] for each reporting period.[22] Projects are not eligible to receive CRTs for GHG reductions that occur as the result of project activities that are not in material compliance with regulatory requirements. Non-compliance solely due to administrative or reporting issues, or due to "acts of nature," will not affect CRT crediting.

Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a project is in a state of material non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance.

[20] 40 CFR 63.1206.
[21] Attestation of Regulatory Compliance form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.
[22] Verification activities not related to confirming the Attestation of Regulatory Compliance (such as site visits or project material eligibility confirmation) may commence prior to this form being uploaded to the Reserve.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers in order to determine the total net change in GHG emissions caused by an ODS project.[23]

Figure 4.1, Figure 4.2, and Figure 4.3 below provide a general illustration of the GHG Assessment Boundaries for different types of ODS destructions projects, indicating which SSRs are included or excluded from the boundary.

Table 4.1 gives greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary.

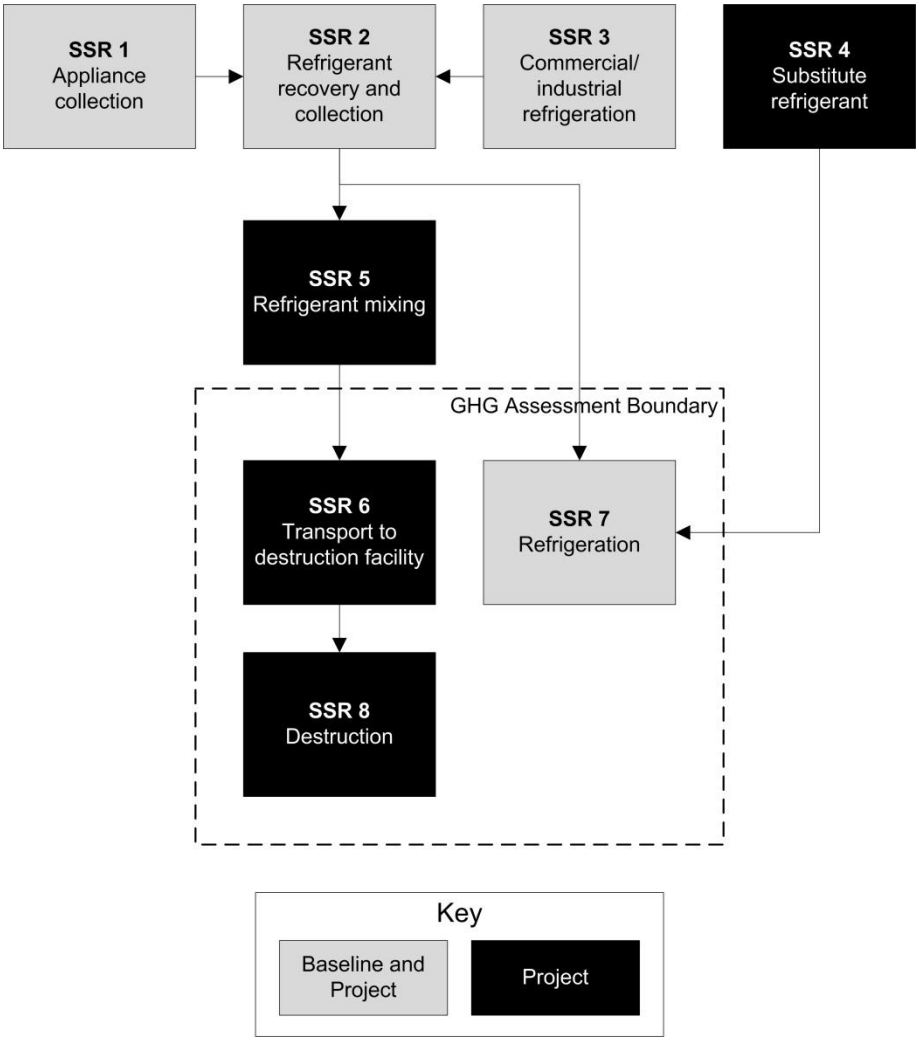

Figure 4.1. Illustration of the GHG Assessment Boundary for Refrigerant Projects

[23] The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.

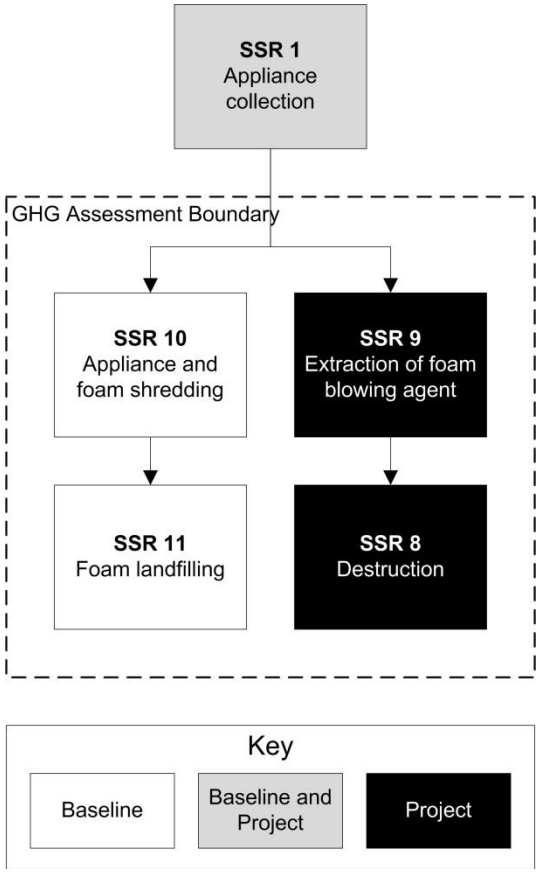

Figure 4.2. Illustration of the GHG Assessment Boundary for Appliance Foam Projects

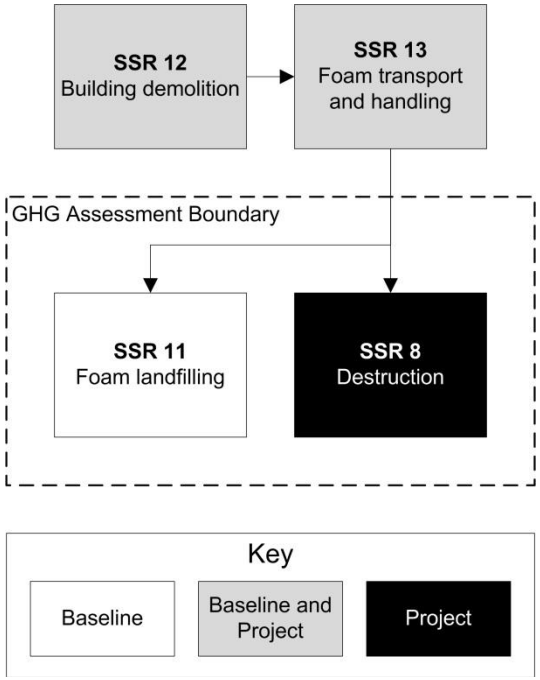

Figure 4.3. Illustration of the GHG Assessment Boundary for Building Foam Projects

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
1	Appliance collection	Fossil fuel emissions from the collection and transport of end-of-life residential appliances	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
2	Refrigerant recovery and collection	Emissions of ODS from the recovery and aggregation of refrigerant at end-of-life or servicing	ODS	E	N/A	Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative
		Fossil fuel emissions from the recovery and aggregation of refrigerant at end-of-life or servicing	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
3	Commercial/ Industrial refrigeration	Emissions of ODS from equipment leak and servicing	ODS	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
		Fossil fuel emissions from the operation of refrigeration and A/C equipment	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
4	Substitute refrigerant production	▪ Emissions of substitute refrigerant occurring during production ▪ Fossil fuel emissions from the production of substitute refrigerants	CO_2e	E	N/A	Excluded, as this emission source is assumed to be very small
			CO_2	E	N/A	Excluded, as this emission source is assumed to be very small
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small
5	Refrigerant mixing	Fossil fuel emissions from ODS mixing activities at mixing facility	CO_2	E	N/A	Excluded, as these emission sources are assumed to be very small
			CH_4			
			N_2O			
6	Transport to destruction facility	Fossil fuel emissions from the vehicular transport of ODS from aggregation point to final destruction facility	CO_2	I	**Baseline:** N/A **Project:** Estimated based on distance and weight transported	Project emissions will be small, and can be calculated using the default factor provided
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small
7	Refrigeration	Emissions of ODS from leaks and servicing through continued operation of equipment	ODS	I	**Baseline:** Estimated based on market-weighted emission rates **Project:** N/A	Baseline equipment emissions will be significant for refrigerant sources, but are not applicable for foam sources
		Emissions of substitute from leaks and servicing through continued operation of equipment	CO_2e	I	**Baseline:** N/A **Project:** Estimated based on market-weighted emissions	Project equipment emissions will be significant for refrigerant sources, but are not applicable for foam sources

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		Indirect emissions from grid-delivered electricity	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
8	Destruction	Emissions of ODS from incomplete destruction at destruction facility	ODS	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
		Emissions from the oxidation of carbon contained in destroyed ODS	CO_2	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
		Fossil fuel emissions from the destruction of ODS at destruction facility	CO_2	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		Indirect emissions from the use of grid-delivered electricity	CO_2	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small
9	Extraction of ODS blowing agent from appliance foam	Emissions of ODS released during the separation of foam from appliance	ODS	I	**Baseline:** N/A **Project:** Estimated based on recovery efficiency	Project emissions may be significant. Site specific recovery efficiency shall be used
10	Appliance and foam shredding	Emissions of ODS from the shredding of appliances for materials recovery, releasing ODS from foam	ODS	I	**Baseline:** Estimated based on total quantity of ODS destroyed and default shredding factors **Project:** N/A	Baseline shredding emissions will be significant for foam sources, but are non-applicable for refrigerant sources
11	Foam landfilling	Emissions of ODS released from foam disposed of in landfills	ODS	I	**Baseline:** Estimated based on release and degradation of ODS in landfill **Project:** N/A	Baseline emissions will be significant for foam sources, but are not applicable for refrigerant sources
		Emissions of ODS degradation products from foam disposed of in landfills	HFC, HCFC	E	N/A	Excluded, as this baseline emission source is assumed to be very small. This exclusion is conservative
		Fossil fuel emissions from the transport and placement of	CO_2	E	N/A	Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		shredded foam waste in landfill	CH_4	E	N/A	Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative
			N_2O	E	N/A	Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative
12	Building demolition	Emissions of ODS from the demolition of buildings and damage to foam insulation panels	ODS	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
		Fossil fuel emissions from the demolition of buildings	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
13	Foam transport and handling	Emissions of ODS released from foam during transport and handling	ODS	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
		Fossil fuel emissions from the transport and handling of building foam	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity

5 Quantifying GHG Emission Reductions

GHG emission reductions from an ODS project are quantified by comparing actual project emissions to calculated baseline emissions. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the ODS destruction project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

A project may not span more than 12 months, and GHG emission reductions must be quantified and verified at least once for the entire project time length. The length of time over which GHG emission reductions are quantified and verified is called a "reporting period." Project developers may choose to have multiple reporting periods within a project or a project time length shorter than 12 months, if desired. The quantification methods presented below are specified for a single reporting period, which may be less than or equal to the entire project time length.

Equation 5.1. Total Emission Reductions

$$ER_t = BE_t - PE_t$$

Where,

			Units
ER_t	=	Total quantity of emission reductions during the reporting period	tCO_2e
BE_t	=	Total quantity of baseline emissions during the reporting period	tCO_2e
PE_t	=	Total quantity of project emissions during the reporting period	tCO_2e

5.1 Quantifying Baseline Emissions

Total baseline emissions must be estimated by calculating and summing the calculated baseline emissions for all relevant SSRs (as indicated in Table 4.1) using Equation 5.2 and the supporting equations presented below. This includes emissions from continued use of ODS in the secondary recharge market for refrigerants, and the emissions from end-of-life disposal for foams. Note that emissions shall be quantified in pounds throughout this section and converted into metric tons in Equation 5.2 below.

Equation 5.2. Total Baseline Emissions

$$BE_t = \frac{BE_{refr} + BE_{foam}}{2204.623}$$

Where,

			Units
BE	=	Total quantity of baseline emissions	tCO_2e
BE_{refr}	=	Total quantity of baseline emissions from refrigerant ODS	lb CO_2e
BE_{foam}	=	Total quantity of baseline emissions from ODS blowing agent	lb CO_2e
2204.623	=	Conversion from pounds to metric tons	lbs/t

Baseline emissions for an ODS destruction project include the total calculated baseline emissions from each eligible source category – ODS refrigerant and ODS blowing agent. If a

project does not destroy any ODS from a particular source category, baseline emissions for that source category are assumed to be zero.

Table 5.1 provides the applicable GWP to be used for calculating baseline emissions in units of CO_2-equivalent tonnes.

Table 5.1. Global Warming Potential of Eligible ODS

ODS Species	100-year Global Warming Potential (CO_2e)[24]
CFC-11	4,750
CFC-12	10,900
CFC-13	14,400
CFC-113	6,130
CFC-114	10,000
CFC-115	7,370
HCFC-22	1,810
HCFC-141b	725

If, during verification, the verification body cannot confirm that a portion of the ODS that was sent for destruction was eligible, this portion of the material shall be considered ineligible. This ineligible ODS shall be excluded from baseline emission calculations. The quantity of ineligible ODS sent for destruction shall be subtracted from $Q_{refr,i}$, $BA_{app,i}$ or $BA_{build,i}$ prior to the calculation of Equation 5.3 or Equation 5.4 in order to calculate baseline emissions only for ODS that was confirmed to be eligible by the verification body. This quantity shall be determined by one of the following methods:

Option A: Confirmed weight and composition

If the project developer can produce data that, based on the verifier's professional judgment, confirm the weight and composition for the specific ODS that is deemed to be ineligible (or whose eligibility cannot be confirmed), these data shall be used to adjust the value of $Q_{refr,i}$, $BA_{app,i}$ or $BA_{build,i}$ accordingly.

Option B: Default values

If sufficient data are not available to satisfy the Option A requirements, then the most conservative estimate of the weight and composition of the ineligible container of ODS shall be used. Specifically, the composition of the ineligible container of ODS shall be assumed to be 100 percent of the ODS species with the highest GWP based on the composition analysis, and the relevant container that was deemed ineligible shall be assumed to have been full. If the project developer has only some of the data required for Option A (i.e. weight or composition, but not both), this may be used in place of the conservative assumptions above, as long as the data can be confirmed by the verification body. The resulting estimate of the weight of ineligible ODS shall be subtracted from the total weight of that ODS species destroyed in the project, not to exceed the actual amount of that ODS species destroyed. See Box 5.1 for an example of Option B.

[24]IPCC, Errata: Climate Change 2007, The Physical Science Basis, The Working Group I contribution to the IPCC Fourth Assessment Report, available at http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf.

Box 5.1. Applying Option B to Adjust for Ineligible ODS After Destruction

This option shall be applied when multiple containers of ODS are combined into a single container for destruction, but the eligibility of the ODS in one or more of the original containers cannot be verified.

Example:

A refrigerant aggregator receives shipments of three different containers (A, B, and C), which are combined into one project container (Z) for destruction. During verification, the project developer is unable to produce documentation to verify the eligibility of container C.

Original Containers from Point of Origin	Maximum Container Volume	Composition
A	1000 L	unknown
B	500 L	unknown
C	500 L	unknown
Project container	**Weight**	**Composition**
Z	5000 lbs	50% CFC-11 50% CFC-12

Based on Option B above, the project developer must assume that the composition of container C was 100 percent CFC-12 and that the container was completely full. Using the temperature recorded on the composition analysis (62°F for this example), the maximum amount of ODS would be equal to the volume of the container (500 L) multiplied by the density of CFC-12 at 62°F (2.9553 lb/L), or 1,478 lbs. This amount is subtracted from the total amount of eligible ODS prior to quantification of emission reductions.

Resulting eligible ODS:

CFC-11: 2500 lbs
CFC-12: 2500 – 1478 = 1022 lbs

5.1.1 Calculating Baseline Emissions from Refrigerant Recovery and Resale

There are several emissions pathways for refrigerant ODS in the United States. At end-of-life and servicing, a significant portion of ODS may be lost through fugitive releases and low recovery efficiencies. However, a portion of the ODS refrigerant in the U.S. is recovered for resale in the secondary market for recharge of existing equipment. Whereas fugitive release and low recovery results in immediate release of the ODS to the atmosphere, recovery and reuse results in a more gradual release of ODS. To ensure that actual GHG reductions from ODS destruction are not overestimated, this protocol requires estimating baseline emissions according to the assumption that refrigerant ODS would be entirely recovered and resold (i.e. there would have been zero emissions from fugitive releases and low recovery).

Because of this simplified and conservative baseline assumption, there is no need to determine why refrigerants were removed from equipment, why equipment may have been decommissioned, or why a stockpile was not utilized. Instead, Equation 5.3 shall be used to estimate the baseline emissions that would have occurred over ten years had the destroyed ODS been used in existing refrigeration or air conditioning equipment. This equation requires

the use of the ODS-specific GWP provided in Table 5.1, and emission rate (inclusive of both leak rate and servicing emissions) provided in Table 5.2.[25]

Equation 5.3. Baseline Emissions from Refrigerant ODS

$$BE_{refr} = \left[\sum_i \left(Q_{refr,i} \times ER_{refr,i} \times GWP_i \right)_i \right] \times (1 - VR)$$

Where,

			Units
BE_{refr}	=	Total quantity of refrigerant baseline emissions during the reporting period	lb CO_2e
$Q_{refr,i}$	=	Total quantity of eligible, pure refrigerant ODS *i* sent for destruction by the project	lb ODS
$ER_{refr,i}$	=	10-year cumulative emission rate of refrigerant ODS *i* (see Table 5.2)	%
GWP_i	=	Global warming potential of ODS *i* (see Table 5.1)	lb CO_2e/ lb ODS
VR	=	Deduction for vapor composition risk (see Section 5.3)	%

Table 5.2. Baseline Emission Rates for ODS Refrigerants

ODS Species	Annual Weighted Average Emission Rate (%/yr)[26]	10-year Cumulative Emission Rate (%/10 years)[27] (ER_{refr})
CFC-11	20%	89%
CFC-12	26%	95%
CFC-13	9%	61%
CFC-113	20%	89%
CFC-114	14%	78%
CFC-115	9%	61%

5.1.2 Calculating Baseline Emissions from Shredding and/or Landfilling ODS Foam Blowing Agents

Depending on the origin of the foam, there are two different predominant baseline practices applicable to foams containing ODS blowing agent. The two baseline practices identified by the Reserve are as follows:

Origin	Baseline Practice
Insulation foam recovered from appliances	The foam is shredded, and subsequently landfilled
Foam recovered from building demolition	The foam is landfilled

[25] See Appendix D for a summary of how these emissions rates were determined.
[26] EPA. (2011). EPA Vintaging Model. *Version VM IO file_v4.4_3.23.11*. CFC-12 estimates include data from private parties on mobile sources.
[27] 10-year cumulative emissions = 1-(1-leak rate)^{10}, or the percent of a given substance which will be released over ten years at a constant leak rate.

Equation 5.4 shall be used to calculate the ODS emissions that would have resulted from the assumed baseline practice applied to foams in the absence of the project. Baseline emissions include the total emissions that would have occurred as a result of foam shredding and landfilling.[28] In order to calculate total baseline emissions, projects destroying blowing agent extracted from appliance foam must calculate a project-specific recovery efficiency for use in Equation 5.4. Guidance on developing the recovery efficiency can be found in Appendix E.

[28] Temperatures achieved by landfill gas flares and engines are not high enough to achieve significant ODS destruction.

Equation 5.4. Baseline Emissions from ODS Blowing Agent

$$BE_{foam} = \sum_{i,j}\left[\left(BA_{app,i} + BA_{build,i}\right) \times ER_{i,j} \times GWP_i\right]$$

Where,

			Units
BE_{foam}	=	Total quantity of ODS blowing agent baseline emissions	lb CO_2e
$BA_{app,i,}$	=	Total quantity of eligible ODS blowing agent *i* from appliance foam prior to treatment or processing, including blowing agent lost during processing	lb ODS
$BA_{build,i}$	=	Total quantity of eligible ODS blowing agent *i* from building foam sent for destruction	lb ODS
$ER_{i,j}$	=	Lifetime emission rate of ODS blowing agent *i* from application *j* at end-of-life (see Table 5.3)	%
GWP_i	=	Global warming potential of ODS *i* (see Table 5.1)	lb CO_2e/ lb ODS

$$BA_{app,i} = Q_{recover} + Q_{recover}\left(\frac{1-RE}{RE}\right)$$

Where,

			Units
$BA_{app,i}$	=	Total quantity of ODS foam blowing agent in foam prior to treatment or processing, including ODS foam blowing agent lost during processing	lb ODS
$Q_{recover}$	=	Total quantity of eligible ODS foam blowing agent recovered during processing and sent for destruction, as determined according to Section 6.6	lb ODS
RE	=	Recovery efficiency of the ODS foam blowing agent recovery process[29] (see Appendix E for calculation of RE)	%

$$BA_{build} = Q_{foam} \times BA\%$$

Where,

			Units
BA_{build}	=	Total quantity of ODS blowing agent *i* from building foam sent for destruction	lb ODS
Q_{foam}	=	Total weight of eligible foam with entrained ODS blowing agent sent for destruction	lbs
BA%	=	Mass ratio of ODS blowing agent entrained in building foam, as determined according to Section 6.4	% (0-1)

[29] RE is similar to the RDE defined in TEAP (2005) Report of the Task Force on Foam End-of-Life Issues, Table 6.1. RE, however, does not extend to the ODS destruction efficiency, which is handled separately under this protocol.

The total percent of ODS foam blowing agent that would be released throughout the end-of-life processing (i.e. 10-year emission rates) for each ODS foam blowing agent and foam origin is presented in Table 5.3. These values include emissions from:

1. ODS blowing agent released during foam shredding,[30] plus
2. ODS blowing agent released during foam compaction, plus
3. Landfilled ODS blowing agent that is released during anaerobic conditions (but is not degraded).

The Reserve recognizes that there is considerable uncertainty regarding the extent of anaerobic degradation of ODS foam blowing agents in U.S. landfills. According to TEAP (2005), the "extent to which [anaerobic degradation] needs to be stimulated in the landfill environment is still under review, but there is a possibility of some degradation occurring under non-optimized conditions."[31] Accordingly, the Reserve has incorporated a factor for anaerobic degradation to be conservative. The factors are drawn from Scheutz et al. (2007)[32] laboratory tests using degradation rates approximating those measured by the researchers in un-inoculated soil from a U.S. landfill. Because Scheutz et al. examined degradation rates under ideal conditions, however, the degradation rates used in this protocol are the lowest of the results reported. The degradation rates selected reflect the parameters derived from actual landfill conditions in the U.S., and more realistically estimate degradation in U.S. landfills; the higher values presented in Scheutz et al. reflect results based on parameters where degradation has been optimized through inoculation of the samples. While lower, the results used in this protocol are a conservative estimate based on laboratory analysis in a controlled environment.

Table 5.3. 10-Year Emission Rates of Appliance and Building Foam at End-of-Life

ODS Blowing Agent	Appliance ODS Blowing Agent 10-Year Emission Rate ($ER_{i,j}$)	Building ODS Blowing Agent 10-Year Emission Rate ($ER_{i,j}$)
CFC-11	44%	20%
CFC-12	55%	36%
HCFC-22	75%	65%
HCFC-141b	50%	29%

The values provided in Table 5.3 have been calculated based on the values in Table 5.4. These values are re-produced here for reference, but are not used directly in any of the calculations within this section.

[30] Note that the emissions from foam shredding have only been factored into the emission rates from appliance ODS blowing agents in Table 5.3, as building foam is not typically shredded before being landfilled.
[31] TEAP. (2005). Report of the Task Force on Foam End-of-Life Issues. *United Nations Environment Programme*, page 39.
[32] Scheutz, C., et al. (2007). Attenuation of insulation foam released fluorocarbons in landfills. *Environmental Science & Technology*, *41*: 7714-7722.

Table 5.4. Emissions from Shredding and Landfilling ODS Foam Blowing Agents

ODS Blowing Agent	Percent of ODS Blowing Agent Released During Shredding[a] (set to zero for demolition debris)	Percent of ODS Blowing Agent Released During Compaction[b]	Percent of Remaining ODS Blowing Agent Released During Anaerobic Conditions[c]	Percent of Released ODS Blowing Agent Not Degraded in Anaerobic Landfill Conditions[c]
CFC-11	24%	19%	35%	5%
CFC-12	24%	19%	52%	40%
HCFC-22	24%	19%	100%	57%
HCFC-141b	24%	19%	41%	29%

[a] Scheutz, C., et al. (2007). Release of fluorocarbons from insulation foam in home appliances during shredding. *Journal of the Air & Waste Management Association*, *57*: 1452-1460.
[b] Fredenslund, A., et al. (2005). Disposal of Refrigerators-Freezers in the U.S. : State of the Practice. *Technical University of Denmark*.
[c] Scheutz, C., et al. (2007). Attenuation of insulation foam released fluorocarbons in landfills. *Environmental Science & Technology*, *41*: 7714-7722.

5.2 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of project activities.

As shown in Equation 5.5, project emissions equal:

- Emissions from non-ODS substitutes (applicable only to refrigerant projects), plus
- Emissions from ODS foam blowing agent extraction (applicable only to appliance foam projects), plus
- Emissions from the transportation of ODS, plus
- Emissions from the destruction of ODS

Note that emissions shall be quantified in pounds throughout this section and converted into metric tons in Equation 5.5 below.

Equation 5.5. Total Project Emissions

$$PE = \frac{Sub_{ref} + BA_{pr} + Tr + Dest}{2204.623}$$

Where,

			Units
PE	=	Total quantity of project emissions during the reporting period	tCO_2e
Sub_{ref}	=	Total emissions from substitute refrigerant	lb CO_2e
BA_{pr}	=	Total quantity of ODS blowing agent from appliance foam released during ODS extraction	lb CO_2e
Tr	=	Total emissions from transportation of ODS (calculated using either the default value in Equation 5.8 or Equation 5.14)	lb CO_2e
Dest	=	Total emissions from the process associated with destruction of ODS (calculated using either the default value in Equation 5.8 or Equation 5.9 through Equation 5.13)	lb CO_2e
2204.623	=	Conversion from pounds to metric tons	lbs/t

5.2.1 Calculating Project Emissions from the Use of Refrigerant Substitutes

When refrigerant ODS are destroyed, continued demand for refrigeration will lead to the production and consumption of other refrigerant chemicals whose production is still legally allowed. Projects that destroy refrigerant ODS must therefore estimate the emissions associated with the non-ODS substitute chemicals that are assumed to be used in their place. Like the estimates of baseline emissions, substitute emissions shall be accounted for based on the projected emissions over a ten year crediting period.

Project emissions from the use of substitute refrigerants shall be calculated for all ODS refrigerant projects according to Equation 5.6 using the emission factors from Table 5.5. The use of site-specific substitute parameters (refrigerant, GWP, and leak rate) is not permitted.

Equation 5.6. Project Emissions from the Use of Non-ODS Refrigerants

$$Sub_{refr} = \sum_i \left(Qref_i \times SE_i \right)$$

Where,

			Units
Sub_{refr}	=	Total quantity of refrigerant substitute emissions	lb CO_2e
$Q_{refr,i}$	=	Total quantity of eligible, pure refrigerant *i* sent for destruction	lbs
SE_i	=	Emission factor for substitute(s) for refrigerant *i*, per Table 5.5	lb CO_2e/ lb ODS destroyed

ODS substitute emissions presented in Table 5.5 are based on the weighted average of expected new refrigerant supplies into the refrigeration market. These substitute refrigerants were modeled using the EPA Vintaging Model and data provided by industry sources. A summary of the ODS substitute emission rates analysis and calculations is provided in Appendix D. The analysis identified substitute emission factors for each ODS refrigerant covered under this protocol (see Appendix D).

Table 5.5. Refrigerant Substitute Emission Factors[33]

ODS Refrigerant	Substitute Emission Factors (lb CO_2e/lb ODS) (SE_i)
CFC-11	202
CFC-12	777
CFC-13	7144
CFC-113	220
CFC-114	659
CFC-115	1689

[33] See Appendix D for a summary of the development of these factors.

5.2.2 Calculating Project Emissions from ODS Blowing Agent Extracted from Appliance Foam

Projects that extract ODS blowing agent from appliance foam must account for the emissions of ODS that occur during processing, separation, and extraction using Equation 5.7. These emissions are calculated in Equation 5.7 based on the quantity of ODS blowing agent sent for destruction ($BA_{app,i}$, as calculated in Equation 5.4), and a project-specific recovery efficiency that represents the percentage of ODS that is *not* lost during these steps. The recovery efficiency must be calculated once per project according to the guidance provided in Appendix E. Although not required under this protocol, well-executed projects should be capable of keeping these emissions to no more than 10 percent of ODS blowing agent contained in the foam, per the recommendations of the TEAP *Report of the Task Force on Foam End-of-Life Issues*.[34]

Equation 5.7. Calculating Project Emissions from the Release of ODS Blowing Agent during Processing

$$BA_{pr} = \sum_i \left(BA_{app,i} \times (1 - RE) \times GWP_i \right)$$

Where,			Units
BA_{pr}	=	Total quantity of ODS blowing agent from appliance foam released during ODS extraction	lb CO_2e
$BA_{app,i}$	=	Total quantity of appliance ODS foam blowing agent in foam prior to treatment or processing, including ODS foam blowing agent lost during processing (see Equation 5.4 to calculate this term)	lb ODS
RE	=	Recovery efficiency of the ODS foam blowing agent recovery process (see Appendix E to calculate RE)	%
GWP_i	=	Global warming potential of ODS *i* (see Table 5.1)	lb CO_2e/ lb ODS

5.2.3 Calculating Default Project Emissions from Transportation and Destruction

Projects must account for emissions that result from the transportation and destruction of ODS. Because these emission sources are both individually and in aggregate very small, the Reserve has developed default emission factors for ODS projects based on conservative assumptions and the SSRs outlined in Table 4.1[35]:

- 7.5 pounds CO_2e per pound ODS for refrigerant or extracted ODS blowing agent projects
- 75 pounds CO_2e per pound ODS for intact building foam projects

These emission factors aggregate both transportation and destruction emissions. Project developers have the option of using the default emission factors or using the guidance in Sections 5.2.4 and 5.2.5 to calculate project-specific emissions. Equation 5.8 shall be used to calculate ODS transportation and destruction emissions if default emission factors are used. If a project developer elects not to use the default emission factors, emissions associated with transportation and destruction of ODS must be calculated separately.

[34] TEAP. (2005). Report of the Task Force on Foam End-of-Life Issues*. United Nations Environment Programme*.
[35] See Appendix F for an explanation of how these default emission factors were derived.

Equation 5.8. Project Emissions from Transportation and Destruction Using the Default Emission Factors

$$Tr + Dest = \sum_i \left(Q_{ODS,i} \times EF_i \right)$$

Where,			Units
Tr+Dest	=	Total emissions from project transportation and destruction, as calculated using default emission factors	lb CO_2e
$Q_{ODS,i}$	=	Total quantity of ODS *i* sent for destruction in the project, including eligible and ineligible material	lb ODS
EF_i	=	Default emission factor for transportation and destruction of ODS *i* (7.5 for refrigerant or extracted ODS blowing agent projects, 75 for intact building foam projects)	lb CO_2e/ lb ODS

5.2.4 Calculating Site-Specific Project Emissions from ODS Destruction

Under this protocol, ODS must be destroyed at destruction facilities that demonstrate compliance with the TEAP recommendations.[36] These facilities are required to demonstrate their ability to achieve destruction efficiencies upwards of 99.99 percent for substances with thermal stability ratings higher than the ODS included under this protocol.[37] Associated with the operation of these facilities are emissions of CO_2 from the fuel and electricity used to power the destruction, as well as emissions of undestroyed ODS. Equation 5.9 through Equation 5.13 provide requirements for calculating emissions from ODS destruction in cases where project developers opt not to use the default factors provided in Section 5.2.3.

Equation 5.9. Project Emissions from the Destruction of ODS

$$Dest = FF_{dest} + EL_{dest} + ODS_{emissions} + ODS_{CO_2}$$

Where,			Units
Dest	=	Total emissions from the destruction of ODS	lb CO_2e
FF_{dest}	=	Total emissions from fossil fuel used in the destruction facility (Equation 5.10)	lb CO_2
EL_{dest}	=	Total indirect emissions from grid electricity used at the destruction facility (Equation 5.11)	lb CO_2
$ODS_{emissions}$	=	Total emissions of undestroyed ODS (Equation 5.12)	lb CO_2e
ODS_{CO2}	=	Total emissions of CO_2 from ODS oxidation (Equation 5.13)	lb CO_2

[36] TEAP: http://uneptie.org/ozonaction/topics/disposal.htm.
[37] ICF International. (2009). ODS Destruction in the United States of America and Abroad. *U.S. EPA*.

Equation 5.10. Fossil Fuel Emissions from the Destruction of ODS

$$FF_{dest} = \frac{\sum_{k}\left(FF_{PR,k} \times EF_{FF,k}\right)}{0.454}$$

Where,

			Units
FF_{dest}	=	Total carbon dioxide emissions from the destruction of fossil fuel used to destroy ODS	lb CO_2
$FF_{PR,k}$	=	Total fossil fuel *k* used to destroy ODS	volume fossil fuel
$EF_{FF,k}$	=	Fuel specific emission factor (see Appendix G)	kg CO_2/ volume fossil fuel
0.454	=	Conversion from kilograms to pounds	kg CO_2/ lb CO_2

Equation 5.11. Electricity Emissions from the Destruction of ODS

$$EL_{dest} = \left(EL_{PR} \times EF_{EL}\right)$$

Where,

			Units
EL_{dest}	=	Total carbon dioxide emissions from the consumption of electricity from the grid used to destroy ODS	lb CO_2
EL_{PR}	=	Total electricity consumed to destroy ODS	MWh
EF_{EL}	=	CO_2 emission factor for electricity used[38]	lb CO_2/ MWh

Equation 5.12. Calculating Project Emissions from ODS Not Destroyed

$$ODS_{emissions} = \sum_{i} Q_{ODS,i} \times 0.0001 \times GWP_i$$

Where,

			Units
$ODS_{emissions}$	=	Total emissions of undestroyed ODS	lb CO_2e
$Q_{ODS,i}$	=	Total quantity of ODS *i* sent for destruction in the project	lb ODS
0.0001	=	Maximum allowable percent of ODS fed to destruction that is not destroyed (0.01 percent)	
GWP_i	=	Global warming potential of ODS *i* (see Table 5.1)	lb CO_2e/ lb ODS

[38] Refer to the version of the EPA eGRID that most closely corresponds to the time period during which the electricity was used. Project shall use the annual total output emission rates for the subregion where the destruction facility is located, not the non-baseload output emission rates. The eGRID tables are available at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

Equation 5.13. Calculating Project Emissions of CO_2 from the Oxidation of ODS

$$ODS_{CO_2} = \sum_i Q_{ODS,i} \times 0.9999 \times CR_i \times \frac{44}{12}$$

Where,			Units
ODS_{CO2}	=	Total emissions of CO_2 from ODS oxidation	lb CO_2
$Q_{ODS,i}$	=	Total quantity of ODS *i* sent for destruction in the project	lb ODS
0.9999	=	Minimum destruction efficiency of destruction facility	% (0-1)
CR_i	=	Carbon ratio of ODS *i* CFC-11: 12/137 CFC-12: 12/121 CFC-13: 12/104 CFC-113: 24/187 CFC-114: 24/171 CFC-115: 24/154 HCFC-22: 12/87 HCFC-141b: 24/117	mole C/ mole ODS
44/12	=	Ratio of CO_2 to C	mole CO_2/ mole C

5.2.5 Calculating Site-Specific Project Emissions from ODS Transportation

As part of any ODS destruction project, ODS will be transported from aggregators to destruction facilities, and emissions from this transportation must be accounted for under this protocol. Equation 5.14 must be used to calculate CO_2 emissions associated with the transport of ODS in cases where project developers choose not to use the default emission factors presented in Section 5.2.3. Emissions shall be calculated for each leg of the transportation process separately, and then summed according to Equation 5.14 below.

Equation 5.14. Calculating Project Emissions from the Transportation of ODS[39]

$$Tr = \sum_i \left(TMT_i \times EF_{TMT}\right)$$

Where,			Units
Tr	=	Total emissions from transportation of ODS	lb CO_2e
PMT_i	=	Pound-miles-traveled[40] for ODS *i* destroyed (to be calculated including the ODS, any accompanying material, and containers from point of aggregation to destruction)	pound-miles
EF_{PMT}	=	CO_2 emissions per pound-mile-traveled On-road truck transport = 0.000297 Rail transport = 0.0000252 Waterborne craft = 0.000048 Aircraft = 0.001527	lb CO_2 / pound-mile

[39] Derived from: U.S. EPA Climate Leaders, (2008). Optional emissions from business travel, commuting, and product transport.

[40] A pound-mile is defined as the product of the distance traveled in miles and the mass transported in pounds. Therefore, 500 lbs transported four miles is equal to 2,000 pound-miles.

5.3 Deduction for Vapor Composition Risk

For any given container of ODS, a portion of the container will be filled with liquid, and the remaining space will be filled with vapor. This protocol only requires that a liquid sample be taken for composition analysis. For containers that hold a mixture of ODS, the composition of ODS in the vapor may be different from the composition of ODS in the liquid due to differences in the thermodynamic properties of the chemicals. If the container holds chemicals that are not eligible for crediting, the quantification of emission reductions based on the analysis of liquid sample could overstate the actual reductions from the destruction of the material.

To address this risk, projects that destroy containers which contain more than one chemical must use Table 5.7 to determine their risk category and applicable value of *VR* to be applied to the calculation of baseline emissions for that container (Equation 5.3). Table 5.6 classifies the eligible ODS species as low or high pressure. For the purposes of this protocol, any ineligible chemical with a boiling point less than 32°F at 1 atm is considered high pressure.

The densities of the liquid and vapor phase components of the project container will be determined by the testing laboratory at the time that the composition analysis is carried out. The testing laboratory will calculate the densities of the liquid phase and vapor phase contents within the container. To support this calculation, the project developer shall provide the laboratory with the temperature of the project container (internal temperature if available, otherwise ambient temperature) at the time of sampling, as well as the volumetric capacity of the project container. Once the weight of the contents of the project container is known, the liquid fill level of the container may be determined using Equation 5.15.

Table 5.6. Eligible Low Pressure and High Pressure ODS

Low Pressure ODS	High Pressure ODS
CFC-11	CFC-12
CFC-113	CFC-13
CFC-114	CFC-115

Table 5.7. Determining the Deduction for Vapor Composition Risk

If the value of $Fill_{liquid}$ is:	AND the concentration of eligible low pressure ODS is:	AND the concentration of ineligible high pressure chemical is:	Then the vapor risk deduction factor (VR) for that container shall be:
> 0.70	N/A	N/A	0
0.50 – 0.70	> 1%	> 10%	0.02
< 0.50	> 1%	> 5%	0.05

The presence of eligible, high pressure ODS may mitigate the risk of over-crediting, so there are two scenarios where a container is exempt from a deduction otherwise required in Table 5.7:

1. The container holds an eligible, high pressure ODS (in any concentration) which has a lower boiling point than the ineligible, high pressure chemical, or
2. The container holds an eligible, high pressure ODS in a concentration greater than that of the ineligible, high pressure chemical.

If the container holds multiple eligible, high pressure ODS, the applicability of the above scenarios will be determined based on the ODS with the highest percent concentration. If the container holds multiple ineligible, high-pressure chemicals, the applicability of the above scenarios will be determined based on the chemical with the highest percent concentration.

This deduction applies to both mixed and non-mixed ODS projects as defined in Section 6.6.

Equation 5.15. Determining Liquid Fill Level in Project Container

$$Fill_{liquid} = \frac{M_{destroyed} - \left(\rho_{vapor} \times V_{container}\right)}{\left(\rho_{liquid} - \rho_{vapor}\right) \times V_{container}}$$

Where,

			Units
$Fill_{liquid}$	=	Fill level of the liquid in the project container	fraction
$V_{container}$	=	Total volume of the project container	gal
$M_{destroyed}$	=	Total mass of the contents of the project container	lbs
ρ_{liquid}	=	Modeled density of the liquid material in the project container at the measured temperature	lbs/gal
ρ_{vapor}	=	Modeled density of the vapor material in the project container at the measured temperature	lbs/gal

6 Project Monitoring and Operation

The Reserve requires a Monitoring and Operations Plan to be established for all monitoring, operational, and reporting activities associated with ODS destruction projects. The Monitoring and Operations Plan will serve as the basis for verification bodies to confirm that the monitoring, operational, and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing for the project. The Monitoring and Operations Plan must cover all aspects of monitoring, operations, and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.2 (below) will be collected and recorded.

At a minimum the Monitoring and Operations Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.3 for minimum record keeping requirements); and the role of individuals performing each specific monitoring or operational activity. The Monitoring and Operations Plan shall also contain a project diagram that illustrates the project ODS point(s) of origin, any reclamation facilities used, information on ODS transportation mode and transportation companies, mixing/sampling facilities, testing laboratories and the destruction facility (see Appendix H for a sample project diagram). The Monitoring and Operations Plan should also include QA/QC provisions to ensure that operations, data acquisition, and ODS analyses are carried out consistently and with precision.

Project developers are responsible for monitoring the performance of the project and ensuring that there is no double-counting of GHG reductions associated with ODS destruction. To achieve this, the Monitoring and Operations Plan must also include a description of how data will be provided to the Reserve ODS tracking system (Section 6.1).

Finally, the Monitoring and Operations Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.4.1).

6.1 Reserve ODS Tracking System

For the purposes of ensuring the integrity of ODS destruction projects, the Reserve maintains an online database of all destruction activities for which CRTs are registered and issued. Entries into this system within the Reserve software must be made by the project developer prior to the beginning of verification activities related to confirming that reductions have not been claimed by other parties for the destruction activity in question.[41]

All projects are required to have one or more Certificate(s) of Destruction accounting for all eligible ODS destroyed as part of that project. The following information shall be entered by the project developer into the Reserve software from the Certificate(s) of Destruction issued by the destruction facility, and a copy of the certificate(s) must be provided to the project verifier:

- Project developer (project account holder)
- Destruction facility
- Generator name
- Certificate of Destruction ID number

[41] Other verification activities (such as site visits) may commence prior to submission of information into the ODS tracking system.

- Start destruction date
- End destruction date
- Total weight of material destroyed (including eligible and ineligible material)

6.2 Point of Origin Documentation Requirements

Project developers are responsible for collecting data on the point of origin of each quantity of ODS, as defined in Table 6.1. The project developer must maintain detailed acquisition records of all quantities of ODS destroyed under the project. Project developers must be able to document the point of origin for all ODS that will be included in the project as defined below.

Table 6.1. Identification of Point of Origin

ODS	Defined Point of Origin
1. Refrigerant ODS stockpiled prior to February 3, 2010	Location of stockpile
2. Refrigerant ODS quantities less than 500 lbs	Location where ODS is first aggregated with other ODS to greater than 500 lbs
3. Refrigerant ODS quantities greater than 500 lbs	Site of installation where ODS is recovered
4. Refrigerant ODS purchased from U.S. Defense Logistics Agency (DLA) Disposition Services[42] auction	Location at the time of sale through a DLA Disposition Services auction
5. ODS blowing agent extracted from foam	Facility where ODS blowing agent is extracted
6. ODS blowing agent in building foam	Location of building from which foam was taken

For destroyed ODS where the point of origin is a reservoir-style stockpile (i.e. ODS was not stored in sealed containers), the date on which the ODS was stockpiled is established using "first-in/first-out" accounting. Specifically, the date on which a quantity of ODS was "stockpiled" is defined as the furthest date in the past on which the quantity of ODS contained in the reservoir was greater than or equal to the total quantity of all ODS removed from the reservoir since that date (including any ODS removed and destroyed as part of the project). The date must be established using management systems and logs that verify the quantities of ODS placed into and removed from the reservoir throughout the relevant period. Provided these conditions are met, and the stockpile follows the "first-in/first-out" accounting, the date on which a quantity of ODS was stockpiled may be established.

For stockpiles, documentation must confirm that the stockpile has been stored at the point of origin prior to February 3, 2010.

For ODS recovered by service technicians in individual quantities less than 500 pounds, the point of origin is defined as the facility where two or more containers were combined and exceeded 500 pounds in a single container. Those handling quantities less than 500 pounds in a single container need not provide the documentation required below. However, once smaller quantities are aggregated and exceed 500 pounds in a single container, tracking is required at that location and point in time forward.

For containers of ODS greater than 500 pounds (determined as the weight of eligible ODS within a single container), the project developer must provide documentation as to the origin of

[42] See Appendix B for more information.

the ODS within that container and when it was recovered. If it is shown that, prior to aggregation in the project container, the ODS was contained as a quantity greater than 500 pounds, then the documentation must extend back to this previous container and its point of origin. The project developer must provide documentation tracking the ODS back to a point in time and location where it was either a) contained or recovered as a quantity of less than 500 pounds, or b) recovered by a service technician as a quantity of greater than 500 pounds.

For refrigerant ODS purchased from a U.S. Defense Logistics Agency (DLA) Disposition Services auction, the point of origin is defined as the facility where the ODS is stored at the time of sale through the auction. Tracking is required from that location and point in time forward. Documentation must show that the ODS was purchased from a DLA Disposition Services auction and include a bill of sale with specifications about the amount and type of ODS purchased. It is possible that the point of origin documentation may not be generated at the point of origin as required below, but rather at the auction location, which is allowable. Refrigerant ODS sourced directly from federal government agencies or installations is not eligible under the protocol.

All data must be generated at the point of origin, except in the case of ODS purchased through DLA Disposition Services auction noted above. Documentation of the point of origin of ODS shall include the following:

- Facility name and physical address, including zip code
- For quantities greater than 500 pounds, identification of the system by serial number, if available, or description, location, and function, if serial number is unavailable
- Serial or ID number of containers used for storage and transport

6.3 Custody and Ownership Documentation Requirements

In conjunction with establishing the point of origin for each quantity of ODS, project developers must also document the custody and ownership of ODS beginning from the point of origin. These records shall include names, addresses, and contact information of persons/entities buying/selling material for destruction and the quantity of the material (the combined mass of refrigerant and contaminants) bought/sold. Such records may include Purchase Orders, Purchase Agreements, packing lists, bills of lading, lab test results, transfer container information, receiving inspections, freight bills, transactional payment information, and any other type of information that will support previous ownership of the material and the transfer of that ownership. The verifier will review these records and will perform other tests necessary to authenticate the previous owners of the material, the physical transfer of the product, and the title transfer of ownership rights of all emissions and emission reductions associated with destroyed ODS to the project developer, as documented through contracts, agreements or other legal documents.

6.4 Building Foam Requirements

The following information shall be collected and recorded related to ODS blowing agents from building insulation foam destroyed by the project:

- Building address
- Date of construction
- Blowing agent used
- Approximate building dimensions

All recovered foam pieces must be placed in air- and water-tight storage for transport to the destruction facility.

ODS blowing agent from building insulation foam may be destroyed intact without extraction of the blowing agent if the following procedures are followed to characterize the mass of foam and type(s) and mass ratio of ODS blowing agent contained in that foam.

1. The mass of the foam shall be determined through weight measurements taken at the destruction facility on a scale which has its calibration tested quarterly by a licensed service company, using certified test weights. A scale is considered calibrated if it is within the maintenance tolerance of the relevant National Institute of Standards and Technology (NIST) Handbook 44 accuracy class. If a scale is found to be outside of this tolerance it must be recalibrated.

2. The composition and mass ratio of the ODS foam blowing agent(s) present in the building insulation foam shall be determined based on a selection of a minimum two samples per building surface taken prior to demolition. Accordingly, a building with four exterior walls and a roof would be required to analyze a total of 10 samples: two for each wall, and two for the roof.

3. All samples must be collected and analyzed according to the following requirements:

    - Each foam sample shall be at a minimum two inches in length, two inches in width, and two inches thick
    - Each sample shall be placed and sealed in a separate waterproof, air-tight container, that is at minimum two millimeters thick for storage and transport
    - The analysis of ODS foam blowing agent content and mass ratio shall be done at an independent laboratory unaffiliated with the project developer
    - The analysis shall be done using the heating method to extract ODS foam blowing agent from the foam samples described in Scheutz et al. (2007):[43]
        - Each sample shall be prepared to a thickness no greater than one centimeter, placed in a 1123 mL glass bottle, weighed using a calibrated scale, and sealed with Teflon-coated septa and aluminum caps
        - To release the ODS blowing agent from the foam, the samples must be incubated in an oven for 48 hours at 140°C
        - When cooled to room temperature, gas samples must be redrawn from the headspace and analyzed using gas chromatography
        - The lids must be removed after analysis, and the headspace must be flushed with atmospheric air for approximately five minutes using a normal compressor. Afterwards, septa and caps must be replaced and the bottles subjected to a second 48-hour heating step to drive out the remaining ODS blowing agent from the sampled foam
        - When cooled down to room temperature after the second heating step, gas samples must be redrawn from the headspace and analyzed using gas chromatography

[43] Scheutz, C., Fredenslund, A.M., Tant, M., & Kjeldsen, P. (2007). Release of fluorocarbons from insulation foam in home appliances during shredding. *Journal of the Air & Waste Management Association*, *57:* 1452-1460.

- The mass of ODS blowing agent(s) recovered shall then be divided by the total mass of the initial foam samples prior to analysis to determine the mass ratio of each ODS foam blowing agent present

4. The results from all samples from a single building shall be averaged to determine the mass ratio of blowing agent to foam, and this value multiplied by the weight of destroyed foam. The result shall represent the total quantity of ODS blowing agent from building foams destroyed for that building, and shall be used for the quantity as BA_{build} in Equation 5.4.

These practices shall be documented in Monitoring and Operations Plan, and must be demonstrated during verification activities (see Section 8.6).

6.5 Appliance Foam Requirements

The following information shall be collected and recorded related to ODS blowing agent from appliance foams destroyed by the project:

- Number of appliances processed
- Facility at which ODS foam blowing agent is extracted to concentrated form
- Facility at which appliance de-manufacture occurs, if applicable

All appliance foam must be processed to recover and destroy concentrated ODS blowing agent. The following requirements must be met:

- The ODS blowing agent must be extracted from the foam to a concentrated form prior to destruction
- ODS blowing agent must be extracted under negative pressure to ensure that fugitive release of ODS is limited
- The recovered ODS blowing agent must be aggregated, stored, and transported in containers meeting U.S. Department of Transportation (DOT) standards for refrigerants

Extraction of the foam blowing agent may be performed using any technology capable of recovering concentrated ODS foam blowing agent. The processes, training, QA/QC, and management systems must be documented in the Monitoring and Operations Plan. The same process, as documented in the Monitoring and Operations Plan must be followed during project implementation and during the calculation of the project-specific recovery efficiency, as described in Appendix E.

Concentrated ODS blowing agent shall be measured according to the procedures provided in Section 6.6.

6.6 Concentrated ODS Composition and Quantity Analysis Requirements

The requirements of this section must be followed to determine the quantities of both ODS refrigerants and concentrated ODS blowing agent. Prior to destruction, the precise mass and composition of ODS to be destroyed must be determined. The following analysis must be conducted:

Mass shall be determined by individually measuring the weight of each container of ODS: (1) when it is full prior to destruction; and (2) after it has been emptied and the contents have been

fully purged and destroyed. The mass of ODS and any contaminants is equal to the difference between the full and empty weight, as measured. The following requirements must be met when weighing the containers of ODS:

1. A single scale must be used for generating both the full and empty weight tickets at the destruction facility
2. The scale used must have its calibration tested quarterly by a licensed service company, using certified test weights. A scale is considered calibrated if it is within the maintenance tolerance of the relevant NIST Handbook 44 accuracy class. If a scale is found to be outside of this tolerance, it must be recalibrated
3. The full weight must be measured no more than two days prior to commencement of destruction per the Certificate of Destruction
4. The empty weight must be measured no more than two days after the conclusion of destruction per the Certificate of Destruction

Composition and concentration of ODS shall be established for each individual container by taking a sample from each container of ODS and having it analyzed for composition and concentration at an Air-Conditioning, Heating and Refrigeration Institute (AHRI) certified laboratory using the AHRI 700-2006 standard,[44] or its successor. The laboratory performing the composition analysis must not be affiliated with the project developer or the project beyond performing these services.

The following requirements must be met for each sample:

1. The sample must be taken while ODS is in the possession of the company that will destroy the ODS
2. Samples must be taken by a technician unaffiliated with the project developer[45]
3. Samples must be taken with a clean, fully evacuated sample bottle that meets applicable U.S. DOT requirements with a minimum capacity of one pound
4. The technician must ensure that the sample is representative of the contents of the container. All valves between the interior of the container and the sample port must be opened for a minimum of 15 minutes before the sample is taken
5. Each sample must be taken in liquid state
6. A minimum sample size of one pound must be drawn for each sample
7. Each sample must be individually labeled and tracked according to the container from which it was taken, and the following information recorded:
    a) Time and date of sample
    b) Name of project developer
    c) Name of technician taking sample
    d) Employer of technician taking sample
    e) Volume of container from which sample was extracted
    f) Ambient air temperature at time of sampling[46]
8. Chain of custody for each sample from the point of sampling to the AHRI laboratory must be documented by paper bills of lading or electronic, third-party tracking that includes proof of delivery (e.g. FedEx, UPS)

[44] AHRI. (2006). Standard 700-2006: Standard for Specifications for Fluorocarbon Refrigerants.
[45] For instances where the project developer is the destruction facility itself, an outside technician must be employed for taking samples.
[46] Projects that destroy ODS prior to the adoption date of this protocol may use proxy data from NOAA recording stations in the area.

All project samples shall be analyzed using AHRI 700-2006 or its successor to confirm the mass percentage and identity of each component of the sample. The analysis shall provide:

1. Identification of the refrigerant
2. Purity (%) of the ODS mixture by weight using gas chromatography
3. Moisture level in parts per million. The moisture content of each sample must be less than 75 percent of the saturation point for the ODS based on the temperature recorded at the time the sample was taken. For containers that hold mixed ODS, the sample's saturation point shall be assumed to be that of the ODS species in the mixture with the lowest saturation point that is at least 10 percent of the mixture by mass
4. Analysis of high boiling residue, which must be less than 10 percent by mass
5. Analysis of other ODS in the case of mixtures of ODS, and their percentage by mass

If any of the requirements above are not met, no GHG reductions may be verified for ODS destruction associated with that container. If a sample is tested and does not meet one of the requirements as defined above, the project developer may elect to have the material re-sampled and re-analyzed. While there is no limit to the number of samples that may be taken, the analysis results of all samples must be disclosed to the verification body, and the most conservative composition analysis from these samples shall be used for the quantification. If a project developer elects to have the material dried prior to resampling, the previous samples (prior to drying) may be disregarded.

Note that the threshold for moisture saturation will be difficult to achieve at very low temperatures, and it is recommended that sampling not occur if the ambient air temperature is below 32°F. Project developers may sample for moisture content and perform any necessary de-watering prior to the required sampling and laboratory analysis.

If the container holds non-mixed ODS (defined as greater than 90 percent composition of a single ODS species) no further information or sampling is required to determine the mass and composition of the ODS.

If the container holds mixed ODS, which is defined as less than 90 percent composition of a single ODS species, the project developer must meet additional requirements as provided in Section 6.6.1.

6.6.1 Analysis of Mixed ODS

If a container holds mixed ODS, its contents must also be processed and measured for composition and concentration according to the requirements of this section (in addition to the requirements of Section 6.6). The sampling required under this section may be conducted at the final destruction facility or prior to delivery to the destruction facility. However, the circulation and sampling activities must be conducted by a third-party organization (i.e. not the project developer), and by individuals who have been properly trained for the functions they perform. Circulation and sampling may be conducted at the project developer's facility, but all activities must be directed by a properly trained and contracted third-party. The project's Monitoring and Operations Plan must specify the procedures by which mixed ODS are analyzed. If the mixing and sampling are conducted at the destruction facility, then the most conservative result of the two samples shall be used to satisfy the requirements of Section 6.6. If the mixing and sampling do not occur at the destruction facility, then the most conservative composition analysis from the mixing facility samples shall be used for the quantification of emission reductions.

The composition and concentration of ODS on a mass basis must be determined using the results of the analysis of this section for each container. The results of the composition analysis in Section 6.6 shall be used by verifiers to confirm that the destroyed ODS is in fact the same ODS that is sampled under these requirements.

Prior to sampling, the ODS mixture must be circulated in a container that meets all of the following criteria:

1. The container has no solid interior obstructions[47]
2. The container was fully evacuated prior to filling
3. The container must have mixing ports to circulate liquid and gas phase ODS
4. The liquid port intake shall be at the bottom of the container, and the vapor port intake shall be at the top of the container. For horizontally-oriented mixing containers, the intakes shall be located in the middle third of the container.
5. The container and associated equipment can circulate the mixture via a closed loop system from the liquid port to the vapor port

If the original mixed ODS container does not meet these requirements, the mixed ODS must be transferred into a temporary holding tank or container that meets all of the above criteria. The weight of the contents placed into the temporary container shall be calculated and recorded. During transfer of ODS into and out of the temporary container, ODS shall be recovered to the vacuum levels required by the U.S. EPA for that ODS (see 40 CFR 82.156).[48]

Once the mixed ODS is in a container or temporary storage unit that meets the criteria above, circulation of mixed ODS must be conducted as follows:

1. Liquid mixture shall be circulated from the liquid port to the vapor port
2. A volume of the mixture equal to two times the volume in the container shall be circulated
3. Circulation must occur at a rate of at least 30 gallons/minute. Alternatively, circulation may occur at a rate that is less than 30 gallons/minute, as long as criterion #2 is achieved within the first 6 hours of mixing
4. Start and end times shall be recorded

Within 30 minutes of the completion of circulation, a minimum of two samples shall be taken from the bottom liquid port according to the procedures in Section 6.6. Both samples shall be analyzed at an AHRI approved laboratory per the requirements of Section 6.6. The mass composition and concentration of the mixed ODS shall be equal to the lesser of the two GWP-weighted concentrations.

6.7 Destruction Facility Requirements

Destruction of ODS must occur at a facility that meets all of the guidelines provided in Appendix C of this protocol and by the TEAP Task Force on Destruction Technologies[49]

[47] Mesh baffles or other interior structures that do not impede the flow of ODS are acceptable.
[48] EPA. Required Levels of Evacuation. Retrieved December 21, 2009, from http://www.epa.gov/Ozone/title6/608/608evtab.html.
[49] http://www.uneptie.org/ozonaction/topics/disposal.htm.

Any destruction facility that is regulated by U.S. EPA as a RCRA-permitted HWC is automatically considered a qualifying destruction facility under this protocol; no further testing for TEAP compliance is required.

Non-RCRA permitted facilities may also be deemed qualifying destruction facilities if they meet the pertinent guidelines reproduced in Appendix C. Destruction facilities must provide third-party certified results indicating that the facility meets all performance criteria set forth in Appendix C. Following the initial performance testing, project developers must demonstrate that the facility has conducted comprehensive performance testing at least every three years to validate compliance with the TEAP DRE and emissions limits as reproduced in Appendix C. No ODS destruction credits shall be issued for destruction that occurs at a facility that has failed to undergo comprehensive performance testing according to the required schedule, or has failed to meet the requirements of such performance testing.

At the time of ODS destruction, all destruction facilities must have a valid Title V air permit, if applicable, and any other air or water permits required by local, state, or federal law to destroy ODS. Facilities must document compliance with all monitoring and operational requirements associated with the destruction of ODS materials, as dictated by these permits, including emission limits, calibration schedules, and training. Any upsets or exceedances must be managed in keeping with an authorized startup, shutdown, and malfunction plan. Non-RCRA facilities must further document operation consistent with the TEAP requirements, as defined in this section and Appendix C.

Operating parameters during destruction of ODS material shall be monitored and recorded as described in the Code of Good Housekeeping[50] approved by the Montreal Protocol. This data will be used in the verification process to demonstrate that during the destruction process, the destruction unit was operating similarly to the period in which the DRE[51] was calculated. The DRE is determined by using the Comprehensive Performance Test (CPT)[52] as a proxy for DRE and is disclosed to the public in the destruction facility's Title V operating permit.

To monitor that the destruction facility operates in accordance with applicable regulations and within the parameters recorded during DRE testing, the following parameters must be tracked continuously during the entire ODS destruction process:

- The ODS feed rate
- The amount and type of consumables used in the process (not required if default project emission factor for transportation and destruction is used)
- The amount of electricity and amount and type of fuel consumed by the destruction unit (not required if default project emission factor for transportation and destruction is used)
- Operating temperature and pressure of the destruction unit during ODS destruction
- Effluent discharges measured in terms of water and pH levels
- Continuous emissions monitoring system (CEMS) data on the emissions of carbon monoxide during ODS destruction

[50] TEAP. (2006). Code of Good Housekeeping. *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer, 7th Edition*.
[51] DRE disclosed in Title V operating permit.
[52] CPT must have been conducted with a less combustible chemical than the ODS in question.

The project developer must maintain records of all of these parameters for review during the verification process.

Destruction facilities shall provide valid Certificate(s) of Destruction for all ODS destroyed as part of the project. The Certificate of Destruction shall include:

- Project developer (project account holder)
- Destruction facility
- Generator name
- Certificate of Destruction ID number
- Serial, tracking or ID number of all containers for which ODS destruction occurred
- Weight of material destroyed from each container (including eligible and ineligible material)
- Type of material destroyed from each container (including all materials listed on laboratory analysis of ODS composition from sampling at the destruction facility)
- Start destruction date
- End destruction date

6.8 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.2 below. In addition to the parameters below that are used in the calculations provided in Section 5, project developers are responsible for maintaining all records required under Sections 6 and 7.

Table 6.2. ODS Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Comment
		Legal Requirement Test	N/A	For each reporting period		Must be monitored and determined for each reporting period
		Mass of ODS (or ODS mixture) in each container	mass of mixture	Per container	M	Must be determined for each container destroyed
		Concentration of ODS (or ODS mixture) in each container	mass ODS/ mass of mixture	Per container	M	Must be determined for each container destroyed
Equation 5.1	ER_t	Total quantity of emission reductions during the reporting period	tCO_2e	For each reporting period	C	
Equation 5.1, Equation 5.2	BE_t	Total quantity of baseline emissions during the reporting period	tCO_2e	For each reporting period	C	
Equation 5.1, Equation 5.5	PE_t	Total quantity of project emissions during the reporting period	tCO_2e	For each reporting period	C	
Equation 5.2, Equation 5.3	BE_{refr}	Total quantity of baseline emissions from refrigerant ODS	lb CO_2e	For each reporting period	C	
Equation 5.2, Equation 5.4	BE_{foam}	Total quantity of baseline emissions from ODS blowing agent	lb CO_2e	For each reporting period	C	
Equation 5.3, Equation 5.6	$Q_{refr,i}$	Total quantity of eligible refrigerant ODS *i* sent for destruction	lb ODS	For each reporting period	M	
Equation 5.3	$ER_{refr,i}$	10-year cumulative emission rate of refrigerant ODS *i*	0 - 1.0	N/A	R	See Table 5.1
Equation 5.3, Equation 5.4, Equation 5.7, Equation 5.12	GWP_i	Global warming potential of ODS *i*	lb CO_2e/ lb ODS	N/A	R	See Table 5.1

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Comment
Equation 5.3	VR	Vapor risk deduction factor	% (0-1)	For each reporting period	R	See Table 5.7
Equation 5.4, Equation 5.7	$BA_{app,i,}$	Total quantity of ODS blowing agent *i* from appliance foam prior to treatment or processing, including blowing agent lost during processing	lb ODS	For each reporting period	C	
Equation 5.4	$BA_{build,i}$	Total quantity of ODS blowing agent *i* from building foam sent for destruction.	lb ODS	For each reporting period	C	
Equation 5.4	$ER_{i,j}$	Lifetime emission rate of ODS blowing agent *i* from application *j* at end-of-life (see Table 5.3)	% (0-1)	N/A	R	
Equation 5.4	$Q_{recover}$	Total quantity of ODS foam blowing agent recovered during processing and sent for destruction	lb ODS	For each reporting period	M	
Equation 5.4, Equation 5.7	RE	Recovery efficiency of the ODS foam blowing agent recovery process	% (0-1)	Once per project	C	See Appendix E for calculation of RE
Equation 5.4	Q_{foam}	Total weight of foam with entrained ODS blowing agent sent for destruction	lb	For each reporting period	M	
Equation 5.4	BA%	Mass ratio of ODS blowing agent entrained in building foam, as determined according to Section 6.4	% (0-1)	For each reporting period	M	
Equation 5.5, Equation 5.6	Sub_{refr}	Total emissions from substitute refrigerant	lb CO_2e	For each reporting period	C	
Equation 5.5, Equation 5.7	$BA_{pr,i}$	Total quantity of ODS foam blowing agent *i* from appliance foam released during ODS extraction	lb CO_2e	For each reporting period	C	

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Comment
Equation 5.5, Equation 5.8, Equation 5.14	Tr	Total emissions from project transportation	lb CO_2e	For each reporting period	C	
Equation 5.5, Equation 5.8, Equation 5.9	Dest	Total emissions from the destruction process associated with destruction of ODS	lb CO_2e	For each reporting period	C	
Equation 5.6	SE_i	Emission factor for substitute emissions of refrigerant *i*	lb CO_2e/ lb ODS destroyed	Per container	R	See Table 5.5 for values and Appendix D for summary of the development of SE
Equation 5.8, Equation 5.12, Equation 5.13	$Q_{ODS,i}$	Total quantity of ODS *i* sent for destruction, including eligible and ineligible material	lb ODS	For each reporting period	M	
Equation 5.8,	EF_i	Default emission factor for transportation and destruction of ODS *i*	lb CO_2e/ lb ODS	N/A	R	Equal to 7.5 for refrigerant projects, and 75 for foam projects
Equation 5.9, Equation 5.10	FF_{dest}	Total emissions from fossil fuel used in the destruction facility	lb CO_2e	For each reporting period	C	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.9, Equation 5.11	EL_{dest}	Total emissions from grid electricity at the destruction facility	lb CO_2e	For each reporting period	C	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.10	$FF_{PR,k}$	Total fossil fuel *k* used to destroy ODS	lb CO_2e	For each reporting period	M	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.10	$EF_{FF,k}$	Fuel specific emission factor	$kgCO_2$/ volume fuel	N/A	R	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.11	EL_{PR}	Total electricity consumed to destroy ODS	MWh	For each reporting period	M	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.11	EF_{EL}	Carbon emission factor for electricity used	lb CO_2/ MWh	N/A	R	Use only if calculating site-specific project emissions from ODS destruction

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Comment
Equation 5.9, Equation 5.12	$ODS_{emissions}$	Total emissions of un-destroyed ODS	lb CO_2e	For each reporting period	C	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.9, Equation 5.13	ODS_{CO2}	Total emissions of CO_2 from ODS oxidation	lb CO_2	For each reporting period	C	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.13	CR_i	Carbon ratio of ODS *i*	mole C/ mole ODS	N/A	R	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.14	PMT_i	Pound-miles-traveled for ODS *i* destroyed	pound-miles	For each reporting period	M	Use only if calculating site-specific project emissions from ODS transportation
Equation 5.14	EF_{PMT}	Mode-specific emission factor	$kgCO_2$/ pound-mile	N/A	R	Use only if calculating site-specific project emissions from ODS transportation
Equation 5.15	$Fill_{liquid}$	Liquid fill level in project container	% (0-1)	For each reporting period	C	
Equation 5.15	$V_{container}$	Volumetric capacity of project container	gallons	For each reporting period	O	
Equation 5.15	$M_{destroyed}$	Total mass of material destroyed in the project container	lbs	For each reporting period	M	
Equation 5.15	ρ_{liquid}	Density of the liquid phase material in the project container	lb/gal	For each reporting period	C	
Equation 5.15	ρ_{vapor}	Density of the vapor phase material in the project container	lb/gal	For each reporting period	C	

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure by project developers. Project developers must submit verified emission reduction reports to the Reserve at the conclusion of every project reporting period.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register an ODS destruction project.

- Project Submittal form
- Certificate(s) of Destruction (not public)
- Laboratory analysis of ODS composition from sampling at destruction facility (not public)
- Laboratory analysis of ODS composition from sampling at mixing facility, if applicable (not public)
- Project diagram from Monitoring and Operations Plan – see Appendix H (not public)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Certificate(s) of Destruction (not public)
- Laboratory analysis of ODS composition from sampling at destruction facility (not public)
- Laboratory analysis of ODS composition from sampling at mixing facility, if applicable (not public)
- Project diagram from Monitoring and Operations Plan – see Appendix H (not public)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form

Unless otherwise specified, the above project documentation will be available to the public via the Reserve's online registry with the Certificate of Destruction tracking information from Section 6.1. Further disclosure and other documentation may be made available by the project developer on a voluntary basis. Project submittal forms can be found at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

7.2 Joint Verification

If desired, it is possible for a single project developer to register multiple concurrent ODS destruction projects at a single destruction facility (e.g. one involving domestically sourced ODS and a second involving ODS sourced from Article 5 countries). In such instances, the concurrent projects may be eligible for joint verification (see Section 8.1 for more detail).

Regardless of whether the project developer chooses to verify multiple projects through a joint project verification or pursue verification of each project separately, the documents and records for each project must be retained according to this section.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after verification. This information will not be publicly available but may be requested by the verification body or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Copies of all permits, Notices of Violations (NOVs), and any relevant administrative or legal consent orders dating back at least three years prior to the project start date
- Executed Attestation of Title forms, Attestation of Regulatory Compliance forms and Attestation of Voluntary Implementation forms
- Destruction facility monitor information (CEMS data, DRE documentation, scale readings, calibration procedures, and permits)
- Verification records and results
- Chain of custody and point of origin documentation
- ODS composition and quantity lab reports

7.4 Reporting Period and Verification Cycle

ODS destruction projects may be no greater than 12 months in duration, measured from the project start date to completion of ODS destruction. As stated in Section 2.2, project developers may choose a shorter time horizon for their project (e.g. three months or six months), but no project may run longer than 12 months. At the project developer's discretion, a project may have one or more reporting periods as defined in Section 5.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions from ODS destruction projects developed to the standards of this protocol. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities in the context of ODS destruction projects.

Verification bodies trained to verify ODS projects must conduct verifications to the standards of the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve U.S. Ozone Depleting Substances Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify ODS destruction project reports. Verification bodies approved under other project protocol types are not permitted to verify ODS destruction projects. Information about verification body accreditation and Reserve project verification training can be found in the Verification Program Manual.

8.1 Joint Project Verification

Because of the possibility for a project developer to have projects under both the U.S. and Article 5 ODS Project Protocols occurring at a single destruction facility, project developers have the option to hire a single verification body to verify multiple projects under a joint project verification. This may provide economies of scale for the project verifications and improve the efficiency of the verification process. Joint project verification is only available as an option for a single project developer; joint project verification cannot be applied to multiple projects registered by different project developers at the same destruction facility.

Provided that the following elements are met, the verifier may, at his or her discretion, conduct a joint verification of two or more projects:

- The project developer has contracted with a single verification body for all projects involved
- All projects involved have an approved NOVA/COI form with designated site visit dates prior to the commencement of joint verification activities
- An appropriate verification plan covering all aspects of the individual projects involved has been prepared prior to any shared site visits or verification activities
- Project activities associated with all involved projects have commenced prior to the shared site visit or verification activity

Under joint project verification, each project, as defined by the protocol and the project developer, must still be registered separately in the Reserve system and each project requires

its own verification process and Verification Statement (i.e. each project is assessed by the verification body separately as if it were the only project at the destruction facility). However, all projects may be verified together by a single site visit to the destruction facility or other common locations. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Finally, the verification body may submit one Notification of Verification Activities/Conflict of Interest (NOVA/COI) Assessment form that details and applies to all of the projects at a single destruction facility that it intends to verify.

If, during joint project verification, the verification activities of one project are delaying the registration of another project, the project developer can choose to forego joint project verification. There are no additional administrative requirements of the project developer or the verification body if a joint project verification is terminated.

8.2 Standard of Verification

The Reserve's standard of verification for ODS destruction projects is the U.S. Ozone Depleting Substances Project Protocol (this document), the Reserve Program Manual, and the Reserve Verification Program Manual. To verify an ODS destruction project report submitted by a project developer, verification bodies must apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Section 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, operational requirements, performance monitoring requirements, and procedures for reporting project information to the Reserve.

8.3 Monitoring and Operations Plan

The Monitoring and Operations Plan serves as the basis for verification bodies to confirm that the monitoring, operational, and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping has been conducted. Verification bodies shall confirm that the Monitoring and Operations Plan covers all aspects of monitoring, operations, and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.2 are collected and recorded.

8.4 Verifying Project Eligibility

Verification bodies must affirm an ODS destruction project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for an ODS destruction project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.3.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Verification Frequency
Start Date	No more than six months prior to project submission	Once per project
Location of Destruction	United States and its territories	Once per project

Eligibility Rule	Eligibility Criteria	Verification Frequency
Point of Origin of ODS	Unites States and its territories	Each verification
Project Definition	▪ Project developer and GHG ownership is the same for all ODS destroyed ▪ A single destruction facility has been used for all ODS destruction ▪ All project activities span no more than 12 months from the project start date to the conclusion of destruction activities ▪ Eligible refrigerant ODS include CFC-11, CFC-12, CFC-13, CFC-113, CFC-114, CFC-115 ▪ Eligible ODS blowing agents include CFC-11, CFC-12, HCFC-22, HCFC-141b	Each verification
Performance Standard	Project destroys ODS refrigerant or ODS blowing agent that meet project definitions	Each verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures that lay out procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Each verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of non-compliance to verifier; project must be in material compliance with all applicable laws	Each verification
Exclusions	▪ ODS sourced from outside of the U.S. ▪ ODS destroyed outside of the U.S. ▪ Solvents and medical aerosols ▪ Destruction of intact appliance foam ▪ ODS sourced from the federal government, except through DLA Disposition Services auction	Each verification

8.5 Core Verification Activities

The U.S. Ozone Depleting Substances Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with the destruction of ODS sourced from the United States. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. These activities are summarized below in the context of an ODS destruction project, but verification bodies shall also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emissions sources, sinks and reservoirs

2. Reviewing operations, GHG management systems, and estimation methodologies
3. Verifying emission reductions and estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as the ODS baseline emissions, substitute emissions, emissions from transportation, and emissions from the destruction of ODS.

Reviewing operations, GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the operations, methodologies and management systems that the ODS project developer employs to perform project activities, to gather data on ODS collected and destroyed and to calculate baseline and project emissions.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the ODS management, sampling and destruction systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body must recalculate a representative sample of the ODS destruction or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.6 Verification Site Visits

Project verifiers shall conduct one or more site visits for each project to assess operations, management systems, QA/QC procedures, personnel training, and conformance with the requirements of this protocol. Each of the sites identified in Table 8.2 shall be visited at least once every 12 months by the project verification body. If one verification body is contracted by multiple projects that involve a single facility, the verification body must only visit that facility once per 12 month period. However, the verification body may visit a facility more frequently if they deem it necessary. For each reporting period, the site visits required in Table 8.2 must have occurred no more than 12 months prior to the end date of the reporting period.

Table 8.2. Verification Site Visit Requirements

Project	Site Visit(s) Required
Refrigerant recovery and destruction: pure ODS	▪ Destruction facility ▪ One additional project facility[a]
Refrigerant recovery and destruction: mixed ODS	▪ Destruction facility ▪ ODS mixing & sampling facility ▪ One additional project facility[a]
Appliance foam collection, ODS foam blowing agent extraction, and destruction	▪ Facility where ODS foam blowing agent is extracted ▪ Destruction facility ▪ One additional project facility[a]
Building foam collection and destruction	▪ Lab performing ODS blowing agent mass ratio analysis ▪ Destruction facility ▪ One additional project facility[a]

[a] The verification body shall visit one additional facility within the project diagram, including but not limited to: a point of recovery, reclamation or aggregation, the project developer's offices, a point of origin, etc. The verification body shall choose this additional facility based upon the project specific risk assessment.

In addition to the site visits specified above, verification bodies may visit any additional sites deemed necessary to verify the project in the context of the project specific risk assessment. In the instance that multiple sampling facilities or foam processing facilities were employed in a single project, verification bodies must determine the appropriate number of facilities to visit, but a minimum of one visit per type of facility is required.

8.7 ODS Verification Items

The following tables provide lists of items that a verification body needs to address while verifying an ODS destruction project. The tables include references to the section in the protocol where requirements are further described. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to ODS destruction projects that must be addressed during verification.

8.7.1 Project Eligibility and CRT Issuance

Table 8.3 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for ODS destruction projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the ODS destroyed. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the ODS destroyed (or sub-set of the ODS destroyed) may be ineligible for issuance of CRTs.

Table 8.3. Project Eligibility Verification Items

Protocol Section	Project Eligibility Qualification Item	Apply Professional Judgment?
2.4	Verify that credits for destroyed ODS have not been claimed on the Reserve or any other registry, using Attestation of Title and Reserve tracking software	No
2.2	Verify that the project meets the definition of a U.S. ODS project	No
2.2	Verify that the destroyed ODS is sourced from the U.S.	Yes
2.2	Verify that the destroyed ODS has been phased out in the U.S.	No
2.2	Verify that the ODS was not used as or produced for use as solvents, medical aerosols or other ODS applications	Yes
2.4	Verify ownership of the reductions by reviewing Attestation of Title	No
2.2	Verify that the project activities involve a single project developer and a single qualifying destruction facility	No
Appendix C	Verify that the destruction facility meets the requirements of this protocol; if the facility is not a RCRA approved HWC, verify that it has been third-party certified as meeting the requirements of the TEAP *Report on the Task Force on HCFC Issues* in Appendix C and has successfully completed the comprehensive performance testing in Appendix C within the three years prior to the end date of destruction	No

Protocol Section	Project Eligibility Qualification Item	Apply Professional Judgment?
	activities	
3.2	Verify eligibility of project start date	No
3.2	Verify project start date based on records	No
2.2	Verify that project activities span no more than 12 months	No
2.3	Verify that the project was correctly characterized as a foam or refrigerant project	No
5.1	Verify that the appropriate baseline scenario was applied for each quantity of ODS destroyed	No
3.4.1	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
6	Verify that the project Monitoring and Operations Plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
3.4.2	Verify that the project meets the Performance Standard Test	No
3.5	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring plans and procedures meet the requirements of the protocol; if they do not, verify that a variance has been approved for monitoring variations	Yes
6	Verify the Monitoring and Operations Plan includes a project diagram, and that the project diagram is complete, accurate, and up-to-date	No
	If any variances were granted, verify that variance requirements were met and properly applied	No

8.7.2 Conformance with Operational Requirements and ODS Eligibility

Table 8.4 lists the verification items to determine the project's conformance with the operational and monitoring requirements of this protocol, and the eligibility of discrete ODS sources. A subset of destroyed ODS may be deemed ineligible if it was obtained in a manner inconsistent with this protocol, or if documentation is insufficient. If any of Table 8.4 is not met, no CRTs may be issued for that quantity of ODS.

Table 8.4. Operational Requirement and ODS Eligibility Verification Items

Protocol Section	Operational Requirement and ODS Eligibility Items	Apply Professional Judgment?
6.1	For all ODS, verify that information has been correctly entered in Reserve tracking system and that the Certificate of Destruction entry is unique to this project	No
6.2	For all ODS, verify that the point of origin is correctly identified and documented	Yes
6.2, 6.6	For all ODS, verify that the point of origin documentation agrees with the data reported at the destruction facility (weight and composition) with no significant discrepancies	Yes
6.3	For all ODS, verify that the ODS can be tracked through retained chain of custody documentation from the Certificate of Destruction back to the point of origin	Yes
6.4, 6.5	For ODS blowing agents, verify that required data has been collected, per Section 6.4 and 6.5	No

Protocol Section	Operational Requirement and ODS Eligibility Items	Apply Professional Judgment?
6.4	For foam ODS blowing agent, verify that that the recovery efficiency has been calculated correctly per Appendix E	Yes
6.6	Verify that the scales used for measuring mass of ODS destroyed are properly maintained and tested for calibration quarterly	No
6.6	Verify that the weight of full and empty ODS containers was measured 48 hours prior to destruction commencing and 48 hours following completion, respectively	No
6.6	Verify that all ODS samples were taken by a third-party technician while in the possession of the destruction facility	No
6.6	Verify the chain of custody by which ODS sample was transferred from the destruction facility to the lab	No
6.6	Verify that all ODS was analyzed for composition and concentration at a lab approved under the AHRI 700-2006 standard or its successor	No
6.6	Verify that the calculation of ODS composition and mass concentration correctly accounted for moisture, mixing, and high boiling residue	No
6.6	For mixed refrigerants, verify that credits are only claimed for refrigerants eligible under this protocol	No
6.6.1	For mixed refrigerants, verify that proper recirculation occurred	No
6.6.1	For mixed refrigerants, verify that recirculation and sampling were performed by properly trained technicians	Yes
6.4	Verify that for destruction of ODS blowing agent from building foam, the correct procedures have been followed for determining the type and mass ratio of ODS in the foam	No
6.7	Verify that all permits are current at the destruction facility	No
6.7, Appendix C	Verify that the destruction facility where the ODS was destroyed has a documented destruction and removal efficiency greater than 99.99 percent, and that CPT was conducted with a material less combustible than the ODS destroyed	No
6.7, Appendix C	Verify that the destruction facility operated within the parameters under which it was tested to achieve a 99.99 percent or greater destruction and removal efficiency	No
6.7	Verify that the destruction facility monitored the parameters identified in Section 6.7	No
6.7	Verify that the Certificate of Destruction contains all required information	No

8.7.3 Quantification of GHG Emission Reductions

Table 8.5 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.5. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project documentation	No
6.7	Verify that all destroyed ODS for which CRTs are claimed appear on a valid Certificate of Destruction	No

Protocol Section	Quantification Item	Apply Professional Judgment?
5.1	Verify that the baseline emissions were calculated with the appropriate emission rate(s) and aggregated correctly	No
5.2.1	Verify that the substitute emissions have been properly characterized, calculated, and aggregated correctly	No
5.1.2, 5.2.2	Verify that the recovery efficiency has been correctly applied for concentrated ODS blowing agent projects	No
5.2.3, 5.2.4	Verify that the project developer correctly quantified and aggregated electricity use, or that the default factor was applied	Yes
5.2.3, 5.2.4	Verify that the project developer correctly quantified and aggregated fossil fuel use, or that the default factor was applied	Yes
5.2.3, 5.2.4	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity, or that the default factors were applied	Yes
5.2.3, 5.2.5	Verify that the project developer correctly quantified and aggregated transportation emissions, or that the default factor was applied	Yes
5.2.3, 5.2.4	Verify that emissions from incomplete ODS destruction and oxidation of ODS carbon have been correctly quantified and aggregated, or that the default factor was applied	Yes

8.7.4 Risk Assessment

Verification bodies will review the following items in Table 8.6 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.6. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring and Operations Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	Yes
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform these functions	Yes
6.5	Verify that the required data on appliances from which foam was sourced has been collected and managed correctly	Yes
6	Verify that appropriate training was provided to personnel assigned to operations, record-keeping, sample-taking, and other project activities	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer and that there is internal oversight to assure the quality of the contractor's work	Yes
7	Verify that all required records have been retained by the project developer	No

8.8 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Certificate of Destruction	An official document provided by the destruction facility certifying the date, quantity, and type of ODS destroyed.
Commencement of destruction process	When the ODS waste-stream is hooked up to the destruction chamber.
Commercial refrigeration equipment	The refrigeration appliances used in the retail food, cold storage warehouse or any other sector that requires cold storage. Retail food includes the refrigeration equipment found in supermarkets, grocery and convenience stores, restaurants, and other food service establishments. Cold storage includes the refrigeration equipment used to house perishable goods or any manufactured product requiring refrigerated storage.
Container	An air- and water-tight unit for storing and/or transporting ODS material without leakage or escape of ODS.
Destruction	Destruction of ozone depleting substances by qualified destruction, transformation or conversion plants achieving greater than 99.99 percent destruction and removal efficiency, in order to avoid their emissions. Destruction may be performed using any technology, including transformation, that results in the complete breakdown of the ODS into either a waste or usable by-product.
Destruction facility	A facility that destroys, transforms or converts ozone depleting substances using a technology that meets the standards defined by the UN Environment Programme Technology and Economic Assessment Panel Task Force on Destruction Technologies.[53]
Emission rate	The rate at which refrigerant is lost to the atmosphere, including emissions from leaks during operation and servicing events.
Generator	The facility from which the ODS material on a single Certificate of Destruction departed prior to receipt by the destruction facility. If the material on a single Certificate of Destruction was aggregated as multiple shipments to the destruction facility, then the destruction facility shall be the Generator.
Ozone Depleting Substances (ODS)	Ozone depleting substances are substances known to deplete the stratospheric ozone layer. The ODS controlled under the Montreal Protocol and its Amendments are chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC), halons, methyl bromide (CH_3Br), carbon tetrachloride (CCl_4), methyl chloroform (CH_3CCl_3), hydrobromofluorocarbons (HBFC) and bromochloromethane (CHBrCl). [54]

[53] United Nations Environment Programme. (2003). Report of the Fifteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. *OzL.Pro.15/9*. Nairobi, November 11, 2003.
[54] Source: IPCC - http://www.mnp.nl/ipcc/pages_media/SROC-final/SROC_A2.pdf

Recovery efficiency	The percent of total ODS blowing agent that is recovered during the process of ODS blowing agent extraction.
Recharge	Replenishment of refrigerant agent (using reclaimed or virgin material) into equipment that is below its full capacity because of leakage or because it has been evacuated for servicing or other maintenance.
Reclaim	Reprocessing and upgrading of a recovered ozone depleting substance through mechanisms such as filtering, drying, distillation and chemical treatment in order to restore the ODS to a specified standard of performance. Chemical analysis is required to determine that appropriate product specifications are met. It often involves processing off-site at a central facility.
Recovery	The removal of ozone depleting substances from machinery, equipment, containment vessels, etc., into an external container during servicing or prior to disposal without necessarily testing or processing it in any way.
Reuse/recycle	Reuse of a recovered ozone depleting substance following a basic cleaning process such as filtering and drying. For refrigerants, recycling normally involves recharge back into equipment and it often occurs 'on-site'.
Startup, shutdown, and malfunction plan	A plan, as specified under 40 CFR 63.1206, that includes a description of potential causes of malfunctions, including releases from emergency safety vents, that may result in significant releases of hazardous air pollutants, and actions the source is taking to minimize the frequency and severity of those malfunctions.
Stockpile	ODS stored for future use or disposal in bulk quantities at a single location. These quantities may be composed of many small containers or a single large container.
Substitute refrigerant	Those refrigerants that will be used to fulfill the function that would have been filled by the destroyed ODS refrigerants. These refrigerants may be drop-in replacements used in equipment that previously used the type of ODS destroyed or may be used in new equipment that fulfills the same market function.
Substitute emissions	A term used in this protocol to describe the greenhouse gases emitted from the use of substitute refrigerants in technologies that are used to replace the ODS destroyed in a project.
Transportation system	A term used to encompass the entirety of the system that moves the ODS from the point of aggregation to the destruction facility.

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Appendix A Summary of Legal Requirement Test Development

Management activities for ozone depleting substances are dictated in the United States by both the Montreal Protocol, to which the U.S. is a party, and the U.S. Clean Air Act. This appendix provides background information on both of these regulatory frameworks. Further, this appendix demonstrates that neither framework requires the destruction of ODS, and destruction therefore meets the Legal Requirement Test under the Climate Action Reserve U.S. Ozone Depleting Substances Project Protocol.

A.1 Montreal Protocol

The original Montreal Protocol, signed in 1987, was the first international treaty with binding commitments to protect stratospheric ozone. Since that time, the Montreal Protocol has been repeatedly strengthened by both controlling additional ODS as well as by moving up the date by which previously controlled substances must be phased out. The Montreal Protocol controls only production and consumption (production plus imports minus exports) and not emissions of ODS. There is no mandatory requirement to destroy ODS in the Montreal Protocol. Therefore, for analyses prepared under the Montreal Protocol, it is assumed that all ODS that are produced will eventually be released to the atmosphere, even though some developed countries have voluntary and/or mandatory requirements to destroy ODS.

Under the original Montreal Protocol agreement (1987), non-Article 5 countries were required to begin phasing out CFC in 1993 and achieve a 50 percent reduction relative to 1986 consumption levels by 1998. Under this agreement, CFC were the only ODS addressed. The London Amendment (1990) changed the ODS emission schedule by requiring the complete phase-out of CFC, halons, and carbon tetrachloride by 2000 in developed countries, and by 2010 in developing countries. Methyl chloroform was also added to the list of controlled ODS, with phase-out in developed countries targeted in 2005, and in 2015 for developing countries.

The Copenhagen Amendment (1992) significantly accelerated the phase-out of ODS and incorporated an HCFC phase-out for developed countries, beginning in 2004. Under this agreement, CFC, halons, carbon tetrachloride, methyl chloroform, and HBFC were targeted for complete phase-out in 1996 in developed countries. In addition, methyl bromide consumption was capped at 1991 levels.

The Montreal Amendment (1997) included the phase-out of HCFC in developing countries, as well as the phase-out of methyl bromide in developed and developing countries in 2005 and 2015, respectively.

The Beijing Amendment (1999) included tightened controls on the production and trade of HCFC. Bromochloromethane was also added to the list of controlled substances with phase-out targeted for 2002.

At the 19th Meeting of the Parties in Montreal in September 2007, the Parties agreed to an adjustment that more aggressively phases out HCFC in both developed and developing countries. Developed countries must reduce HCFC production and consumption by 75 percent of their baseline by 2010, 99.5 percent by 2020, and 100 percent by 2030. The 0.5 percent during the period 2020-2030 is restricted to the servicing of existing refrigeration and air-conditioning equipment and is subject to review in 2015. Developing countries must freeze

production and consumption of HCFC in 2013 at their baseline and then reduce it by 10 percent in 2015, 35 percent by 2020, 67.5 percent by 2025, 97.5 percent by 2030 and 100 percent by 2040. The 2.5 percent during the period 2030-2039 is the average over that time frame (e.g. it can be five percent for five years and zero percent for the other five years), is restricted to the servicing of existing refrigeration and air-conditioning equipment, and is subject to review in 2015.

The result of the Montreal Protocol with its amendments and adjustments is that as of January 1, 2010, CFC, halons, methyl chloroform, carbon tetrachloride, methyl bromide, and bromochloromethane will be phased out of production in both developed and developing countries. Therefore any ongoing uses of these substances must be supplied from already existing stocks that were never used, or from recycled or reclaimed material. However, it should be noted that there are allowances for some ongoing limited production of these substances for certain essential uses and critical uses approved by the Montreal Protocol Parties (e.g. as process agents and for quarantine and pre-shipment uses). Also, production and use of these substances as feedstock is not considered production since they are consumed in the feedstock process. Destruction of ODS from these sources is not eligible under this protocol.

The Reserve's review of the U.S. commitment under the Montreal Protocol and its amendments indicates that destruction of ODS is not required in the U.S. at this time. Further, review of the Montreal Protocol makes clear that destruction is not required. The scope of the Montreal Protocol is limited to the production end of ODS management, and does not require destruction of extant stocks. As such, in reference to the Montreal Protocol and international law, destruction of U.S. sources of ODS meets the Legal Requirement Test.

A.2 Title VI of the Clean Air Act and 40 CFR 82

In 1988, the United States ratified the Montreal Protocol. By ratifying the Montreal Protocol and its subsequent amendments, the United States committed to a collaborative, international effort to regulate and phase out ODS, including CFC, HCFC, halons, carbon tetrachloride, methyl chloroform, methyl bromide, bromochloromethane, and HBFC.

The Montreal Protocol led to the inclusion of Title VI, Stratospheric Ozone Protection in the Clean Air Act Amendments of 1990. Title VI authorizes the EPA to manage the phase-out of ODS. Among the regulations established by EPA are requirements for the safe handling of ODS and prohibitions on the known venting or release of ODS into the atmosphere for the majority of applications, including refrigerants and fire suppressants. Therefore, as ODS are phased out, surplus ODS must be stored, reused (after recycling or reclamation) or destroyed.

EPA regulations issued under Sections 601-607 of the CAA phase out the production and import of ODS, consistent with the schedules developed under the Montreal Protocol. However, in the case of HCFC, EPA has used a "worst-first" approach to meet the Montreal Protocol required reduction caps. Under this approach, those HCFC with the highest ozone depletion potential (ODP) are phased out first. As of January 1, 2003, EPA banned production and import of HCFC-141b, the HCFC with the highest ODP. This action allowed the United States to reduce its consumption by 35 percent below the cap by the January 1, 2004 deadline and meet its obligations under the Montreal Protocol. As such, HCFC-141b is now entirely phased out and therefore eligible per this protocol.

In 2003 EPA issued baseline allowances for production and import of HCFC-22 and HCFC-142b, the two HCFC with the next highest ODP. The United States plans to meet the rest of the Montreal Protocol phase-out schedule through the following actions:

January 1, 2010	Ban on production and import of HCFC-22 and HCFC-142b except for on-going servicing needs in equipment manufactured before January 1, 2010.*
January 1, 2015	Ban on introduction into interstate commerce or use of HCFC except where the HCFC are used as a refrigerant in appliances manufactured prior to January 1, 2020.*
January 1, 2020	Ban on remaining production and import of HCFC-22 and HCFC-142b.*
January 1, 2030	Ban on remaining production and import of all other HCFC.*

* Certain additional exemptions apply, including exemptions for (1) HCFC used in processes resulting in their transformation or destruction, or (2) pre-authorized import of HCFC that are recovered and either recycled or reclaimed.

The Reserve's review of the CAA indicates that destruction of ODS is not required in the U.S. at this time. The CAA dictates a phase-out schedule for the production of ODS, and proffers guidance on handling, disposal, and other requirements but does not dictate that destruction of ODS occur. As such, in reference to the U.S. CAA and domestic law, destruction of U.S. sources of ODS meets the Legal Requirement Test.

Appendix B Summary of Performance Standard Development

The Reserve assesses the additionality of projects through application of a Performance Standard Test and a Legal Requirement Test. The purpose of a performance standard is to establish a standard of performance applicable to all ODS projects that is significantly better than average ODS management practice, which, if met or exceeded by a project developer, satisfies the criterion of "additionality." [55]

The sections below describe the analysis that forms the basis of the performance standard for each of the ODS sources within this protocol. The analysis included an examination of current practice related to 1) the destruction of ODS refrigerant and ODS foam blowing agent, and 2) the end-of-life treatment of foam.

B.1 Destruction of ODS from Refrigerants and Foam

Appendix A described the regulatory framework surrounding the end-of-life treatment of refrigerant and foam ODS and demonstrated that destruction is not required by law in the U.S. However, the Reserve looks not only at what the regulatory requirements are, but also at the prevailing practices in the industry. Therefore, with the project defined as destruction of ODS refrigerant or ODS blowing agent, the question remains: is destruction of ODS refrigerant and ODS blowing agent sourced within the U.S. standard practice or does it exceed standard practice?

For this analysis, the Reserve assessed common practice for CFC refrigerants and foams that have been phased out of U.S. production under the Montreal Protocol and U.S. Clean Air Act. This was done by comparing the proportion of recoverable ODS in the U.S. within a given year to the amount that was destroyed during that same time period to determine to what extent available ODS was being destroyed.

The Reserve's starting point for this assessment was U.S. EPA data records, including a report produced by ICF International entitled *ODS Destruction in the United States of America and Abroad* (2009). In addition to providing information on ODS destruction techniques and practices, the report supplies the specific quantity of ODS destroyed for the years 2003 and 2004 in the U.S.

The years 2003 and 2004 are particularly useful as they represent common practice before the initiation of carbon offset projects in the U.S. Subsequent to 2004, several ODS destruction projects were conducted for carbon credits on the Chicago Climate Exchange (CCX), and in possible anticipation of other offset programs. As such, destruction numbers from this post-2004 time period may artificially inflate the amount of ODS that is destroyed due to standard industry practice. The goal of this analysis is to determine what happened *in the absence* of a carbon incentive. Therefore, the 2003 to 2004 data represents a balance of current data on common practice *after* the CAA phase-out of ODS went into effect but *prior* to the availability of a carbon incentive.

[55] See the Climate Action Reserve's Program Manual for further discussion of the Reserve's general approach to determining additionality.

Table B.1. Destruction of ODS in the U.S.

CFC	2003 Destroyed (kg)	2004 Destroyed (kg)
CFC-11	58,846	109,884
CFC-12	23,709	62,364
CFC-114	464	4,044
CFC-115	4,401	6,737

Source: Reproduced from ICF, ODS Destruction in the United States of America and Abroad (2009), prepared for U.S. EPA.

While the 2003-2004 data above is useful because it is not yet influenced by the carbon market, it does nonetheless over-state the amount of destruction that took place during this time period because of the inclusion of ODS sourced from outside the U.S.

The applicability of this protocol is limited to ODS sourced from within the U.S. Therefore, the analysis of common practice must include only destroyed ODS that originated within the U.S. Several countries, including Canada and Australia, have taken a proactive approach to managing ODS and have strong ODS destruction programs that regularly send material to the U.S. for destruction. The Reserve compiled data from destruction facilities to determine the amount of destruction that could be attributed to these imports and subsequently subtracted from total U.S. destruction. Table B.2 presents this analysis including the resulting net U.S. destruction. To protect proprietary company data, Table B.2 provides only the aggregate amounts of ODS that was destroyed from imported stocks.

Table B.2. ODS Destroyed from Ineligible Imported Sources

ODS	Destroyed in U.S. (kg)		Imported for Destruction (kg)[56]		Net U.S. Sourced ODS Destroyed (kg)	
	2003	2004	2003[57]	2004	2003	2004
CFC-11	58,846	109,884	-	55,113	58,846	54,771
CFC-12	23,709	62,364	-	25,611	23,709	36,753
CFC-114	464	4,044	-	2,316	464	1,728
CFC-115	4,401	6,737	-	1,710	4,401	5,027

The goal of the performance standard is to determine the market penetration of a given activity. In order to determine the extent to which destruction occurred relative to the amount of ODS available in the U.S. prior to carbon incentives, the Reserve obtained data from U.S. EPA on the amount of ODS from refrigerant and foam that could be recovered for re-use and/or destruction in 2003 to 2004. The data source is U.S. EPA's Vintaging Model that tracks the type, age, refrigerant, leak rates, and other information for equipment and ODS applications within the U.S. market. By tracking this data through cooperation with industry, the U.S. EPA Vintaging Model is able to approximate when stocks of ODS will reach end-of-life.

At the Reserve's request, the U.S. EPA provided estimates of the quantity of ODS refrigerant that was contained in equipment reaching end-of-life in 2003-2004.[58] In addition to determining the amount of ODS that could be made available from refrigerants, the U.S. EPA provided

[56] Data provided by industry is presented anonymously to protect proprietary information.
[57] Data on imports could not be obtained for 2003. This results in a conservative performance standard analysis.
[58] The use of data from the U.S. EPA Vintaging Model into this protocol does not constitute an endorsement by EPA of the Climate Action Reserve or its methodology. Where actual measurements or other data was made available to and used by the Reserve in this protocol in lieu of the Vintaging Model data, this has been indicated in the protocol.

estimates of the number of residential refrigerators reaching end-of-life in 2003 and 2004. U.S. EPA assumed an ODS content of one pound CFC-11 foam blowing agent per refrigerator to establish the total amount ODS that could be made available for destruction from these appliances.

Table B.3. Recoverable ODS from End-of-Life Refrigeration Equipment and Foam Appliances in the U.S., 2003-2004[59]

ODS	Recoverable Refrigerant (kg)		Residential Refrigerator Foam at End of Life (kg)		Total Available for Destruction (kg)	
	2003	2004	2003	2004	2003	2004
CFC-11	717,140	700,310	3,499,545	3,516,364	4,216,685	4,216,674
CFC-12	12,725,841	10,997,307			12,725,841	10,997,307
CFC-114	154,710	154,710			154,710	154,710
CFC-115	1,833,654	2,207,326			1,833,654	2,207,326

Using the destruction data compiled by ICF International and the data on recoverable ODS refrigerants and ODS blowing agent from the U.S. EPA Vintaging Model, the Reserve derived the percentage of recoverable ODS that was destroyed in 2003-2004 (see Table B.4). Because the percentage of recoverable ODS destroyed was very low, the Reserve concluded that the destruction of refrigerant ODS without the incentive from the carbon market is not common practice. Therefore, any project that destroys the refrigerants listed in Table B.4 exceeds the performance standard.

Table B.4. Destruction of Recoverable, U.S. Sourced End-of-Life ODS

ODS	Total Available for Destruction (kg)		Domestic Sourced Destroyed (kg)		Performance Standard (Destroyed/Available)	
	2003	2004	2003	2004	2003	2004
CFC-11	4,216,685	4,216,674	58,846	54,771	1.40%	1.30%
CFC-12	12,725,841	10,997,307	23,709	36,753	0.19%	0.33%
CFC-114	154,710	154,710	464	1,728	0.30%	1.12%
CFC-115	1,833,654	2,207,326	4,401	5,027	0.24%	0.23%

The Reserve consulted with representatives from government, industry, and the destruction facilities responsible for ODS destruction to characterize the limited ODS destruction that did occur in 2003 to 2004. Although these representatives were unable to provide records indicating a precise breakdown of destruction purposes, they indicated that the destroyed ODS was primarily solvent that was deemed hazardous waste and required destruction, ODS destroyed by the U.S. government , and medical grade ODS. None of these sources are eligible under this protocol. Only a very small amount of highly contaminated ODS was sent for destruction by industry.

Under Version 1.0, ODS sourced from federal government installations or stockpiles was deemed ineligible. One reason for this decision was because some ODS sourced from the federal government was already being destroyed and it was suggested that this destruction was undertaken voluntarily as part of its existing commitment to responsible waste disposal. Since the issuance of Version 1.0, the Reserve has learned that the only ODS destroyed by the federal government is through a small number of demonstration projects and is not required by

[59] U.S. EPA. (2008). EPA Vintaging Model. *Version VM IO file_v4.2_10.07.08*.

any responsible waste disposal policies. While there is an executive order[60] that sets forth the following policy on ODS management, it does not mandate destruction:

"Each agency shall amend its personal property management policies and procedures to preclude the disposal of ODSs removed or reclaimed from its facilities or equipment, including disposal as part of a contract, trade, or donation, without prior coordination with the Department of Defense (DoD)."

The DoD operates an ODS Reserve to ensure adequate supplies of halons and refrigerants for weapons use. Communications with the staff at the DoD ODS Reserve have confirmed that there is no mandate or policy in place requiring or recommending the federal government destroy ODS. In fact, if there is excess refrigerant available from federal installations beyond the inventory needs of the DoD ODS Reserve, the refrigerant is turned over to the U.S. Defense Logistics Agency Disposition Services for resale to the public.

It is important to note that the federal government also comes to possess refrigerants through seizures of illegal material by U.S. Customs. This seized material would not be available through the U.S. Defense Logistics Agency Disposition Services, but rather through separate auctions conducted by U.S. Customs. ODS sourced from illegal seizures is not eligible under this protocol because it was not produced in the United States.

B.2 End-of-Life Treatment of Foam

The Reserve also reviewed separately the common practice in the end-of-life treatment of foams containing ODS blowing agents. Whereas U.S. EPA regulations prohibit the intentional release of ODS refrigerants to the atmosphere, there is no preclusion against disposal practices that result in release of ODS blowing agents.

According to the 2005 TEAP *Report of the Task Force on Foam End-of-Life Issues*, there is little or no experience with the recovery of foams from buildings or of the ODS contained within the foams. This is mainly because few buildings containing foam with ODS blowing agent have been demolished, deconstructed, or renovated yet. The average overall lifecycle of buildings in North America and other developed countries ranges from 30 to 50 years. Meanwhile, the common use of foam in insulation only really began in the mid 1970s after the energy crisis led to increased use of insulation. With an average turnover rate of building stock in North America of less than one percent per year, buildings with foam insulation are only just beginning to enter the waste stream. As a result, the management of ODS from building foam has not yet become a focus of regulators. Other factors that have prevented the recovery and destruction of building foam include challenges involved with separating foam from the building structure, the common practice of landfilling construction waste without any pretreatment (only 20 to 30 percent of building materials are recycled or sold in the United States), the very small proportion of ODS foam compared to overall construction waste, and a lack of regulations in the United States governing recovery of building foam insulation and the ODS contained therein.

The destruction of ODS from foam in appliances and equipment is also very limited in the U.S. The 2005 TEAP *Report of the Task Force on Foam End-of-Life Issues* describes the results of an AHAM survey which provides the following breakdown of common appliance disposal practices in the United States:

[60] Executive Order 13423 - "Strengthening Federal Environmental, Energy, and Transportation Management", March 29, 2007.

- 90 percent appliances shredded without blowing agent recovery and landfilled
- 7.5 percent appliances crushed whole and landfilled
- 1.5 percent appliances shredded with blowing agent recovery or destruction
- One percent appliances abandoned

As noted in the survey results, only 1.5 percent of appliances are being shredded with the containing foam blowing agent either being recovered for reuse in the refrigeration market or destroyed. This foam shredding and recovery is being driven mainly by state, local and utility energy efficiency initiatives with some program administrators adding a second requirement that the blowing agent must be recovered as well. Most of these programs are voluntary and meet their objectives by incentivizing early appliance retirement and recycling through rebates or discounts on new units. As noted in the TEAP report, the process for recovering ODS from appliance foam is costly and is currently not self-sustaining unless outside sponsorship is provided. Although U.S. EPA and others track information on the amount of foam that is being shredded and the blowing agent that is being recovered, there is no data available on the share of blowing agent that is being reused versus destroyed. According to industry analysts, most of the recovered blowing agent is being resold into the refrigeration market because of the economic incentive to do so. Destruction will only occur in cases where the utility or other entity participating in the appliance program specifically requests that this must take place. As a result, the destruction of ODS blowing agent is likely significantly less than the 1.5 percent share of appliances where the disposal includes management of the blowing agent.

Because the destruction of blowing agent from building foam does not occur and the destruction from appliances is very low, the Reserve concluded that the destruction of foam blowing agent is not common practice.

Appendix C Rules Governing ODS Destruction

This protocol requires that all ODS be destroyed at a destruction facility that is compliant with both the international standards specified in the TEAP *Report of the Task Force on Destruction Technologies*,[61] as well as the requirements of domestic law. This appendix provides a brief summary of the U.S. rules for destruction of ODS, and the criteria that must be met for a destruction facility to qualify under this protocol.

All ODS destruction is regulated under stratospheric ozone protection regulations under the Clean Air Act (CAA) (40 CFR 82). Additionally, because some ODS are classified as hazardous wastes (such as CFC-113, methyl chloroform, and carbon tetrachloride), facilities that handle these ODS are regulated under the Resource Conservation and Recovery Act (RCRA). Hazardous waste combustors (HWCs, e.g. incinerators) that destroy ODS classified as hazardous waste are also regulated by the Maximum Achievable Control Technology (MACT) standard under the CAA.

Under the authority of the CAA, the stratospheric ozone protection regulations (40 CFR Part 82, Subpart A) require that ODS be destroyed using one of the following destruction technologies approved by the Montreal Protocol Parties:

1. Liquid injection incineration
2. Reactor cracking
3. Gaseous/fume oxidation
4. Rotary kiln incineration
5. Cement kiln
6. Radio frequency plasma
7. Municipal waste incinerators (only for the destruction of foams)
8. Argon arc plasma

Additionally, if the substance is to be considered "completely destroyed" as defined in the regulations, it must be destroyed to a 98 percent destruction efficiency (DE). This is slightly different from the Montreal Protocol Technology and Economic Assessment Panel which recommends a destruction and removal efficiency (DRE) limit of 99.99 percent. DE is a more comprehensive measure of destruction than DRE as it includes emissions of undestroyed chemical from all points (e.g. stack gases, fly ash, scrubber, water, bottom ash), while DRE includes emissions of undestroyed chemical from the stack gas only. However, because of the relatively volatile nature of ODS and because, with the exception of foams, they are generally introduced as relatively clean fluids, one would not expect a very significant difference between DRE and DE.

Any destruction facility that is regulated by U.S. EPA as a RCRA-permitted HWC is automatically considered a qualifying destruction facility under this protocol.

Non-RCRA permitted facilities may also be deemed qualifying destruction facilities if they meet the pertinent guidelines provided by the TEAP *Report of the Task Force on Destruction Technologies*, and reproduced below. By inclusion here, the recommendations of the excerpted section of the TEAP report shall be binding on all non-RCRA destruction facilities. Destruction

[61] TEAP. (2002). Report of the Task Force on Destruction Technologies. *Volume 3B*.

facilities must provide third-party certified results indicating that the facility meets all performance criteria set forth below. Following the initial performance testing, project developers must demonstrate that the facility has conducted comprehensive performance testing at least every three years to validate compliance with the TEAP DRE and emissions limits as reproduced below.

(Reproduced in full from TEAP *Report of the Task Force on Destruction Technologies*, Chapter 2 (2002). References in the following section pertain to the *Report* document, not this protocol.)

CHAPTER 2

2.0 TECHNOLOGY SCREENING PROCESS

2.1 Criteria for Technology Screening

The following screening criteria were developed by the UNEP TFDT. Technologies for use by the signatories to the Montreal Protocol to dispose of surplus inventories of ODS were assessed on the basis of:

1. Destruction and Removal Efficiency (DRE)
2. Emissions of dioxins/furans
3. Emissions of other pollutants (acid gases, particulate matter, and carbon monoxide)
4. Technical capability

The first three refer to technical performance criteria selected as measures of potential impacts of the technology on human health and the environment. The technical capability criterion indicates the extent to which the technology has been demonstrated to be able to dispose of ODS (or a comparable recalcitrant halogenated organic substance such as PCB) effectively and on a commercial scale.

For convenience, the technical performance criteria are summarized in Table 2-1. These represent the minimum destruction and removal efficiencies and maximum emission of pollutants to the atmosphere permitted by technologies that qualify for consideration by the TFDT for recommendation to the Parties of the Montreal Protocol for approval as ODS destruction technologies. The technologies must also satisfy the criteria for technical capability as defined in Section 2.1.4.

Table 2-1: Summary of Technical Performance Qualifications[62]

Performance Qualification	Units	Diluted Sources	Concentrated Sources
DRE	%	95	99.99
PCDDs/PCDFs	ng-ITEQ/Nm^3	0.5	0.2
HCl/Cl_2	mg/Nm^3	100	100
HF	mg/Nm^3	5	5
HBr/Br_2	mg/Nm^3	5	5
Particulates (TSP)	mg/Nm^3	50	50
CO	mg/Nm^3	100	100

[62] All concentrations of pollutants in stack gases and stack gas flow rates are expressed on the basis of dry gas at normal conditions of 0ºC and 101.3 kPa, and with the stack gas corrected to 11 percent O_2.

2.1.1 Destruction and Removal Efficiency

Destruction Efficiency (DE)[63] is a measure of how completely a particular technology destroys a contaminant of interest – in this case the transformation of ODS material into non-ODS by-products. There are two commonly used but different ways of measuring the extent of destruction – DE and Destruction and Removal Efficiency (DRE).[64] For a more detailed explanation of how DRE is calculated, see section 4.2.1. The terms are sometimes interchanged or used inappropriately. DE is a more comprehensive measure of destruction than DRE, because DE considers the amount of the chemical of interest that escapes destruction by being removed from the process in the stack gases and in all other residue streams. Most references citing performance of ODS destruction processes only provide data for stack emissions and thus, generally, data is only available for DRE and not DE.

Because of the relatively volatile nature of ODS and because, with the exception of foams, they are generally introduced as relatively clean fluids, one would not expect a very significant difference between DRE and DE.

For these reasons this update of ODS destruction technologies uses DRE as the measure of destruction efficiency.

For the purposes of screening destruction technologies, the minimum acceptable DRE is:

- 95 percent for foams; and,
- 99.99 percent for concentrated sources.

It should be noted that measurements of the products of destruction of CFC, HCFC and halons in a plasma destruction process have indicated that interconversion of ODS can occur during the process. For example, under some conditions, the DRE of CFC-12 (CCl_2F_2) was measured as 99.9998 percent, but this was accompanied by a conversion of 25 percent of the input CFC-12 to CFC-13 ($CClF_3$), which has the same ozone-depleting potential. The interconversion is less severe when hydrogen is present in the process, but can nonetheless be significant.[65] For this reason, it is important to take into account all types of ODS in the stack gas in defining the DRE.

For the reasons described in the previous paragraph, the Task Force recommends that future calculations of DRE use the approach described below.[66]

[63] Destruction Efficiency (DE) is determined by subtracting from the mass of a chemical fed into a destruction system during a specific period of time the mass of that chemical that is released in stack gases, fly ash, scrubber water, bottom ash, and any other system residues and expressing that difference as a percentage of the mass of the chemical fed into the system.

[64] Destruction and Removal Efficiency (DRE) has traditionally been determined by subtracting from the mass of a chemical fed into a destruction system during a specific period of time the mass of that chemical alone that is released in stack gases, and expressing that difference as a percentage of the mass of that chemical fed into the system.

[65] Deam, R. T., Dayal, A. R., McAllister, T., Mundy, A. E., Western, R. J., Besley, L. M., Farmer, A. J. D., Horrigan, E. C., & Murphy, A. B. (1995). Interconversion of chlorofluorocarbons in plasmas. *J. Chem. Soc.: Chem. Commun. No. 3,* 347-348; Murphy, A. B., Farmer, A. J. D., Horrigan, E. C., & McAllister, T. (2002). Plasma destruction of ozone depleting substances, *Plasma Chem. Plasma Process, 22,* 371-385.

[66] Since different ODS have different ODP, consideration should be given to taking into account the ODP of each type of ODS present in the stack gas in calculating the DRE. An appropriate definition that takes into account the differences in ODP is: *DRE of an ODS is determined by subtracting from the number of moles of the ODS fed into a destruction system during a specific period of time, the total number of moles of all types of ODS that are released in*

DRE of an ODS should be determined by subtracting from the number of moles of the ODS fed into a destruction system during a specific period of time, the total number of moles of all types of ODS that are released in stack gases, and expressing that difference as a percentage of the number of moles of the ODS fed into the system.

In mathematical terms, $$\mathrm{DRE} = \frac{N_1^{\mathrm{in}} - \sum_i N_i^{\mathrm{out}}}{N_1^{\mathrm{in}}}$$

Where N_1^{in} is the number of moles of the ODS fed into the destruction system, and N_i^{out} is the number of moles of the *i*th type of ODS that is released in the stack gases.

2.1.2 Emissions of Dioxins and Furans

Any high temperature process used to destroy ODS has associated with it the potential formation (as by-products) of polychlorinated dibenzo-paradioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). These substances are among the products of incomplete combustion (or PICs) of greatest concern for potential adverse effects on public health and the environment. The internationally recognized measure of the toxicity of these compounds is the toxic equivalency factor (ITEQ),[67] which is a weighted measure of the toxicity for all the members of the families of these toxic compounds that are determined to be present.

The task force members note that the World Health Organization has developed a new system for calculating TEQs, however, most of the existing data on emissions is expressed in the former ITEQ system established in 1988.

For purposes of screening destruction technologies, the maximum concentration of dioxins and furans in the stack gas from destruction technologies is:

- 0.5 ng-ITEQ/Nm^3 for foams; and,
- 0.2 ng-ITEQ/Nm^3 for concentrated sources.

These criteria were determined to represent a reasonable compromise between more stringent standards already in place in some industrialized countries [for example, the Canada-Wide Standard of 0.08 ng/m^3 (ITEQ)], and the situation in developing countries where standards may be less stringent or non-existent. Although a previous standard of 1.0 ng/m^3 (ITEQ) had been

stack gases, weighted by their ODP relative to that of the feed ODS, and expressing that difference as a percentage of the number of moles of the ODS fed into the system.

[67] There are 75 chlorinated dibenzo-p-dioxins and 135 chlorinated dibenzofurans that share a similar chemical structure but that have a wide range in degree of chlorination and a corresponding wide range in toxicity. Of these, one specific dioxin [2,3,7,8-Tetrachlorodibenzo-p-dioxin, or (TCDD)] is the most toxic and best characterized of this family of compounds. Since PCDDs and PCDFs are generally released to the environment as mixtures of these compounds, the scientific community has developed a system of toxic equivalency factors (TEFs) which relate the biological potency of compounds in the dioxin/furan family to the reference TCDD compound. The concentration of each specific compound is multiplied by its corresponding TEF value, and the resulting potency-weighted concentration values are summed to form an expression of the mixture's overall toxic equivalence (TEQ). The result of this exercise is a standardized expression of toxicity of a given mixture in terms of an equivalent amount of TCDD (the reference compound). The internationally accepted protocol for determining TEQ – i.e. ITEQ – was established by NATO in 1988. [North Atlantic Treaty Organization/Committee on the Challenge of Modern Society. (1988). Scientific Basis for the Development of International Toxicity Equivalency Factor (I-TEF), Method of Risk Assessment for Risk Assessment of Complex Mixtures of Dioxins and Related Compounds. *Report No. 176*, Washington, D.C.]

suggested in the UNEP 1992 report, advances in technology in recent years, and the level of concern for emissions of these highly toxic substances justified a significantly more stringent level.

2.1.3 Emissions of Acid Gases, Particulate Matter and Carbon Monoxide

Acid gases are generally formed when ODS are destroyed and these must be removed from the stack gases before the gases are released to the atmosphere. The following criteria for acid gases have been set for purposes of screening destruction technologies:

- a maximum concentration in stack gases of 100 mg/Nm^3 HCl/Cl_2;
- a maximum concentration in stack gases of 5 mg/Nm^3 HF; and,
- a maximum concentration in stack gases of 5 mg/Nm^3 HBr/Br_2.

Particulate matter is generally emitted in the stack gases of incinerators for a variety of reasons and can also be emitted in the stack gases of facilities using non-incineration technologies. For the purposes of screening technologies, the criterion for particulate matter is established as:

- a maximum concentration of total suspended particulate (TSP) of 50 mg/Nm^3.

Carbon monoxide (CO) is generally released from incinerators resulting from incomplete combustion and may be released from some ODS destruction facilities because it is one form by which the carbon content of the ODS can exit the process. Carbon monoxide is a good measure of how well the destruction process is being controlled. For the purposes of screening technologies, the following criterion has been established:

- a maximum CO concentration in the stack gas of 100 mg/Nm^3.

These maximum concentrations apply to both foams and concentrated sources. They were set to be achievable by a variety of available technologies while ensuring adequate protection of human health and the environment.

2.1.4 Technical Capability

As well as meeting the above performance requirements it is necessary that the destruction technologies have been demonstrated to be technically capable at an appropriate scale of operation. In practical terms, this means that the technology should be demonstrated to achieve the required DRE while satisfying the emissions criteria established above. Demonstration of destruction of ODS is preferred but not necessarily required. Destruction of halogenated compounds that are refractory, i.e. resistant to destruction, is acceptable. For example, demonstrated destruction of polychlorinated biphenyls (PCBs) was often accepted as an adequate surrogate for demonstrated ODS destruction.

For this evaluation, an ODS destruction technology is considered technically capable if it meets the following minimum criteria:

- It has been demonstrated to have destroyed ODS to the technical performance standards, on at least a pilot scale or demonstration scale (designated in Table 2-2 as “Yes”).

- It has been demonstrated to have destroyed a refractory chlorinated organic compound other than an ODS, to the technical performance standards, on at least a pilot scale or demonstration scale (designated in Table 2-2 as “P,” which indicates

that the technology is considered to have a high potential for application with ODS, but has not actually been demonstrated with ODS).

- The processing capacity of an acceptable pilot plant or demonstration plant must be no less than 1.0 kg/hr of the substance to be destroyed, whether ODS or a suitable surrogate.

These criteria of technical capability will minimize the risk associated with technical performance and ensure that destruction of ODS will be performed in a predictable manner consistent with protecting the environment.

Appendix B presents a detailed discussion of the selection of 1.0 kg/hr as the minimum capacity for a pilot plant in order to demonstrate technical capability, which represents a change from the criterion originally selected in the 1992 UNEP report.

Appendix D Development of Refrigerant Emissions Rates

Under this protocol refrigerant emissions are estimated in reference to the emission loss rates of the equipment into which those refrigerants would have been installed in the baseline. This appendix explains the methodology the Reserve followed to determine the protocol's prescribed emission rates for refrigerant baseline and project emissions.

As described in Appendix A, the CAA and 40 CFR 82 prohibit intentional venting of ODS to the atmosphere. However, due to the disperse nature of servicing and ODS recovery, a significant portion of ODS refrigerants are unintentionally lost during recovery. As a result, every year a significant quantity of ODS is released directly to the atmosphere during equipment servicing and handling, but due to the dispersed nature of these emissions it is difficult to determine the overall share that is being emitted rather than re-used.

The CAA allows the recovery and sale of reclaimed ODS to the refrigeration and air conditioning markets. In fact, because they can no longer be produced or imported, ODS refrigerants still have a high value for recovery and reuse. Whereas destruction of recovered ODS imposes a cost on industry, resale provides positive revenue from recovered ODS.

As previously noted, the share of ODS refrigerant that is recovered and sold to market versus the share that is released during servicing and end-of-life is unknown. To avoid overestimating emissions in the baseline, the conservative approach for estimating GHG reductions is to assume that all ODS is being recovered and recycled into the ODS end use market. The baseline scenario for refrigerants under this protocol is therefore defined as full recovery and recharge for refrigeration and air conditioning applications.

The population of equipment that utilizes ODS refrigerants is rapidly aging and approaching end of life. As such, this equipment exhibits relatively high emission rates and refrigerants are lost to the atmosphere at a rapid rate. For the purposes of this protocol, the baseline emissions of ODS are defined as the amount of ODS that would have been released over the ten-year crediting period had it not been destroyed, but rather been used to recharge existing equipment (see Figure D.1).

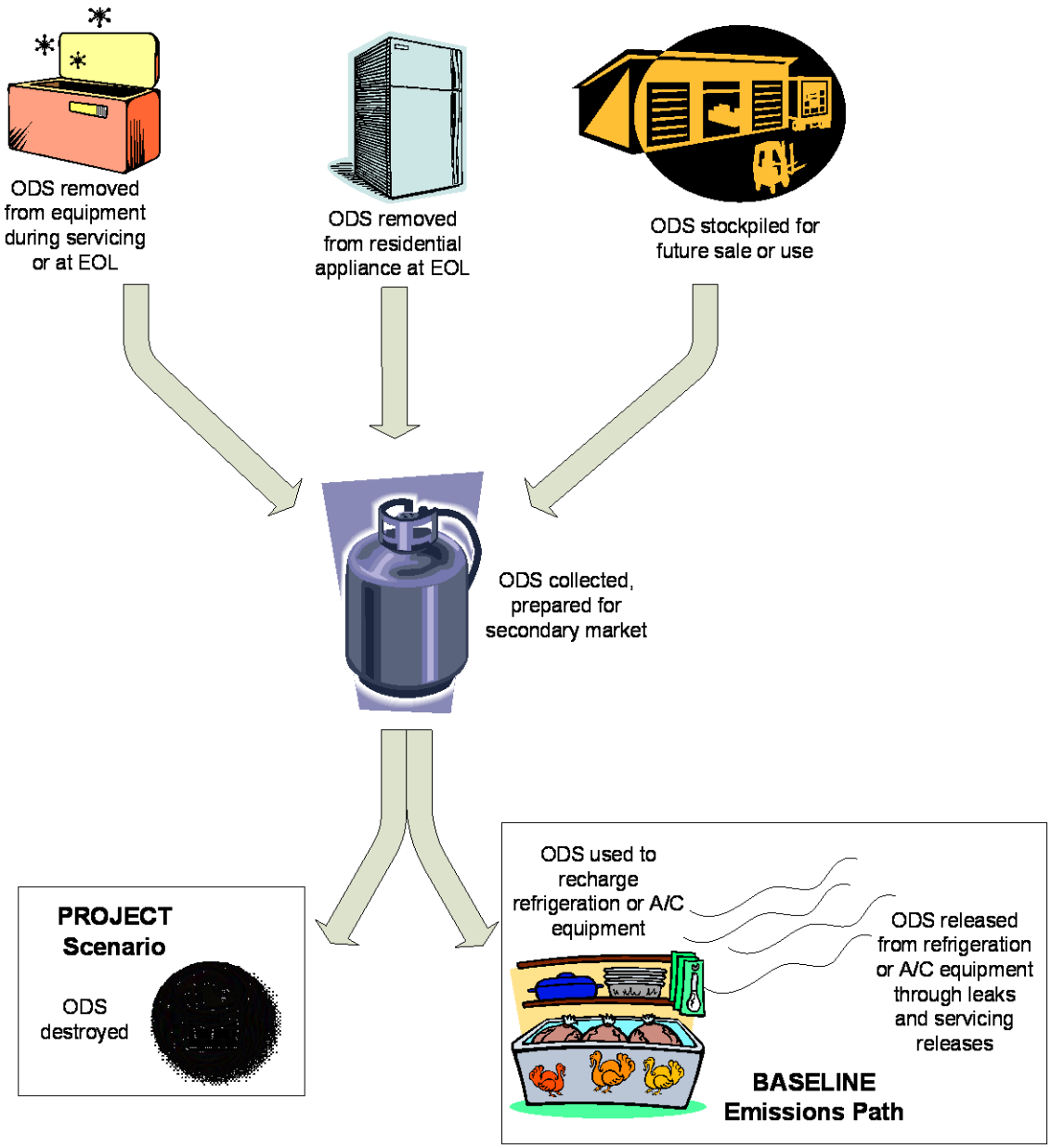


Figure D.1. Illustration of Refrigerant Project Baseline Scenario and Project Scenario

D.1 Baseline Emissions Rates

The refrigerant baseline scenario is defined as recirculation into the refrigerant re-sale market. This market can either be supplied by recovered, or recoverable, ODS refrigerant or refrigerant currently being stockpiled. Determining why refrigerant may have been removed from certain equipment – why a chiller may have been decommissioned or likewise, why excess supplies may exist and why a stockpile was not utilized – is beyond the scope of this protocol because it cannot be assessed in the standardized manner required by the Reserve. Therefore, to enable standardization the baseline is calculated from the time that ODS refrigerant has been recovered, and focuses on what would have happened to a given quantity of ODS refrigerant in the re-sale market. By defining the baseline in this way, the Reserve is able to utilize a single

baseline for refrigerant removed from residential appliances (e.g. refrigerators or A/C units) and commercial or industrial equipment.

When ODS enters the re-sale market it could be used in any refrigeration or A/C equipment that needs servicing, regardless of whether it is for large refrigeration, large A/C, or mobile A/C. Since it is impossible to know the exact equipment that the destroyed ODS would have been used in, and the associated emission rate, the ODS baseline is defined as the weighted average of all end-use emission rates of ODS refrigerant in the market under the assumption that it would be absorbed into the overall market. The emission rate for refrigerants is defined as the total annual emissions resulting from both leaks and servicing events of the equipment that would have been recharged by the ODS refrigerant had it not been destroyed.

To determine the applicable weighted emission rate for each ODS refrigerant, the Reserve used data provided by the U.S. EPA from the Vintaging Model. This model compiles estimates of the type, age, refrigerant, leak rates, servicing emission rates, and other information for equipment and ODS applications within the U.S. market. The EPA has tracked this data through years of cooperation with industry, and as a result the EPA Vintaging Model is able to approximate when stocks of ODS will reach end-of-life, and the rates at which installed banks of ODS will be emitted from various equipment categories.

The Vintaging Model is based on industry surveys, engineering estimates, stakeholder feedback, and approximations of industry trends and technologies and is used primarily as a predictive tool rather than a tool for regulating industry. As a result, estimates of emission rates for individual equipment categories may be uncertain and may either over- or under-estimate actual emissions. However, at an aggregate level the model provides a reasonably accurate representation of ongoing emissions for the ODS market as a whole. Despite its limitations, the Vintaging Model represents a comprehensive data source on the U.S. ODS industry, and is therefore the best source for developing emission estimates for each source of ODS in the protocol.

The accuracy of the Vintaging Model increases with greater levels of data aggregation. That is, it likely more accurately estimates CFC emissions from the U.S. economy as a whole than it does CFC emissions from a specific end use like centrifugal chillers. In this protocol, the Reserve has aggregated data to an intermediate level. The categories provided in this protocol were selected because they were determined to be an appropriate balance of specificity and aggregation by the Reserve in consultation with the working group and stakeholders. While finer resolution data is presented in this appendix to illustrate the way in which the Reserve calculated these aggregated values, it should be stressed that each individual value is an approximation and not an exact value.

At the Reserve's request, the EPA ran the Vintaging Model and provided data on the weighted average emission rates for CFC-11, CFC-12, CFC-114, and CFC-115 as indicated in Table D.1. These outputs are composites of emission rates associated with dozens of separate subcategories within the refrigeration market that are reflected in the Vintaging Model.

As illustrated in Table D.1, the resulting weighted average emission rates derived from the Vintaging Model are based on emissions from the Mobile A/C, Large Refrigeration, and Large A/C sub-sectors, as these were identified as the sub-sectors of the market where refrigerant recharge predominantly will occur in 2012.

The EPA Vintaging Model assumptions rely on the expected life of various types of equipment that utilize ODS. Because vehicles with CFC-12 systems are older than the assumed 12-year lifespan of a vehicle, the Vintaging Model indicated that no CFC-12 will be used in the automotive sector in 2012. Consultation with members of the refrigerant reclaim and wholesale industry indicated that CFC-12 is still being sold in large quantities for mobile A/C applications. In fact, upwards of 50 percent of the U.S. CFC-12 demand may be in the mobile market. The Reserve confirmed this finding through review of confidential sales records that indicated a majority of CFC-12 sales were intended for the automotive market. Accordingly, a 50 percent mobile market share has been assumed to be conservative, and the Vintaging Model data has been adjusted accordingly. For the mobile market the Reserve further assumed an emission rate of 40.7 percent (leak and servicing emissions) per year for CFC-12, and 18 percent emission rate for the replacement, HFC-134a.

As the EPA Vintaging Model does not track CFC-13 and CFC-113 as refrigerants, the Reserve used conservative assumptions to derive appropriate emission rates. Our understanding is that CFC-13 is used as a very low temperature refrigerant. Since the system size it is utilized in is uncertain, the Reserve assumed a large refrigeration system to be conservative. The California Air Resources Board (ARB) Compliance Offset Protocol for ODS projects utilizes a nine percent annual leak rate for large refrigeration systems, in accordance with the impact of California's Refrigerant Management Program. To be conservative and consistent with the ARB compliance protocol, the Reserve has used this same nine percent annual leak rate. CFC-113 is used primarily in chillers, much like CFC-11. The Reserve conservatively assumed that all CFC-113 went into large A/C applications. The same emission rate and substitution rate as CFC-11 were used, as the chemicals' application and use are similar. This is also consistent with the ARB compliance protocol.

The results, incorporating both industry and Vintaging Model data, are presented in Table D.1.

Table D.1. Weighted Average Annual Loss Rate Percent and Market Share for Class I ODS [68]

	2010 Weighted Average Annual Loss Rate Percent and Market Share for Class I ODS											
	CFC-11		CFC-12		CFC-13		CFC-113		CFC-114		CFC-115	
Refrigeration and A/C Sector	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate
Mobile[69]	-	-	50%	41%	-	-	-	-	-	-	-	-
Large Refrigeration	3%	19%	33%	10%	100%	9%	-	-	-	-	100%	25%
Large AC	97%	20%	17%	14%	-	-	100%	20%	100%	14%	-	-
Market-Weighted Annual Loss Rate	**20%**		**26%**		**9%**		**20%**		**14%**		**25%**	
10-year Total Loss	**89%**		**95%**		**61%**		**89%**		**77%**		**94%**	

[68] EPA. (2011). EPA Vintaging Model. *Version VM IO file_v4.4_3.23.11.*
[69] The market share for mobile refrigeration was derived from industry surveys conducted by Reserve staff.

The categories identified in Table D.1 are weighted aggregates of the subsectors presented in Table D.2.

Table D.2. Characterization of Categories from the EPA Vintaging Model

Category	End Use
Large AC	Centrifugal Chillers
	Positive Displacement Chillers
Large Refrigeration	Large Retail Food
	Cold Storage
	Refrigerated Transport
	Industrial Process Refrigeration
Mobile	Mobile AC
	School & Tour Buses AC
	Transit Buses AC
	Trains AC
Small AC	Dehumidifiers
	Window Units
	Unitary A/C
	Water & Ground Source HP
	Packaged Terminal AC/HP
Small Refrigeration	Small and Medium Retail Food
	Household Refrigerated Appliances
	Ice Makers

Interviews with industry experts indicated that a large share of recoverable refrigerant is vented to the atmosphere directly rather than re-introduced as recycled or reclaimed material into the market. As this would result in 100 percent immediate release, calculating all refrigerant ODS baseline emissions according to a market emission rate as described above is conservative.

The weighted annual emission rates calculated in Table D.1 are used in the protocol to calculate baseline emissions from the release of ODS refrigerant in Equation 5.3.

D.2 Project Emissions Rates

By removing ODS refrigerant from the re-sale market through destruction projects, substitute refrigerants will be required to fulfill the U.S. refrigeration need. Much as predicting the baseline use of destroyed ODS is difficult and inappropriate, so too is predicting the specific refrigerant that will fill the void when the ODS is destroyed and the baseline does not come to pass because of the project. Therefore, the Reserve employed the same technique used for establishing the emissions rate of the baseline when developing a generic, weighted substitute GWP and emission rate for the project.

Substitute emissions for CFC-11, CFC-12, CFC-114, and CFC-115 are based on the weighted average of new market entrants for their respective refrigeration purposes as modeled by the EPA Vintaging Model for 2012. Pulling from industry expertise and internal EPA research, the Vintaging Model predicts that the ODS substitutes in Table D.3 through Table D.8 will be the dominant refrigerant substitutes. The model further provides the emission rates associated with each substitute, the relative charge size of the substitute required to meet the same refrigerant

need as the replaced ODS,[70] and data on the market share attributable to each substitute. Using this information, the Reserve calculated the weighted average substitute emissions per pound of ODS destroyed.

The parameters of substitute emissions are used in the protocol to estimate the project scenario emissions associated with the use of substitute refrigerants in Equation 5.6.

[70] In many cases, more or less of a substitute refrigerant is needed to perform the same function as the replaced ODS.

Table D.3. Calculation of Substitute Emissions for CFC-11

Application	CFC-11 Recharge Market Share	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-11 Market Share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub Used to Replace One lb CFC-11 (lbs)	Loss Rate of Sub (%/yr)	10-year $lbCO_2e$/ODS Destroyed
Large Refrigeration	3%	HCFC-123	65%	2%	90	0.88	0.017	5%	1
		HFC-134a	35%	1%	1300	1.4	0.019	5%	8
Large AC	97%	HCFC-123	41%	33%	90	0.88	0.289	2%	7
		HFC-134a	59%	64%	1300	1.4	0.894	2%	186
					CFC-Sub Emissions ($lbCO_2e$/lbODS destroyed)				**202**

Table D.4. Calculation of Substitute Emissions for CFC-12

Application	CFC-12 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-12 Market Share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub Used to Replace One lb CFC-12 (lbs)	Loss Rate of Sub (%/yr)	10-year $lbCO_2e$/ODS Destroyed
Mobile	50%	HFC-134a	100%	50%	1300	.74	0.370	18%	415
Large Refrigeration	33%	HCFC-123	14%	8%	90	0.88	0.068	4%	1
		HFC-134a	34%	20%	1300	1.4	0.278	4%	73
		R-404A	36%	3%	2028	0.78	0.026	11%	130
		R-410A	1%	1%	1725	0.88	0.005	5%	2
		R-507A	16%	1%	3300	0.78	0.008	12%	95
Large AC	17%	HCFC-123	19%	2%	90	0.88	0.014	1%	0
		HFC-134a	78%	14%	1300	1.4	0.196	3%	59
		R-407C	3%	2%	1526	0.76	0.012	2%	1
		R-410A	1%	0%	1725	0.76	0.003	1%	0
					CFC-Sub Emissions ($lbCO_2e$/lbODS destroyed)				**777**

Table D.5. Calculation of Substitute Emissions for CFC-13

Application	CFC-13 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-13 market share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub Used to Replace One lb CFC-13 (lbs)	Loss Rate of Sub (%/yr)	10-year $lbCO_2e$/ODS Destroyed
Large Refrigeration	100%	HFC-23	100%	100%	11700	1	1.000	9%	7144
					CFC-Sub Emissions ($lbCO_2e$/lbODS destroyed)				**7144**

Table D.6. Calculation of Substitute Emissions for CFC-113

Application	CFC-113 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-113 Market Share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub used to Replace One lb CFC-113 (lbs)	Loss Rate of Sub (%/yr)	10-year $lbCO_2e$/ODS Destroyed
Large AC	100%	HCFC-123	34%	34%	77	0.88	0.299	2%	5
		HFC-134a	66%	66%	1300	1.4	0.925	2%	215
					CFC-Sub Emissions ($lbCO_2e$/lbODS destroyed)				**220**

Table D.7. Calculation of Substitute Emissions for CFC-114

Application	CFC-114 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-114 Market Share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub Used to Replace One lb CFC-114 (lbs)	Loss Rate of Sub (%/yr)	10-year $lbCO_2e$/ODS Destroyed
Large AC	100%	HFC-134a	100%	100%	1300	1.4	1.400	4%	659
					CFC-Sub Emissions ($lbCO_2e$/lbODS destroyed)				**659**

Table D.8. Calculation of Substitute Emissions for CFC-115

Application	CFC-115 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-115 Market Share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub used to Replace One lb CFC-115 (lbs)	Loss Rate of Sub (%/yr)	10-year $lbCO_2e$/ODS Destroyed
Large Refrigeration	100%	R-404A	68%	53%	2028	0.85	0.448	17%	999
		R-507A	31%	12%	3300	0.85	0.101	15%	691
		Non-ODP/GWP	1%	36%	0	1	0.355	15%	0
					CFC-Sub Emissions ($lbCO_2e$/lbODS destroyed)				**1689**

Appendix E Foam Recovery Efficiency and Calculations

The following methodology calculates the site- or process-specific recovery efficiency for blowing agent recovery projects, and uses this value for calculation of emission reductions in Section 5. Determination of accurate recovery efficiency allows baseline emissions and project emissions to be calculated in reference to the initial quantity of foam blowing agent diverted from baseline treatment.

The methodology prescribed in this appendix uses a mass balance approach similar to that utilized by the Waste Electrical and Electronic Equipment Directive (WEEE),[71] RAL Quality Assurance Association (RAL),[72] and other internationally recognized standards. However, applying these standards directly to projects using this protocol was deemed inappropriate for several reasons.

First, these standards are based on assumptions about the size of appliances, quantity of foam, and concentration of CFC foam blowing agent in the polyurethane (PU) foam found in Europe. The empirical work underlying these assumptions was conducted in Europe, and it is unclear whether these values are similar in the U.S. The Reserve's research indicates that U.S. appliances are larger, have a greater quantity of foam per appliance, and a higher concentration of CFC foam blowing agent in the PU foam.

Second, the existing international standards are intended to benchmark best practices in appliance recycling and ODS recovery. Accordingly, uncertainty in the assumptions of these standards (e.g. kg foam per appliance, concentration of ODS blowing agent) is acceptable provided that the standard is consistently applied from one project to the next. As such, these standards provide a means of comparison between processes or practices, but do not provide a mechanism by which to calculate losses of ODS that may occur during the project activity. As a GHG accounting methodology, this protocol must provide a mechanism for estimating project emissions that occur during recycling.

The methodology provided in this appendix differs in one significant way from the internationally accepted standards that precede it. The other standards dictate a minimum recover efficiency of 90 percent that must be demonstrated. This protocol does not specify a minimum recovery efficiency, but instead builds in an incentive to optimize ODS blowing agent recovery. For application in the U.S., where blowing agent recovery to a concentrated form is rare, this approach has several advantages.

While the Reserve fully endorses a 90 percent or higher recovery efficiency as the end goal, this method will allow gap or bridge technologies and processes with lower than 90 percent recovery to be eligible provided that emissions accounting is properly conducted and credited.

Additionally, higher recovery efficiencies – including those above 90 percent – are incentivized by minimizing project emissions (deducted at 100 percent) in the calculations, in addition to increasing the quantity of ODS recovered and destroyed (calculated only as released portion, per Equation 5.7).

[71] WEEE Forum. (2007). Requirements for the Collection, Transportation, Storage, Handling and Treatment of Household Cooling and Freezing Appliances containing CFC, HCFC, or HFC.
[72] RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V. (2007). Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment.

E.1 Calculating Recovery Efficiency

All appliance foam projects must calculate a recovery efficiency once per project based on a run of a minimum ten appliances. Basing this analysis on a number of appliances greater than ten will likely result in a higher calculated recovery efficiency due to the 90 percent upper confidence limit used for calculating the concentration of ODS blowing agent in the foam. A larger sample size will decrease uncertainty and thus lower the estimated blowing agent concentration and increase recovery efficiency; however, sampling of additional appliances will also increase testing costs.

The procedures below shall be used to calculate recovery efficiency.

Estimate initial blowing agent concentration

The concentration of ODS blowing agent in the PU foam prior to any appliance treatment shall either be assumed to equal to 14.9 percent (a conservative value identified by Fredenslund et al. (2005) for U.S. appliances[73]) or calculated according to the steps below. Calculating a sample-specific value allows project developers to document a lower ODS blowing agent concentration, which will result in a higher estimated recovery efficiency.

The following steps shall be followed to document a sample-specific ODS blowing agent concentration:

1. Cut four PU foam samples from each appliance (left side, right side, top, bottom) using a reciprocating saw. Samples must be at least four inches square and the full thickness of the insulation
2. Seal the cut edges of each foam sample using aluminum tape or similar product that prevents off-gassing
3. Individually label each sample to record appliance model, and site of sample (left, right, top, or bottom)
4. Analyze samples according to the procedures dictated for building foam in Section 6.4. Samples may be analyzed individually (four analyses per appliance), or a single analysis may be done using equal masses of foam from each sample (one analysis per appliance)
5. Based on the average of the samples for each appliance, calculate the 90 percent upper confidence limit of the concentration. The 90 percent upper confidence limit shall be used as the parameter BA_{conc} in the equations below

Extract the ODS blowing agent and separate foam residual

The ODS blowing agent from the sampled appliances must be collected and quantified according to the steps below.

1. Begin processing with all equipment shut down and emptied of all materials.
2. Process all sample appliances
3. Extract and collect concentrated BA. The mass of the recovered blowing agent shall be determined by comparison of the mass of the fully evacuated receiving containers to their mass when filled. This value shall be used as the parameter BA_{post} in the equations below

[73] Fredenslund, A. et al. (2005). Disposal of Refrigerators-Freezers in the U.S.: State of the Practice. *Technical University of Denmark.*

Separate foam residual

The quantity of foam in the processed appliances must be established either through use of a default value of 12.9 pounds per appliance,[74] or according to step the following steps. If the value of 12.9 pounds per appliance is used, it shall be multiplied by the number of appliances processed to determine $Foam_{res}$ in the calculation of recovery efficiency.

1. Separate and collect all foam residual, which may be in a fluff, powder, or pelletized form. Processes must be documented to demonstrate that no significant quantity of foam residual is lost in the air or other waste streams
2. If desired, manually separate non-foam components in the residual (e.g. plastic) to determine a percent of foam in residual. If performed, this analysis must be conducted on at least one kilogram of residual, and results may be no lower than 90 percent
3. Weigh the total recovered foam residual, and, if performed, multiply by the percent foam in residual, to calculate total mass of foam recovered. This value shall be used as the parameter $Foam_{res}$

Calculate recovery efficiency

To calculate the recovery efficiency, apply the calculated values to the equations below. The recovery efficiency (RE) calculated below shall be used in the calculations of Section 5.

$$BA_{init} = \frac{Foam_{res}}{(1 - BA_{conc})} \times BA_{conc}$$

Where,			Units
$Foam_{res}$	=	Mass of foam recovered	lbs foam
BA_{conc}	=	Initial concentration of blowing agent in PU foam	lbs BA / lbs PU
BA_{init}	=	Initial quantity of blowing agent in appliances prior to treatment	lbs BA

$$RE = \frac{BA_{post}}{BA_{init}}$$

Where,			Units
RE	=	Recovery efficiency	%
BA_{post}	=	Quantity of recovered blowing agent in concentrated form	lbs BA
BA_{init}	=	Initial quantity of blowing agent in appliances prior to treatment	lbs BA

[74] EcoSolutions Recycling. (2010). Foam content and CFC recovery in residential appliances. *EcoSolutions Recycling, Inc., Quebec*.

Appendix F Default Emission Factors for Calculating ODS Transportation and Destruction Emissions

F.1 Summary

The GHG Assessment Boundary for ODS destruction projects under the Reserve includes emissions in both the baseline and project scenario. These emission sources include the following:

Baseline	Project
▪ Emissions of ODS from foam shredding ▪ Emissions of ODS from foam landfilling ▪ Emissions of ODS from refrigerant applications	▪ Extraction of ODS blowing agent ▪ Emissions of substitute refrigerant applications ▪ CO_2 emissions from fossil fuel and electricity used in destruction facility ▪ CO_2 emissions from fossil fuel used in transport to destruction facility ▪ ODS emissions from incomplete destruction of ODS ▪ CO_2 emissions from ODS oxidation during destruction

All of these emission sources must be accounted for to ensure complete, accurate, and conservative calculations of project emission reductions. However, some of these emission sources are of a significantly greater magnitude than others, and some of the smaller sources are costly to track and verify, and difficult to assess. In order to lessen the burden on project developers and verifiers, the Reserve has calculated a standard deduction that can be applied to all projects to account for the following project scenario emissions:

1. CO_2 emissions from fossil fuel and electricity used by the destruction facility
2. CO_2 emissions from fossil fuel used for transporting the ODS to the destruction facility
3. ODS emissions from incomplete destruction of ODS
4. CO_2 emissions from ODS oxidation during destruction

The aggregate of these emission sources amounts to less than 0.5 percent of total emission reductions under even the most conservative assumptions. As a result, a conservative emission factor can be applied. This appendix provides background on the development of these default emission factors.

F.2 Methodology and Analysis

The Reserve created a model to conservatively calculate all emissions in the baseline and project scenario for ODS projects. The model incorporated all equations from Section 5. The equations that have been rolled up into this emission factor are Equation 5.9 through Equation 5.14.

In many cases, the equations used for estimating emissions required additional input and emissions factors. Where calculations required such inputs (e.g. electricity grid emission factors), the most conservative factors available were used. Fossil fuel emissions from the destruction process were calculated based on confidential industry records made available to

the Reserve that describe the energy requirements associated with ODS destruction projects. The assumptions used in this analysis are as follows:

Parameter	Assumption
ODS_i =	1 tonne ODS
$FF_{PR,k}$ =	0.0009 MMBtu natural gas/lb ODS destroyed (for foams and refrigerants)
$EF_{FF,k}$ =	54.01 kg CO_2/MMBtu[75]
EL_{PR} =	0.0002 MWh/lb ODS destroyed for foam, 0.0018 MWh/lb ODS destroyed for refrigerants and extracted ODS blowing agent
EF_{EL} =	0.889 tCO_2/MWh[76]
TMTi =	2,000 miles
EF_{TMT} =	0.000297 $kgCO_2$/PMT[77]
CRi =	Actual per ODS
Foam weight =	8.5% ODS blowing agent by weight (foam weight used for transport and energy use)

Under these assumptions, and the equations provided in Section 5, the calculations provided the following results for different ODS project categories:

Table F.1. Project Emissions (Excluding Substitutes)
All quantities in tonnes CO_2/tonne ODS destroyed.

	Fossil Fuel Emissions from the Destruction	Electricity Emissions from the Destruction	Emissions from ODS Not Destroyed	Emissions from CO_2	Emissions from the Transporta-tion of ODS	Total
CFC-11 refrigerant or extracted BA	0.04	3.53	0.47	0.32	0.59	4.95
CFC-12 refrigerant or extracted BA	0.04	3.53	1.07	0.36	0.59	5.59
CFC-114 refrigerant	0.04	3.53	1.00	0.47	0.59	5.63
CFC-115 refrigerant	0.04	3.53	0.74	0.47	0.59	5.36
CFC-11 building foam	0.42	41.50	0.47	0.32	6.99	49.70
CFC-12 building foam	0.42	41.50	1.07	0.36	6.99	50.35
HCFC-141b building foam	0.42	41.50	0.07	0.75	6.99	49.74

Because the ODS covered in this protocol have such high GWPs (750 to 10,900) even emissions of 50 tonnes CO_2e per tonne of ODS destroyed are relatively small compared to emissions of the overall baseline and project scenarios. For refrigerant projects, the emissions

[75] U.S. EPA Climate Leaders. (2007). Stationary Combustion Guidance. Note: The highest emission factor was selected to be conservative.
[76] U.S. EPA eGRID2007, Version 1.1 Year 2005 GHG Annual Output Emission Rates (December 2008). Note: the highest emission factor in the nation was selected to be conservative.
[77] U.S. EPA Climate Leaders. (2008). Optional emissions from business travel, commuting, and product transport. Note: the highest emitting mode of transportation was selected to be conservative.

amount to less than 0.15 percent of baseline emissions. For building foams, emissions from the four emission sources can be as high as five percent of baseline emissions.

F.3 Conclusion

To account for the emission sources analyzed above, project developers may apply a 7.5 tonne CO_2e/tonne ODS emission factor to all ODS refrigerant projects and to appliance ODS blowing agent projects. A 75 tonne CO_2e/tonne ODS emission factor must be applied to building ODS blowing agent projects that destroy intact foam. These default emission factors represent a conservative estimate of the potential emissions from the four selected sources and were derived using worst-case emission factors and empirical data.

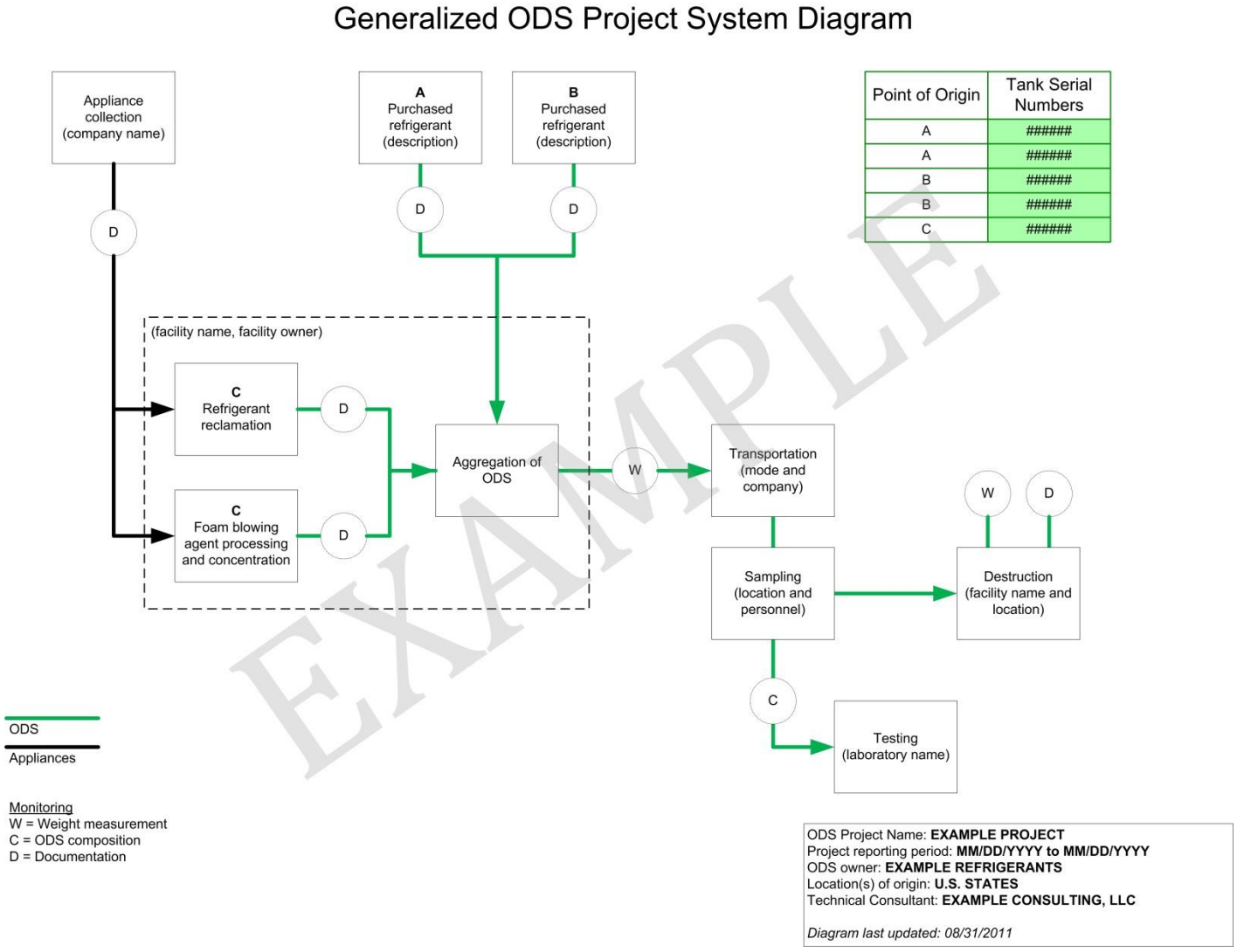
Appendix G Emission Factor Tables

Table G.1. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBtu / Short ton**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**Btu / Standard cubic foot**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Standard cub. ft.**
975 to 1,000 Btu / Std cubic foot	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Std cubic foot	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Std cubic foot	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Std cubic foot	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Std cubic foot	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Std cubic foot	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBtu / Barrel**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2 & 4)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 & 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401 deg. F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401 deg. F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders. (2007). Stationary Combustion Guidance. Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable).
Heat content factors are based on higher heating values (HHV).

Appendix H ODS Project Diagram Sample



EXAMPLE

U.S. Ozone Depleting Substances Project Protocol Version 2.0

ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its U.S. Ozone Depleting Substances Project Protocol Version 2.0 (U.S. ODS V2.0) in June 2012. While the Reserve intends for the U.S. ODS V2.0 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the U.S. ODS V2.0.[1]

Per the Reserve's Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered U.S. ODS projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the U.S. ODS Project Protocol.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact Policy at policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Climate Action Reserve Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications to the U.S. ODS protocol are contained in this single document.

Errata and Clarifications (arranged by protocol section)

Section 5

1. Accounting for Non-ODS Material (CLARIFICATION – January 29, 2013) 2
2. Performance Requirements for Destruction Facilities (ERRATUM – July 16, 2015) 2

Section 6

3. Determining the Mass of ODS Destroyed (CLARIFICATION – April 11, 2013) 3

Section 5

1. Accounting for Non-ODS Material (CLARIFICATION – January 29, 2013)

Section: 5.1.1 (Calculating Baseline Emissions from Refrigerant Recovery and Resale)

Context: The protocol states that projects shall only include the weight of pure ODS when calculating emission reductions. There are additional specific adjustments that were not mentioned in the protocol and it may not be clear how these adjustments should be made. Specifically, project developers shall exclude the weight of high boiling residue (HBR) in their calculation of emission reductions.

Clarification: The definition of the term "$Q_{refr,i}$" in Equation 5.3 on page 21 shall read "Total quantity of pure refrigerant ODS *i* sent for destruction by the project." The total weight of material destroyed by the project shall be adjusted to exclude the weight of ineligible material, including high boiling residue, as determined by the laboratory analysis required in Section 6.6 (in the case of multiple laboratory analyses, the highest reported value for HBR shall be used). In any case where the composition of the single ODS species is less than 100%, the value of this term must be adjusted to reflect the weight of pure ODS for each eligible chemical.

For example, if a project destroys 1,000 lbs. of material that contains 5% high boiling residue and 95% eligible ODS *i*, the value of $Q_{refr,i}$ would be 902.5 lbs.

While water is also considered ineligible material, the moisture content requirement in Section 6.6 of the protocol (i.e. that the moisture content must be less than 75% of the saturation point for the ODS) already ensures that the weight of any moisture present will not have a material impact on the quantification of emission reductions. Thus the weight does not need to be adjusted to reflect the weight of moisture present in the sample.

2. Performance Requirements for Destruction Facilities (ERRATUM – July 16, 2015)

Section: 5.2.4 (Calculating Site-Specific Project Emissions from ODS Destruction)

Context: The protocol states that destruction "facilities are required to demonstrate their ability to achieve destruction efficiencies upwards of 99.99 percent for substances with thermal stability ratings *higher* than the ODS included under this protocol" (emphasis added). The reference cited for this statement explains a ranking system for the incinerability of ODS species based on their thermal stability. In this system, ODS species that are more thermally stable are more difficult to destroy. This results in a *lower* ranking. Thus, the lowest ranking (1) indicates the chemical that is most difficult to destroy, while the highest ranking (320) indicates the chemical that is easiest to destroy. The above-quoted statement in the U.S. ODS Project Protocol includes an error that communicates the opposite of the intended meaning of the statement.

Correction: The second sentence in the first paragraph of this section shall read:

"These facilities are required to demonstrate their ability to achieve destruction efficiencies upwards of 99.99 percent for substances with thermal stability rankings lower than the ODS included under this protocol."

Section 6

3. Determining the Mass of ODS Destroyed (CLARIFICATION – April 11, 2013)

Section: 6.6 (Concentrated ODS Composition and Quantity Analysis Requirements)

Context: The protocol requires that the mass of ODS destroyed by the project be determined using (1) the difference between the measured weight of each container when it is full prior to destruction and the measured weight after it has been emptied and (2) the composition and concentration of material destroyed as determined by laboratory analyses of samples from each container.

Clarification: The mass of ODS and any contaminants destroyed shall be considered equal to the difference between the full and empty weights of the containers, as measured by the scale at the destruction facility and recorded by the destruction facility on the weight tickets and the Certificate of Destruction. No adjustments shall be made by the project developer to the weights as measured and recorded by the destruction facility in calculating the mass of ODS and contaminants.

Verifiers shall confirm that the weights recorded on the weight tickets and the Certificate of Destruction by the destruction facility are used without adjustment to calculate emission reductions. The mass of eligible ODS shall then be determined using these weights and the results of the laboratory analyses.

CLIMATE ACTION RESERVE

Version 1.1 | June 3, 2013

Rice Cultivation

Project Protocol

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Released June 3, 2013

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
2 The GHG Reduction Project 3
2.1 Background 3
2.1.1 Rice Cultivation Techniques 4
2.1.2 California Rice Cultivation Practices 4
2.2 Project Definition 6
2.2.1 Defining Field Boundaries 7
2.2.2 Defining the Cultivation Cycle 8
2.3 The Project Developer 8
2.4 Project Aggregates 9
2.4.1 Field Size Limits and Other Requirements 10
2.4.2 Entering an Aggregate 10
2.4.3 Leaving an Aggregate 10
2.4.4 Changes in Land Ownership, Management or Tenant Occupancy 11
3 Eligibility Rules 12
3.1 Location 12
3.1.1 Rice Growing Regions 12
3.1.2 High Carbon Content Soils 12
3.1.3 Fields Using Nitrification/Urea Inhibitors and Controlled Release Fertilizers 12
3.2 Project Start Date 13
3.3 Crediting Period 13
3.4 Anaerobic Baseline Conditions 13
3.5 Additionality 14
3.5.1 The Performance Standard Test 14
3.5.2 The Legal Requirement Test 15
3.5.3 Ecosystem Services Payment Stacking 16
3.6 Regulatory Compliance 17
3.6.1 California Rice Straw Burning Regulation 18
3.6.2 Regulations on Special-Status Species 18
4 The GHG Assessment Boundary 19
5 Quantification Overview 23
5.1 Defining the Reporting Period 23
5.2 Baseline Modeling Inputs 24
5.3 Deriving Cultivation Cycle Emissions from Calendar-Year Modeling Results 24
5.4 Quantifying GHG Emission Reductions 25
5.4.1 Step 1: Calculate Primary Emissions for Baseline and Project Scenarios for Each Field 26
5.4.2 Step 2: Calculate Primary Emission Reductions for Each Field (Unadjusted for Uncertainty) 29
5.4.3 Step 3: Calculate Uncertainty-Adjusted Primary Emission Reductions for each Field 29
5.5 Quantifying Secondary Effects 31
5.5.1 Step 4: Calculate Project Emissions from Onsite Fossil Fuel Combustion 31
5.5.2 Step 5: Calculate Project Emissions from Rice Straw Residue Management/Use 33

5.5.3 Step 6: Calculate GHG Emissions from the Shift of Rice Production Outside of Project Boundaries (Leakage) 35
5.5.4 Step 7: Calculate Total Secondary Emissions from Project Activity 38
6 Project Monitoring 39
6.1 Single-Field Monitoring Plan 39
6.2 Aggregate Monitoring Plan 39
6.3 Field Monitoring Plan for Project Participants in an Aggregate 40
6.4 Field Data 40
6.4.1 General Field Tracking Data 41
6.4.2 Field Management Data 41
6.4.3 Project Activity Data and Documentation 42
6.4.4 Field Monitoring Parameters 42
7 Reporting and Record Keeping 49
7.1 Project Submittal Documentation 49
7.1.1 Determining Field Serial Numbers 49
7.2 Annual Reports and Documentation 49
7.2.1 Single-Field Report 50
7.2.2 Aggregate Report 50
7.2.3 Field Report 51
7.3 Record Keeping 51
7.3.1 Record Keeping for Single-Field Projects 51
7.3.2 Record Keeping for Project Aggregates 52
7.4 Reporting Period and Verification Cycle 53
7.4.1 Additional Reporting and Verification Options for Single-Field Projects 53
8 Verification Guidance 55
8.1 Preparing for Verification 55
8.2 Verification Schedule for Single-Field Projects 56
8.2.1 Option 1: Twelve-Month Maximum Verification Period 56
8.2.2 Option 2: Twelve-Month Verification Period with Desktop Verification 56
8.2.3 Option 3: Twenty-Four Month Maximum Verification Period 57
8.3 Verification Sampling and Schedule for Project Aggregates 57
8.3.1 Verification Schedule for Small Aggregates 58
8.3.2 Verification Schedule for Large Single-Participant Aggregates 59
8.3.3 Verification Schedule for Large Multi-Participant Aggregates 59
8.4 Standard of Verification 60
8.5 Monitoring Plan 60
8.5.1 Annual Reports 60
8.6 Verifying Eligibility at the Field Level 61
8.7 Core Verification Activities 62
8.8 Project Type Verification Items 63
8.8.1 Project Eligibility and CRT Issuance 63
8.8.2 Quantification 64
8.8.3 Risk Assessment 65
8.9 Successful and Unsuccessful Verifications 65
8.9.1 Field-Level and Project Participant-Level Errors 65
8.9.2 Aggregate-Level Errors 66
8.10 Completing Verification 66
9 Glossary of Terms 67
10 References 69

Appendix A Parameter Look-Up Tables 71
Appendix B Step by Step Guide to Modeling RCPP Emissions Using DNDC 73
Appendix C RCPP General Quantification Guidance 91
Introduction 91
Development of Ex Ante Input Data and Assessment of Offset Potential 91
Collection of Climate Data for DNDC Modeling 92
Collection of Climate and Soil Data for DNDC Modeling 92
Calculation of Input for *Ex Post* Offset Calculations 92
Example: Assessing Impact of Input Uncertainties on Modeled Offsets 93
DNDC Modeling Overview 95
Sources of Data 96
Creating Site Input Files 96
Crop Model Calibration 96
Running the Model and Viewing Results 98
Greenhouse Gas Emissions Scenarios: Overview 98
General Effects of Model Parameter Changes 98
Modeling Potential Project Scenarios 99
Case Study: Paddy Rice 99
Entering Input Data 99
Crop Model Calibration 106
Creating Alternative Management Scenarios 108
Appendix D Derivation of Structural Uncertainty Deduction Factors 113
Appendix E Summary of Performance Standard Research 118
Appendix F Wildlife Habitat Conservation and the Rice Industry 122

List of Tables

Table 2.1. Approved Project Activities 7
Table 2.2. Maximum Field Size, as a Percent of Aggregate Acreage 10
Table 3.1. Approved Project Activities 15
Table 3.2. Payment Stacking Scenarios 17
Table 4.1. Description of RC Project Sources, Sinks, and Reservoirs 21
Table 5.1. Overview of Quantification Steps 25
Table 6.1. DNDC Model Input Parameters 43
Table 6.2. Field Monitoring Parameters 45
Table 8.1. Summary of Eligibility Criteria for a Rice Cultivation Project 61
Table 8.2. Eligibility Verification Items 63
Table 8.3. Quantification Verification Items 64
Table 8.4. Risk Assessment Verification Items 65

List of Figures

Figure 2.1. California's Sacramento Valley Rice Growing Region 6
Figure 4.1. General illustration of the GHG Assessment Boundary 20

List of Equations

Equation 5.1. Calculating GHG Emission Reductions 25
Equation 5.2. Calculating GHG Emissions from Monte Carlo Runs for Field i 28
Equation 5.3. Total Primary Effect GHG Emission Reductions for each Field (Unadjusted for Uncertainty) 29
Equation 5.4. Applying Uncertainty Deductions to Primary Emission Reductions 30
Equation 5.5. Project Emissions from Cultivation Equipment (Approach 1) 32
Equation 5.6. Increased Emissions from Cultivation Equipment (Approach 2) 33
Equation 5.7. Emissions from Rice Straw End-Use 34
Equation 5.8. Normalized Yield for Each Year *t* 36
Equation 5.9. GHG Emissions Outside the Project Boundary 37
Equation 5.10. Change in Soil Organic Carbon in the Baseline Cultivation Cycle 38
Equation 5.11. Total Secondary Effect Emissions from Project Activity 38

Abbreviations and Acronyms

CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
CSV	California Sacramento Valley
DNDC	Denitrification-Decomposition biogeochemical process model
DOC	Dissolved organic carbon
DS	Dry seeding
EPA	Environmental Protection Agency
GHG	Greenhouse gas
GUI	Graphical user interface
HCP	Habitat Conservation Plan
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
lb	Pound
MT (t)	Metric ton (or tonne)
N_2O	Nitrous oxide
NRCS	Natural Resources Conservation Service of the USDA
RC	Rice cultivation
Reserve	Climate Action Reserve
SOC	Soil organic carbon
SHA	Safe Harbor Agreement
SSR	Source, sink, and reservoir
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture

1 Introduction

The Climate Action Reserve (Reserve) Rice Cultivation Project Protocol (RCPP) provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the implementation of rice cultivation practice changes that result in a decrease in methane emissions to the atmosphere.

The Climate Action Reserve is the most experienced, trusted and efficient offset registry to serve the California cap-and-trade program and the voluntary carbon market. With deep roots in California and a reach across North America, the Reserve encourages actions to reduce greenhouse gas emissions and works to ensure environmental benefit, integrity and transparency in market-based solutions to address global climate change. It operates the largest accredited registry for the California compliance market and has played an integral role in the development and administration of the state's cap-and-trade program. For the voluntary market, the Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies and issues and tracks the transaction of carbon credits (Climate Reserve Tonnes) generated from such projects in a transparent, publicly-accessible system. The Reserve program promotes immediate environmental and health benefits to local communities and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California.

Project developers and aggregators that initiate rice cultivation (RC) projects use this document to quantify and register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project aggregates receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a rice cultivation project.

2 The GHG Reduction Project

2.1 Background

Methane (CH_4), a potent GHG, can be formed as a by-product of microbial respiration reactions that occur when organic materials decompose in the absence of oxygen (i.e. under anaerobic conditions). In the United States, rice is almost exclusively grown on flooded fields.[1] When fields are flooded during rice cultivation, oxygen retained in soil pores is rapidly depleted by aerobic decomposition of organic plant residues in the soil, and the soil environment becomes anaerobic. Organic matter continues to decompose under anaerobic conditions, resulting in formation of methane gas. While as much as 60 to 90 percent of the CH_4 produced by the anaerobic microbes is oxidized within the soil by aerobic microbes, remaining un-oxidized CH_4 is transported from the soil to the atmosphere via diffusive transport through the rice plants and the floodwaters.[1]

The annual quantity of methane emitted to the atmosphere at a given rice field will depend on numerous factors related primarily to the water and plant residue management systems in place. Other contributing factors include fertilization practices (using organic vs. synthetic fertilizer), soil properties (type, temperature), rice variety, and other cultivation practices (i.e. tillage, seeding, and weeding practices).

According to the U.S. EPA, rice is currently cultivated in eight states (AR, CA, FL, LA, MS, MO, OK, TX), and rice cultivation is considered to be a relatively small source of CH_4 emissions in the U.S., with total 2009 emissions estimated to be 7.3 MMT CO_2e.[2] Nevertheless, opportunity exists to reduce the methane generated by rice cultivation through implementation of cultivation practice changes related to water and residue management. Management practice changes that decrease the amount of organic matter deposited in the soil, or decrease the amount of time a field is flooded, will typically reduce GHG emissions compared to baseline management practices.

Due to the complexities involved with accurately quantifying GHG emissions resulting from the biogeochemical interactions that occur in cropped rice field systems, this protocol relies on the application of the Denitrification-Decomposition (DNDC) biogeochemical process model for quantification of baseline and project GHG emissions to quantify associated emission reductions. Because of the significant geographic variability related to soil types, climate, and cultivation management practices, the DNDC model must be properly validated for the geographic area and for all relevant cultivation practices in order for the model to perform with an acceptable degree of certainty. Therefore, this protocol will apply only to the regions and practices for which the DNDC model has been explicitly validated with measured data. While this version of the RCPP is valid only in specified rice growing regions, the Reserve expects to periodically update the protocol to expand the geographic scope to include other U.S. rice growing regions as data and model calibration results become available. Currently, however, this protocol only applies to RC projects located in the California Sacramento Valley (CSV) rice growing region.

[1] U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks.
[2] Ibid.

2.1.1 Rice Cultivation Techniques

In the U.S. there are three dominant flooding systems for rice cultivation: continuous flood, pinpoint flood, and delayed flood.

1. **Continuous flood**: In a continuous flood system, fields are flooded prior to seeding. Once the flood is established, pre-germinated or sprouted seeds are sown (typically by aircraft) into a flooded field. These fields are then maintained in a flooded state until they are drained just before harvest.
2. **Pinpoint flood**: In the pinpoint flood system, pre-germinated seeds are sown into floodwater. The field is drained after seeding for several days to allow the roots to establish or "peg" in the soil. This drain period varies based on soil conditions and weather, but typically lasts for three to five days to enable the roots to establish. During this drain period, oxygen can permeate back into the soil. Once the rice seeds have pegged into the soil, the fields are re-flooded and maintained in flooded conditions until just before harvest.
3. **Delayed flood**: In a delayed flood system, fields are either dry seeded and irrigated for germination or water seeded using pre-germinated seeds that are sown directly into flooded fields, after which the fields are immediately drained. The fields are then kept drained for three to four weeks while the rice canopy is established. Once the canopy is established then the fields are flooded and remain flooded until the typical pre-harvest drain.

Producer decisions regarding which seeding method to use are targeted at selecting the method that will result in proper seedling emergence and lead to a uniform canopy. Seeding methods depend on soil type, weather conditions, and producer preferences. Differences in seeding methods for rice production relate to (a) dry versus water seeded, (b) drill seeding versus broadcast, and (c) use of stale seedbed or conventional seedbed.

1. **Water seeding**: Water seeding describes sowing of dry or soaked seed into a flooded field. It is usually implemented for any or all of the following reasons: red rice control, wet planting season, planting efficiency and earlier crop maturity.
2. **Dry seeding**: Dry seeding simply describes sowing seed into a dry seedbed by drilling or broadcasting. This method usually offers more flexibility in planting but may require more time to do so. This system is also weather dependent.

2.1.2 California Rice Cultivation Practices

In California's Sacramento Valley rice growing region (see Figure 2.1 below), continuous flood is the dominant water management technique.[3] Fields are typically flooded to a depth of 4 to 5 inches just prior to aerial seeding. While deeper flooding reduces weed pressures, it also can lead to poor stand establishment. Once the rice stand is established and the panicle initiation has occurred, many growers will increase the depth of the flood water to 8 inches. This helps with further weed control and protects the rice from cool nighttime temperatures that can lead to reduced yields. Occasionally, several weeks after seeding, fields are drained for one day to apply herbicide for weed control. This drain is short-lived and does not lead to drying of the soil surface and does not affect CH_4 emissions. Prior to harvest, water is drained from fields to allow fields to dry, as harvesting equipment cannot function as well on wet soil. The timing of pre-harvest field draining varies from field to field, and can influence total yields. The University of California Cooperative Extension recommends growers to drain their fields when the panicles

[3] Correspondence with Paul Buttner (CalRice).

are 100 percent "fully tipped and golden," although fields are often drained earlier due to other contributing factors such as soil type (e.g. soils with high clay content require longer time for drying) and weather.

A continuous flooding and water seeded regime is estimated to be used on over 96 percent of the acreage in California.[4] A small fraction of the rice acreage is dry seeded in California. The flood for dry seeded rice starts approximately 25 to 30 days after seeding. During this period, fields are periodically irrigated to promote germination and stand establishment.

Rice straw can have a significant impact on GHG emissions. Timing of straw amendment/incorporation can impact GHG emissions by altering the timing and availability of substrate (dissolved organic carbon or DOC) released from the fresh straw to methanogens in the soil. The timing of the residue incorporation relative to the flooding period will impact total methane production, as will the availability of rice straw on the field. Rice straw incorporation is currently the dominant management practice in California.

Burning of rice straw was the prevailing management practice in California until 1991. Following the 1991 Rice Straw Burning Reduction Act, burning of rice straw decreased dramatically on an annual basis. By the 2001 growing season, burning of rice straw was permitted for disease control only with a cap of 25 percent of total rice acreage in the state burned annually. Currently, burning occurs on only 10 to 12 percent of rice acreage in California.[5]

Some growers bale rice straw for off-field uses. The current estimate for baling adoption in California is 2 to 6 percent of California rice acres per year.[6] This fluctuates slightly coincident with the various straw markets. Baling does not remove all of the rice straw following harvest. Due to operational constraints and the market for straw, baling typically removes between one and two tons of rice straw per acre, out of an average of about three tons of rice straw available per acre. Of the straw that is baled, much of the straw is sold to end-users, while the straw that goes un-used is typically left onsite. Presently, the majority of rice straw is sold for dairy heifer and beef cattle high roughage feed (estimated to be 75 to 85 percent), with some straw used for erosion control (15 to 25 percent), and very little sold for building construction. The straw that is baled and left onsite is typically composted in large static piles.

[4] Based on communication with P. Buttner (CalRice), R. Mutters, and L. Espino (University of California Cooperative Extension).
[5] Communication with Paul Buttner.
[6] Based on communication with P. Buttner (CalRice), R. Mutters, L. Espino, and G Nader (University of California Cooperative Extension).

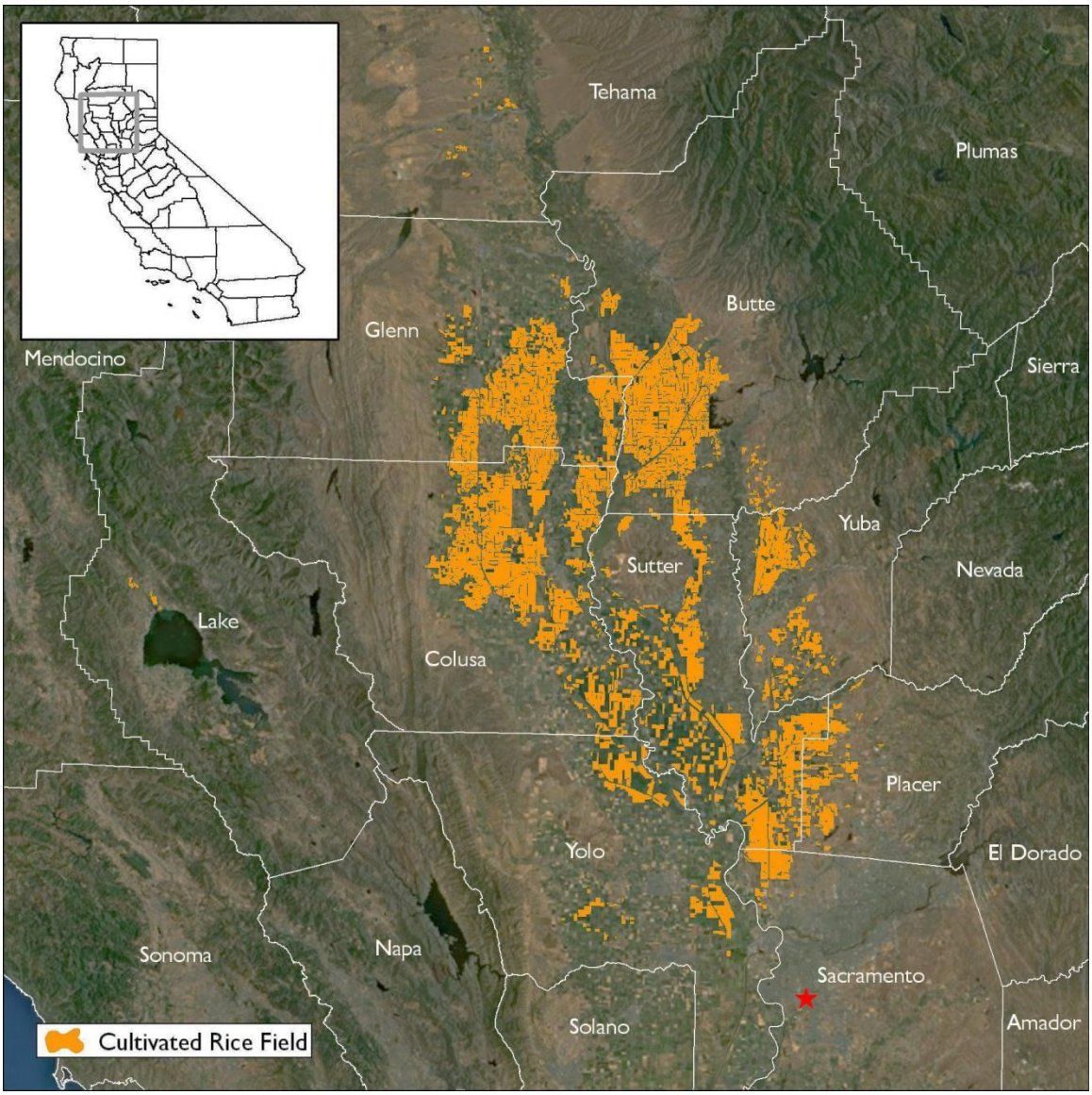

Figure 2.1. California's Sacramento Valley Rice Growing Region

2.2 Project Definition

For the purpose of this protocol, a GHG reduction project (project) is defined as the adoption and maintenance of one or more of the approved rice cultivation project activities[7] that reduce methane (CH_4) emissions. Specific project activities must be adopted and maintained on individual rice fields, with at least one approved project activity implemented on each individual field. Approved rice cultivation project activities may be implemented on a single field, known as a "single-field project," or may be implemented on two or more individual fields combined into a single project area, known as a "project aggregate." Specific requirements for project aggregates are outlined in Section 2.4 below. Physical boundaries for individual fields must be defined according to the requirements in Section 2.2.1.

[7] Note that a project is defined by the adoption of management changes; however, GHG reductions are quantified based on actual project performance in terms of reduced CH_4 emissions.

Practice changes described in Table 2.1 below are the approved project activities (by geographic scope).

Table 2.1. Approved Project Activities

Project Activity	Description	Geographic Scope
Dry seeding (DS) with delayed flood	Adoption of a dry seeding method that involves sowing of dry seeds into dry or moist (non-flooded[8]) soil with field flooding delayed until rice stand is established (typically 25 to 30 days after seeding). Dry seeding can be performed by spreading seeds onto the soil surface and transferring soil on top of the seeds or by drilling seeds into a prepared seedbed, a practice known as "drill seeding." Regardless of the dry seeding method utilized, the methane reductions occur due to the subsequent delay in flooding of the dry seeded field.	California
Post-harvest rice straw removal and baling (baling)	After harvest, rice straw residue is traditionally left on agricultural fields and incorporated into soil; however, rice straw can be removed by baling. Doing so reduces the net soil dissolved organic carbon and therefore decreases methane production from anaerobic decay over the winter season. Baled straw can be sold even though the market is currently small. In California, rice straw can be used for erosion control, animal bedding or as an alternative feed for cow and calf producers.[9]	California

2.2.1 Defining Field Boundaries

For the purposes of quantifying emission reductions with this protocol, a field must be defined as an area of rice cultivation across which management practices are homogenous.[10] Thus if management practices differ across a single rice paddy, the paddy would need to be divided into multiple "fields" corresponding to different management practices for the purpose of this protocol.

An individual rice field must be defined by the following criteria:[11]

1. The field must be under the direct management control of a single rice-producing legal entity.
2. The field area must be contiguous across field 'checks'.
3. Water management (flooding and drainage events) within the field boundary must be relatively homogenous across the field area during a reporting period. There is no set definition for homogeneous water management; however standard practice suggests that most rice fields have a flood-up duration across all field checks of less than 96 hours from start to finish (4 acre-inches per acre or more).[12]

[8] For the purposes of this protocol, non-flooded should be interpreted to mean that there is not standing water (1 inch or more) on the field.
[9] DANR, publication 8425.
[10] More specifically, to effectively quantify field-level emissions using the biogeochemical process model DNDC, the management practices (model inputs) must be homogeneous across the field.
[11] The Reserve believes that in most cases a field defined according to the specified criteria in this protocol will be compatible with a field as defined by the UDSA Farm Service Agency (FSA) Field I.D. protocols.
[12] Note that when recording the date of flood-up for modeling purposes, the date shall be equal to the date when the last field 'check' was flooded to approximately 4 inches or more. This is conservative.

4. Fertilizer management must be relatively homogenous. This criterion is met when application rates across the field do not vary by more than 15 percent of the average application rate for the entire field. During a reporting period, every fertilizer application event must be completed for the entire field on the same day with the same type of fertilizer. A field may have multiple fertilizer application events, as long as each application is homogenous (e.g. consistent rate, timing and type) across the field.
5. Crop residue management within the field boundary must be homogenous across the field area within a reporting period. For example, any burning or baling that occurs on a field must occur across the entire field; there can be no fields that have been partially burnt or baled.
6. The field must have at least five years of rice yield data available for DNDC model calibration.[13]

The above criteria shall be confirmed by the verification body using professional judgment when necessary. If a field does not meet the criteria above, the field shall be divided into sub-fields that meet the field definition criteria, and each sub-field shall be modeled and reported on separately.

2.2.2 Defining the Cultivation Cycle

For the purposes of this protocol, a cultivation cycle is defined as the period starting the day immediately after harvest of one rice crop and ending the last day of the next rice crop harvest the following calendar year. Since this protocol is only applicable to annual rice crops, the cultivation cycle is further defined as approximately 365 days. See Section 5.1 for guidance on how a reporting period is defined and Section 5.3 for guidance on requirements for modeling annual versus cultivation-cycle emissions.

2.3 The Project Developer

The project developer is an entity that has an active account in good standing on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. According to this protocol, project developers may also be project aggregators, and can represent one or more projects. Project developers/aggregators must be a legally constituted entity (e.g. a corporation, city, county, state agency, agricultural producer, or a combination thereof). An individual rice grower may serve as a project developer of a single-field project, project aggregator for his/her own fields, or as a project aggregator for a group of fields. Rice growers who elect to enroll in a project aggregate and not serve as a project developer are referred to as "project participants." Project participants must have authority to make cultivation management decisions on their fields that are enrolled in the project aggregate. Project participants are also required to be a legally constituted entity (e.g. an individual, corporation etc.).

Project developers/aggregators act as official agents to the Reserve on behalf of project participants and are ultimately responsible for submitting all required forms and complying with the terms of this protocol. Project developers/aggregators manage the flow of ongoing monitoring and verification reports to the Reserve and may engage in other project development activities such as developing monitoring plans, modeling emission reductions, managing data collection and retention etc., or may hire technical contractors to perform these services on their

[13] USDA FSA Abbreviated Farm Records may be a useful resource for documenting historical yields and/or practices on a particular rice field, however these reports are not required to be used. Note that in this protocol yield refers to the weight of the rice before it is milled, so it includes the weight of the husks.

behalf. The scope of project developer/aggregator services is negotiated between the project participants and the project developer/aggregator and should be reflected in contracts between the project participants and the project developer/aggregator.

Project aggregators have the authority to develop their own internal monitoring, reporting, and other participation requirements for individual fields as they deem necessary, as long as these internal requirements do not conflict with any requirements outlined in this protocol.

Aggregators also have the discretion to exclude individual fields enrolled in their aggregate from participating in verification activities for any given reporting period; however, in such cases there can be no CRTs claimed by those fields in the aggregate total.

In all cases, the project developer/aggregator must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from all fields in the project. The Project developer/aggregator must attest to this requirement by submitting a signed Attestation of Title form for single-field projects or Aggregator Attestation of Title[14] form for project aggregates, prior to the commencement of verification activities each time the project is verified (see Section 8). In the case of project activities taking place on leased fields (i.e. the project developer/participant is not the land owner, but rather a lessee), the project developer must notify the land owner with a Letter of Notification of the Intent to Implement a GHG Mitigation Project on the respective field. Sufficient evidence must be given to the verifier to demonstrate that such a letter was sent (e.g. evidencing the use of certified mail).

Although the aggregator must have exclusive claim to CRTs for the project to complete verification, this protocol does not dictate the terms for how that exclusive title will be established; allowing the aggregator, project participant, and land owner (if separate from the project participant) maximum flexibility for the terms of contracts between the respective parties.

As part of verification activities, verifiers shall review contracts and letters of notification as a means of confirming exclusive title to the CRTs. The Reserve will not issue CRTs for GHG reductions that are reported or claimed by entities other than the aggregator.

2.4 Project Aggregates

Incorporated into the RCPP is an option for project aggregation that aims to facilitate greater participation by farmers by leveraging economies of scale and technical expertise of aggregators. Through aggregation, technical complexities of the methodology and other potential barriers to adopting practice changes in agriculture may be overcome. Specifically, aggregators can acquire appropriate technical expertise, enabling them to implement and manage projects that fulfill protocol requirements on behalf of farmers. Aggregation allows for "economies of scale" within the methodology, in terms of streamlined requirements for individual farmers, while upholding rigorous standards at the level of the aggregate. This is primarily accomplished through pooling and sampling fields for verification activities. In addition, aggregation can help to increase the accuracy of GHG reduction estimates at a program level by encouraging greater participation, which reduces structural uncertainty within the DNDC model.

[14] The Reserve Aggregator Attestation of Title form is available at http://www.climateactionreserve.org/how/program/documents/.

2.4.1 Field Size Limits and Other Requirements

The project aggregate does not need to be comprised of contiguous fields, and can encompass fields located on one farming operation or distributed amongst different farms and/or producers.

There is no limit on the total number of rice acres enrolled in a project aggregate, assuming each individual field meets the requirements of Section 2.2.1. There are, however, limits on how large a single field may be, in relation to the total combined acreage in a project aggregate, as defined by Table 2.2 below. Field size limitations are in place to minimize the influence a single large field may have on a project aggregate's calculations.

Table 2.2. Maximum Field Size, as a Percent of Aggregate Acreage

Number of Fields in Aggregate	Maximum Acreage of a Single Field (% of Aggregate Acreage)
2	70%
3	50%
4	33%
5 or more	25%

2.4.2 Entering an Aggregate

Individual fields may join a project aggregate by being added to the aggregate's Project Submittal Form (if joining at aggregate initiation) or by being added through the New Field Enrollment Form (if joining once the aggregate is underway).

Single-field projects that have already been submitted to the Reserve may choose to join an existing aggregate at any time by submitting a Project Aggregate Transfer Form to the Reserve. The project aggregator will also need to submit a New Field Enrollment Form, listing that field. However, emission reductions for a given field may only be reported to one project in a given cultivation cycle. Thus in the case of a single-field project joining an aggregate during a cultivation cycle, the project developer must chose to either continue to report as an SFP for the remainder of the cultivation cycle or report the entire current cultivation cycle as part of the aggregate.

When a field enters an aggregate, the project aggregator must ensure that all other requirements for each field (as outlined in Sections 2.2, 2.3 and 2.4) continue to be met with all the necessary documentation on file.

2.4.3 Leaving an Aggregate

Fields must meet the requirements in this section in order to leave or change aggregates and continue reporting emission reductions to the Reserve. In all cases, emission reductions must be reported for a complete cultivation cycle, as defined in Section 2.2.2, and no CRTs may be claimed for a field that does not participate and report data for a full cultivation cycle.

Project activities on an individual field may be terminated and the field may elect to leave an aggregate at any time.

Individual fields may elect to leave an aggregate and participate as a single-field project for the duration of their crediting period. To leave an aggregate and become a single-field project, the project participant must open a project developer account on the Reserve and submit a Project

Submittal Form to the Reserve, noting both that it is a transfer project and the aggregate from where it transferred.

Fields can change aggregates during a crediting period if and only if:

1. The field changes ownership, tenant occupancy or management control during the crediting period and the new owner, tenant or manager has other fields already enrolled with a different aggregator
2. The original aggregate is terminated (e.g. goes out of business)
3. The aggregator breaches its contract with the project participant

Fields seeking to change aggregates during a crediting period under one of the above allowed circumstances must submit a Project Aggregate Transfer Form to the Reserve prior to enrolling in the new aggregate.

After completing the crediting period, a field may elect to enroll in a different aggregate when renewing for an additional crediting period.

2.4.4 Changes in Land Ownership, Management or Tenant Occupancy

A field in an aggregate may change ownership, tenant occupancy or management control during a crediting period, and remain in the project aggregate with uninterrupted crediting, if and only if the following criteria are met:

- The contract with the project aggregator is transferred from the old to the new project participant
- The new project participant submits a Field Management Transfer Form to the Reserve via their project aggregator prior to the beginning of the subsequent cultivation cycle
- Implementation of the approved management practices continues without change until the end of the current reporting period[15]

Where any of the criteria immediately above are not met, a field will forfeit the opportunity to generate CRTs for the cultivation cycle during which the ownership, tenant occupancy or management control change occurs. The field may re-enter the project aggregate at any time during the remainder of the five-year crediting period by fulfilling the three requirements above.

[15] See Section 5 for definition of reporting period.

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to register with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project (Section 2.2).

Eligibility Rule I:	Location	→	*California*
Eligibility Rule II:	Project Start Date	→	*First day of cultivation cycle during which approved activity is implemented*
Eligibility Rule III:	Anaerobic Baseline Conditions	→	*Demonstrate baseline flooded rice cultivation practice*
Eligibility Rule IV:	Other Eligibility Conditions	→	*Demonstrate compliance with other eligibility criteria*
Eligibility Rule IV:	Additionality	→	*Meet performance standard*
		→	*Exceed regulatory requirements*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Projects must be located in approved rice growing regions for which the DNDC model has been validated against field measured methane emissions, and for which a regional performance standard has been developed and included in this protocol. Reductions from projects outside of the approved rice growing regions are not eligible to register with the Reserve at this time.

3.1.1 Rice Growing Regions

Currently, only the California rice growing region is approved under this protocol. Therefore, only RC projects located in California are eligible to register reductions with the Reserve. In the future, projects located in other parts of the United States or on U.S. tribal lands may be eligible to register reductions with the Reserve under this protocol as the DNDC model becomes validated in more regions.

3.1.2 High Carbon Content Soils

As the DNDC model has not been validated on soils with SOC content greater than 3 percent, fields that have soil with organic carbon content greater than 3 percent in the top 10 cm of soil are not eligible at this time. The organic carbon content of the field shall be determined by using SSURGO data or soil sampling in accordance with Appendix B, Step 1.4. Where SSURGO data on SOC content is not available to a depth of 10 cm for any given field, that field must use field measurements or data from the STATSGO database to determine eligibility.

3.1.3 Fields Using Nitrification/Urea Inhibitors and Controlled Release Fertilizers

The DNDC model has not been validated for use on fields that have been treated with nitrification inhibitors, urea inhibitors or controlled release fertilizers. Therefore, fields that have used such products in either the five year baseline period or a project year are not eligible under this protocol.

3.2 Project Start Date

In order to produce accurate GHG emission modeling results, the DNDC model used for calculating GHG reductions must be run for each annual cultivation cycle. A complete cultivation cycle begins with post-harvest residue management and culminates at the end of the rice crop harvest and thus may be slightly greater or less than 365 days depending on planting/harvest dates. More information on how to define a cultivation cycle is found in Section 2.2.2.

Each field has a unique start date, defined as the first day of a cultivation cycle during which one or more of the approved project activities are implemented at the field. Approved project activities initiated prior to the start date (i.e. during the baseline period) are permissible, but must be represented in the field's baseline; as such project activities must go beyond baseline practices in order to generate any additional emission reductions.

To be eligible, a field must submit as a single-field project or join an active or new aggregate before the end of the first cultivation cycle after the start date.[16] Fields may always be submitted for listing by the Reserve prior to their start date.

3.3 Crediting Period

The crediting period for fields under this protocol is five years. The crediting period is renewable up to three times (for a potential of 20 years of crediting). During the last six months of a field's crediting period, project developers/aggregators may apply for a field's eligibility under a second, third or fourth crediting period. During a crediting period, project reporting for each field must be continuous with no gaps between reporting periods. Reporting periods in which a field does not meet the performance standard (see Section 3.5) or is not included in the pool of fields potentially selected for verification, for any number of reasons, still count towards the five-year crediting period. If a project developer wishes to apply for another crediting period, the project must meet the requirements of the most current version of this protocol, including any updates to the Performance Standard Test (Section 3.5.1). The pre-project baseline for the initial crediting period shall be retained for any subsequent crediting periods.[17]

Crediting periods do not apply to project aggregates, but rather only to individual fields within a project aggregate and to single-field projects.

The Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of four five-year crediting periods after the field's start date. Section 3.5.1 describes requirements for qualifying for a second, third, and fourth crediting period.

3.4 Anaerobic Baseline Conditions

All fields must demonstrate that previous rice cultivation practices prior to the field's start date resulted in anaerobic conditions. This requirement is met by demonstrating all the following criteria are met:

1. Each individual rice field has been under continuous rice cultivation for five cultivation cycles preceding the field's start date, with no more than one fallow season. In instances

[16] Fields are considered submitted when the project developer/aggregator has fully completed and filed with the Reserve the appropriate Submittal Form, or the New Field Enrollment form, available on the Reserve's website.
[17] This is known as a continuation of current practices baseline scenario, and is considered appropriate in the circumstances.

where a fallow season occurred, the field must have been under rice cultivation for five of the six years prior to the start date; and

2. Each individual rice field was flooded for a period of at least 100 days during each of the five rice-growing cultivation cycles preceding the field's start date. Fields that are unable to meet this requirement due to events beyond management control (e.g. drought conditions), can meet this requirement by demonstrating that 100 or more days of flooding is common practice for the field, and that drought conditions or other conditions beyond management control prevented normal flooding practices; and
3. Management records for each individual rice field are available for each of the past five rice-growing cultivation cycles preceding the field's start date. At a minimum, management records must include:
    - Annual rice yields
    - Planting and harvest dates
    - Flooding and draining dates
    - Fertilizer application dates and amounts

3.5 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The Performance Standard Test
2. The Legal Requirement Test

3.5.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all RC projects, established by this protocol.

For this protocol, the Reserve uses practice-based thresholds, which serve as "best practice standards" for management practices governing methane emissions from rice cultivation. By meeting the performance threshold for a specific management activity, a rice field demonstrates that cultivation management exceeds the regional common practice standard for methane emissions management. Although multiple fields are submitted together in the case of a project aggregate, each participating field must separately pass the Performance Standard Test, for each approved project activity that is implemented on the field, in order to be eligible.

The performance standard research, summarized in Appendix D, reviewed common water management, residue management, and other RC management practices in the approved rice growing region.[18] Based on the performance standard analysis, the Reserve has developed Performance Standard Tests for each approved project activity, as defined in Section 2.2.

Table 3.1 below provides the Performance Standard Test for each approved project activity.

[18] Based on the geographic limitations imposed by data availability, only management data from California rice cropping systems were sufficiently analyzed in the performance standard for this protocol. The Reserve plans to expand the geographic scope of this protocol to other U.S. regions based upon future data availability and successful peer-reviewed DNDC model validation results.

Table 3.1. Approved Project Activities

Region	Approved Project Activity	Performance Standard Test	Justification
CA	Dry seeding with a delayed flood	A rice field passes the Performance Standard Test by implementing a dry seeding technique combined with delayed flooding.	Research indicates that dry seeding is currently practiced on less than 3 percent of the CA rice acreage.[19]
	Post-harvest rice straw removal and baling	A rice field passes the Performance Standard Test by implementing post-harvest rice straw removal and "baling."	Research indicates that residue removal (baling) is currently very limited and variable, occurring on an estimated 2 to 7 percent of the CA rice acreage. Despite initiatives launched by state agencies and private partnerships, the market for rice straw has not grown as expected.[19]

3.5.2 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state or local regulations, or other legally binding mandates. An RC project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, binding contractual obligations or other legally binding mandates in place on the project start date (including, but not limited to, conservation management plans and deed restrictions) that require the adoption or continued use of any approved project activities on the project rice fields. Should a field initially pass the Legal Requirement Test, the field is eligible to earn CRTs from a project activity for the remainder of the five-year crediting period, regardless of changes in legal requirements.

To satisfy the Legal Requirement Test, project developers (including aggregators) must submit a signed Attestation of Voluntary Implementation form[20] prior to the commencement of verification activities for the first verification period. Aggregators must also submit a signed Attestation of Voluntary Implementation form on behalf of new project fields in the aggregate prior to the commencement of verification activities each time new fields join the project aggregate. Individual project participants who are part of a project aggregate are not separately required to attest to the voluntary nature of project activities to the Reserve. However, supporting documentation should be made available to the verifier during verification, if requested. In addition, the Aggregate Monitoring Plan (Section 6.2) must include procedures that the aggregator will follow to ascertain and demonstrate that all new fields in the project aggregate pass the Legal Requirement Test at the time of the field's start date.

As of the Effective Date of this protocol, the Reserve could identify no existing federal, state or local regulations that explicitly obligate rice producers to adopt the project activities approved under this protocol.

[19] See Appendix C for a summary of performance standard research.
[20] Form available at http://www.climateactionreserve.org/how/program/documents/.

3.5.3 Ecosystem Services Payment Stacking

When multiple ecosystem services credits or payments are sought for a single activity on a single piece of land, it is referred to as credit stacking or payment stacking, respectively.[21]

As of the Effective Date of this protocol, the Reserve did not identify any ecosystem service markets besides the carbon market that issues credits for the project activities included in this protocol.[22] As such, credit stacking does not need to be addressed by this protocol at this time.

The USDA Natural Resources Conservation Service (NRCS) provides payments for ecosystem services through programs like the Environmental Quality Incentives Program and the Conservation Stewardship Program. These are federal programs that are implemented at the state and local level. In California, NRCS Conservation Practice Standard (CPS) 344A – *Residue Management, Seasonal Rice Straw Residue* provides assistance to farmers to reduce the amount of rice straw residues on their fields through a variety of methods, including baling the rice straw residue,[23] and CPS 329 – *Residue and Tillage Management, No Till/Strip Till/Direct Seed* can provide support for dry seeding.[24]

CPS 344A and CPS 329 have primarily been used in California to fund other management practices besides baling and dry seeding.[25] Because baling and dry seeding are expensive, uncommon, and generally not already funded by NRCS programs, the use of NRCS payments to help finance either project activity under this protocol is allowed, except as specified below.

Stacking NRCS payments for baling under CPS 344A with CRTs for baling under this protocol is not allowed if a NRCS contract for baling on a project field was in place and the baling was completed prior to the project being submitted to the Reserve.

Stacking NRCS payments for dry seeding under CPS 329 with CRTs for dry seeding under this protocol is not allowed if dry seeding was specified in the conservation plan developed with NRCS for a project field and dry seeding was implemented prior to the project being submitted to the Reserve.

Note that if a field receives NRCS payments for any activity *other than* baling or dry seeding, those payments do not affect field eligibility, as the payments were awarded for different activities than those credited by this protocol and thus are not considered "stacked."

Furthermore, other fields owned by the farmer are eligible if they are not under agreement to receive NRCS funding for CPS 344A or CPS 329 activities that include project activities. Fields

[21] Cooley, David, and Lydia Olander (September 2011). "Stacking Ecosystem Services Payments: Risk and Solutions," Nicholas Institute for Environmental Policy Solutions, Duke University. NI WP 11-04. Available at: http://nicholasinstitute.duke.edu/ecosystem/land/stacking-ecosystem-services-payments/.

[22] The Reserve did identify a type of air quality offset that is issued in California under the Connelly-Areias-Chandler Rice Straw Phase-down Act of 1991 (Act); however, credits from the program are not issued for the project activities included in this protocol, but rather for reduced rice straw burning. The Reserve does not consider project participants receiving credits under both the Act and this protocol to be "stacking" credits.

[23] NRCS CPS 344A is available on the NRCS Field Officer Technical Guide website at http://efotg.sc.egov.usda.gov//efotg_locator.aspx. To find the appropriate standard, choose state, county, Section IV: Practice Standards and Specifications, and then the Conservation Practices folder.

[24] NRCS CPS 329 is available on the NRCS Field Officer Technical Guide website at http://efotg.sc.egov.usda.gov//efotg_locator.aspx. To find the appropriate standard, choose state, county, Section IV: Practice Standards and Specifications, and then the Conservation Practices folder.

[25] Personal communication with NRCS field personnel in California.

that have received CPS 344A or CPS 329 payments in the past (e.g. prior to the field's start date) but have not received payments for at least one year are also eligible.

Table 3.2. Payment Stacking Scenarios

Scenario		Is Project Eligible?	Is the Project Stacking?
1	Field under CPS 344A or 329 agreement that includes baling or dry seeding and agreement was signed *prior* to the project field's start date or submittal to the Reserve (whichever is earlier)	No	n/a
2	Field under NRCS CPS 344A or 329 agreement for activities that do not include baling or dry seeding	Yes	No
3	Field under NRCS agreement for any other CPS	Yes	No
4	Field under CPS 344A or 329 agreement that includes baling or dry seeding and agreement was signed *after* the project field's start date or submittal to the Reserve (whichever is earlier)	Yes	Yes
5	Field that received CPS 344A or 329 payment for the year prior to the project field's start date	No	n/a
6	Field that received CPS 344A or 329 payment in the past, but has not received payment for more than one year	Yes	No

For informational purposes, any other type of ecosystem service payment or credit received for activities on a project field must be disclosed by the project developer/aggregator to the verification body and the Reserve.

3.6 Regulatory Compliance

As a final eligibility requirement, project developers/aggregators must attest that activities on the project fields (including, but not limited to, project activities) do not cause material violations of applicable laws (e.g. air, water quality, water discharge, nutrient management, safety, labor, endangered species protection, etc.) prior to verification activities commencing each time a project is verified. To satisfy this eligibility requirement, the project developers/aggregators must submit a signed Attestation of Regulatory Compliance form[26] or an Attestation of Regulatory Compliance form on behalf of themselves or all enrolled project participants prior to the commencement of verification activities each time the project is verified. Project developers/aggregators are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by activities on project fields.

If a verifier finds that activities on project fields have caused a material violation, then CRTs will not be issued for GHG reductions that occurred on the field during the period(s) when the violation(s) occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurrent administrative violations directly related to activities on project fields may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

[26] Attestation of Regulatory Compliance form available at http://www.climateactionreserve.org/how/program/documents/.

Individual project participants who are part of a project aggregate are not required to attest to their status of regulatory compliance to the Reserve. However, the project aggregator is encouraged to have in place routine procedures for assessing field-level compliance. The verifier may request supporting documentation about the project aggregator's procedures or about specific fields and such information shall be made available to the verification body during verification, if requested.

3.6.1 California Rice Straw Burning Regulation

In California, rice producers are required to comply with the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 and the subsequent regulations of the Conditional Rice Straw Burn Permit Program, which limit the amount of rice straw residue producers may burn in any given year. The 1991 Act required a phase down of rice straw burning in the Sacramento Valley over a ten-year period, starting in 1992. Since September 2001, the Conditional Rice Straw Burn Permit Program has limited rice straw burning to less than 25 percent of an individual grower's planted acreage, not to exceed 125,000 acres in the Sacramento Valley Basin. Initially, rice fields were only allowed to be burned for disease control, which required demonstration of the presence of significant levels of disease in order to secure a Conditional Rice Straw Burn Permit ("Burn Permit"). However, after 100 percent of rice fields were consistently found to have the "significant" level of disease, this requirement was eliminated. Today, rice producers must secure Burn Permits (for up to 25 percent of their rice acreage) in order to burn straw.[27]

When project developers in California sign the Attestation of Regulatory Compliance, they are attesting that they are also in compliance with this regulation and that they have secured the appropriate "Conditional Rice Straw Burn Permits" from the appropriate local air district. Wherever rice straw burning occurs, the project developer must demonstrate that the amount of burning was within legal limits, if legal limits exist such as in California, and that all necessary permits have been secured.

Burning of rice straw is assumed to be an activity that will occur occasionally under "business as usual" as a pest management strategy. As such, whenever burning occurs, project input parameters to the model (see Appendix B, Step 1) should be adjusted, to reflect the correct percentage of rice straw burned in both the baseline and the project. Additionally, it should be noted that rice straw burning is not an approved project activity; although an increase in rice straw burning may reduce methane emissions, it is not an eligible activity under this protocol, even in cases when an increase in rice burning may be permissible by law.

3.6.2 Regulations on Special-Status Species

Regulations exist at the federal, state, and local level to protect threatened and endangered species (i.e. "special-status species") of wildlife and their habitats. These regulations include the federal and many state-level Endangered Species Acts and the Migratory Bird Treaty Act. As a component of the federal Endangered Species Act, the U.S. Fish and Wildlife Service works with private landowners to develop Habitat Conservation Plans (HCP) and Safe Harbor Agreements (SHA). When in effect on a rice field, an HCP or SHA should be considered a legally binding mandate. Project developers/aggregators shall disclose to the verifier any instances when a field is not in compliance with HCP or SHA requirements.

[27] Regulations establishing the Conditional Rice Straw Burning Program can be found in the California Code of Regulations, Title 17, § 80156. More information can also be found on the California Air Resources Board webpage at http://www.arb.ca.gov/smp/rice/condburn/condburn.htm.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project developers in order to determine the net change in emissions caused by a rice cultivation project.[28]

The GHG Assessment Boundary encompasses all the GHG SSRs that may be significantly affected by project activities, including sources of CH_4 and N_2O emissions from the soil, biological CO_2 emissions and soil carbon sinks, and fossil fuel combustion GHG emissions. For accounting purposes, the SSRs included in the GHG Assessment Boundary are organized according to whether they are predominantly associated with an RC project's "primary effects" (i.e. changes in the RC project's soil dynamics, including the predominant CH_4 source but also N_2O emissions from the soil and biological CO_2 emissions) or its "secondary effects" (i.e. unintended changes in emissions due to on-field practice change or upstream/off-field changes in production)).[29] Secondary effects may include increases in mobile combustion CO_2 emissions associated with site preparation, as well as increased GHG emissions caused by the shifting of cultivation activities from the project area to other agricultural lands (often referred to as "leakage"). Projects are required to account for all SSRs that are included in the GHG Assessment Boundary regardless of whether the particular SSR is designated as a primary or secondary effect.

Note that primary emissions contain some 'indirect' emissions (e.g. N_2O emissions), while secondary effect emissions contain some modeled soil dynamics (e.g. SOC decreases associated with shifting rice production outside of the project area).

Figure 4.1 below provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the project boundary.

Table 4.1 provides a comprehensive list of the GHG SSRs that may be affected by an RC project, and indicates which SSRs must be included in the GHG Assessment Boundary.

Note that for SSRs 6 and 7, some scenarios may require quantification of the SSRs for the project only.

[28] The definition and assessment of sources, sinks, and reservoirs (SSRs) is consistent with ISO 14064-2 guidance.
[29] The terms "primary effect" and "secondary effect" come from WRI/WBCSD, 2005. *The Greenhouse Gas Protocol for Project Accounting*, World Resources Institute, Washington, DC. Available at http://www.ghgprotocol.org.

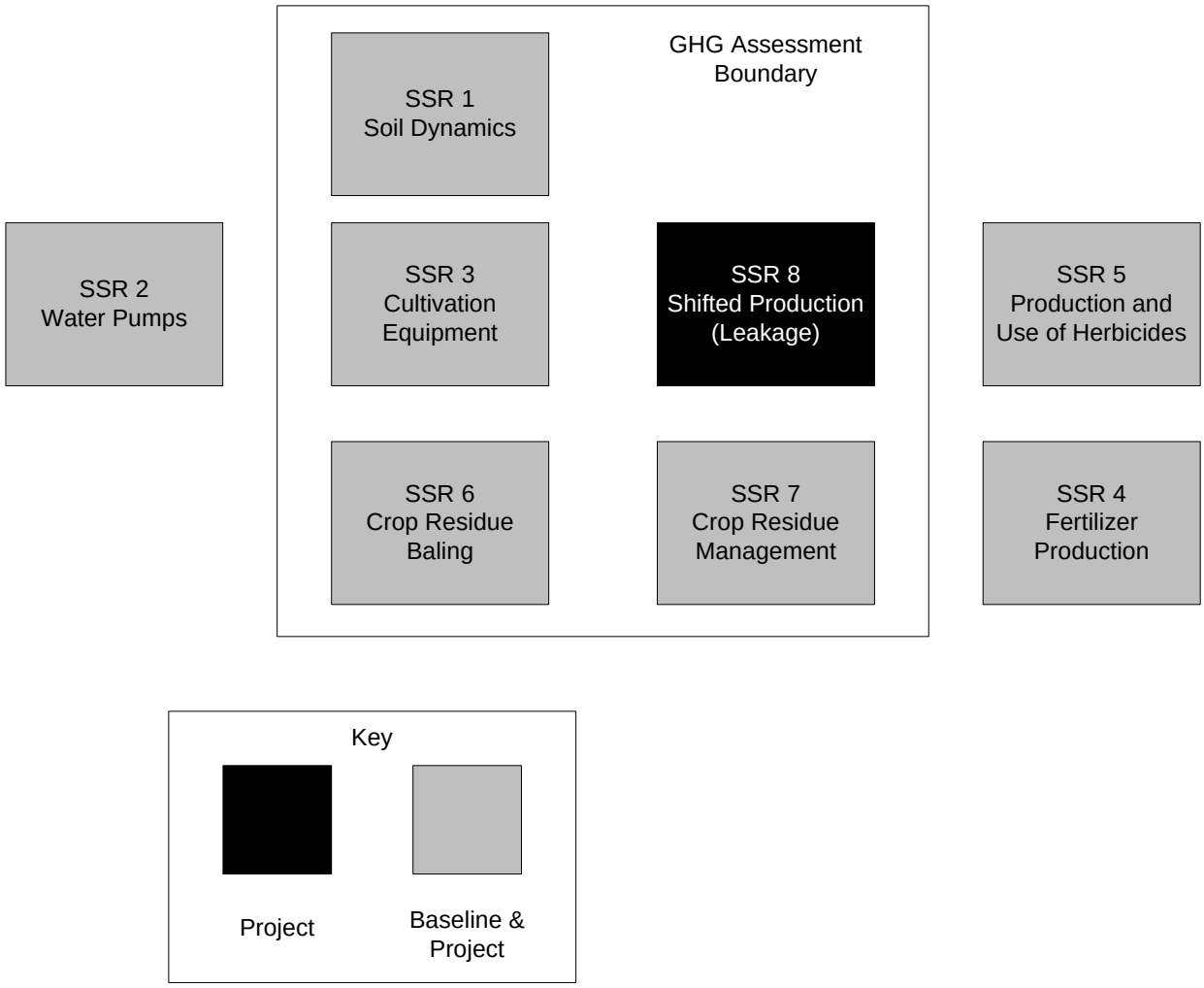

Figure 4.1. General illustration of the GHG Assessment Boundary

Table 4.1. Description of RC Project Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs					
1. Soil Dynamics	Soil dynamics refer to the biogeochemical interactions occurring in the soil that produce emissions of CO_2 (biogenic), CH_4, N_2O, and changes in soil carbon stocks. GHG flux rates from soils are dependent on water management (including during seeding and after harvest), residue management, fertilizer application, and other site-specific variables	CO_2	I (if SOC decreased)	DNDC	Changes in soil carbon stocks resulting from project activity may be significant. Decreases in carbon stocks must be accounted for.
		CH_4	I	DNDC	The primary effect of an RC project is reduction in CH_4 emissions from soil due to reduced flooding and/or reduced organic residues available for decomposition.
		N_2O	I (if increased)	Direct: DNDC Indirect: DNDC and IPCC emission factors	A significant source affected by project activities if fertilizer application amounts and/or dates are changed, or seeding practice is altered. Increases in direct and/or indirect N_2O must be accounted for.
Secondary Effect Sources, Sinks, and Reservoirs					
2. Water Pumps	Indirect fossil fuel emissions from transport of water onto fields	CO_2	E	N/A	Excluded, as project activity is very likely to reduce or not impact the quantity of water used during the cultivation process as compared to baseline management.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
3. Cultivation Equipment	Fossil fuel emissions increases from equipment used for field preparation, seeding, fertilizer/pesticide/herbicide application, and harvest	CO_2	I	Emission factors	Emissions may be significant if management is altered. Increased emissions due to project activity must be accounted for.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
4. GHG Emissions from Fertilizer Production	GHG emissions from synthetic N fertilizer production	CO_2	E	N/A	Excluded, the very small increase in fertilizer demand due to RC projects is unlikely to have an effect on fertilizer production.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
		N_2O	E	N/A	Excluded, the very small increase in fertilizer demand due to RC projects is unlikely to have an effect on fertilizer production.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
5. GHG Emissions from Production and Use of Herbicides	Fossil fuel emissions from Herbicide production	CO_2	E	N/A	Excluded, the very small increase in herbicide demand due to RC projects is unlikely to have an effect on herbicide production.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small
6. Crop Residue Baling	Fossil fuel emissions from baling and transportation of baled rice straw for offsite use/management	CO_2	I	Baling emission factors	Emissions may be significant if residue management is altered. Increased emissions due to project activity must be accounted for.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
7. Crop Residue Management	Fugitive emissions from aerobic or semi-anaerobic rice straw management (onsite or offsite)	CO_2	E	N/A	Emissions from rice straw burning are excluded as they are not considered likely to increase relative to baseline and are biogenic.
		CH_4	I	Emission factors	May be a significant source of fugitive CH_4 emissions, depending on management/use of rice straw.
		N_2O	E	N/A	Due to low N content of rice straw, changes in N_2O emissions from alternative rice straw management are likely insignificant.
8. GHG Emissions from Shifted Production (Leakage)	If project activity results in a statistically significant decrease in yield, rice production and associated GHG emissions may be shifted outside the project area	CO_2	I		If rice yield totaled over all fields in an aggregate are found to have statistically decreased due to project activity, the associated GHG emissions from shifted rice production must be estimated.
		CH_4	I		
		N_2O	I		

5 Quantification Overview

GHG emission reductions from an RC project are quantified by comparing actual project emissions to baseline emissions from rice cultivation. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of an RC project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project total net GHG emission reductions. GHG emission reductions are calculated for each individual field and summed together over the entire project area. The calculation approach in this section is applicable to single-field projects and aggregates.

The primary effect of an RC project is a reduction in methane emissions due to either (i) a decrease in duration of flooded conditions (switching to dry seeding with delayed flood), or (ii) a decrease in the availability of dissolved organic matter in the soil (residue baling). While there is directional certainty (i.e. it is likely that project cultivation changes will reduce methane emissions compared to the baseline scenario), the magnitude of reductions is highly variable and dependent on numerous other parameters related to field-scale management techniques, soil characteristics, and climatic conditions.

This protocol relies on the application of the DNDC model for quantification of baseline and project emissions from soil dynamics (SSR 1) defined in Section 4. Detailed requirements for accurate and consistent application of the DNDC model are provided in Appendix B. In addition to SSR 1, RC projects may result in unintended increases of GHG emissions from secondary effect SSRs. Section 5.5 provides the requirements for calculating those secondary GHG emissions resulting from the project activity that do not rely on use of the DNDC model. Total emission reductions from a field are equal to the combined primary effect emission reductions from SSR 1 for all fields in the project boundary, minus the increase in emissions from all other SSRs due to the project activity.

In addition to changes in CH_4, the DNDC model also provides estimates of nitrate leaching, and ammonia and nitric oxide emissions that are used to estimate the changes in indirect N_2O emissions associated with an RC project. The DNDC model also provides estimates of changes in SOC. If emissions of N_2O (both direct and indirect) increase or SOC decrease due to project activity, these emissions must be deducted from the emission reduction estimate. If N_2O (direct or indirect) emissions are reduced or SOC increased due to the project activity, these changes must be excluded from the emission reduction estimate.

5.1 Defining the Reporting Period

Under this protocol, project emission reductions must be quantified per cultivation cycle. The length of time over which GHG emission reductions are quantified is called a “reporting period”. The length of time over which GHG emission reductions are verified is called a “verification period.” For single-field projects, a verification period can cover multiple reporting periods (see Section 7.4.1). For aggregate projects, the verification period is limited to a single reporting period (i.e. a single cultivation cycle).

For single field projects, the reporting period shall be defined using the exact dates corresponding to the beginning and the end of the cultivation cycle for the particular field.

For an aggregate, the individual fields will likely have cultivation cycles that start on different dates, and the length of the cultivation cycle may be slightly more or less than a full 365 days for each individual field. Therefore, the reporting period must be uniformly defined for the aggregate for reporting purposes. For reporting reductions from each cultivation cycle to the Reserve, the aggregate reporting period shall be defined as starting on October 1 and ending on September 30 of the following year. This defined reporting period is for reporting purposes only; the emission reductions reported for the aggregate must include the emission reductions achieved over the complete cultivation cycle for each participating field in the aggregate.[30]

Note that in order to model emissions for any given cultivation cycle, it is necessary to model two full years of data, as each cultivation cycle spans across two calendar years. See Section 5.3 for guidance on how to reconcile modeling annual emissions with modeling emissions for the cultivation cycle.

5.2 Baseline Modeling Inputs

To set the baseline scenario inputs within the DNDC model for each cultivation cycle, the project developer must use field management data from five cultivation cycles prior. Given that two calendar years of data are required for every cultivation cycle being modeled (as set out in Section 5.3 below), inputs for the first baseline cultivation cycle must be derived from records starting in the fall of the fifth year prior to the start date and ending with the following rice harvest in the fall of the fourth year prior to the start date. The last baseline cultivation cycle in the crediting period shall include data from the fall of the year before the project started through to the rice harvest immediately preceding the project start date. In subsequent crediting periods, the baseline scenario will continue to be set using data from the five cultivation cycles immediately prior to the project.

5.3 Deriving Cultivation Cycle Emissions from Calendar-Year Modeling Results

It is important to note that the DNDC model operates on a calendar year, beginning on January 1 and ending on December 31. The model's daily output files use Julian days, where January 1 represents Julian Day 1, January 2 represent Julian Day 2, and December 31 represents Julian Day 365.[31] However, project developers must quantify emissions and emission reductions that occur during the reporting period of a given field, which is defined by the rice crop's cultivation cycle beginning in fall and running through the fall of the following year (e.g. October 1 to September 30). As such, for every instance in this protocol where the project developer is directed to model a cultivation cycle, the project developer must model two full calendar years, so as to capture the last two to three months in the first year, and the first nine to ten months in the following year that make up the relevant cultivation cycle.[32]

For ease of monitoring, reporting, and verification, the Reserve encourages project developers to use Julian Dates in addition to calendar dates wherever possible, but particularly when

[30] All emissions reductions from each field's cultivation cycle must be reported under the corresponding reporting period for the aggregate, even if the dates of the cultivation cycle and reporting period do not completely overlap. For any given field, emissions reductions achieved during a cultivation cycle may only be reported under a single aggregate reporting period.

[31] A Julian Day calendar provided by NASA is available at: http://www-air.larc.nasa.gov/tools/jday.htm.

[32] In determining project emissions, one strategy for economizing on required modeling runs is to conduct modeling only after input data for the entire two calendar years have been collected, i.e. at the end of the second calendar year, rather than at the end of the cultivation cycle. This will generate results for the initial 2-3 months of the subsequent cultivation cycle, avoiding the need to model the entire calendar year again.

reporting the first and last days of a cultivation cycle, as this will ease project accounting and reduce human error associated with model inputs.

5.4 Quantifying GHG Emission Reductions

The emission reductions for a project are calculated by subtracting the total secondary effect emissions (SE) from the total primary emission reductions (PER) (adjusted for uncertainty) for the entire project area. Equation 5.1 below provides the general emission reduction calculation, applicable to all projects.

Equation 5.1. Calculating GHG Emission Reductions

$$\boldsymbol{ER = PER - SE}$$

Where,

			Units
ER	=	Total emission reductions from the project area for the reporting period	tCO_2e
PER	=	Total primary GHG emission reductions from soil dynamics (SSR 1) from each project during the reporting period adjusted for uncertainty (as calculated in Section 5.4.3)	tCO_2e
SE	=	Total secondary effect GHG emissions caused by project activity during the reporting period for each project (as calculated in Section 5.5)	tCO_2e

Table 5.1 below provides an overview of the key steps, calculations and equations necessary to quantify PER and SE emissions for each field and the project as a whole.

Table 5.1. Overview of Quantification Steps

STEP	OVERVIEW	EQUATION
1. Calculate primary emissions for baseline scenario and project scenario for each field	Calculate average cultivation cycle baseline and project scenario GHG values. This involves: ▪ Conducting 2,000 Monte Carlo runs of the DNDC model for both calendar years within which the cultivation cycle falls, for both the baseline and project scenarios (4 years total); ▪ Extracting data from DNDC modeling results corresponding to the cultivation cycle; ▪ Calculating cultivation cycle GHG parameter values for each Monte Carlo run; and ▪ Averaging these values across the 2,000 Monte Carlo runs for both the baseline and project scenarios.	Equation 5.2
2. Calculate primary effect emission reductions for each field (unadjusted for uncertainty)	Preliminary primary effect emission reductions for each field are calculated using results from the baseline and project modeling calculations in Step 1.	Equation 5.3
3. Calculate uncertainty-adjusted primary emission reductions for each field	Apply soil and structural uncertainty deductions to preliminary primary effect emission reductions for each field to calculate final primary effect emission reductions.	Equation 5.4

4. Calculate increased emissions from cultivation equipment	Choose from two alternative approaches to calculate emissions from increased fuel emissions from cultivation equipment.	Equation 5.5 or Equation 5.6
5. Calculate emissions from rice straw end use	Calculate emissions associated with changes in rice straw management, using default emission factors provided in Appendix A.	Equation 5.7
6. Calculate emissions from activity leakage	Calculate emissions associated with any shift in rice production outside of the project boundary, attributed to reductions in project yields.	Equation 5.8 Equation 5.9 Equation 5.10
7. Calculate total secondary effect emissions for the project	Sum together emissions from increased fossil fuel usage, alternative residue management activities, and activity leakage.	Equation 5.11

5.4.1 Step 1: Calculate Primary Emissions for Baseline and Project Scenarios for Each Field

This section provides guidance on how to use results from DNDC Monte Carlo modeling runs to calculate average cultivation cycle emissions for both the baseline and project scenarios for each field. These average cultivation cycle emissions are then input into Equation 5.3 to calculate primary emission reductions for each field. For the purposes of this protocol, the modeling of GHG emissions from soil dynamics under baseline and project scenarios must be performed using Version 9.5 of the DNDC model, which shall be obtained directly from the Reserve.

Detailed guidance is provided in Appendix B on how to undertake the modeling itself, extract relevant results and develop the necessary inputs for Equation 5.2 below. Specifically, Appendix B, Step 1 provides guidance to help project developers understand the necessary DNDC data input parameters; Step 2 instructs project developers on how to prepare input files and what to do in case of missing data; Step 3 instructs project developers on how to properly prepare DNDC for modeling; and Step 4 instructs project developers on how to undertake the modeling of emissions, extract relevant results and develop the values to be input into Equation 5.2 below.

In order to quantify primary emission reductions for each field, project developers shall first calculate annual baseline and project scenario GHG values using data extracted from DNDC modeling results.

For both the baseline and project scenarios, GHG emissions are calculated by performing 2,000 Monte Carlo runs of the DNDC model for each field, for each calendar year being modeled.[33]

For each of the 2000 Monte Carlo runs for a field, the project developer must extract GHG parameter values corresponding to the dates of the field's cultivation cycle (i.e. extracted from the appropriate range within each modeled calendar year). A single cultivation cycle value is then determined for each GHG parameter, by summing daily values (for emissions) or by

[33] As set out in Section 5.3, emissions will need to be modeled separately for four calendar years: the two calendar years that capture the baseline scenario cultivation cycle and the two calendar years that capture the project scenario cultivation cycle.

identifying the value on the last day of the cultivation cycle (soil carbon).These single values are then input into Equation 5.2 to be averaged across the 2,000 Monte Carlo runs in order to generate a single average value for each GHG parameter for the cultivation cycle. Refer to Step 4 in Appendix B for detailed guidance on how to perform these steps. Appendix C also provides more general guidance on how to use the DNDC model, including screen shots, step by step instructions, and advice on performing project feasibility analysis with the model. Further guidance can also be found in the *DNDC User's Guide*, available on the Reserve's RCPP webpage.[34]

The results of Equation 5.2 are a single average value for each of the direct emission parameters (N_2O, CH_4, and SOC content) and indirect emission parameters (NO_3 and NH_3+NO_x) that are used to calculate primary GHG reductions. Once these values are calculated for both the baseline and project scenarios, they are input into Equation 5.3, to calculate the total primary emission reductions for each field.

[34] A copy of the *DNDC User's Guide* can be found on the protocol webpage at http://www.climateactionreserve.org/how/protocols/rice-cultivation/.

Equation 5.2. Calculating GHG Emissions from Monte Carlo Runs for Field i

$$N_2O_i = \frac{\sum_{j=1}^{2000}\left\{\left(N_2O_{Dir,j,i} + \left(N_{Leach,j,i} \times 0.0075\right) + \left(N_{Vol,j,i} \times 0.01\right)\right\}}{2000} \times \frac{44}{28} \times 310$$

$$CH_{4_i} = \frac{\sum_{j=1}^{2000}\left(CH_{4_{j,i}}\right)}{2000} \times \frac{16}{12} \times 21$$

$$SOC_{LDcc,i} = \frac{\sum_{j=1}^{2000}\left(SOC_{LDcc,j,i}\right)}{2000} \times \frac{44}{12}$$

Where,			Units
N_2O_i	=	Average cultivation cycle direct and indirect N_2O emissions (for either the baseline or project scenario) from rice field *i*, equal to the average value of all Monte Carlo runs *j*	kg CO_2e/ha
j	=	*1, 2, 3 …2000* Monte Carlo runs	
$N_2O_{Dir,j,i}$	=	Cultivation cycle N_2O emissions from rice field *i* (for either the baseline or project scenario) from Monte Carlo run *j*	kg N_2O-N/ha
$N_{Leach,j,i}$	=	Cultivation cycle nitrate leaching loss from rice field *i* (for either the baseline or project scenario) from Monte Carlo run *j*	kg NO_3-N/ha
$N_{Vol,j,i}$	=	Cultivation cycle ammonia volatilization and nitric oxide emissions from rice field *i* (for either the baseline or project scenario)from Monte Carlo run *j*	kg NH_3-N + kg NO_x-N /ha volatized
44/28	=	Unit conversion from kg N_2O-N to kg N_2O	
310	=	Global warming potential of N_2O	
$CH_{4\ i}$	=	Average cultivation cycle CH_4 emissions (for either the baseline or project scenario)from rice field *i*, equal to the average value of all Monte Carlo runs *j*	kg CO_2e/ha
$CH_{4\ j,i}$	=	Cultivation cycle CH_4 emissions from rice field *i* (for either the baseline or project scenario) from Monte Carlo run *j*	kg CH_4-C/ha
16/12	=	Unit conversion of C to CH_4	
21	=	Global warming potential of CH_4	
$SOC_{LDcc,i}$	=	Average cultivation cycle final SOC, equal to the average value of all Monte Carlo runs *j,* of the soil organic carbon content of rice field *i* on the last day of the cultivation cycle (for either the baseline or project scenario)	kg CO_2e/ha
$SOC_{LDcc,j,i}$	=	SOC content of rice field *i* on the last day of the cultivation cycle (for either the baseline or project scenario) from Monte Carlo run *j*	kg SOC-C/ha
44/12	=	Unit conversion of C to CO_2	
0.0075	=	Emission factor for N_2O emissions from N leaching and runoff[35]	kg N_2O-N / kg NO_3-N
0.01	=	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatization[36]	kg N_2O-N / (kg NH_3-N + kg NO_x-N)

[35] IPCC Guidelines for National GHG Inventories (2006), Vol.4, Ch.11, Table 11.3.
[36] Ibid.

5.4.2 Step 2: Calculate Primary Emission Reductions for Each Field (Unadjusted for Uncertainty)

In order to calculate the total PER for each field (PER_i) (unadjusted for uncertainty), project developers must compare the baseline and project scenario results calculated in Step 1 for the key GHG parameters CH_4, N_2O, and SOC. Any decreases in N_2O or increases in SOC are excluded from the total PER_i results, as the protocol does not credit projects for such changes.

The calculations necessary to quantify PER_i are set out in Equation 5.3 below.

Equation 5.3. Total Primary Effect GHG Emission Reductions for each Field (Unadjusted for Uncertainty)

$$PER_i = \frac{\left\{(N_2O_{B,i} - N_2O_{P,i}) + (CH_{4_{B,i}} - CH_{4_{P,i}}) - (SOC_{LDBcc,i} - SOC_{LDPcc,i})\right\}}{1000} \times Area_i$$

Where,

			Units
PER_i	=	Primary effect GHG emission reductions for field *i* ***** (unadjusted for uncertainty)	tCO_2e
$N_2O_{B,i}$	=	Average baseline cultivation cycle N_2O emissions for field *i*	kg CO_2e/ha
$N_2O_{P,i}$	=	Average project cultivation cycle N_2O emissions for field *i*	kg CO_2e/ha
$CH_{4\ B,i}$	=	Average baseline cultivation cycle CH_4 emissions for field *i*	kg CO_2e/ha
$CH_{4\ P,i}$	=	Average project cultivation cycle CH_4 emissions for field *i*	kg CO_2e/ha
$SOC_{LDBcc,i}$	=	Average SOC value on the last day of the baseline cultivation cycle for field *i*	kg CO_2e/ha
$SOC_{LDPcc,i}$	=	Average SOC value on the last day of the project cultivation cycle for field *i*	kg CO_2e/ha
$Area_i$	=	Area of field *i* in hectares	ha

***** In order to ensure that only reductions in CH_4 are credited on each field, the term ($N_2O_{B,i} - N_2O_{P,i}$), must be set equal to zero if it is > 0; and the term ($SOC_{LDBcc,i} - SOC_{LDPcc,i}$) must be set equal to zero if it is < 0.

5.4.3 Step 3: Calculate Uncertainty-Adjusted Primary Emission Reductions for each Field

When calculating PER, this protocol requires project developers to account for two types of uncertainty: model structural uncertainty and soil input uncertainty. Inherent in biogeochemical models (like DNDC) are uncertainties due to imperfect science in the models. This uncertainty is often referred to as model structural uncertainty, and roughly quantifies how well the model represents reality. Because physical and chemical properties of soil have a significant impact on CH_4 and N_2O production, consumption, and emissions, further variability and uncertainty is also introduced to the model in the sampling of soil data and the subsequent modeling of GHG emissions using such data. This is known as soil input uncertainty.

The protocol requires that project developers account for both types of uncertainty by applying the appropriate uncertainty deductions to the modeled primary emission reductions. The soil input uncertainty deduction must be calculated by project developers for each field based on results from DNDC to model baseline and project scenario emissions for that field. The model structural uncertainty deduction is provided by the Reserve. Further guidance on each type of uncertainty deduction is provided below.

5.4.3.1 Model Structural Uncertainty Deduction

Model structural uncertainty is quantified by comparing model estimates of greenhouse gases with measured emission estimates. The measured data are assumed to have no uncertainty (although measurements can have sources of uncertainties in practice). Project developers do not need to calculate the model structural uncertainty deduction, but instead obtain the appropriate structural uncertainty deduction from the Reserve at the time of verification.

Appendix C provides the structural uncertainty derivation procedure developed to adjust DNDC results for model structural uncertainty. To ensure conservativeness in estimates of project emission reductions, all projects must use the adjustments provided by the Reserve to account for structural uncertainty for Version 9.5 of the DNDC model, as specified in Equation 5.4.

Because there is ongoing field research actively collecting GHG emissions data for California rice, new data may become available for model validation. Periodically, as data become available, the calculation of model structural uncertainty and the table of structural uncertainty factors will be updated. Further, the factors decline as more fields implement rice cultivation projects. As such, the most up-to-date factors will be available on the Reserve website. Project developers must use the structural uncertainty deduction factor (μ_{struct}) for the appropriate reporting year that is published on the Reserve website at the time of verification.

5.4.3.2 Soil Input Uncertainty Deduction

Project developers must calculate an appropriate soil input uncertainty deduction using results from the same Monte Carlo analyses performed to model baseline and project emissions for each field. Detailed guidance on conducting Monte Carlo analyses and developing soil input uncertainty deductions is provided in Appendix B, Step 4 and Step 5 respectively.

5.4.3.3 Applying Uncertainty Deductions to Primary Emission Reductions

Once an appropriate soil input uncertainty deduction has been calculated, in accordance with Appendix B, Step 5.1, and an appropriate structural uncertainty deduction has been obtained from the Reserve, both deductions are applied to PER_i in order to calculate uncertainty adjusted total PER for each field. The application of the uncertainty deductions to PER_i is shown in Equation 5.4 below.

Equation 5.4. Applying Uncertainty Deductions to Primary Emission Reductions

$$\boldsymbol{PERud} = \sum_{\boldsymbol{i=1}}^{\boldsymbol{m}} \left\{ \left(\mu_{\boldsymbol{inputs_i}} \times \boldsymbol{PER_i} \right) - \mu_{\boldsymbol{struct}} \right\}$$

Where,

			Units
PERud	=	Primary GHG emission reductions over the entire project area, accounting for uncertainty deductions	tCO_2e
m	=	Number of individual rice fields included in the project area	
$\mu_{inputs,i}$	=	Accuracy deduction factor for the cultivation cycle for individual rice field *i* due to soil input uncertainties, refer to Appendix B, Step 5.1	fraction
PER_i	=	Primary GHG emission reductions for field *i* (from Equation 5.3)	tCO_2e
μ_{struct}	=	Accuracy deduction from model structural uncertainty for the reporting period, values available on Reserve website	

5.5 Quantifying Secondary Effects

Secondary effect GHG emissions are unintentional changes in GHG emissions from the secondary SSRs within the GHG Assessment Boundary. Secondary effect emissions may increase, decrease or go unchanged as a result of the project activity. If emissions from secondary SSRs increase as a result of the project, these emissions must be subtracted from the total modeled primary emission reductions (as specified in Equation 5.1) for each reporting period on an *ex post* basis.

The total secondary effect GHG emissions are equal to:

- Increased CO_2 emissions from mobile combustion of fossil fuels by farm equipment used for field preparation, seeding, and cultivation (SSR 3, Step 4), plus
- CO_2 emissions from transport and processing of rice straw residues (SSR 6, Step 5), and methane emissions from aerobic or semi-anaerobic treatment/use of baled rice straw residue (SSR 7, Step 5), plus
- Emissions of CH_4 and CO_2 due to shifted rice production outside the project boundary (SSR 8, Step 6)

5.5.1 Step 4: Calculate Project Emissions from Onsite Fossil Fuel Combustion

Included in the GHG Assessment Boundary are secondary CO_2 emissions resulting from increased fossil fuel combustion for onsite equipment used for performing RC management activities related to seeding, fertilizer application, and herbicide application. Fossil fuel emissions from baling rice straw are incorporated into the emission calculation in Section 5.5.2 below and are not to be included when quantifying increased fossil fuel emissions per this section. Secondary emissions from cultivation equipment need not be quantified if there is no change in the type or hours of cultivation equipment usage due to implementation of the project (e.g. no new equipment used for dry seeding). But if the project management changes require new equipment or an increase in the operational hours for existing equipment, the CO_2 emissions from the increased fossil fuel combustion shall be calculated using either Equation 5.5 or Equation 5.6 below.

Two approaches are provided to calculate secondary emissions from cultivation equipment. Approach 1 calculates emissions based on the time needed for each rice cultivation related field operation, the horsepower required for this field operation, and a default emission factor for GHG emissions per horsepower-hours. Approach 2 calculates emissions based on the change in fuel consumption for field operations related to rice cultivation and a default emission factor for GHG emissions per unit of fuel consumed.

Approach 1 is designed to require minimal documentation. The project participant must provide manufacturer's specifications on the horsepower requirements for the new cultivation equipment used, and the time needed per hectare for implementation of the project-specific activity. The time needed to implement the activity should be reported based on work-hour records. However, lacking those records, they may be derived based on the average operation or ground speed of the equipment and the application width per pass (e.g. width of boom). Using Approach 1, project emissions from cultivation equipment are calculated using Equation 5.5.

Equation 5.5. Project Emissions from Cultivation Equipment (Approach 1)

$$SE_{FF,f} = \left(\sum_{i}\left(EF_{HP-hr,P,i,f} \times HP_{P,i,f} \times t_{P,i,f}\right) - \sum_{k}\left(EF_{HP-hr,B,k,f} \times HP_{B,k,f} \times t_{B,k,f}\right)\right) \times 10^{-6}$$

If $SE_{FF,f}$ < 0, set $SE_{FF,f}$ to 0

Where,

			Units
$SE_{FF,f}$	=	Increase in secondary emissions from a change in cultivation equipment on field *f*	Mg CO_2e/ha
$EF_{HP-hr,P,i,f}$	=	Emission factor for project operation *i* on field *f*. Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations[37]	g CO_2e/HP-hr
$HP_{P,i,f}$	=	Horsepower requirement for project operation *i* on field *f*	HP
$t_{P,i,f}$	=	Time required to perform project operation *i* on field *f*	hr/field
$EF_{HP-hr,B,k,f}$	=	Default emission factor for baseline operation *k* on field *f* Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations[38]	g CO_2e/HP-hr
$HP_{B,k,f}$	=	Horsepower requirement for baseline operation *k* on field *f*	HP
$t_{B,k,f}$	=	Time required to perform baseline operation *k* on field *f*	hr/field
10^{-6}	=	Converting g CO_2e to Mg CO_2e	

Optional Method (determination of *t*)
If time records are not available, use the method below in both baseline and project estimates.

$$t = \frac{10000}{(width \times speed \times 1000)} \times A_f$$

Where,

			Units
t	=	Time requirement for field operation	hr
10000	=	Area unit conversion	m^2/ha
width	=	Application width covered by equipment	m
speed	=	Average ground speed of the operation equipment	km/hr
1000	=	Length unit conversion	m/km
A_f	=	Size of field *f*	ha

Alternately, project participants may choose to quantify secondary emissions from changes in the use of cultivation equipment based on their fuel consumption records (see Equation 5.6, Approach 2, below). If insufficient fuel consumption records are available, Approach 1 must be used.

[37] California Air Resources Board, OFFROAD2007. Available at http://www.arb.ca.gov/msei/offroad/offroad.htm.
[38] Ibid.

Equation 5.6. Increased Emissions from Cultivation Equipment (Approach 2)

$$SE_{FF,f} = \frac{\sum_i [(FF_{RP,j} \times EF_{FF,j}]}{1000}$$

If $SE_{FF,f} < 0$, set $SE_{FF,f}$ to 0

Where,			Units
$SE_{FF,f}$	=	Increase in secondary emissions from a change in cultivation equipment on field *f*	Mg CO_2e/ha
$FF_{RP,j}$	=	Total change in fossil fuel consumption for field *f* during the reporting period, by fuel type *j*	gallons
$EF_{FF,j}$	=	Fuel-specific emission factor. Default values are 17.4 for gasoline and 13.7 for diesel[39]	kg CO_2/gallon fossil fuel
1000	=	Kilograms per megagram	kg CO_2/Mg CO_2

5.5.2 Step 5: Calculate Project Emissions from Rice Straw Residue Management/Use

Project emissions from rice straw management consist of CH_4 produced from anaerobic or semi-anaerobic decay of the rice straw, and fossil fuel emissions that are used for swathing, raking, and baling of the rice straw. Depending on the end-use of the rice straw, the magnitude of the emissions will vary, but may be significant. If rice straw is unused and accumulates in piles on or near the farm, anaerobic decay will produce emissions that are quite significant, potentially outweighing the GHG benefits of baling the rice straw. Because the swathing, raking, and baling services are most often performed by third-party contractors, fossil fuel emissions from the swathing, raking, and baling process are estimated using conservative default factors.

For calculating the emissions from rice straw management and/or use, emission factors were developed for the following identified end-uses:[40]

- **Dairy replacement heifer feed:** Wheat straw is traditionally used in heifer feed. Rice straw can be used if it is cut to the right length. Quality of the straw (crude protein content, moisture content, etc.) must meet minimal standards before it can be used. There may be a significant effect on enteric fermentation from replacing wheat straw with rice straw due to feeding animals lower quality straw.

- **Beef cattle feed:** Rice straw is used by beef cattle operations as a dry matter supplement to pasture feeding during fall and winter. Cattle ranchers spread the large bales out on the range in fall and allow the cattle to feed on the bales. Quality of the straw (crude protein content, moisture content, etc.) must meet minimal standards before it can be used. There may be some effects on enteric fermentation by feeding lower quality straw.

- **Fiberboard manufacturing:** Rice straw may be used as an alternative to wood products for the manufacturing of fiberboard. The avoided emissions from harvest and transport of wood products very likely outweigh emissions from transporting rice straw.

[39] California Air Resources Board, OFFROAD2007. Available at http://www.arb.ca.gov/msei/offroad/offroad.htm.
[40] End-uses and descriptions referenced from ANR, 2010.

- **Spread out on bare soils as erosion control:** Rice straw is particularly valuable for erosion control since it is produced in an aquatic environment and does not pose a risk of introducing upland weeds like wheat or barley straw. When used for erosion control, rice straw will decompose aerobically because it is spread out on top soil, ensuring an oxygen rich environment during decomposition.

- **Other uses:** Rice straw may be used in small quantities for other uses, such as animal bedding, being stuffed into netted rolls for soil loss prevention, or for use in mushroom farming (among other potential uses). Because of a lack of detailed emissions data, straw that is sent to an end-use other than those specified above must use the default emission factor for 'unknown or other' end-uses in Appendix A.

Each field must use Equation 5.7 to calculate the project CH_4 emissions from the end-use of all baled rice straw. Because growers may not be able to track the end fate for some or all of the field rice straw, a conservative default factor can be used in place of an end-use specific default factor. If electing to use end-use specific factors, the project developer must collect and retain straw sales documentation to demonstrate rice straw end-use(s). See Section 6.4.3 for detailed baling monitoring requirements.

Projects must use the emission factor in Table A.1 in Appendix A corresponding to the appropriate end-use, or the default factor. If rice straw is unused and accumulates in piles on or near the field, the portion of rice straw that is left unused must be estimated, and the default factor for unused rice straw must be used to quantify the emissions from this source.

Equation 5.7. Emissions from Rice Straw End-Use

$$SE_{RM,i} = \left(W_{RS,i} \times EF_{SRB}\right) + \sum_{U}\left[W_{RS,U} \times EF_{U}\right]$$

Where,			Units
$SE_{RM,i}$	=	Total secondary effect GHG emissions from alternative residue management for field *i*	tCO_2e
$W_{RS,i}$	=	Total weight of rice straw in dry tonnes that is swathed, raked, and baled on the field *i*	dry tonne
EF_{SRB}	=	Emission factor for increased fossil fuel emissions from swathing, raking, and baling. The emission factor shall be equal to 0.01 for all fields[41]	tCO_2e / dry tonne
$W_{RS,U}$	=	Weight of rice straw in dry tonnes with end-use *U*. The sum weight of rice straw for all end-uses must equal the total weight of rice straw baled on the field	dry tonne
EF_U	=	Emission factor from Table A.1 in Appendix A for end-use *U*	tCO_2e / dry tonne

[41] Emissions from swathing, raking, and baling the rice straw are likely to be similar to emissions from the avoided chopping and disking of the field. From University of California cost and return studies for rice (2007) and orchard grass hay (2006), conservative estimates of fuel usage were obtained for both scenarios. The emission factor assumes an increase in fuel usage equivalent to 2 gallons of diesel fuel per acre for the swathing, raking, and baling. Using EPA diesel emission factor of 8.78 kg CO_2 per gallon of diesel, and assuming 3 tonnes of rice straw per acre, the emissions increase from swathing, raking, and baling is estimated to be 5.85 kg CO_2 per tonne of rice straw.

5.5.3 Step 6: Calculate GHG Emissions from the Shift of Rice Production Outside of Project Boundaries (Leakage)

If rice yields decrease as a direct result of project activity, to be conservative it is assumed that the decrease in rice production causes a net increase in production elsewhere outside the project boundary. The emissions associated with this shift in production must be estimated if project related yield losses are statistically significant compared to historic and average yields. Although rice production in California and the U.S. is likely fairly inelastic in relation to price changes,[42] it is assumed for conservativeness that a statistically significant drop in rice yields due to project activities would result in an increase of production outside of the project boundary.

If a simple summation of project yield, or in the case of aggregate, the aggregate project area yields, shows that yields did not decrease compared to the average historic rice yield for the same area, then this protocol assumes leakage has not occurred and subsequently emissions associated with shifting production do not need to be estimated (i.e. the remainder of this section can be skipped).

In order to determine if rice yields have decreased across the project area during the cultivation cycle as a result of project activity, the annual yield from the project area must be compared to historical yields from the same project area. Because yields fluctuate annually depending on numerous climatic drivers, all yields are normalized to average annual county yields using USDA NASS statistics.[43]

The following procedure must be followed for each cultivation cycle to ensure that the yields from the project area have not declined due to project activity. The following procedure is applicable for a single field project. All project aggregates must apply the following procedure to the entire project area, defined as the sum of individual fields included in verification activities:

1. For the five rice cultivation years *t* prior to implementation of the project, normalize the rice yield of the field by the county average for that year, $\boldsymbol{y_norm_t}$. If the project is an aggregate, calculate $\boldsymbol{y_norm_t}$ for each of the historical years as the weighted average (by percent of field area) of all fields in the aggregate following Equation 5.8. The distribution of $\boldsymbol{y_norm_t}$ will have five data points. If a fallow year is present in the baseline period, ignore that year for the purpose of calculating leakage for that particular field. As an additional year of historic yield should have been reported, the field with a fallow year should still have five data points.

[42] McDonald et al. (2002), Russo et al. (2008).
[43] Available at http://quickstats.nass.usda.gov.

Equation 5.8. Normalized Yield for Each Year *t*

For single-field projects: $\boldsymbol{y_norm_t} = \frac{Y_{f,t}}{Y_{county,t}}$

For aggregate projects: $\boldsymbol{y_norm_t} = \sum_f \left(A_f \times \frac{Y_{f,t}}{Y_{county,t}} \right) / \sum_f A_f$

Where,

			Units
y_norm_t	=	Normalized yield for each year *t*	fraction
$Y_{f,t}$	=	Yield of field *f* in year *t*	Mg/ha
$Y_{county,t}$	=	County average yield in year *t*	Mg/ha
A_f	=	Size of field *f*	ha

If aggregates span multiple counties, $Y_{county,t}$ must correspond with the county in which field *f* is located.

2. Take the standard deviation, ***s***, and mean of the $\boldsymbol{y_norm_t}$ distribution:

   $$\boldsymbol{s = stdev(y_norm_t)}$$

   $$\boldsymbol{\overline{y_norm_t} = average(y_norm_t)}$$

3. Calculate the minimum yield threshold below which normalized yields are significantly smaller than the historical average. This shall be done as follows:

   $$\boldsymbol{y_{min} = \overline{y_{norm_t}} - 2.132 \times s}$$

   Where 2.132 is the t-distribution value with 95 percent confidence for a one-tailed test with four degrees of freedom (i.e. n is 5),[44] and ***s*** is the standard deviation of the $\boldsymbol{y_norm_t}$ distribution, as calculated in Step 2.

4. For the present cultivation cycle, normalize the yield of each field by the county average for the growing season for the year, and, if the project is an aggregate, calculate the weighted average for all fields in the aggregate to get $\boldsymbol{y_norm_{t0}}$ using Equation 5.8 above and replacing ***t*** with $\boldsymbol{t_0}$, i.e. the year of the present reporting period.

5. For every year of the crediting period, calculate $\boldsymbol{y_norm_{t0}}$ and compare this value to ***y_min***. If $\boldsymbol{y_norm_{t0}}$ is smaller than ***y_min***, it must be assumed that emissions increased outside of the project area. The aggregate must account for increased emissions as specified in Equation 5.9 below. Alternatively, if $\boldsymbol{y_norm_{t0}}$ is larger than ***y_min*** then no emissions associated with shifts in production are assumed to occur and therefore do not need to be calculated.

[44] The t-distribution value of 2.132 = t(0.05, n – 1), where n is 5, and n-1 degrees of freedom is 4. There should always be five data points when performing this calculation in the RCPP as there shall always be 5 years of rice yield data for a given field.

Equation 5.9. GHG Emissions Outside the Project Boundary

$$SE_{PS} = \left(1 - \frac{y_norm_{t_0}}{y_min}\right) \times \frac{\sum_i \left(N_2O_{B,i} + CH_{4_{B,i}} - \Delta SOC_{B,i}\right)}{1000}$$

Where,			Units
SE_{PS}	=	Total secondary effect GHG emissions for the project aggregate from production shifting outside of the project boundary	tCO_2e
y_norm_{t0}	=	Sum of yields for the current cultivation cycle normalized to the county averages	fraction
y_min	=	Minimum yield threshold below which normalized yields are significantly smaller than the historical average	fraction
$N_2O_{B,i}$	=	Baseline cultivation cycle direct and indirect N_2O emissions from rice field *i*, equal to the average of the values of all Monte Carlo runs *j*	kg CO_2e/ha
$CH_{4\ B,i}$	=	Baseline cultivation cycle CH_4 emissions from rice field *i*, equal to the average of the values for all Monte Carlo runs *j*	kg CO_2e/ha
$\Delta SOC_{B,i}$	=	Change in SOC content of rice field *i* during the baseline cultivation cycle, as calculated in Equation 5.10 below	kg CO_2e/ha
1000	=	kg per tonne	kg CO_2/tCO_2

Note: Guidance on how to calculate $N_2O_{B,I,}$ and $CH_{4\ B,I}$ values is provided in Appendix B, Step 4.2, and guidance on how to calculate the $\Delta SOC_{B,I}$ value is provided below.

5.5.3.1 Accounting for Change in Soil Organic Carbon

Unlike N_2O and CH_4 emissions, the baseline SOC value cannot be used as an input in Equation 5.9 as it does not itself represent emissions. Rather, the change in SOC over a given baseline cultivation cycle ($\Delta SOC_{B,i}$) must be calculated using Equation 5.10 below.

In order to calculate $\Delta SOC_{B,i}$, the project developer must calculate the change in SOC that occurred over the relevant baseline cultivation cycle. The project developer must extract the SOC value corresponding to the first Julian day of the baseline cultivation cycle from the first baseline year being modeled and the last Julian day of the baseline cultivation cycle from the second baseline year being modeled.[45] Per Equation 5.10, the project developer must then subtract the SOC value on the first day of the cultivation cycle from the SOC value on the last day of the cultivation cycle. The results must then be converted into CO_2e. This process must be repeated for the 2,000 Monte Carlo runs, and then averaged to determine the appropriate $\Delta SOC_{B,i}$ value to be used in Equation 5.9.

[45] See Section 5.3 for detailed guidance on using two calendar years of modeling for a single cultivation cycle.

Equation 5.10. Change in Soil Organic Carbon in the Baseline Cultivation Cycle

$$\Delta SOC_{B,i} = \frac{\sum_{j=1}^{2000} SOC_{LDBcc} - SOC_{FDBcc}}{2000} \times \frac{44}{12}$$

Where,			Units
$\Delta SOC_{B,i}$	=	Change in SOC content of rice field *i* during the baseline cultivation cycle	kg CO_2e/ha
SOC_{LDBcc}	=	SOC stock value on the last day of the baseline cultivation cycle (i.e. the day harvest is complete)	kg C/ha
SOC_{FDBcc}	=	SOC stock value on the first day of the baseline cultivation cycle (i.e. the day after the previous year's harvest is complete)	kg C/ha
44/12	=	Unit conversion of C to CO_2e	

5.5.4 Step 7: Calculate Total Secondary Emissions from Project Activity

Once all of the sources of relevant secondary emissions have been accounted for, the project developer shall calculate total secondary emissions using Equation 5.11 below. The total secondary effect emissions calculated in Equation 5.11 are then input into Equation 5.1 (in Section 5.4) to calculate the total emission reductions for the project.

Equation 5.11. Total Secondary Effect Emissions from Project Activity

$$SE = \sum_{i} (SE_{FF,i} + SE_{RM,i}) + SE_{PS}$$

Where,			Units
SE	=	Total secondary effect emissions	tCO_2e
$SE_{FF,i}$	=	Total secondary effect GHG emissions from increased fossil fuel combustion for field *i*, as calculated in Section 5.5.1 (Step 4)	tCO_2e
$SE_{RM,i}$	=	Total secondary effect GHG emissions from alternative residue management for field *i*, as calculated in Section 5.5.2 (Step 5)	tCO_2e
SE_{PS}	=	Total secondary effect GHG emissions for each project from production shifting outside of the project boundary, as calculated in Section 5.5.3 (Step 6)	tCO_2e

6 Project Monitoring

The Reserve requires that Monitoring Plans and Reports be established for all monitoring and reporting activities associated with the project. Under this protocol, two distinct types of Monitoring Plans and Reports must be developed: aggregate level and field level.

A field serial number must appear in the file name of all monitoring records for each distinct field and kept in accordance with this protocol (see Section 7.1.1 for details on how to create field serial numbers).

6.1 Single-Field Monitoring Plan

The Single-Field Monitoring Plan (SFMP) will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in this section and Section 7 are met for single-field projects, and that consistent, rigorous monitoring and record keeping is ongoing at the project field. The SFMP must be developed and maintained by the project developer. The SFMP must outline procedures on how all of the data included in the Single-Field Report, particularly the parameters in Table 6.1 and Table 6.2, will be collected, recorded, and managed, as specified below and in Section 7.2.1 (see Section 7.3.1 for minimum record keeping requirements). It is the responsibility of the project developer to ensure that the SFMP meets all requirements specified and is kept on file and up-to-date for verification.

The SFMP will outline the following procedures:

- How the GIS shape file and/or KML file will be created
- How the crediting period, verification schedule, and quantification results will be tracked for each field included in the project aggregate
- How to ensure that the project developer holds title to the GHG emission reductions as required in Section 2.3
- Procedures that the project developer will follow to ascertain and demonstrate that the project field at all times passes the Legal Requirement Test and Regulatory Compliance (Section 3.5.2 and 3.6 respectively)
- A plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 7.3.1
- The frequency of data acquisition
- The frequency of sampling activities
- The role of individuals performing each specific activity, particularly monitoring and sampling
- QA/QC provisions to ensure that data acquisition is carried out consistently and with precision

6.2 Aggregate Monitoring Plan

The Aggregate Monitoring Plan (AMP) will serve as the basis for verifiers to confirm that the project aggregate tracking requirements have been and will continue to be met for each reporting period. The AMP must be developed and maintained by the aggregator. The AMP must outline procedures on how all of the data included in the Aggregate Report will be collected and managed, as specified below and in Section 7.2.2 (see Section 7.3.2 for minimum record keeping requirements).

The AMP will outline the following procedures:

- How the GIS shape file and/or KML file will be created for each field
- How the crediting period, verification schedule, and quantification results will be tracked for each field included in the project aggregate
- How to ensure that the title to the GHG emission reductions has been conferred to the aggregator as required in Section 2.3 for each field in the aggregate
- Procedures that the aggregator will follow to ascertain and demonstrate that all fields in the project aggregate at all times pass the Legal Requirement Test and Regulatory Compliance (Section 3.5.2 and 3.6 respectively)
- A plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 7.3.2
- The role of individuals performing each specific activity
- QA/QC provisions to ensure that data collected from the field level, according to data acquisition requirements outlined in the Field Monitoring Plan (FMP) described below, is carried out consistently and with precision at the aggregate level

6.3 Field Monitoring Plan for Project Participants in an Aggregate

The Field Monitoring Plan (FMP) will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in Sections 6 and 7 are met at each field in a project aggregate, and that consistent, rigorous monitoring and record keeping is ongoing at each field. The FMP must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 and Table 6.2 are collected and recorded at each field.

One FMP must be developed for each project participant. If a project participant has multiple fields enrolled in the aggregate, only one FMP is required as long as it addresses the monitoring requirements at each field. The FMP can be developed by the project participant or the aggregator, depending on the arrangement specified in contractual agreements. It is the responsibility of the aggregator to ensure that the FMP meets all requirements specified, and is kept on file and up-to-date for verification.

At a minimum the FMP shall stipulate:

- The frequency of data acquisition
- The frequency of sampling activities
- The role of individuals performing each specific monitoring and sampling activity
- A record keeping plan (see Section 7.3.2.2 for minimum record keeping requirements)
- QA/QC provisions to ensure that data acquisition is carried out consistently and with precision

6.4 Field Data

All fields, whether enrolled in a project aggregate or participating as a single-field project, must monitor the necessary DNDC input data and field management data as specified below. All field-level data and information specified in Sections 6.4.1, 6.4.2, 6.4.3, and 6.4.4 must be collected and retained for verification purposes.

6.4.1 General Field Tracking Data

- Either a GIS shape file or a KML file clearly defining the field boundary (or boundaries), as defined in Section 2.2.1, of each distinct field that is part of the project (Note: project developers may wish to provide verifiers with additional GIS shape files with underlying information about how fields were stratified, e.g. further delineate where management activities are homogenous, how field boundaries map to legal parcels, etc.).
- The coordinates of the most north-westerly point of the field, reported in degrees to four decimal places[46] (to be used for creating field serial numbers)
- The serial number of the field, constructed as specified in Section 7.1.1
- The start date of the field
- Disclosure of any material and immaterial regulatory violations, with copies of all Notices of Violations (NOVs) included in the report
- A list of the project activities implemented on the field during the cultivation cycle
- Field rice yield during the relevant project cultivation cycle and all five baseline cultivation cycles

6.4.2 Field Management Data

The following management data must be collected and retained at each field for each cultivation cycle during the reporting period:

- Planting preparation description and date
- Planting date and method
- Fertilization types, amounts (used in both the baseline scenario cultivation cycle and the project scenario cultivation cycle, and application dates[47]
- Flooding[48] and drainage[49] dates (during the growing season and during post-harvest period)
- Begin and end date of harvesting on the field
- Post-harvesting residue management (e.g. burning, incorporation or baling) description and dates
- Amount of herbicides applied for the baseline scenario cultivation cycle and the project scenario cultivation cycle[50]
- All DNDC input files and output files in *.csv file format
- A summary of all data inputs where permissible deviations from using DNDC or default parameters sourced from UC Davis[51] has occurred (i.e. using field data in place of DNDC defaults for calibration purposes), a justification for any such deviation and appropriate supporting evidentiary material

[46] Longitude reported in degrees to four decimal places provides a spatial resolution of about 11 meters, the resolution of the latitude is slightly less than that.
[47] Amounts of fertilizer used in the baseline scenario cultivation cycle do not need to be verified.
[48] For each field, the flood date shall be equal to the date that the first 'check' began filling.
[49] For each field, the drainage date shall be equal to the date that the last 'check' began draining.
[50] Amounts of herbicide used in the baseline scenario cultivation cycle do not need to be verified.
[51] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.

6.4.3 Project Activity Data and Documentation

To corroborate field management assertions, each field must collect and retain the following documentation.

Dry Seeding with Delayed Flood:

- Seeding equipment purchase or rental records, and/or seeding service contracts/agreements/receipts
- At least four time-stamped digital photographs per field 'check' taken from various vantage points no more than 15 days after seeding. The pictures must clearly show an establishing stand with no standing water present
- At least four time-stamped digital photographs per field 'check' taken from various vantage points during flood-up. The pictures must clearly show the established stand

Rice Straw Baling:

- Baling equipment purchase or rental records, and/or baling service agreements/receipts
- At least four time-stamped digital photographs per field 'check' taken from various vantage points during the swathing, raking, and baling process. Pictures must clearly show the baled hay post-baling
- Log of baling process, recorded at the time of baling, including:
    - Date(s) that each stage of the swathing, raking, and baling process commenced and ended
    - Number of acres baled
    - Quantity of rice straw removed
    - Quantity of rice straw left unused in piles at or near the field
    - List of equipment used
    - Height of the cutting bar used
    - Name of third-party baling service provider (if applicable)
- End-use of rice straw (if using an end-use specific emission factor). All sales contracts or receipts for the rice straw must be retained for verification purposes

6.4.4 Field Monitoring Parameters

Prescribed monitoring parameters, including those specific to DNDC as well as additional parameters necessary to calculate baseline and project emissions, are provided below in Table 6.1 and Table 6.2, respectively. Field monitoring parameters and DNDC input parameters must be determined according to the data source and frequency specified in the tables. Note that verifiers will also need to verify that defaults provided by DNDC for additional parameters not listed in the tables have not been altered. Further guidance on all of the DNDC input parameters can be found in Appendix B, Step 1.1.

Table 6.1. DNDC Model Input Parameters

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Climate	GPS location of field	° decimal to four places	m	Once per project	
	Atmospheric background NH_3 concentration	μg N/m^3	r	Once per crediting period	Source: National Atmospheric Deposition Program data or data from UC Davis.
	Atmospheric background CO_2 concentration	ppm	r	Once per crediting period	Source: National Atmospheric Deposition Program data or data from UC Davis.
	Daily precipitation	cm	m	Daily	Source: Nearest CIMIS station
	Daily maximum temperature	°C	m	Daily	Source: Nearest CIMIS station
	Daily minimum temperature	°C	m	Daily	Source: Nearest CIMIS station
	N concentration in rainfall	mg N/l or ppm	r	Once per crediting period	Source: National Atmospheric Deposition Program data or data from UC Davis.
Soils**	Land-use type	type	m	Once per project	
	Clay content	0-1	m/r	Annual	Source: Measured or SSURGO
	Bulk density	g/cm^3	m/r	Annual	Source: Measured or SSURGO
	Soil pH	value	m/r	Annual	Source: Measured or SSURGO
	SOC at surface soil	kg C/kg	m/r	Annual	Source: Measured or SSURGO
	Soil texture	type	m/r	Annual	Source: Measured or SSURGO
Crop	Planting date	date	m	Annual	Famer records
	Harvest date	date	m	Annual	Famer records
	C/N ratio of the grain	ratio	m/r	Once per variety	Can use default *.dnd file values or defaults derived from UC Davis Jenkins Lab
	C/N ratio of the leaf + stem tissue	ratio	m/r	Once per variety	Can use default *.dnd file values or defaults derived from UC Davis Jenkins Lab
	C/N ratio of the root tissue	ratio	m/r	Once per variety	Can use default *.dnd file values or defaults derived from UC Davis Jenkins Lab
	Fraction of leaves + stem left in field after harvest	0-1	m	Annual	Farmer records
	Maximum yield	kg dry	m	Annual	Farmer records

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
		matter/ha			
	Number of tillage events	number	o	Annual	Farmer records
	Date of tillage events	date	o	Annual	Farmer records
	Depth of tillage events	cm (select from 7 default depths) †	o	Annual	Farmer records
Tillage	Number of fertilizer applications	number	o	Annual	Farmer records
	Date of each fertilizer application	date	o	Annual	Farmer records
	Application method	surface / injection	o	Annual	Farmer records
Fertilization	Type of fertilizer	type*	o	Annual	Farmer records
	Fertilizer application rate	kg N/ha	o	Annual	Farmer records (field average if using variable rate applications)
	Number of organic applications per year	number	o	Annual	Farmer records
	Date of application	date	o	Annual	Farmer records
	Type of organic amendment	type	o	Annual	Farmer records
Manure amendment[52] (if used)	Application rate	kg C/ha	o	Annual	Farmer records
	Amendment C/N ratio	ratio	o	Annual	DNDC defaults or Farmer records
	Number of irrigation events	number	o	Annual	Farmer records
	Date of irrigation events		o	Annual	Farmer records
	Irrigation type	Must use the 'flood' default type	o	Annual	Farmer records
Irrigation	Irrigation application rate	mm	o	Annual	Farmer records
	Date of flood-up for growing season	date	o	Annual	Farmer records
	Date of drain for crop harvest	date	o	Annual	Farmer records
	Date of flood-up for winter flooding (if applicable)	date	o	Annual	Farmer records

[52] DNDC allows for data on any soil amendment to be input into the model, and provides default parameters (i.e. C/N ratio) for several types of soil amendments. See Appendix B Step 1.4 for further guidance.

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Flooding	Date of drain for winter flooding (if applicable)	date	o	Annual	Farmer records

† 0, 5, 10, 20, 30, 50 cm.
* DNDC accepts seven types of fertilizers: Urea, Anhydrous Ammonia, Ammonium Nitrate, Nitrate, Ammonium Bicarbonate, Ammonium Sulfate and Ammonium Phosphate.
‡ Flood, sprinkler or surface drip tape.
** Soil parameters for DNDC are for the properties of the top layer of the soil profile. If look up values from the NRCS SSURGO database are not used, then data taken from field samples is required.

Table 6.2. Field Monitoring Parameters

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.1	ER	Total emission reductions from the project area for the reporting period	tCO_2e	c,m	Cultivation cycle	
Equation 5.1 Equation 5.3 Equation 5.4	PER	Total primary GHG emission reductions	tCO_2e	c,m	Cultivation cycle	
Equation 5.1 Equation 5.11	SE	Total secondary effect GHG emission reductions	tCO_2e	c,m	Cultivation cycle	
Equation 5.2 Equation 5.3	N_2O_i	Average cultivation cycle direct and indirect N_2O emissions from rice field *i*, equal to the average of the values of all Monte Carlo runs *j*	kg CO_2e/ha	c	Cultivation cycle	Note: In Equation 5.3 this parameter contains additional subscript denoting whether it pertains to the baseline or project scenario cultivation cycles.

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.2 Equation 5.3	$CH_{4\ i}$	Average cultivation cycle CH_4 emissions from rice field *i*, equal to the average of the values for all Monte Carlo runs *j*	kg CO_2e/ha	c	Cultivation cycle	Note: In Equation 5.3 this parameter contains additional subscript denoting whether it pertains to the baseline or project scenario cultivation cycles.
Equation 5.2 Equation 5.3	$SOC_{LDcc,i}$	Average cultivation cycle final soil organic carbon content of rice field *i* on the last day of either the baseline or project scenario cultivation cycle, equal to the average of the values for all Monte Carlo runs *j*	kg CO_2e/ha	c	Cultivation cycle	Note: In Equation 5.3 this parameter contains additional subscript denoting whether it pertains to the baseline or project scenario cultivation cycles.
Equation 5.2	$N_2O_{Dir,j,i}$	N_2O emissions from rice field *i* from Monte Carlo run *j*	kg N_2O-N/ha	c	Cultivation cycle	
Equation 5.2	$N_{Leach,j,i}$	Nitrate leaching loss from rice field *i* from Monte Carlo run *j*	kg NO_3-N/ha	c	Cultivation cycle	
Equation 5.2	$N_{Vol,j,i}$	Ammonia volatilization and nitric oxide emissions from rice field *i* from Monte Carlo run *j*	kg NH_3-N + kg NO_x-N /ha volatized	c	Cultivation cycle	
Equation 5.3	$Area_i$	Area of the rice field *i*	ha	m	Cultivation cycle	
Equation 5.4	PERud	Total primary GHG emission reductions from the entire project, corrected for uncertainty deductions	tCO_2e	c,m	Cultivation cycle	
Equation 5.4	μ_{struct}	Accuracy deduction from model structural uncertainty		r	Cultivation cycle	Values will be made available on Reserve website
Equation 5.4	$\mu_{inputs,i}$	Accuracy deduction factor for individual rice field *i* due to input uncertainties	fraction	c	Cultivation cycle	As calculated in Appendix B Step 5.1

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.5 Equation 5.11	$SE_{FF,i}$	Total secondary effect GHG emissions from increased fossil fuel combustion for field *i*	tCO_2e	c	Cultivation cycle	As calculated in Section 5.5
Equation 5.5	$EF_{HP\text{-}hr,i,f}$	Emission factors for fossil fuel emissions	g CO_2e/HP-hr	r	Cultivation cycle	
Equation 5.5	$HP_{i,f}$	Horsepower requirement for machinery operated *i* on field *f*	HP	r	Cultivation cycle	
Equation 5.5	$t_{i,f}$	Time required to perform operation *i* on field *f*	hr/field	m	Cultivation cycle	Note: Additional subscript is used to denote whether the parameter is used in the baseline or project scenario. In the baseline scenario, *j* is replaced by the letter *k*.
Equation 5.5 Equation 5.8	A_f	Size of field	ha	m	Cultivation cycle	
Equation 5.6	FF_j	Total change in fossil fuel consumption for field *f*, by fuel type *j*	gallons	m	Cultivation cycle	
Equation 5.7	$W_{RS,i}$	Total weight of rice straw in dry tonnes that is swathed, raked, and baled on the field *i*	dry tonne	m	Cultivation cycle	
Equation 5.7	EF_{SRB}	Emission factor for increased fossil fuel emissions from swathing, raking, and baling	tCO_2e / dry tonne	r	Cultivation cycle	
Equation 5.7	$W_{RS,U}$	Weight of rice straw in dry tonnes with end-use *U*. The sum weight of rice straw for all end-uses must equal the total weight of rice straw baled on the field	dry tonne	m	Cultivation cycle	
Equation 5.7 Table A.1	EF_U	Emission factor for end-use *U*	tCO_2e / dry tonne	r	Cultivation cycle	From Table A.1 in Appendix A

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.8	$Y_{f,t}$	Yield of field *f* in year *t*	Mg/ha	m	Cultivation cycle	
Equation 5.8	$Y_{county,t}$	County average yield in year *t*	Mg/ha	c	Cultivation cycle	
Equation 5.8 Equation 5.9	y_norm_t	Normalized yield for each year *t*	fraction	c	Cultivation cycle	
Equation 5.9	y_min	Minimum yield threshold below which normalized yields are significantly smaller than the historical average	fraction	c	Cultivation cycle	
Equation 5.9 Equation 5.10	$\Delta SOC_{B,i}$	Change in soil organic carbon content of rice field i during the baseline cultivation cycle	kg CO_2e/ha	c	Cultivation cycle	
Equation 5.10	SOC_{LDBcc}	Soil organic carbon stock value on the last day of the baseline cultivation cycle (i.e. the day harvest is complete)	kgC/ha	c	Cultivation cycle	
Equation 5.10	SOC_{FDBcc}	Soil organic carbon stock value on the first day of the baseline cultivation cycle (i.e. the day after the previous year's harvest is complete)	kgC/ha	c	Cultivation cycle	
Equation 5.11	$SE_{RM,i}$	Total secondary effect GHG emissions from alternative residue management for field *i*	tCO_2e	c	Cultivation cycle	As calculated in Section 5.5
Equation 5.11	SE_{PS}	Total secondary effect GHG emissions for the project aggregate from production shifting outside of the project boundary	tCO_2e	c	Cultivation cycle	As calculated in Section 5.5

7 Reporting and Record Keeping

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers.

A field serial number must appear in the file name of all monitoring records for each distinct field and kept in accordance with this protocol (see Section 7.1.1 for details on how to create field serial numbers).

7.1 Project Submittal Documentation

For each rice cultivation project, project developers/aggregators must provide the following documentation to the Reserve in order to submit an RC project for listing on the Reserve.

- Project Submittal form
- Project Submittal *.csv file

The Project Submittal form is the same for both single-field projects and aggregates. Both single-field and aggregate projects are also required to submit a Project Submittal *.csv file, which shall include the initial "List of Enrolled Fields"; each field's serial number (according to Section 7.1.1 below), county and state; and the names of project participants for each field. In the case of a single-field project, the List of Enrolled Fields shall include only the single field. The List of Enrolled fields for aggregate projects shall include all fields enrolled in the aggregate at the time of submittal. Aggregate projects are required to update the List of Enrolled Fields prior to commencement of verification activities (i.e. prior to submission of the NOVA/COI), to include all fields actually enrolled in the aggregate at that point (e.g. if fields have been added or removed from the aggregate between submittal and contracting a verifier[53]). The list must also be updated prior to each subsequent verification.

Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.1.1 Determining Field Serial Numbers

The field serial number, which must be included in the List of Enrolled Fields, shall be determined by the following algorithm, with each element separated by a dash (-):

First state postal abbreviation, followed by the first letter of the County, followed by degrees of the most north-western point of the field (latitude then longitude, both reported to four decimal places), followed by the acreage of the field.[54] (Example: CA-*B-39.6123-121.5332-76* would be a 76 acre field in Butte County, CA.)

7.2 Annual Reports and Documentation

Once a project has been listed, project developers must provide the following documentation to the Reserve in order to register an RC project. This documentation must be submitted to the

[53] See the Reserve Verification Program Manual at http://www.climateactionreserve.org/how/program/program-manual/.

[54] Because all fields are located in the United States, the latitude will always be positive (i.e. degrees north of the equator), and longitude will always be negative (i.e. degrees west of the Prime Meridian). Therefore, in the example serial number, the field in Butte County California is at *+39.6123º latitude, and -121.5332º longitude.*

Reserve within 12 months of the end of each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.

The following documentation is required of both single-field projects and aggregates:

- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form (initial verification only for single-field projects; aggregates, see guidance in Section 3.6)
- Signed Attestation of Title form or Aggregator Attestation of Title form[55]
- Annual reports (as outlined in Sections 7.2.1 and 7.2.2)
- Verification Report
- Verification Statement

With the exception of the annual reports, all of the above project documentation will be available to the public via the Reserve's online registry. Further disclosure (e.g. of the annual reports) and other documentation may be made available on a voluntary basis through the Reserve, at the request of the project developer.

In the event that a project participant transfers from one aggregate to a different aggregate, the new aggregator is responsible for submitting a Field Management Transfer form, which requires the project participant's signature, to the Reserve prior to the beginning of the subsequent reporting period. The new aggregator should also make sure to obtain and have on file all necessary documentation for the new field, as required by this protocol.

Project forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.2.1 Single-Field Report

For each cultivation cycle, project developers of single-field projects must include the following information in an annual report submitted to the Reserve as a *.csv file:

- The field serial number (see Section 7.1.1)
- The acreage of the field (acres)
- Start date of the field
- Whether the field had previously been enrolled in an aggregate
    - If so, include the name of the project aggregate and dates of enrollment
- The field's emission reduction calculation results for the current verified cultivation cycle (both corrected and uncorrected for model uncertainty)

7.2.2 Aggregate Report

For each cultivation cycle, all aggregate-level monitoring information must be included in an annual Aggregate Report that is submitted to the Reserve as a *.csv file, with accompanying documentation, at verification. The Aggregate Report must contain a list of all fields and the following information for each field:

- The field serial number (see Section 7.1.1)
- The acreage of the field (acres)

[55] Although the single-field project will submit the general Attestation of Title form, aggregators will be required to submit an Aggregator Attestation of Title form, which will include language attesting to the fact that the aggregator has not and will not knowingly allow a third party (e.g. project participant) to provide false, fraudulent, or misleading data or statements.

- Start date of the field
- Date field enrolled in the aggregate
    - Including a flag specifying whether the field is a new addition to the aggregate in the particular year
- Current status of field (active, terminated, transferred to a different aggregate) as well as a description of any notable changes in management control and/or management practices
- Name of project participant associated with the field
- A flag for which fields had site visit or desktop verifications, or were unverified, in the previous reporting period
- The emission reduction calculation results for each field (both uncorrected and corrected for uncertainty) for that calculation period
- The total verified emission reductions for the aggregate (corrected for model structural uncertainty and any deductions due to errors or misrepresentations at the verified fields)

7.2.3 Field Report

For each cultivation cycle, all fields within an aggregate must submit an annual Field Report to the aggregator. This report is not submitted to the Reserve. Although the Reserve encourages participants to submit a Field Report in the form of a *.csv file, the format of the report is at the discretion of the aggregator.

At a minimum, the Field Report is required to include the following:

- A signed statement by the project participant attesting to the fact that all statements and data contained therein are true and accurate
- Field management data (as specified in Section 6.4.2)
- Project activity data (as specified in Section 6.4.3)

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or seven years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

7.3.1 Record Keeping for Single-Field Projects

The project developer shall retain the following records and documentation, as well as documentation to substantiate the information in the annual Single-Field Report and all field-level data and calculations. These records include:

- Contractual arrangements with each project participant and/or land owner (if applicable)
- Copies of letters of notification sent to land owners, including the dates letters were sent
- GIS or KML shape files clearly defining the field boundary, as defined in Section 2.2.1
- Northwestern latitude/longitude coordinates of field (to four decimal places)
- Serial number of field (according to the guidance in Section 7.1.1)
- Data inputs for the calculation of the project emission reductions, including all required sampled data and all DNDC input files (*.dnd files)
- Copies of all DNDC output files (*dnd files)
- Copies of air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project

- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Field management data (as specified in Section 6.4.2)
- Onsite fossil fuel use records
- Fertilizer purchase records
- Project activity data (as specified in Section 6.4.3), including:
    - All time-stamped digital photographs of the seeding, flooding, and baling activities
    - Rice baling logs
    - Rice straw sales receipts or contracts (if applicable)
    - All maintenance records relevant to the farm equipment and monitoring equipment
- Rice sales/milling records
- Copies of soil laboratory statements and the Soil Sampling Log (Appendix B, Step 1.4) for any sampled soil parameters
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results

7.3.2 Record Keeping for Project Aggregates

7.3.2.1 Aggregate-Level Record Keeping

The aggregator shall retain the following records and documentation, as well as documentation required by Section 6 to substantiate the information in the annual Aggregate Report. System information must be retained for each field, but collected and managed at the aggregate level. These records include all:

- Contractual arrangements with each project participant and/or land owner
- Copies of letters of notification sent to land owners, including the dates letters were sent
- GIS or KML shape files clearly defining the field boundaries, as defined in Section 2.2.1, of each distinct field in the aggregate
- Northwestern latitude/longitude coordinates for each field (to four decimal places)
- Serial numbers for each field (according to the guidance in Section 7.1.1)
- Data inputs for the calculation of the project emission reductions, including all required sampled data and all DNDC input files (*.dnd files)
- Copies of all DNDC output files (*.dnd files)
- Copies of air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project activities
- Executed Aggregator Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results

7.3.2.2 Field-Level Record Keeping

The project developer/aggregator shall retain the following records and documentation, as well as documentation required in Section 6.4 for each field.

- Field management data (as specified in Section 6.4.2)
- Onsite fossil fuel use records
- Fertilizer purchase records

- Project activity data (as specified in Section 6.4.3), including:
  - All time-stamped digital photographs of the seeding, flooding, and baling activities
  - Rice baling logs
  - Rice straw sales receipts or contracts (if applicable)
  - All maintenance records relevant to the farm equipment and monitoring equipment
- Rice sales/milling records
- Copies of soil laboratory statements and the Soil Sampling Log (Appendix B, Step 1.4) for any sampled soil parameters

7.4 Reporting Period and Verification Cycle

Though the requirements for reporting periods vary slightly between single field projects and aggregates, reporting periods generally correspond to a single year-long cultivation cycle. Aggregate projects undergo verification annually, while single field projects may choose from multiple flexible options for the verification cycle upon completing the first verification as detailed below.

Project developers/aggregators must report GHG reductions resulting from project activities for all fields during each reporting period, which represents a complete cultivation cycle. A complete cultivation cycle may be slightly greater or less than 365 days for each field depending on planting/harvest dates.

The reporting period must be uniformly defined for the aggregate. Thus, for reporting purposes, the aggregate reporting period shall always be defined as starting on October 1 and ending on September 30 of the next year. Each field must quantify their emission reductions for its entire cultivation cycle, and the aggregate reductions must be reported on the uniform reporting period. For project aggregates, no more than one reporting period can be verified at once.

Both reporting periods and cultivation cycles must be contiguous; there can be no time gaps in reporting during the crediting period of an aggregate or single field project once the initial reporting period has commenced.[56] Because a single reporting period spans two calendar years (from fall of one year to late summer/fall of the next year), a single "vintage" must be assigned for reporting purposes. The calendar year in which the rice crop is harvested is used as the vintage year for the reporting cycle. For instance, all GHG reductions from a cycle beginning in fall 2012 and ending with harvest in late summer 2013 shall be assigned a 2013 vintage.

7.4.1 Additional Reporting and Verification Options for Single-Field Projects

For single-field projects, however, there are three verification options to choose from, which provide the project developer more flexibility and help manage verification costs associated with RC projects. The project developer may choose from these additional options after a project has completed its initial verification and registration.

A project developer may choose to use one option for the duration of a project's crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.

[56] An entire aggregate can willingly forfeit CRTs for an entire cultivation cycle in accordance with the zero-credit reporting period policy in section 3.3.3 of the Reserve Program Manual, available at http://www.climateactionreserve.org/how/program/program-manual/.

If a single-field project joins a project aggregate, that field is immediately subject to the verification schedule of the aggregate moving forward.

If a field exits a project aggregate to become a single-field project, that project is subject to the reporting and verification requirements of an initial reporting and verification period. In other words, that single-field project's first verification as a single-field project may not take advantage of Options 2 or 3, below.

7.4.1.1 Initial Reporting and Verification Period

The reporting period for projects undergoing their initial verification and registration cannot exceed one complete cultivation cycle. Once a project is registered and has had at least one complete cultivation cycle of emission reductions verified, the project developer may choose one of the verification options below.

7.4.1.2 Option 1: Twelve-Month Maximum Verification Period

Under this option, the verification period may not exceed one complete cultivation cycle, which may be slightly greater or less than 365 days. Verification with a site visit is required for CRT issuance.

7.4.1.3 Option 2: Twelve-Month Verification Period with Desktop Verification

Under this option, the verification period cannot exceed one complete cultivation cycle. However, CRTs may be issued upon successful completion of a desktop verification as long as: (1) Site visit verifications occur at two-year intervals; and (2) The verification body has confirmed that there have been no significant changes in selected project activities, field management or ownership and/or management control of the field since the previous site visit. Desktop verifications must cover all other required verification activities (i.e. a full desktop verification of the Single-Field Report).

Desktop verifications are allowed only for a single 12-month verification period in between 12-month verification periods that are verified by a site visit.

7.4.1.4 Option 3: Twenty-Four Month Maximum Verification Period

Under this option, the verification period cannot exceed two complete cultivation cycles (approximately 730 days or 24 months) and the project monitoring plan and Single-Field Report must be submitted to the Reserve for the interim cultivation cycle's reporting period. The project monitoring plan and report must be submitted for projects that choose Option 3 in order to meet the annual documentation requirement of the Reserve program. They are meant to provide the Reserve with information and documentation on project operations and performance. They also demonstrate how the project monitoring plan was met over the course of the first half of the verification period. They are submitted via the Reserve online registry, but are not publicly available documents. The monitoring plan and report shall be submitted within 30 days of the end of the reporting period.

Under this option, CRTs may be issued upon successful completion of a site visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of project monitoring plans or reports. Project developers may choose to have a verification period shorter than 24 months.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the project activity. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to RC projects.

Verification bodies trained to verify RC projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Rice Cultivation Project Protocol

The Reserve Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only ISO-accredited verification bodies with lead verifiers trained by the Reserve for this project type are eligible to verify RC project reports. Verification bodies approved under other project protocol types are not permitted to verify RC projects. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/.

In addition, all verification bodies must have an accredited Professional Agronomist or Certified Crop Advisor on the verification team in order to verify RC projects.

8.1 Preparing for Verification

The project developer is responsible for coordinating all aspects of the verification process, coordinating with the verification body, project participants (in the case of a project aggregate), and the Reserve, and submitting all necessary documentation to the verification body and the Reserve.

The project developer is responsible for selecting a single verification body for the entire project or project aggregate for each reporting period. The same verification body may be used up to six consecutive years (the number of consecutive years allowed, according the Reserve Verification Program Manual[57]). Verification bodies must pass a conflict-of-interest review against the project developer, and in the case of project aggregates, all project participants and the aggregator. Consequently, the submitted List of Enrolled Fields must be updated by the aggregator prior to the conflict of interest review.

Each year, project developers of single-field projects must make the Single-Field Report, which is submitted to the Reserve annually, and the Single-Field Monitoring Plan available to the verification body. These documents must meet the requirements in Sections 6 and 7.

In project aggregates, each year, project participants must submit all field data to the aggregator according to the guidelines in Sections 6 and 7. Aggregators must make all Field Monitoring Plans, the Aggregate Monitoring Plan, DNDC output files and the Aggregate Report available to the verification body.

[57] Available at http://www.climateactionreserve.org/how/verification/verification-program-manual/.

In all cases, the above documentation should be made available to the verification body after the NOVA/COI process is complete.

Aggregators may assist project participants in preparing documents for verification and in facilitating the verification process. The scope of these services is determined by the specific contract between project participants and the aggregator. However, the ultimate responsibility for monitoring reports and verification compliance is assigned to the aggregator.

For project aggregates, a field is considered verified if it is in the pool of fields for which site visits or desktop verifications are conducted, even if not selected for either a site visit or desktop verification. As a preliminary step in preparing for verification, the aggregator may choose to exclude fields from the pool of fields that may be selected for verification activities. Aggregators must report to the verification body all instances of field exclusion. The excluded fields shall be removed from the acreage totals and from field numbers used to determine field eligibility and verification sampling methodologies (in Section 8.2) and are therefore not considered verified.

8.2 Verification Schedule for Single-Field Projects

Single-field projects are comprised of exactly one field, and as such, there is no sampling methodology to select the fields undergoing verification. The single-field project shall be verified according to the verification schedule outlined below.

This protocol provides project developers three verification options, Sections 8.2.1 to 8.2.3, for a single-field project after its initial verification and registration in order to provide flexibility and help manage verification costs associated with rice projects. For each option, verification bodies may need to confirm additional requirements specific to this protocol, and in some instances, utilize professional judgment on the appropriateness of the option selected.

The actual requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any reporting period if the verification body determines that the risks for that field warrant a site visit.

8.2.1 Option 1: Twelve-Month Maximum Verification Period

Option 1 does not require verification bodies to confirm any additional requirements beyond what is specified in the protocol.

8.2.2 Option 2: Twelve-Month Verification Period with Desktop Verification

Option 2 requires verification bodies to review the documentation specified in Section 7.4.1.3 in order to determine if a desktop verification is appropriate. The verifier shall use their professional judgment to assess any changes that have occurred related to project data management systems, equipment or personnel and determine whether a site visit should be required as part of verification activities in order to provide a reasonable level of assurance on the project verification. The documentation shall be reviewed prior to the NOVA/COI renewal submitted to the Reserve, and the verification body shall provide a summary of its assessment and decision on the appropriateness of a desktop verification when submitting the NOVA/COI renewal. The Reserve reserves the right to review the documentation provided by the project developer and the decision made by the verification body on whether a desktop verification is appropriate.

8.2.3 Option 3: Twenty-Four Month Maximum Verification Period

Under Option 3 (see Section 7.4.1.4), verification bodies shall look to the project monitoring report submitted by the project developer to the Reserve for the interim 12-month reporting period as a resource to inform its planned verification activities. While verification bodies are not expected to provide a reasonable level of assurance on the accuracy of the monitoring report as part of verification, the verification body shall list a summary of discrepancies between the monitoring report and what was ultimately verified in the List of Findings.

8.3 Verification Sampling and Schedule for Project Aggregates

Guidelines for verification sampling of the aggregate and the aggregate's verification schedule are different for "small aggregates," "large single-participant aggregates," and "large multi-participant aggregates." This approach allows a consistent application of verification requirements across all aggregates regardless of size or number of participants.

In all cases, the verification schedule shall be established by the verification body using random sampling, according to the verification schedule and sampling methodologies outlined in Sections 8.3.1, 8.3.2, and 8.3.3. These sampling methodologies establish the minimum verification frequencies; the verification body may at any time add fields beyond the minimum number required for site visit and/or desktop verification and may use verifier judgment to determine the number of additional fields and method for selecting fields if a risk-based review indicates a high probability of non-compliance. The verification sampling requirements are mandatory regardless of the mix of entry dates represented by the group of fields in the project aggregate.

The initial site visit verification schedule for a given year shall be established after the completion of the NOVA/COI process and prior to the commencement of any verification activities. This is meant to allow for the aggregator and verification body to work together to develop a cost-effective and efficient site visit schedule. Specifically, once the sample fields designated for a site visit have been determined, the verification body shall document all fields selected for planned site visit verification and provide a list to the aggregator and the Reserve. The aggregator shall be responsible for informing project participants of their selection for a planned site visit. Following this notification, the aggregator shall supply the verification body with all the required documentation to demonstrate field-level conformance to the protocol. When a verification body determines that additional sampling is necessary, due to suspected non-compliance, however, a similar level of advance notice may not be possible.

Aggregators and project participants shall not be made aware, in advance, of which fields' data will be subject to desktop verification in a given year.

Regardless of the size of an aggregate, if the aggregate contains any fields that did not pass site visit verification the year before and wish to re-enter the aggregate, those fields must have a full verification with site visit for the subsequent reporting period. These fields must be site visited *in addition* to the verification sampling methodology and requirements outlined below in Sections 8.3.1, 8.3.2, and 8.3.3.

For the purposes of verification, a "small aggregate" is defined as an aggregate comprised of 10 or fewer fields, regardless of the number of project participants. Small aggregates will meet fixed site visit and desktop verification frequency requirements based on a verification schedule determined by the verifier, in compliance with Section 8.3.1 of this protocol.

A "large single-participant aggregate" is defined as an aggregate comprised of more than 10 fields all managed by one single project participant. For large single-participant aggregates, fields will be randomly selected for site visit and desktop verification, according to the sampling method in Section 8.3.2, which is based on a non-linear scale where the relative fraction of fields undergoing verification activities gets smaller as the aggregate size gets larger.

A "large multi-participant aggregate" is defined as an aggregate comprised of more than 10 fields and more than one project participant. For large multi-participant aggregates, participants and their fields will be randomly selected for site visit and desktop verification, according to the sampling method in Section 8.3.3, which is based on a non-linear scale where the relative fraction of participants undergoing verification activities gets smaller as the aggregate size, in terms of number of participants, gets larger.

In all cases, when determining the sample size for site visits and desktop verifications, the verification body shall round up to the nearest whole number.

The actual requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any reporting period if the verification body determines that the risks for that field warrant a site visit. Any site visits initiated at the discretion of a verifier shall be in addition to the required site visit verification schedule.

8.3.1 Verification Schedule for Small Aggregates

8.3.1.1 Site Visit Verification Schedule for Small Aggregates

Each field in a small aggregate shall undergo initial site visit verification within the first two cultivation cycles for each crediting period. In the first year of the aggregate or in subsequent years when new fields enter the aggregate, a minimum of 30 percent of the newly enrolled fields shall complete the initial site visit verification in their first year of enrollment.

In addition, site visit verifications must be conducted on a schedule such that:

- Each field in the aggregate must successfully complete a minimum of two site visit verifications per crediting period (e.g. the initial site verification in addition to one more)
- A minimum of 20 percent of the fields in the aggregate shall be site verified in any given year, selected at random

8.3.1.2 Desktop Verification Schedule for Small Aggregates

In any given year, a number of desktop verifications of field data must be conducted, with the number inversely related to the number of fields undergoing a site visit that year. Specifically, the number of desktop verifications (**D**) shall equal 50 percent of the number of fields (**n**) in the aggregate that will not receive a site visit that year, rounding up in the case of an uneven number of fields. In other words,

$$\boldsymbol{D = \frac{(n - S)}{2}}$$

Where,

n	=	Number of fields in the aggregate
S	=	Number of site visits
D	=	Number of desktop verifications

Fields shall not be selected for a desktop verification in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the value of **D** per the equation above.

8.3.2 Verification Schedule for Large Single-Participant Aggregates

In contrast to small aggregates, it is possible that a field in a large aggregate is never verified, either via site visit or desktop verification, during its entire crediting period. Therefore, random sampling is a particularly important component of enforcement.

8.3.2.1 Sampling for Site Visit Verification for Large Single-Participant Aggregates

The verification body determines the number of enrolled fields that must be randomly selected for site visit verification in a given year. The required number of site visits (**S**) shall equal the square root of the total number of fields (**n**) enrolled in the large single-participant aggregate that year (i.e. $\boldsymbol{S} = \sqrt{\boldsymbol{n}}$ rounded up to the nearest whole number).

8.3.2.2 Sampling for Desktop Verification for Large Single-Participant Aggregates

In addition to site visit verifications, verification bodies shall randomly select a sample of fields to undergo a desktop verification (**D**) equal to two times the square root of the total number of fields in the aggregate.

Fields shall not be selected for a desktop verification in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the square root of the total number of fields in the aggregate.

8.3.3 Verification Schedule for Large Multi-Participant Aggregates

The random sampling methodology shall be applied first at the project participant level and then at the field level. A random sampling methodology will be applied for site visit and desktop verification selection. However, the verification body shall select fields for site visits first as described in Section 8.3.3.1 and desktop verifications second as described in Section 8.3.3.2.

In contrast to small aggregates, it is possible that a field in a large aggregate is never verified, either via site visit or desktop verification, during its entire crediting period. Therefore, random sampling is a particularly important component of the enforcement mechanism.

8.3.3.1 Sampling for Site Visit Verification for Large Multi-Participant Aggregates

The verification body shall determine the number of project participants that must be randomly selected for a site visit in a given year, as follows:

$$\boldsymbol{S} = \left(\mathbf{1} + \left(\frac{\boldsymbol{P}}{\mathbf{500}}\right)\right) \times \sqrt{\boldsymbol{P}}$$

Where,

S	=	Number of project participants that must receive site visits
P	=	Number of project participants in the aggregate

The verification body shall randomly select (**S**) project participants to receive site visits that year.

The verification body shall select which fields of the selected project participants will receive a site visit. For project participants with six enrolled fields or fewer, the verification body shall site visit at least 50 percent of the fields, selected at random. For project participants with more than six fields enrolled in the aggregate, the verification body shall site visit at least 33.3 percent of the fields, selected at random.

A minimum of the square root of the total number of fields in the aggregate must be site visited. If this number is not met after following Steps 1 to 3, then the verification body shall randomly select one additional project participant and the sample of fields, according to Step 2 and 3 above, and repeat this until the number of site visits meets this minimum requirement. Note that Step 3 must be completed in full and therefore could result in a greater number of fields selected for site visits than the minimum requirement.

8.3.3.2 Sampling for Desktop Verification for Large Multi-Participant Aggregates

In addition to site visit verifications, each year verification bodies shall also randomly select fields to undergo a desktop verification of their field data. Verification bodies shall randomly select a sample of fields to undergo a desktop verification equal to two times the square root of the total number of fields in the aggregate (rounded up to the next whole number).

Fields shall not be selected for a desk-audit in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the square root of the total number of fields in the aggregate.

8.4 Standard of Verification

The Reserve's standard of verification for RC projects is the Rice Cultivation Project Protocol (this document) and the Reserve Program Manual and Verification Program Manual. To verify a RC project aggregate, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.5 Monitoring Plan

The Aggregate Monitoring Plan and Field Monitoring Plan serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in Sections 6 and 7 have been met, and that consistent, rigorous monitoring and record keeping is ongoing by the aggregator and all enrolled fields. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 and Table 6.2 are collected and recorded.

8.5.1 Annual Reports

The single-field project's project developer must annually submit field data for single-field projects to the Reserve. The Single-Field Report will consist of a *.csv file and attachments, as described in Section 7.2.1. Verification bodies must review the Single-Field Report to confirm project information and data collected according to the SFMP.

The project aggregate must annually submit an Aggregate Report to the Reserve. The report will consist of a *.csv file and attachments, as described in Section 7.2.2. Verification bodies must review the Aggregate Report to confirm project information and data collected according to the AMP.

The verification body will need to review field data during desktop verifications of randomly selected fields in an aggregate. The field data must be made available to the verification body in order to confirm field-level information collected according to the FMP.

8.6 Verifying Eligibility at the Field Level

Verification bodies must affirm each project field's eligibility during site visit and/or desktop verifications according to the rules described in this protocol. Table 8.1 below outlines the eligibility criteria for each project field. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for a Rice Cultivation Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	The first day of the cultivation cycle, which begins immediately after completion of a rice crop harvest, in which one or more of the approved project activities is adopted at the field. Projects must be submitted for listing before the end of the first cultivation cycle in which the project activity is implemented.	Once during first verification
Location	All fields must be located in the California rice growing region.	Once during first verification
	Must not include fields with SOC greater than 3% in the top 10 cm.	Every verification
	Must not include fields that have been treated with nitrification inhibitors, urea inhibitors or controlled release fertilizers.	Every verification
Anaerobic Baseline	All fields must demonstrate that previous rice cultivation practices resulted in anaerobic conditions.	Once during first verification
Performance Standard	The field passes the Performance Standard Test for at least one of the approved project activities.	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test.	Single Field Project: once during first verification Aggregate: once during first verification and once during first verification for new fields that have joined aggregate
Legal Title to CRTs	Aggregator Attestation of Title to CRTs.	Every verification
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verification body; project must be in material compliance with all applicable laws.	Every verification

8.7 Core Verification Activities

The RCPP provides explicit requirements and guidance for quantifying the GHG reductions associated with the implementation of approved RC management practice changes on project fields. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of an RC project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

- Identifying emission sources, sinks, and reservoirs
- Reviewing GHG management systems and estimation methodologies
- Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs for each field
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a single-field project or project aggregate, ensuring that all relevant secondary effect SSRs for each field are identified.

Reviewing GHG management systems and estimation methodologies at the field level
The verification body reviews and assesses the appropriateness of the methodologies and management systems that are used to gather data and calculate baseline and project emissions for each field.

Reviewing GHG management systems and estimation methodologies at the aggregate level
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the project aggregator uses to gather data and calculate baseline and project emissions on the aggregate level.

Verifying emission reduction estimates at the field level
The verification body further investigates areas that have the greatest potential for material misstatements and confirms whether or not material misstatements have occurred for all fields undergoing verification. This involves site visits to a random sample of project fields, according to the sampling methodology outlined in Section 8.3.2.1, to ensure systems on the ground correspond to and are consistent with data provided to the verification body, combined with a random sample of desktop verifications of remaining project fields according to Section 8.3.2.2. In addition, the verification body recalculates a representative sample of the performance or emissions data from fields for comparison with data reported by the project aggregator in order to confirm calculations of GHG emission reductions.

Verifying emission reduction estimates at the aggregate level
The verification body further investigates areas that have the greatest potential for material misstatements at the aggregate level, including whether the appropriate modeling structural uncertainty factors (Section 5.4.3) and yield-loss statistical tests (Section 5.5.3) have been performed for the aggregate.

8.8 Project Type Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a RC project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to RC projects that must be addressed during verification.

8.8.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for RC project aggregates. These requirements determine if the aggregate is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any single requirement is not met, either for one or more fields, then the entire aggregate may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in Section 3.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that all verified fields meet the definition of an RC project	Yes
2.3	Verify ownership of the reductions by reviewing Aggregator Attestation of Title	No
2.3	Verify ownership of the reductions by reviewing Letters of Notification and contracts between aggregators, project participants, and land owners	No
3.2	Verify project start date for all fields	No
3.2	Verify accuracy of project start date for all verified fields based on operational records	Yes
3.3	Verify that each field is within the 5-year crediting period (or a subsequent 5-year crediting period)	No
3.4	Verify that the management records at each verified field are adequate to document the anaerobic baseline requirements	No
3.4	Verify that all verified fields have a SOC content less than 3% in the top soil	No
3.5.1	Verify that each field meets the Performance Standard Test	No
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.5.3	Verify that any ecosystem service payment or credit received for activities on a project field has been disclosed and is allowed to be stacked	No
3.6	Verify that the project activities at all verified fields comply with applicable laws by reviewing any instances of non-compliance provided by the aggregator and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
6.1, 6.2, 6.3	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that all fields pass the Legal Requirement Test at all times	No
6.1, 6.3, 6.4	Verify that field-level and aggregate-level monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No

8.8.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project aggregate GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	For each field, verify that all SSRs in the GHG Assessment Boundary are accounted for, particularly secondary effect emissions	No
5.4.2	For the aggregate, verify that all field emission reductions are summed correctly, and that the structural uncertainty factor is properly applied	No
5.4.3.3 and Appendix B Step 5	For each field, verify that the soil input uncertainty discount is quantified and applied correctly	No
5.5.1	Verify that the aggregator correctly monitored, quantified and aggregated fossil fuel and electricity use changes	Yes
5.5.2	For each field, verify that baled rice straw end-uses are properly characterized, and the appropriate emission factors are used	Yes
5.5.3	For the aggregate, verify that the statistical test for reduced yield is properly performed, and that increased emissions outside the project boundary are properly quantified for significant yield losses	No
Appendix B Step 1.2	For each field, verify that the project parameters and the static parameters are represented by the appropriate data and the DNDC input files are accurate for the baseline modeling and the project modeling	Yes
Appendix B Step 1.2	For each field, verify that the baseline and project emission models have the same static parameters, and that the project model adequately represents the project activities during the cultivation cycle	No
Appendix B Step 2.1	Confirm that the missing data substitution methodology has been applied correctly	Yes
Appendix B Step 3	For each field, verify that the DNDC model is adequately calibrated to historical yields, and that the 20-year historical calculation was run correctly	Yes
Appendix B Step 4	For each field, verify that the Monte Carlo analysis was performed correctly for the baseline and project modeling runs for each field	No

8.8.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that all contractors are qualified to perform the duties expected. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6.1, 6.2, 6.3	Verify that the project has documented and implemented the Single-Field Monitoring Plan or Aggregate Monitoring Plan, and all necessary Field Monitoring Plans	No
6.1, 6.2, 6.3	Verify that the project monitoring plans are sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6.4	Verify that appropriate monitoring data is measured or referenced accurately	No
6, 7	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6, 7	Verify that appropriate training was provided to personnel assigned to GHG reporting duties	Yes
7.2	Verify that the Single-Field Report or Aggregate Report was uploaded to the Reserve software	No
7.2, 7.3	Verify that field data has been gathered by project participants and made available to the aggregator	No
7.3	Verify that all required records have been retained by the project developer	No

8.9 Successful and Unsuccessful Verifications

Successful verification of each field in the sample of fields selected for site visit and desktop verifications results in the crediting of all fields participating in the entire project aggregate, as calculated by the aggregator according to the quantification methodology in Section 5.

Verification may uncover any number of material and immaterial errors at the field, project participant or aggregate level, and the extent to which an error was propagated through the aggregate can affect whether a verification is determined to be "unsuccessful."

8.9.1 Field-Level and Project Participant-Level Errors

If material issues arise during verification of a participating field, verification bodies shall issue Corrective Action Requests, as needed. The aggregator will need to work with the project participant to independently address the issues and required corrective actions using the same process taken with standalone projects. These are described in the verification guidance of this protocol and the Reserve Verification Program Manual. If the error can be corrected at the field level and is the type of error which will not be propagated across an individual participant's fields or the entire aggregate, then the error shall be corrected and the field verification shall be considered successful. Errors shall be considered immaterial at the field level if they result in a discrepancy that is less than 5 percent of the total emission reductions quantified for that field.

If verification of a field reveals material non-compliance with the protocol, and no corrective action is possible, that field shall receive a negative verification and no CRTs shall be issued for

that field, effectively removing the field from the aggregate for that year. When verification is unsuccessful for a participating field, the verification body must verify additional fields until the total number of successful verifications reaches the required number (as described in Section 8.2), starting with fields managed by the same participant, as follows. If the project participant managing the unsuccessfully verified field also manages other fields enrolled in the aggregate, the verification body shall site visit a minimum of two additional fields or 50 percent of the remaining unverified fields, whichever is larger, that are managed by that project participant. If the verification of the additional fields is also unsuccessful, no CRTs shall be issued for any of the fields managed by the project participant.

Deliberate non-compliance may result in disqualification of the project participant including all of their enrolled fields. Additionally, if the project participant failing verification and their negatively verified fields re-enter the aggregate the following year, each of the fields that failed verification the previous year shall be required to undergo a site visit, in addition to the minimum sampling requirements in Section 8.2.

Whenever a project participant receives a negative verification for all of their enrolled fields, the verification body shall use their professional judgment and a risk-based assessment to determine whether sampling additional project participants for site visit verification, beyond the minimum requirements of this protocol, is necessary to verify the entire aggregate to a reasonable level of assurance.

8.9.1.1 Cumulative Field-Level Error of Sampled Fields

Total errors and/or non-compliance shall be determined for the sampled fields and the offset issuance for those fields corrected, as required, by the Verification Program Manual. Should the aggregated error and/or non-compliance rate for the sampled fields be less than 5 percent, CRT issuance for fields not subjected to site visit or desktop verification shall be equal to the amount reported by the aggregator. However, if the aggregated percent error and/or non-compliance rate (i.e. the percentage of verified fields failing verification) for sampled fields is greater than 5 percent, CRT issuance for fields not subjected to site visit or desktop verification shall be reduced by the total amount of aggregated percent error or non-compliance rate.

8.9.2 Aggregate-Level Errors

If verification reveals a potential systemic error, which may be propagated out to the aggregate level (e.g. a qualitative error with regard to the model input parameters or a quantitative error repeated in multiple field-level model runs), the verification body shall use their professional judgment to sample additional fields, as necessary, to determine whether the error is truly systemic. Systemic errors must be corrected at the aggregate level.

8.10 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Practices that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Aggregator	A project developer responsible for a project comprising multiple fields.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resulting from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, deforestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Effective date	The date of initial adoption of this protocol by the Reserve Board: December 14, 2011.
Emission factor (EF)	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Field checks	Low dikes that are employed by rice farmers to control water distribution to their fields.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.

GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Metric ton or "tonne" (MT, t)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
Project baseline	A "business as usual" GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a GHG project.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
Verification	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification statement and provide verification services for operators subject to reporting under this protocol.

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Appendix A Parameter Look-Up Tables

Rice Straw End-Use Emission Factors

The emission factors included in Table A.1 below were derived based on the conservative use of best available information regarding emissions associated with the transport and decay of rice straw given various end-use scenarios. Transportation energy use data came primarily from California rice straw time and motion studies[58] that examined, through survey responses within the industry, the costs associated with collection, storage, and transport of rice straw to various end-uses (primarily for use as cattle feed). Because of the uncertain nature of these emissions factors, the Reserve consistently applied conservative assumptions to estimate each emission factor, as described in the footnotes to Table A.1. A conservative default factor for 'unknown' or 'non-specified' offsite management has been included for cases where the ultimate fate of the rice straw is unknown.

Table A.1. Rice Straw End-Use Emission Factors

Rice Straw End-Use	Emission Factor (tCO_2e/t baled straw)
Unknown (or 'other' offsite management)	0.083 [1]
Dairy and Beef Cattle Feed	0.075 [2,4]
Fiberboard Manufacturing	0 [5]
Spread on Bare Soils for Erosion Control	0.012 [2,3]
Unused (left piled/stacked onsite)	0.210 [6]

1. Using survey responses from California rice baling experts, end-use emission factors were determined for each of the expert's estimates of the current rice straw end-use market. The most conservative estimate was used for this emission factor. The scenario that is used assumes that close to 100% of rice straw goes to Dairy and Beef Cattle Feed, with negligible amounts going to other end-uses. The resulting estimate of 75 kg CO_2e/t of baled straw was increased by 10% for conservativeness
2. Transportation emissions per MT of rice straw are estimated as being 13.14 kg CO_2e using the following assumptions:[58]
   a. Bales are transported 200 km
   b. Average truck capacity of 16 MT rice straw
   c. Diesel fuel efficiency of 6 MPG
   d. The emission factor for Diesel Fuel Use is 10.15 kg CO_2e/gal[59]
3. Anaerobic decay is unlikely because the straw is spread across the landscape, therefore maximizing oxygen availability during decomposition
4. Change in enteric emissions may occur due to low nutritional quality of rice straw. It is assumed for conservativeness that the enteric CH_4 conversion factor is increased by 1% due to switching to low-digestible food (2006 IPCC *Guidelines for National Greenhouse Gas Inventories*, Vol. 4, pg. 10.30). Emission factor assumes a calorific value of dry rice straw of 15 MJ/kg (Putun et al., 2004), and an energy content of CH_4 of 55.65 MJ/kg (2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 4, pg. 10.32)
5. Rice straw replaces wood products for manufacturing of fiber board

[58] Transport distance and truck capacity assumptions are conservative estimates based on information from time and motion studies in California (Jenkins et al. (2000), Table 3).
[59] US EPA (2008) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance: Direct Emissions from Mobile Combustion Sources, Appendix B, pg 26.

Avoidance of harvesting and transport of wood products provides likely net-positive GHG benefits 6. Equal to the IPCC default emission factor for aerobic composting (0.10 kg CH_4/t input). Low N residues (such as rice straw) would have discounted fugitive emissions compared with other compostable organic residues (Brown et al., 2008).	

Appendix B Step by Step Guide to Modeling RCPP Emissions Using DNDC

This protocol relies on the application of the DNDC model for quantification of baseline and project emissions from soil dynamics (SSR 1) defined in Section 4. Detailed requirements for accurate and consistent application of the DNDC model are provided in this appendix. Table B.1 below provides an overview of the process to model primary GHG emissions for this protocol using DNDC, as well as references to additional guidance.

Table B.1. Overview of DNDC Modeling

STEP	DNDC MODELING OVERVIEW	ADDITIONAL INFORMATION
Step 1: Become familiar with necessary DNDC inputs		
Step 1.1 Overview of DNDC site input parameters	This section introduces two typologies used to categorize DNDC input parameters.	*DNDC User's Guide* (Version 9.5) Appendix C
Step 1.2 Defining project inputs and static inputs	This section provides guidance on how to classify DNDC inputs as either project inputs or static inputs and where to source data for such inputs depending on their classification.	
Step 1.3 Climate input parameters	This section provides guidance on climate input parameters.	
Step 1.4 Soil input parameters	This section provides guidance on soil input parameters, including further guidance on: ▪ Using soil inputs from the SSURGO database ▪ Using soil inputs from field samples	
Step 1.5 Cropping input parameters	This section provides guidance on cropping input parameters, including multiple subcategories of cropping inputs: crop, tillage, fertilization, manure amendments, irrigation and flooding.	
Step 2: Prepare input files		
Step 2.1 Missing climate or soil data	This section provides a methodology to substitute data in the event that discrete climate or soil data is missing.	
Step 2.2 Historical modeling	This section provides guidance on how to prepare the necessary historical data needed to model emissions and to calibrate the DNDC model.	*DNDC User's Guide* (Version 9.5) Appendix C
Step 2.3 Preparing DNDC input files	This section provides guidance on how to create separate input files for the baseline and project scenarios, that each contains data from both the baseline year and the project scenario.	*DNDC User's Guide* (Version 9.5) Appendix C
Step 3: Calibrate the DNDC model		
Calibrating the DNDC model	This section provides guidance on how to prepare DNDC for modeling by undertaking the calibration exercises.	*DNDC User's Guide* (Version 9.5) Appendix C

Step 4: Model emissions using DNDC		
Step 4.1 Modeling emissions using Monte Carlo simulations	This section provides guidance on how to conduct Monte Carlo simulations using the DNDC model, in order to calculate primary emissions for the baseline and then repeat the process to calculate primary emissions for the project scenario.	*DNDC User's Guide* (Version 9.5) Appendix C
Step 4.2 Extracting DNDC modeling results for calculating emission reductions	This section provides guidance on how to extract data from DNDC Monte Carlo run results and use that data to calculate primary emission reductions for each of the baseline and project scenarios respectively.	
Step 5 Calculate the soil input uncertainty deduction		
Calculating soil input uncertainty	This section provides guidance on how to use the results of the same Monte Carlo runs used to model emissions in order to calculate the soil input uncertainty deduction for each field.	Appendix C

Step 1.1 Overview of DNDC Site Input Parameters

The DNDC model must be properly parameterized with appropriate field-level data related to climatic drivers, soil characteristics and data on various rice cultivation management actions. DNDC's Graphical User Interface (GUI) divides the parameters required for modeling GHG emissions into three main categories: climate, soil, and cropping inputs. Within the cropping input parameter classification are six additional subcategories, for a total of eight parameter categories. For the purposes of quantifying emission reductions under this protocol, these DNDC input parameter categories are classified into two types; static input parameters and project input parameters. The distinction denotes whether data for those parameters must be sourced from the project scenario cultivation cycle only or both the project scenario cultivation cycle and the baseline scenario cultivation cycle. This classification is not reflected in the GUI, but rather explained and detailed in the protocol. Determining what parameters are categorized as "static" versus "project" input parameters is discussed in Appendix B Step 1.2.

When entering data into DNDC, project developers first use the DNDC GUI. Once a particular dataset has been entered into the GUI, the data should be saved as an input file. Whenever the project developer wishes to re-enter this field's data into the model in the future, he/she should do so by selecting this input file to be input into the model. The input file is also one of a number of digital resources that is necessary for monitoring, reporting, and verification (as discussed further in Sections 6, 7, and 8). The input files created by project developers contain data on all of the parameters required by DNDC, except for climate data. Separate input files are created for climate data in accordance with the formatting requirement stipulated in Appendix B Step 1.3 on climate input parameters. However, the input file can reference the relevant climate data files required to model the desired scenario, allowing DNDC to automatically draw climate data from existing data files. Project developers need to ensure they reference the 20 historical climate input files in correct order (i.e. the five historical years, repeated four times, in that specific order). Additional guidance on use of input files can be found in the User's Guide for the DNDC Model Version 9.5 and in Appendix B of this protocol. Additional guidance on the requirements for the historical 20 year period can be found in Appendix B Step 2.3.

Once project developers become familiar with the DNDC model, they can more efficiently alter the input text files manually so that most data will not need to be input using the DNDC GUI.

Some values will still need to be manually input into the DNDC GUI each time, as described in the sections below.

No DNDC default parameters shall be altered (i.e. values changed or data input where no values existed), unless explicitly directed to do so by this protocol. This can result in an incorrect parameterization of the DNDC model.

This section outlines which of these parameters are 'project' input parameters and which are static. The section then gives further guidance on the DNDC input parameters, according to the climate, soil and cropping DNDC GUI classification.

Table B.2 provides an overview of all of the DNDC input parameter subcategories and identifies which contain project and/or static inputs.

Table B.2. Overview of DNDC Input Parameters

Parameter	Static or Project Input Parameter?	Description	Source of Data for Project Cultivation Cycle Scenario	Source of Data for Baseline Cultivation Cycle Scenario
Climate	Static	Climatic variables	Project scenario cultivation cycle	Project scenario cultivation cycle
Soil	Static	Soil conditions	SSURGO data or, where unavailable, from project scenario cultivation cycle soil samples	SSURGO data or, where unavailable, from project scenario cultivation cycle soil samples
Cropping	Static	Cropping systems and cycles – rotations, etc.	Project scenario cultivation cycle	Project scenario cultivation cycle
Crop	Project/ Static	(1) Types of crops (2) Planting/harvest dates (3) Crop residue management (4) Crop physiology/phenology (DNDC default values used)	Project scenario cultivation cycle and DNDC defaults or values obtained from the UC Davis Jenkins Lab[60]	Residue Management = PROJECT input, taken from baseline scenario cultivation cycle All other inputs = STATIC inputs, taken from project scenario cultivation cycle and DNDC defaults or values obtained from the UC Davis Jenkins Lab[61]
Tillage	Project	Timing and method	Project scenario cultivation cycle	Baseline scenario cultivation cycle
Fertilization	Project	Must choose manual application	Project scenario cultivation cycle	Baseline scenario cultivation cycle
Manure amendment	Static	Timing, type and amount of soil amendments	Project scenario cultivation cycle	Project scenario cultivation cycle

[60] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.
[61] Ibid.

Irrigation	Static	Use the DNDC default irrigation index value of 1	Project scenario cultivation cycle	Project scenario cultivation cycle
Flooding	Project	Must use irrigation option (Control 1) to input data	Project scenario cultivation cycle	Baseline scenario cultivation cycle

Step 1.2 Defining Project Inputs and Static Inputs

For the purposes of this protocol, all DNDC model inputs are classified into two types: project inputs and static inputs. As stated above, the distinction denotes whether data for those parameters must be sourced from the project scenario cultivation cycle only or both the project scenario cultivation cycle and the baseline scenario cultivation cycle.

Project inputs are those that relate to the management parameters that are being changed as a result of the project activity. Project inputs to the DNDC model are the only parameters that may vary when modeling baseline and project emissions to determine the GHG reductions related to the field's management change. For example, when modeling dry seeding, the only change would be the dates for when flooding up occurred (and perhaps added irrigation events to get germination), but other project inputs may remain unchanged (and thus be treated as static inputs). All other inputs that are used to parameterize the model are referred to hereafter as static inputs because once determined for a field for a given cultivation cycle, these inputs must remain unchanged when modeling baseline versus project emission scenarios over the reporting period.

Static inputs may change from year to year, and therefore must be set using measured data from the cultivation cycle of the reporting period undergoing quantification. However, the value for a static input for any single cultivation cycle is assumed to be the same for both project and baseline scenarios.

Table B.3 lists all of the project input parameters.

Table B.3. List of Baseline Project Inputs

Baseline Practice	Project Input
Flooding at seeding	Dates of flooding relative to the planting date (other than winter flooding)
Residue Management	Fraction of straw removed after harvest (0 if no straw removed)
Fertilizer	Dates of all fertilizer applications
	Rate, type of fertilizer and application method for each fertilizer application
Tillage	Dates and depth of all tillage events for preparing the fields for planting and post-harvest residue management

Step 1.3 DNDC Climate Input Parameters

Table B.4 summarizes the climate parameters for which data must be input into DNDC by project developers to model emission reductions.

Table B.4. Climate Parameters

Input Parameters	Unit	Default or Site-Specific?
Jday (Julian day)[62]	Day of year	Site-specific
MaxT (maximum temperature)	°C	Site-specific
MinT (minimum temperature)	°C	Site-specific
Precipitation	cm/day	Site-specific
Humidity	%	Site-specific
Wind speed (daily average)	meters/second/day	Site-specific
N concentration in rainfall	Mg	Default
NH_3 background atmospheric concentration	µg N/m^3	Default
CO_2 background atmospheric concentration	ppm	Default

Seasonal weather can significantly affect methane emissions and, hence, the reduction in methane emissions due to project activities. Weather during the cultivation cycle will impact decisions made regarding the planting and harvesting dates and therefore impacts the length of the growing season. The following requirements for determining climate parameter inputs for each cultivation cycle calculation must be met:

- Daily climate data must come from a weather station that is located maximally 20 miles away, or the nearest station to the field if there are none within 20 miles. If the project area is located in California, it is recommended to use weather data from the nearest CIMIS weather station (http://wwwcimis.water.ca.gov).[63]
- Weather data for the five years preceding the start of the crediting period must be collected. Weather data for the 20-year historic period modeling run (see Appendix B Step 2.3) must be set by repeating this five-year weather data set four times.
- Daily values of maximum temperature, minimum temperature, precipitation, relative humidity and wind speed must be collected and formatted according to DNDC's climate file mode 6 format (see Table B.5 below).
- Default values for N concentration in rainfall, NH_3 background concentration and CO_2 background concentration shall be obtained from the National Atmospheric Deposition Program.[64] Project developers shall select an appropriate default value based on any given day during the first reporting period, which shall be used for the entire crediting period.

Data for N concentration in rainfall, NH_3 background concentration and CO_2 background concentration, are input directly into the DNDC GUI and will thus be contained in input files created by DNDC. Data for the remaining climate input parameters can only be input into the model via the use of climate input files that the project developer must create. When creating the climate input files for these variables, the data must be ordered in the precise manner set out in Table B.4 above, as outlined in the DNDC GUI file format default field. In other words, data needs to be input in text files in the following format: Jday, MaxT, MinT, Precipitation, Humidity, Wind Speed, Humidity.

[62] A Julian Day calendar provided by NASA can be viewed here: http://www-air.larc.nasa.gov/tools/jday.htm. See also Section 5.3.
[63] Note that not all weather stations include data on all the requisite parameters, in particular wind speed and relative humidity, and so may not be a suitable source of climate data.
[64] See http://ucanr.edu/sites/UCRiceProject/. For the NADP see: http://nadp.sws.uiuc.edu/.

For example, the data for the first four days would appear in the input file looking as follows:

Table B.5. Required Formatting for Climate Input Files

1	14	12.1	5.2	4	0.028	0.032	0.048
2	18	11.1	6.2	4	0.029	0.031	0.042
3	13	10.1	7.2	4	0.023	0.033	0.047
4	12	11.1	8.2	5	0.025	0.032	0.048

Step 1.4 DNDC Soil Input Parameters

Table B.6 summarizes the soil parameters for which data must be input into DNDC by project developers to model emission reductions.

Table B.6. DNDC Soil Input Parameters

Input Parameters	Unit	Default or Site- Specific?
Clay content	Fraction	Site-specific
Bulk density	g/cm^3	Site-specific
Soil pH	pH	Site-specific
Soil organic carbon (SOC) at surface soil (0-10 cm)	kg C/kg soil	Site-specific
Soil texture	Fraction	Default

Some soil parameters affect methane emissions to a significant extent. Therefore, for each of the individual rice fields, values for the input parameters listed in Table B.6 must be obtained either from the USDA NRCS SSURGO data set, or based on soil measurements. The Reserve strongly advises project developers to use the SSURGO database, as this will avoid the resource expenditure needed for soil sampling and may reduce the uncertainty surrounding soil sampling results.

Data for the first four soil input parameters listed in Table B.6 needs to be sourced from the SSURGO database. A default soil texture input shall be selected from a drop down menu directly within the DNDC GUI. Project developers must choose a value from the drop down menu that most closely corresponds to the clay content fraction in the soil. Once entered into the DNDC GUI, data for all soil input parameters appears in the relevant DNDC input file.

Note that there are multiple additional soil data input points in the DNDC GUI for which default parameters are provided by DNDC. Unless specifically stated above, such defaults should not be altered.

Further guidance is given below regarding the use of soil data obtained from either the SSURGO database or field sampling.

Using Soil Data Inputs from the SSURGO Database

If the NRCS SSURGO soil database is used, then project developers must calculate the soil parameters for each project field on an area-weighted basis. Figure B.1 below illustrates this concept for a rice field in Yolo County.

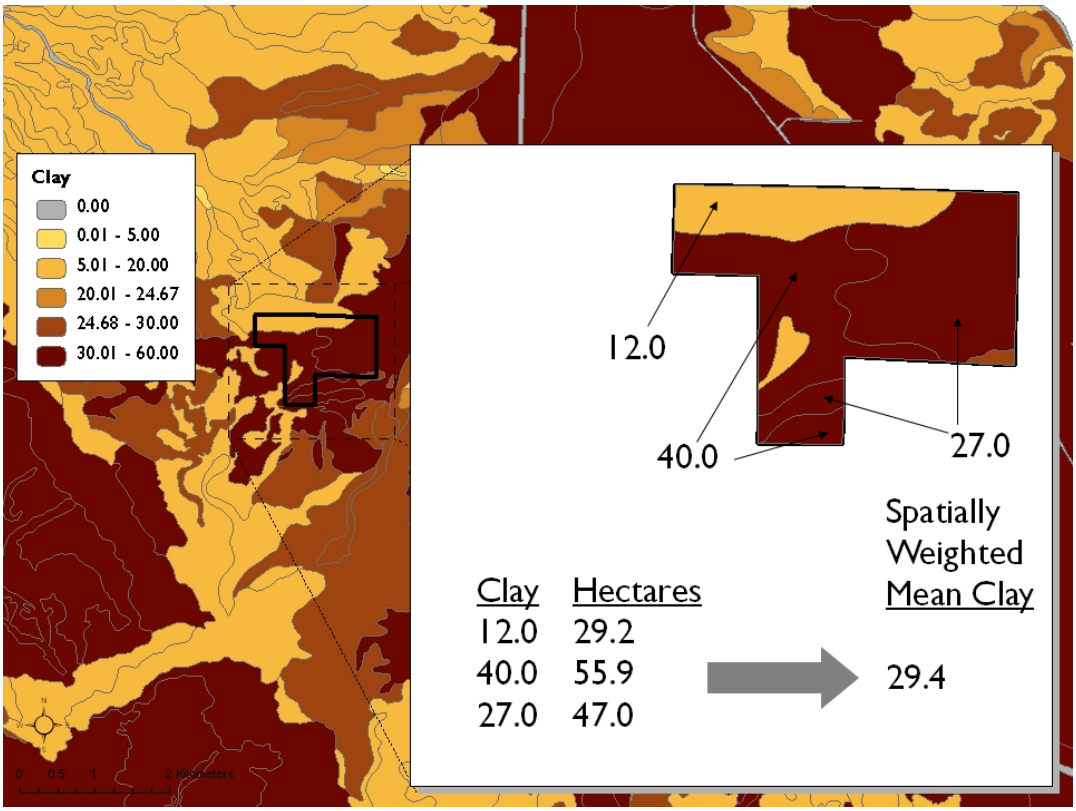

Figure B.1. Example of Soil Parameter Area-Weighting using SSURGO Data

Using Soil Inputs from Samples

If using soil measurements, data may not be older than 10 years prior to the field project start date and must meet the criteria for soil sampling outlined below. Official soil laboratory statements must be available during the verification process.

DNDC requires inputs of soil organic carbon content, soil bulk density, pH and clay fraction of the top 10 cm. If collecting samples for analysis (i.e. not using SSURGO data), the following procedure must be used for each field:

- Samples must be collected at a depth of 0-10 cm
- Samples must be collected using a core method
- 20 samples must be collected for the entire field
- To ensure spatial independence of soil properties, use a random sampling pattern
- Samples should be combined into one composite sample
- The GPS coordinates and depth at each sampling location must be recorded
- The combined 0-10 cm samples must be tested for all parameters
- Soil samples must be analyzed by a certified soil laboratory

A suggested mass of soil of at least 500 g should be collected from each depth for the initial (i.e. time zero) sampling. Future soil sample mass can be adjusted for the assessments being conducted.

Soil samples should be kept cool in the field and during transport. Samples should be maintained at 4°C as much as possible during processing. Samples should be sent to a soil lab for measurement of SOC, clay fraction, pH and bulk density.

For each field sampling event, a Soil Sampling Log must be developed, including the following information:

- Date of sampling event
- Description of the core method and compositing procedure
- The GPS coordinates of each sampling location
- The core depth of each sample
- The name/address of the third-party soil sampling contractor (if applicable)
- The name/address of the certified soil laboratory used for analysis

Step 1.5 DNDC Cropping Parameter Subcategories: Management Parameters

Cropping input parameters capture data on the approved project activities, and are therefore crucial in modeling emissions under this protocol. As set out in Appendix B Step 1.1, the Cropping input parameter category is made up of six subcategories, namely Crop, Tillage, Fertilization, Manure Amendment, Irrigation and Flooding.

Table B.7 summarizes the six subcategories of cropping parameters, referred to as crop management parameters, for which data must be input into DNDC by project developers to model emission reductions.

Table B.7. DNDC Cropping Parameters by Subcategory

Crop Input Parameters	**Unit**	**Default or Site-Specific?**
Planting date	Date	Site-specific
Harvest date	Date	Site-specific
C/N ratio of the grain	Ratio	Default
C/N ratio of the leaf + stem	Ratio	Default
C/N ratio of the root tissue	Ratio	Default
Fraction of leaves + stem left in field after harvest	Fraction	Site-specific
Maximum biomass (yield)	kg dry matter/ha/yr	Site-specific
Thermal degree days (TDD)	°C	Default
Biomass fraction	Fraction	Default
Water demand	g water/g dry matter	Default
Tillage Input Parameters		
Number of tillage events	Number	Site-specific
Date of tillage events	Date	Site-specific
Depth of tillage events	cm	Site-specific
Fertilization Input Parameters	**Unit**	
Number of fertilizer applications	Number	Site-specific
Date of each fertilizer application	Date	Site-specific
Application method	Surface/injection	Site-specific
Type of fertilizer	Type	Site-specific
Fertilizer application rate	kg N/ha	Site-specific
Manure Amendment Input Parameters		
Number of organic applications per year	Number	Site-specific

Date of application	Date	Site-specific
Type of organic amendment	Type	Default
Application rate	kg C/ha	Site-specific
Amendment C/N ratio	Ratio	Site-specific
Irrigation Input Parameters		
Number of irrigation events	Number	Site-specific
Date of irrigation events	Date	Site-specific
Irrigation types	Types	Default
Amount of water applied	cm	Site-specific
Flooding Input Parameters		
Date of flood-up for growing season	Date	Site-specific
Date of drain for crop harvest	Date	Site-specific
Date of flood-up for winter flooding (if applicable)	Date	Site-specific
Date of drain for winter flooding (if applicable)	Date	Site-specific

Crop Input Parameters

Default values for biomass fraction at maturity, biomass C/N ratio at maturity (i.e. C/N ratio of grain, leaf+stem, and root tissue, respectively), water demand and N fixation index are provided within DNDC for most rice cultivars and can be found in the "C:\DNDC\Library\Lib_crop" directory. The "crop.lst" file provides the look-up table for each crop. Where DNDC defaults are not available for the particular rice cultivar in use on a given field, data for biomass fraction, biomass C/N ratio, water demand[65] and N fixation index[66] should be obtained from UC Davis Jenkins Lab. The Thermal degree days value, defined as the cumulative air temperature from seeding to maturity of the crop, will need to be manually input based on default values sourced from UC Davis Jenkins Lab.[67]

The maximum biomass parameter is site-specific and refers to the maximum grain yield (measured in kg dry matter/ha/yr) which has been recorded for each field for the given cultivation cycle. Once this value is set in the GUI, the model will automatically create maximum biomass values for leaf, stem and root. Maximum yields are used in model calibration (see Appendix B Step 3) and in modeling emissions (see Appendix B Step 4).

When entering the fraction of leaves and stem left in the field after harvest, the project developer must ensure they provide sufficient evidence to their verifier to demonstrate their chosen value is appropriate. The provision of time/date stamped photographs of the height of the cutting blades used, close up photos of the residues in the field etc., may be helpful in this regard.

Tillage Input Parameters

The number and date of tillage events needs to be set based on field observations. The depth of tillage events parameter is set based on defaults provided in the DNDC GUI. When setting the depth of tillage events in DNDC, the project developer must set the value closest to the tillage method they used. The project developer needs to retain sufficient evidence to demonstrate to

[65] Water demand represents the amount of water needed for the crop to produce a unit of dry matter of biomass (in g water/ g dry matter).
[66] While the default N fixation index is 1 for non-legume crops, it must be calculated for legume crops, such as rice. The N fixation index is equal to the ratio (total N content in the plant)/(plant N taken from soil).
[67] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.

their verifier that they have chosen an appropriate default value. Photographic evidence and interviews with relevant staff may be useful in this regard.

Fertilization Input Parameters

The number, date, method and rate of fertilizer application events need to be set based on field observations. DNDC accepts seven types of fertilizers: urea, anhydrous ammonia, ammonium nitrate, nitrate, ammonium bicarbonate, ammonium sulfate, and ammonium phosphate. Where a project developer has used a fertilizer that combines several of these products, they will need to ensure that they enter the correct amount of each of these types of fertilizers. This information can typically be found on fertilizer packaging or by contacting the manufacturer, an agronomist, or a university agricultural extension officer.

Manure Amendment Input Parameters

DNDC allows for data on any soil amendment to be input into the model, and provides default parameters (i.e. C/N ratio) for several types of soil amendments. Project developers must use the DNDC default values for the soil amendments listed, unless no suitable DNDC defaults are provided. If no suitable DNDC default value is provided, project developers must provide verifiers with sufficient material to justify the use of any alternative value.

Irrigation Input Parameters

The number, date, and rate of irrigation events need to be set based on field observations. Project developers must select the “flood irrigation” type within the DNDC GUI, as this is the only type relevant to rice cultivation.

Flooding Input Parameters

The date of all flooding events needs to be set based on field observations. Note that flooding events that carry over from December to January of the next year must be set to end on December 35 in the DNDC GUI in order to be recorded correctly in the model.

Step 2.1 Missing Climate or Soil Data

The DNDC model will crash if instructed to run without a full set of data for each input parameter. In situations where portions of the climate or soil input data are missing, the project developer must apply the data substitution methodology outlined in this section. This methodology may also be used for periods when the project developer can show that the data are available but known to be corrupted or inaccurate (and where the corruption/inaccuracy can be verified with reasonable assurance). For periods when it is not possible to use the data substitution procedure below to fill gaps, no emission reductions may be claimed.

Missing Climate Data

The method used to correct or complete missing climate data depends on a number of factors, including:

- The length of time that data were missing
- Availability of data from alternative sources
- The climate variable that is being corrected

For gaps in climate data that do not exceed 14 days, project developers shall use the average value of the previous and following 14 days from the same source of data. For gaps that are

longer than 14 days, project developers shall use data for that same region from another source, or data from the nearest alternative weather station.

Missing Soil Data

If using SSURGO data for soil input parameters and data is missing in relation to one or more parameters, then project developers shall use data from the STATSGO database for those missing data. If data to replace the missing data is not available from the STATSGO database, then data must be sourced from field samples.

If using field samples for all soil inputs, and some data is missing, the project developer must either resample for those parameters or use data from the SSURGO database. Where SSURGO data is unavailable, data from the STATSGO database may be used.

Step 2.2 Historical Modeling

When preparing DNDC for modeling (i.e. calibrating the model, as discussed in Step 3 below) and when using DNDC to model emissions for both the project and baseline scenarios, historical data must be input into the model. This is necessary to ensure DNDC has adequate background data to accurately model emissions. The rules for using historical data depend on whether the data is being used for calibration or for modeling emissions.

When performing calibration, five years of historical data from the years immediately prior to the start date of the project must be used. No baseline or project scenario data are needed for calibration (other than for observed yield, as set out in Step 3 below). The same 5 years of data from the 5 years prior to the start of the project will be used as the historical period for the duration of the project.

When modeling emissions, each time DNDC is run to calculate either the baseline scenario or project scenario emissions for a given cultivation cycle, it must be run using data from the cultivation cycle being modeled as well as 20 years of historical data, for a total of 21 years of data. The input parameters for the 20-year historical period are set by repeating all parameters from the five years before the start of the project four times.

Additional guidance on using input files to create this 20-year historical period is provided in Appendix C and the *DNDC User's Guide* Version 9.5. Table B.8 below provides an overview of this process.

Table B.8. Schematic of Modeling and Calibration Periods

Year -20 to -15*	**Year -15 to -10***	**Year -10 to -5***	**Year -5 to 0**	**Year 0 to 5**	**Year 5 to 10**
Historical Period				*Crediting Period*	
Model Equilibration					
			Crop Yield Calibration	Crediting Period 1	Crediting Period 2

Source: Figure adapted from Proposed VCS Methodology: Calculating Emission Reductions in Rice Management Systems.
* Represented by repeating historical parameter values for years -5 to 0.

Step 2.3 Preparing DNDC Input Files

As indicated in the Step 2.2 guidance above, each time DNDC is used to model emissions for either the baseline or project scenario, it requires 21 years of data. Inputting the requisite 21 years of data can be done using a single input file.

When entering data into DNDC, project developers first use the DNDC GUI. Once a particular dataset has been entered into the GUI, the data should be saved as an input file. Whenever the project developer wishes to re-enter this field's data into the model in the future, he/she should do so by selecting this input file to be input into the model. The input file is also one of a number of digital resources that is necessary for monitoring, reporting, and verification (as discussed further in Sections 6, 7, and 8).

The input files created by project developers contain data on all of the parameters required by DNDC, except for climate data. Separate input files are created for climate data in accordance with the formatting requirement stipulated in Appendix B Step 1.3 on climate input parameters. However, the input file can reference the relevant climate data files required to model the desired scenario, allowing DNDC to automatically draw climate data from existing data files. Project developers need to ensure they reference the 20 historical climate input files in correct order (i.e. the five historical years, repeated four times, in that specific order). Additional guidance on use of input files can be found in the User's Guide for the DNDC Model (Version 9.5) and in Appendix C of this protocol. Additional guidance on the requirements for the historical 20 year period can be found in Appendix B Step 2.2.

Once project developers become familiar with the DNDC model, they can more efficiently alter the input text files manually so that most data will not need to be input using the DNDC GUI. Some values will still need to be manually input into the DNDC GUI each time, as described in the sections below.

No DNDC default parameters shall be altered (i.e. values changed or data input where no values existed), unless explicitly directed to do so by this protocol. This can result in an incorrect parameterization of the DNDC model.

Step 3 Calibrating the DNDC Model

Prior to modeling baseline and project emissions for the first reporting period for each field, the DNDC model must be calibrated in order for the model to attain equilibrium in certain critical variables for which empirical data are lacking, such as the sizes and quality of the different carbon pools, and the inorganic nitrogen contents of soil pore water. This calibration step only needs to be performed once for the duration of the project, for each field.

Proper parameterization of soil physical conditions (which drive soil moisture dynamics) and crop simulation play a crucial role in modeling C and N biogeochemistry and N_2O emissions. Through transpiration and N uptake as well as depositing litter into soil, plant growth regulates soil water, C and N regimes, which in turn determine a series of biogeochemical reactions impacting soil carbon dynamics and CH_4 and N_2O emissions.

Users shall calibrate the DNDC crop model for cropping systems to be included in the project. Figure B.2 outlines the steps for crop calibration.

When undertaking the calibration process, the majority of data on soil input parameters comes from the historical baseline period (i.e. the five years immediately prior to the project start date):

- Maximum grain yield (kg dry matter/ha) shall be set based on the highest observed yield in the five year historical baseline period
- TDD value shall be manually input based on data obtained from UC Davis Jenkins Lab[68]
- Soil texture class shall be manually set based on the observed clay fraction in the soil

The remaining soil values shall be set manually based on DNDC defaults. Where DNDC defaults are not available for the particular rice cultivar in use on a given field, defaults shall be obtained from UC Davis Jenkins Lab.[69]

The steps for crop calibration are outlined below. Calibrating the DNDC model is an iterative process. To carry out the calibration process, the project developer must first run a five year simulation using data from the historical baseline period for that field. Once the simulation has been run, the project developer must then extract crop yields for the five years from the annual summary file. The project developer shall compare the difference between modeled outputs and observed yield for those five years. The maximum biomass and the thermal degree day parameters of the DNDC model must be manually adjusted so that DNDC predicts the maximum recorded yield during the five years before the start of the project with a maximal relative Root Mean Squared Error (RMSE) of 10 percent of the observed mean.

To achieve this calibration, the project developer must use the following process for the single year out of the historic five years that had the maximum observed rice yield.

1. **Adjust maximum biomass parameter:**
    a. Enter observed maximum biomass
    b. Provide more than adequate fertilization (i.e. use the auto-fertilization option in DNDC)
    c. Provide more than adequate irrigation (i.e. use the irrigation index mode and set the index to 1)
    d. Run the year (or rotation) with the actual local climate/soil conditions
    e. Check the modeled grain yield – the difference between the modeled and the recorded yields during the five years before the start of the project observed grain yield should be within a maximal relative Root Mean Squared Error (RMSE) of 10 percent of the observed mean. If the difference is greater than 10 percent, keep repeating steps (i) and/or (ii) below, until the result is below 10 percent. It is suggested that the user should alter the maximum biomass value by a percentage similar to the observed difference, in order to arrive at a properly calibrated result:
        i. If the difference is greater than 10 percent and the modeled grain yield is less than the actual yield, increase the maximum biomass parameter
        ii. If the difference is greater than 10 percent and the modeled grain yield is greater than the actual yield, decrease the maximum biomass parameter

2. **Adjust cumulative thermal degree days (TDD):** Check the modeled maturity date which can be found in the "Day_FieldCrop.csv" file.[70] The modeled maturity date must be brought to within seven days of the harvest date, for the model to be effectively

[68] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.
[69] Ibid.
[70] This file will only be available in the site results if the "record daily results" option is selected on the climate tab of the DNDC Graphical User Interface (GUI).

calibrated.[71] The last column of this file, "GrainC," shows daily grain weight (kg C/ha); the maturity date can be inferred by checking the last day where there is an increase in grain weight (i.e. the first day where the grain weight levels off):

a. If the modeled maturity date is more than seven days later than the harvest date, you will need to reduce the TDD value
b. If the modeled maturity date is more than seven days earlier than the harvest date, you will need to increase the TDD value

Figure B.2 below illustrates this calibration process.

[71] It is not necessary for the difference between observed and modeled TDD to be within seven days for each of the five historical years, but rather that the average over the five years be within seven days.

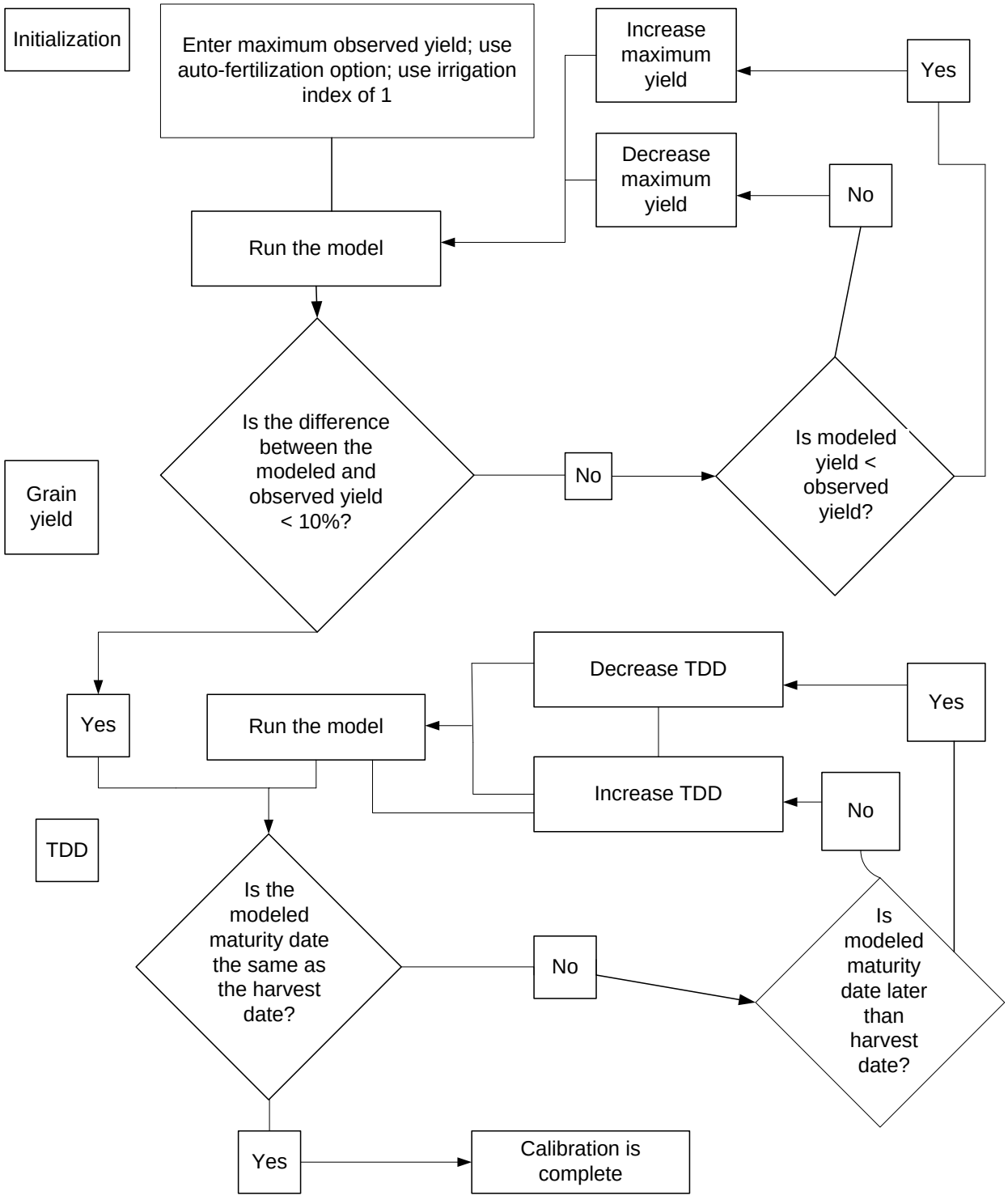

Figure B.2. Calibrating the DNDC Model

Step 4.1 Modeling Emissions using Monte Carlo Simulations

To calculate emissions reductions, project developers need to first model emissions from the baseline scenario and then model emissions from the project scenario. These emissions are compared to calculate associated emission reductions. This section outlines the process for modeling the emissions.

For this protocol, the DNDC model must be run using Monte Carlo batch runs to calculate emission estimates for a given cultivation cycle. A full set of 2,000 Monte Carlo runs must be performed for each calendar year within the baseline scenario and then a full set of 2,000 Monte Carlo runs must be performed for each calendar year within the project scenario.

Monte Carlo simulations are a class of computational algorithm that rely on repeated random sampling within a set range of input values to compute results. Monte Carlo simulations are particularly useful when there is uncertainty with respect to data inputs, as thousands of runs can be performed quickly, an average result determined, and the variance in results calculated. The duration of each Monte Carlo run should be the same as the duration of the cultivation cycle for the field (i.e. approximately 365 days).The Monte Carlo runs are accomplished by running DNDC in batch mode with each entry in the batch file list representing a separate Monte Carlo run (see *DNDC User's Guide* Version 9.5, for more information).

For each field, a Monte Carlo simulation of 2,000 model runs shall be performed for each calendar year within both the baseline cultivation cycle and the project cultivation cycle corresponding to the current reporting period. For each of these 2,000 baseline cultivation cycle and 2,000 project scenario cultivation cycle runs, the project developer needs to input data for both the 20-year historical period and the cultivation cycle being modeled (see Appendix B Step 1.2 for further guidance on sourcing data for project and static input parameters). Once the Monte Carlo simulation has been run using 21 years of data, results from the modeling of the 20 year historical period shall be ignored; only the results from the 21st year (i.e. the cultivation cycle in either the project scenario or the baseline scenario being modeled), are used.

It should be noted that modeling 21 years, as instructed, can be done using one single input file. Refer to Appendix B Step 2.3 and the *DNDC User's Guide* Version 9.5 for further guidance on developing input files, Appendix B Step 1.2 for guidance on sourcing data for project and static input parameters and Appendix B Step 2.3 for guidance on how to set a 20-year historical baseline period appropriate to each crediting period.

Once the Monte Carlo simulations are complete, results are recorded in a *.csv file. The name of the file shall be the site name as entered into DNDC. Project developers are strongly encouraged to use naming conventions for DNDC files based on the field serial number methodology described in Section 7.1.1.

Note that DNDC saves the results from each Monte Carlo batch run into both annual summary files and daily summary files. When quantifying emission reductions and calculating the soil input uncertainty deduction, results need to be extracted from the daily results files, and only for those dates that fall within each field's cultivation cycle.

Specifying Monte Carlo Analysis Soil Input Uncertainty

This protocol allows project developers the choice of using soil survey data (i.e. SSURGO) or field soil samples to estimate soil conditions. The method for parameterizing DNDC for Monte

Carlo analyses depends on whether SSURGO or directly measured soil data are used as inputs.

If NRCS SSURGO soil survey data[72] are used for setting soil parameter values, then default uncertainty estimates shall be set based on the uncertainty estimates and probability distribution functions (PDF) listed in Table B.9. For each soil stratum, the mean value shall be calculated as the area-weighted sum of the representative values for all of the relevant SSURGO data.

Table B.9. Uncertainty Estimates and Probability Distribution Functions for Soil Parameters

Parameter	PDF	Uncertainty
Bulk density	Log-normal	+/- 0.1 g/cm^3
Clay content	Log-normal	+/- 10%
SOC	Log-normal	+/- 20%
pH	Normal	+/- 1 pH unit

Source: Selected from http://www.abdn.ac.uk/modelling/cost627/Questionnaire.htm.

If field measurements are used, then the uncertainty level for each soil parameter shall be +/- 10 percent of the mean at a 90 percent confidence level.

Step 4.2 Extracting DNDC Modeling Results for Calculating Emission Reductions

The DNDC GUI creates estimates of primary emissions that occurred over the given year being modeled; however the model uses emission factors not employed by this protocol. Therefore, it is important that project developers do not extract emissions estimates from the DNDC user interface, but instead extract data from the daily *.csv files to manually generate emission results for the baseline and projects scenarios separately, using the emission factors stipulated in Equation 5.2.

It is also important that project developers understand that the entire modeling process must be undertaken twice for each cultivation cycle being modeled, once for the calendar year within which the cultivation cycle starts, and again for the subsequent calendar year in which the cultivation cycle ends. Section 5.3 provides further explanation of the need to model two calendar years of emission reductions for each cultivation cycle.

At the conclusion of a modeling exercise (for either the baseline or project scenario), the project developer extracts data from 2,000 separate results files for the 21st year being modeled, [73] for each calendar year being modeled. Specifically, from the daily *.csv files, project developers shall extract the direct GHG emission parameter values (N_2O, CH_4, and SOC content), and the indirect parameter values (NO_3 and NH_3+NO_x). The SOC and CH_4 values (expressed in DNDC as SOC and CH_4*flux* respectively) shall be extracted from the Day_SoilC file. Data on all of the nitrogen-related parameters (i.e. N_2O, NO_3, and NH_3+NO_x) shall be extracted from the Day_SoilN file.

The DNDC *.csv files contain data for each of the Julian days being modeled for a calendar year (i.e. approximately 365 days of data in each results file). From each of the 4,000 results files (2,000 from each calendar year), the project developer must extract data for only those dates

[72] See http://soils.usda.gov/survey/geography/ssurgo/.
[73] As explained in Step 4.1, the first 20 years of data/results are for historical modeling only.

that fit within the field's cultivation cycle. The results for the cultivation cycle are then added together (for all parameters except SOC; SOC values are taken only for the last Julian day in the cultivation cycle), such that the project developer has a single value for each GHG parameter for the cultivation cycle, for each of the 2,000 Monte Carlo runs. Once these values have been generated they must be averaged according to Equation 5.2 in Section 5.4.1. At the end of this process, the project developer has a single value for each key GHG parameter, representing the average value for that parameter for the cultivation cycle across all of the Monte Carlo runs.

This process must be repeated for both the baseline scenario and the project scenario.

Step 5 Calculating Soil Input Uncertainty

Project developers shall sum together primary emissions for the baseline scenario ($CH_{4B} + N_2O_B + \Delta SOC_{B,I}$),[74] and then sum together primary emissions for the project scenario ($CH_{4P} + N_2O_P +$ ΔSOC value for the project scenario).[75] The input uncertainty ($\mu_{inputs,i}$) for greenhouse gas emissions due to uncertainty in soil input parameters for field *i* shall be calculated as the half-width of the 90 percent confidence interval of the difference between the baseline and project scenario cultivation cycle primary emissions, where the primary emissions for each Monte Carlo run *j* are expressed as a percent of the mean GHG cultivation cycle emissions of field *i.*

The soil input uncertainty deduction is used in Equation 5.4 to correct the total modeled primary emission reductions for soil input uncertainty.

Further guidance on the development of soil input uncertainty deductions is provided in Appendix C.

[74] Using CH_{4B} and N_2O_B from Equation 5.3 and $\Delta SOC_{B,I}$ from Equation 5.10, with each parameter converted into CO_2 equivalents.

[75] Using CH_{4P} and N_2O_P from Equation 5.3 and deriving a ΔSOC value for project scenario, in the same manner as the baseline ΔSOC value is derived in Equation 5.10, with each parameter converted into CO_2 equivalents.

Appendix C RCPP General Quantification Guidance

Quantification Guide Index:

Introduction
- Development of Ex Ante Input Data and Assessment of Offset Potential
- Collection of Climate Data for DNDC Modeling
- Collection of Climate and Soil Data for DNDC Modeling
- Calculation of Input for *Ex Post* Offset Calculations
- Example: Assessing Impact of Input Uncertainties on Modeled Offsets

DNDC Modeling Overview
- Sources of Data
- Creating Site Input Files
- Crop Model Calibration
- Running the Model and Viewing Results

Greenhouse Gas Emissions Scenarios: Overview
- General Effects of Model Parameter Changes
- Modeling Potential Project Scenarios

Case Study: Paddy Rice
- Entering Input Data
- Crop Model Calibration
- Creating Alternative Management Scenarios

Introduction

This appendix is intended to be a practical guide for users of the DNDC model. As such, this appendix includes information that is not strictly needed for this protocol (for instance guidance on using the DNDC model for pre-project feasibility analyses).

This guide describes the use of the DNDC model for the Reserve Rice Cultivation Project Protocol (RCPP). This guide assumes a basic familiarity with the model and its use and is meant to be used in conjunction with the *User's Guide for the DNDC Model* (Version 9.5) (*DNDC User's Guide*), which explains the background mechanics of the model as well as the functionality of the DNDC graphical user interface (GUI).

Development of Ex Ante Input Data and Assessment of Offset Potential

Prior to developing rice offset projects, project developers may want to assess opportunities prior to implementing projects. Such assessments are not required for this protocol. This assessment entails several steps, including collection of current agricultural management data, *ex ante* modeling of general baseline emissions and a suite of mitigation options, and first order assessment of economic feasibility of the mitigation measures.

The first step in developing rice offset projects and applying the DNDC model to evaluate the potential magnitude of emission reductions requires collection of basic rice management data (plant/harvest dates, flooding/irrigation and tillage practices, fertilizer use, etc). Collection of soils and climate data for DNDC modeling is discussed below.

Farmers decisions regarding when to plant rice, how much fertilizer to apply, when to till the soils, when to flood and when to harvest are driven by a combination of factors including

commodity prices, prices of resources (e.g. fertilizer) and weather patterns. Over a crop season it is possible that farmers have a good estimate of commodity prices and cost of inputs. However, climatic conditions and associated impacts on agricultural management decisions are difficult to predict prior to the growing season. We also know that management practices and weather both have a significant impact on greenhouse gas (GHG) emissions from agricultural soils.

Given the reliance on weather patterns for decisions regarding agricultural management practices, the *ex ante* modeling is based on an estimation of what the growers think they will do in the future. The *ex ante* input data on management (see detailed discussion below on DNDC model inputs) for the baseline scenario should be based on recent management practices to satisfy both the performance standard criteria and simplify *ex ante* calculations. Once the baseline management practices are set, the project developers can assess what eligible mitigation measures they wish to implement by running DNDC with those changes in management that are both economically viable and have potential to reduce GHG emissions. Later in this document we present an example of the mechanics in using DNDC to evaluate potential offset management changes.

Once a project is implemented, the project developer must collect all of the necessary input data for running the DNDC model. These data are collected through the growing season to insure that the data reflect exactly what the farmer did. The change in approved practice changes implemented by the project must be represented in the model inputs. The key to reliable and genuine project modeling is to define what and how management practices are changed under the project scenario.

Collection of Climate Data for DNDC Modeling

The DNDC model requires daily data on maximum and minimum temperature, precipitation and average wind speed. In California, these data can be collected from the CIMIS (California Irrigation Management Information System) network of weather stations.

Collection of Climate and Soil Data for DNDC Modeling

DNDC requires inputs of soil organic carbon content, soil bulk density, pH and clay fraction of the top 10 cm. Data on soil conditions for a given field can either be collected from existing soil surveys (NRCS SSURGO) or through direct measurement. The RCPP describes some general guidelines on soil sampling for measuring soil properties for DNDC model simulations.

Calculation of Input for *Ex Post* Offset Calculations

The *ex ante* calculations are just an estimate of the potential reductions from implementing one or more of the approved project activities. The *ex post* calculations, performed in accordance with Section 5.4.1 of the RCPP, determines the primary effect GHG reductions that occur on a field due to RC project activity. Once a farmer implements a project and changes management practices from what they would have done in the "baseline," the baseline becomes a fictitious scenario that represents what the grower "would have done" in the absence of the RC project.

The *ex post* model simulations are done for both the project management practices (what was actually done and recorded by the project) and the "baseline" management. The baseline management practices are the same as the project except for the specific changes in management selected for the project (e.g. those management practices that are recognized as approved project activity practices in Section 2.2 of the RCPP). Because *ex post* calculations

represent the real reductions achieved at the field over the course of a complete cultivation cycle, actual weather data must be used for the *ex post* model simulations.

Example: Assessing Impact of Input Uncertainties on Modeled Offsets

This section describes how to calculate the impact of input uncertainties on DNDC modeled emission reductions following the procedures summarized in Section 5.4.2 of the RCPP. Input uncertainty must be quantified when using the DNDC model because the DNDC model can be sensitive to changes in input parameters, specifically changes in soil conditions. The Monte Carlo Input Uncertainty assessment models the GHG emissions thousands of times for a specific field, with each model run using slightly different soil parameters. The soil parameters for each Monte Carlo run are randomly selected based on the probability distribution function (PDF) expected for each soil input used to parameterize the model. Project developers can choose to use either the SSURGO database or field sampling to characterize the soil input parameters.

The following example demonstrates the Monte Carlo modeling approach described in Appendix B Step 4.1 of the RCPP. To apply this method for assessing the impact of uncertainty of soil conditions, the first step entails defining a possible range and probability distribution of the soil conditions. For this example, we use soil databases developed by the U.S. Department of Agriculture Natural Resources Conservation Services (USDA NRCS). The general approach is to assume some variability in site soil attributes (clay fraction, organic matter fraction, bulk density, and pH) as modeled in the USDA NRCS SSURGO soil model. Using a Monte Carlo simulation, one must model identical crop management practices and meteorological conditions while varying soil conditions through the expected range of conditions. The current uncertainty tool in DNDC allows users to run thousands of model simulations in a Monte Carlo mode for most input parameters. However, the current tool in the model assumes an *even* distribution (PDF) for each parameter. The RCPP requires the Monte Carlo run to assume a *log-normal* distribution of each of the soil attributes as well as some amount of correlation between them. The three steps for running the model in Monte Carlo mode can be described as:

- An analysis of correlation between the four soil attributes. In the development of the RCPP an analysis of SSURGO soil data for over 6000 rice fields was completed to develop default correlation coefficients for key soil input parameters. The default correlation coefficients are provided in Table C.1 below.
- Programmatic generation of DNDC inputs based on the Monte Carlo method and pre-defined correlation coefficients.
- Running the DNDC model in site mode using the batch processing option and synthesizing the results.

We demonstrate this approach in two ways; the first assumes no correlation between soil parameters, which is conservative since we know that there is significant correlation between soil parameters. The second set of Monte Carlo runs utilized correlation statistics as part of the sampling procedure.

Soil attributes are stored within the SSURGO database according to the following relationships:

Horizon	Contains soil attribute data (low, representative, and high values) based on an assessment of soil field conditions
⇩	[one to many]
Component	The basic soil type (roughly equivalent to soil series) – soil components have many horizons and have no explicit spatial location
⇩	[one to many]
Map Unit	The smallest mapped polygon in the SSURGO model – soil map units have many components of varying fractions

To assess correlation among soils in rice growing areas of California, all map units intersecting rice fields as mapped in the California Department of Water Resources land use database were selected. From this selection, we identified all soil components contained within the map units. Soil attribute data came from the top horizon for each component. Thus, the final database represents all soil horizons intersecting rice fields.

Pearson correlation coefficients we calculated for each set of pairs for representative values of the four soil attributes:

Table C.1. Soil Correlation Coefficients

	Clay fraction	OM fraction	Bulk Density	pH
Clay Fraction	1	-	-	-
OM Fraction	0.139	1	-	-
Bulk Density	-0.526	-0.685	1	-
pH	0.263	0.098	-0.126	1

The Monte Carlo simulation should randomly generate 2,000 numbers for each of the four soil properties with the correlation matrix and with each following a log-normal distribution. This can be done by using the Cholesky decomposition of the correlation matrix to transform a set of standard-normal random numbers in the logarithm space. The representative value are used as the mean, while the low and high values are transformed into log space and treated as a range of +/- 3 standard deviations. This will result in four sets of 2,000 correlated random numbers, normally distributed. The soil properties, other than pH, are then calculated by taking the exponent of the numbers.

The DNDC model should then be run as a batch using the DNDC site mode (see *DNDC User's Guide*). To demonstrate this, we ran two scenarios (one with a winter flood, one without a winter flood) for a single field as follows:

- Rice planted May 1, harvested September 11
- Tillage on April 23, April 26, April 27, April 29, and September 15
- Fertilizer on April 30 (injected anhydrous ammonia), May 1 (surface application of $(NH_4)_2HPO_4$), May 26 (surface application of $(NH_4)_2SO_4$)
- Flooded from May 1 to September 1
- Winter flood from November 15 to January 31 (only for the winter flood scenario)
- Rice straw burned once every eight years

These results indicate the modeled methane emissions and net GHG emissions are quite sensitive to soil conditions. At 90 percent confidence interval, the range in modeled CH_4 and net

GHG emissions were significant (over 14 percent in both baseline and project simulations) (see Table C.2 below). However, the impact of soil uncertainties on modeled changes in emissions from baseline to project conditions were quite small (<3 percent). Figure C.1 below shows the histogram of the Monte Carlo simulation results for the case assuming no correlation between soil input parameters. It is clear for this baseline and project scenario, that uncertainty in soil input parameters impacted both baseline and project modeled emissions in a similar degree. Accounting for correlation between soil input parameters reduced uncertainties. The table below summarizes these results.

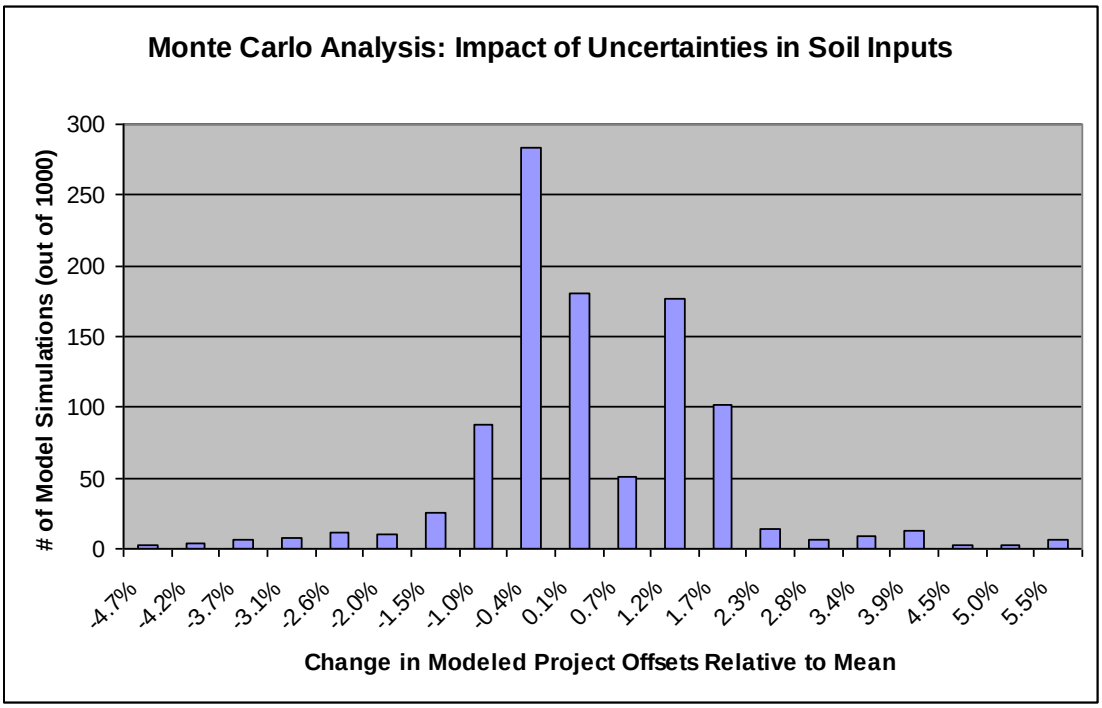

Figure C.1. Change in Modeled Offsets Based on Running Monte Carlo Analysis on Soil Input Uncertainty

Table C.2. Uncertainty in Modeled GHG Emissions and Change in Emissions at 90 Percent Confidence Interval due to Uncertainty in Soil Values

	Assuming No Correlation in Soil Input Parameters		Accounting for Correlation of Soil Input Parameters	
	CH_4 GWP (90% CI / Mean)	Total GHG GWP (90% CI / Mean)	CH_4 GWP (90% CI / Mean)	Total GWP (90% CI / Mean)
Baseline	14.7%	14.4%	14.0%	13.7%
Project	18.5%	20.0%	17.5%	19.1%
Baseline-Project	**1.0%**	**2.2%**	**0.2%**	**1.4%**

DNDC Modeling Overview

This section of the guide is a general overview of the modeling process to give the user a sense of the steps involved in evaluating various land management scenarios. It presents material on gathering input data for the model, using the DNDC GUI to enter data, setting up appropriate soil conditions for the model, calibrating parameters for crops, viewing results, and estimating model uncertainty.

Sources of Data

Prior to running the DNDC model, numerous input data are required, including information on soil, meteorology (climate), and management practices. As DNDC looks principally at soil dynamics, accurate soil parameters are critical: at a minimum, users should gather precise data for soil organic matter content (kg C/kg soil), bulk density (g/cm^3), soil texture (soil clay fraction can be used as a proxy here), and pH. Daily meteorological data for the modeling timeframe should include maximum and minimum air temperatures (°C) and precipitation (cm).

Creating Site Input Files

Once the user has gathered natural conditions and management information for the site, DNDC input files can be created using the DNDC GUI. The user will enter information for the following twelve thematic areas:

- Site
- Climate
- Soil
- Farming rotation management
- Crop
- Tillage
- Fertilization
- Manure amendment[76]
- Irrigation
- Flooding
- Plastic mulch (not relevant for RCPP)
- Grazing and cutting (not relevant for RCPP)

For a step-by-step guide to data input, the user may refer to the *DNDC User's Guide*, Section III-1.1.

Crop Model Calibration

Crop simulation plays a crucial role in modeling carbon and nitrogen biogeochemistry in and greenhouse gas emissions from the agroecosystems. DNDC default parameters for California rice are provided. Where DNDC defaults are not available for the particular rice cultivar in use on a given field, alternative values for defaults prescribed by this protocol may be obtained from the UC Davis Jenkins Lab.[77] The parameters for soil crop simulation are:

- ***Maximum biomass (kg C/ha)*:** The maximum biomass productions for grain, leaves and stems (non-harvest above ground biomass), and roots under optimum growing conditions (namely, maximum biomass assuming no N, water or growing degree day limitations). The unit is kg C/ha (1 kg dry matter contains 0.4 kg C). If local data are not available, then California default values must be used.
- ***Biomass fraction*:** The grain, leaves and stem, and root fractions of total rice biomass at maturity.
- ***Biomass C/N ratio*:** Ratio of C/N for grain, leaves and stem, and roots at maturity.

[76] DNDC allows for data on any soil amendment to be input into the model, and provides default parameters (i.e. C/N ratio) for several types of soil amendments. Users must adopt the DNDC default values for the soil amendments listed, unless no suitable DNDC defaults are provided. Where no DNDC default is provided or alternative values are believed to be more appropriate, users may provide verifiers with sufficient material to justify the use of any such alternative data.

[77] This information can be sourced directly from UC Davis.

- ***Thermal degree days (°C)*:** Cumulative air temperature from seeding until rice maturity.
- ***Water demand (g water/g dry matter)*:** Amount of water needed for the rice crop to produce a unit of dry matter of biomass (also known as transpiration efficiency).
- ***N fixation index*:** The default number is 1 for non-legume crops. For legume crops, the N fixation index is equal to the ratio of total plant N content to plant N taken from soil. For rice, this value must be set at 1.

Default values for N deposition, NH_3 background and CO_2 concentration should be obtained from the National Atmospheric Deposition Program data or data from UC Davis Jenkins Lab.[78] The TDD value will need to be manually input based on a default value found in a look up table derived from UC Davis Jenkins Lab. The remaining soil values will need to be set manually based on DNDC defaults and can be found in the "C:\DNDC\Library\Lib_crop directory." The "crop.lst" file provides the look-up table for crop numbers for each crop. In addition to the crop libraries included with DNDC, the Crop Creator feature (see "Tools" tab on DNDC user interface) allows the user to create a new crop library (by entering in all of the parameters listed above) or modify an existing crop library. Figure C.2, below, shows the DNDC Crop Creator interface. For information on using the Crop Creator, the user may refer to *DNDC User's Guide*, Section III-2.3. The crop creator tool can be used to develop the input parameters for a new rice variety. Where DNDC defaults are not available for the particular rice cultivar in use on a given field, defaults may be obtained from UC Davis Jenkins Lab.

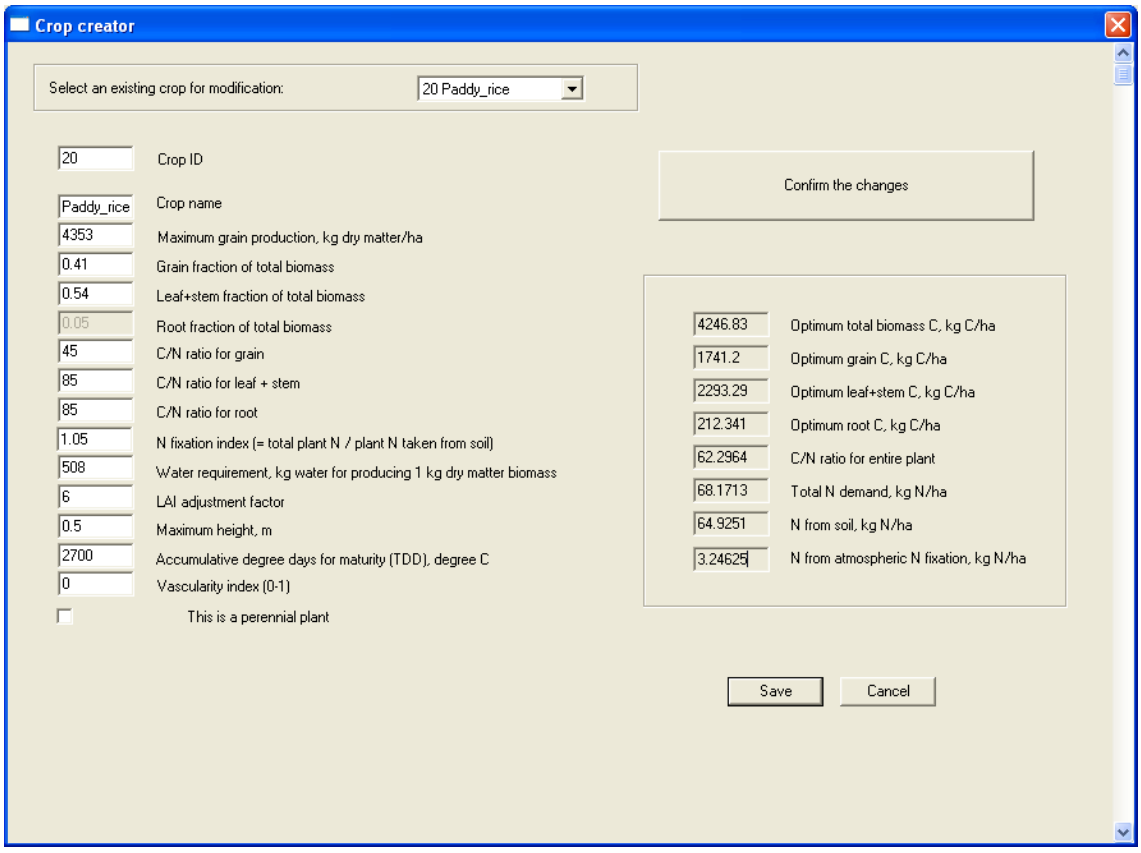

Figure C.2. DNDC Crop Creator

[78] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.

To use the model according to the RCPP, the user must calibrate the DNDC crop model based on actual site conditions. At least five years of observed crop yields should be used for setting maximum rice grain yield (kg C/ha). In addition, for the particular rice variety used, the biomass fraction (% grain and % leaf and stem), and biomass C/N ratio for grain, leaves and stem, and roots should be obtained from the look up tables derived from UC Davis Jenkins lab.[79] DNDC default parameters which can be found in the "C:\DNDC\Library\Lib_crop" directory. DNDC provided default values or defaults sourced from UC Davis must be used for all of these parameters except the maximum biomass parameter, which must be manually set in the model based on historical yields. Biomass fraction and C/N ratios are typically constant for a cultivar, so if no DNDC default value can be found for the particular cultivar used on a given field, an alternative default value can be sourced from UC Davis (see Appendix B Step 1.4 for RCPP requirements). The steps for crop calibration are outlined in Appendix B Step 3.

Running the Model and Viewing Results

Once soil and crop calibration are complete, input parameters are entered, and input files are saved for later use, the model can be run. For details on running the model, the user may refer to the *DNDC User's Guide*, Section III-1.3. Model run results can be viewed either through the DNDC GUI or in text files saved to the user's hard-drive. Results in the DNDC GUI give a quick overview of results by year for crop(s), nitrogen, carbon, water, and greenhouse gas emissions. Viewing results via the GUI is described in detail in the *DNDC User's Guide*, Section III-1.4.

Daily and annual results are saved in text file format so that they can be retrieved and reprocessed with any spreadsheet or word processor tools (e.g. Microsoft Excel or OpenOffice Calc). Daily results include information on crop growth, soil carbon and nitrogen pools and fluxes, soil climate, and water budget. In addition, summarized annual results are saved in report and tabular format. Text file results are described in detail in the *DNDC User's Guide*, Section IV-1.

Greenhouse Gas Emissions Scenarios: Overview

This appendix provides an overview of the GHG emission evaluation process using DNDC. While this document is not intended to be used to select the actual scenarios to be used, we provide some background material here on the general effects of parameter changes in DNDC and a brief discussion of trade-offs between management practices, GHG emission, and crop yield. In addition, we describe the general framework for the ideal approach to scenario evaluation.

General Effects of Model Parameter Changes

The user should consider what GHG mitigation options make sense for their particular application and set-up DNDC modeling appropriately. Seeking input from local experts and surveying literature specific to the system of interest is the preferred approach. This section (and the accompanying tables in the appendix) provides a very general overview of methane mitigation options.

Reductions to CH_4 emissions fall into four categories: changes to soil character, organic matter management, crop/plant management, and flooding. Changes to soil character (such as by converting wetland soils to upland crop) often affect other GHG emissions such as C sequestration or N_2O emissions. Crop or plant management and organic matter management

[79] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.

are typically effective in wetlands soils. Changes to flooding regime are often the most feasible option, but can also influence N_2O emissions.

Modeling Potential Project Scenarios

Ideally, each scenario should be run for the same time period, using the same site characteristics for several years (five or more): because of climate-related interannual variability, emissions and yields can vary significantly from year to year. Running the model for several years will ensure a reasonable average. If a multi-year run is not possible, a Monte Carlo simulation may provide better results. Due to the use of annual reporting periods, this protocol requires the use of Monte Carlo simulations to reduce model uncertainty.

The general process for evaluating scenarios is as follows (a specific example can be found in the Case Studies section):

- Create baseline input files for DNDC (including *.dnd file and climate files)
- Create management alternatives based on approved project activities
- Run baseline and project management scenarios
- Import text results into spreadsheet software (e.g. Microsoft Excel or OpenOffice Calc) and generate mean annual per hectare values (in CO_2 equivalents) for the principal parameters;
    - Change to soil organic carbon (ΔSOC)
    - Methane (CH_4)
    - Nitrous oxide (N_2O)
- Sum CO_2 equivalents to derive total annual GHG emissions (zeroing out any net emission reductions from SOC or N_2O, as reductions to these gases are not credited in the RCPP)
- Useful graphs might include:
    - Bar chart comparing total GHG emissions by scenario
    - Bar chart comparing grain yield by scenario

Case Study: Paddy Rice

In this section we will provide a step-by-step example of an evaluation of management scenarios for a 20.8 hectare rice paddy in California. In this case, we are using data from an actual field, with six years of detailed management, meteorological and atmospheric, and soils data. Here is the baseline management scenario:

- Single crop: rice
- No removal of crop residue
- Tillage prior to and after cropping
- Fertilizer applications prior to and after planting
- Flooded field from late May through early September
- Winter flood from December through February/March

Entering Input Data

As one would do with any DNDC model site run, we will begin by entering all of the site, soil, and cropping information available to us; this initial set-up will form the basis for the crop calibration process and the baseline run. Figure C.3 shows the basic site information and climate information for our rice paddy. Climate files were created based on data from a nearby agricultural weather station. Nitrogen concentration from rainfall was generated from data from a

nearby monitoring station and represents annual average total deposition averaged over the six years.

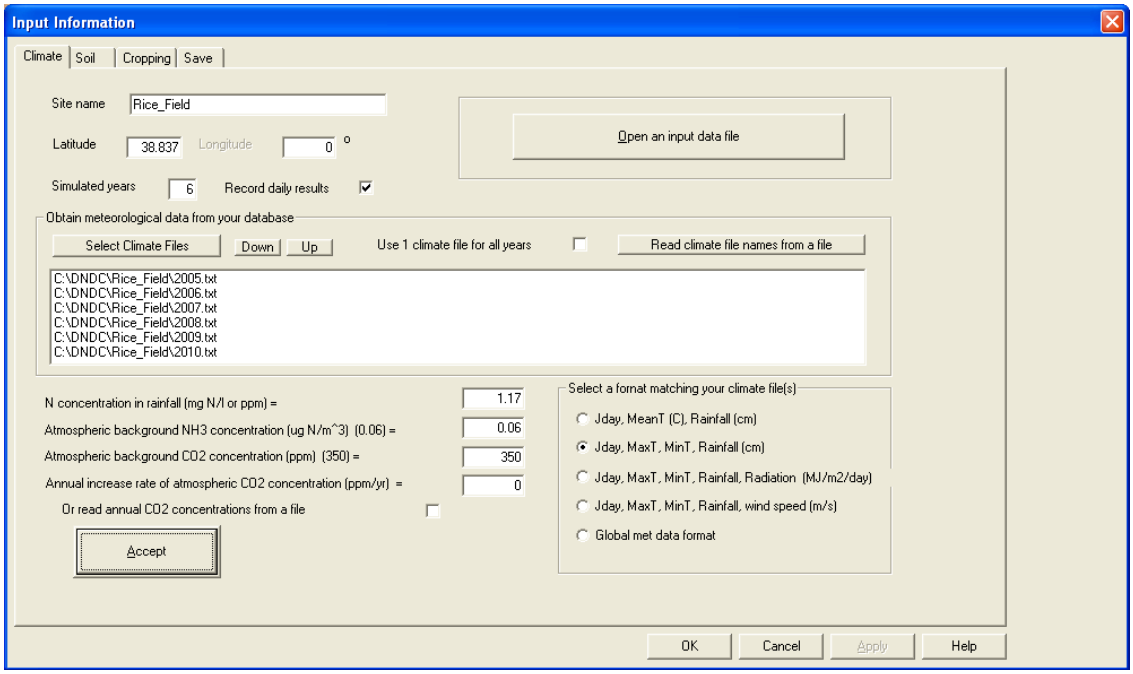

Figure C.3. Rice Site and Climate Input

Figure C.4 shows the soil data for our rice field based on site soil sampling. In this case we have data for the land use type (rice paddy), clay fraction (0.31), bulk density (1.45 g/cm^3), soil pH (7.5), and surface soil organic carbon (0.75 percent). For the rest of the parameters we will use the DNDC defaults.

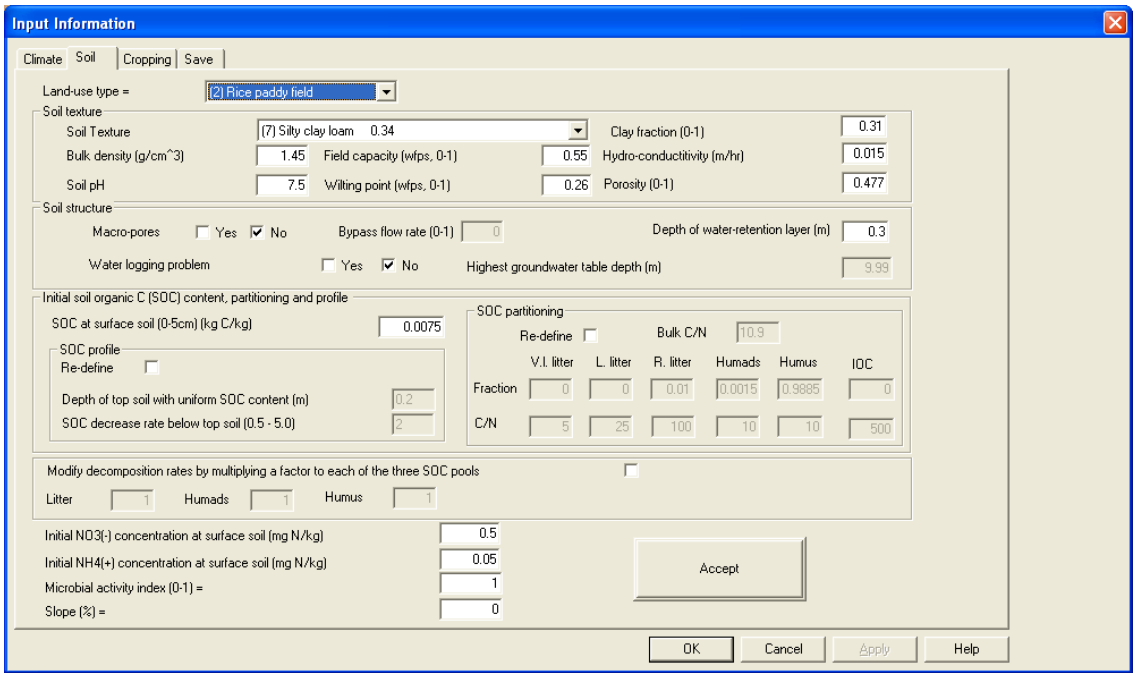

Figure C.4. Rice Soil Input

Next we will setup the cropping systems for our rice paddy. Figure C.5 shows how our cropping systems will be arranged for our six-year time period. The total years of the model run will be six years (based on the input in the Climate/Site tab); since each year of the run will have slightly different parameters, we will set these up as six different cropping systems (i.e. "Number of cropping systems applied…" should be set to 6) each of which lasts one year (i.e. "Duration of this cropping system…" should be set to 1 for each year).

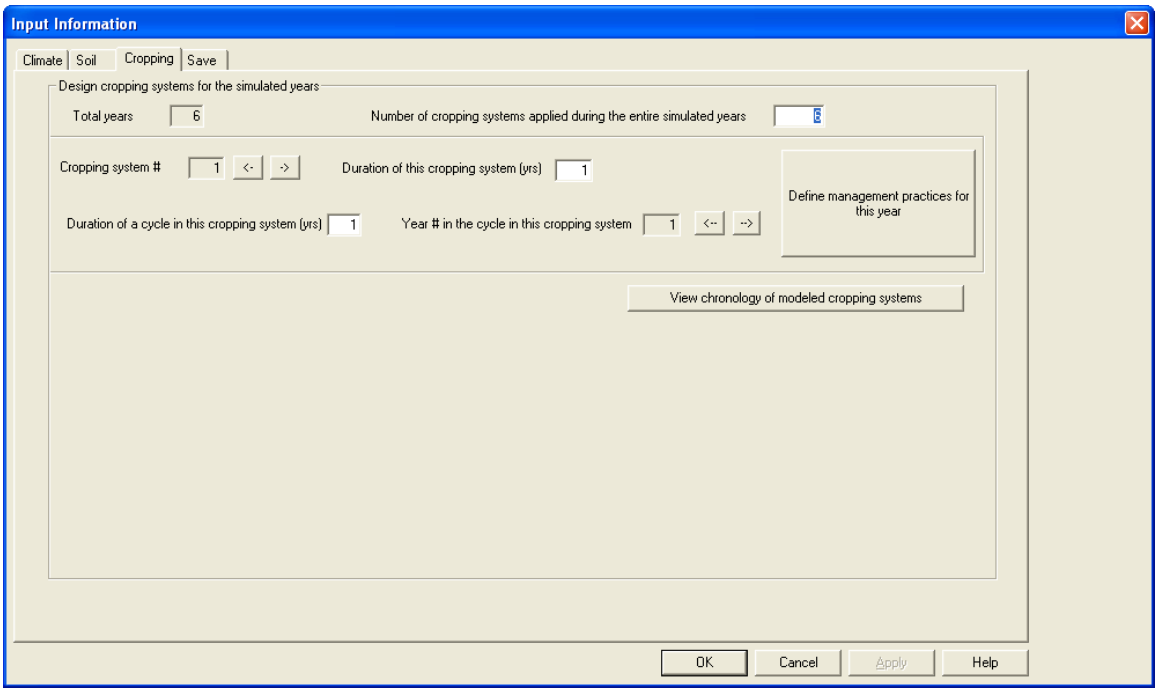

Figure C.5. Rice Cropping Systems

For this demonstration, we will show a single cropping system (year 1) as entered into DNDC (Figure C.6 through Figure C.8). The user can enter the cropping information for years 2 through 6 based on the information shown in Table C.3.

Table C.3. Rice Cropping System Information

Year	2005	2006	2007	2008	2009	2010
Cropping System	**1**	**2**	**3**	**4**	**5**	**6**
Plant Date	5/19	6/1	5/22	5/22	5/21	5/30
Harvest Date	10/12	10/30	10/15	10/13	10/29	11/12
Tillage 1	5/12 – 10 cm	5/25 – 10 cm	5/15 – 10 cm	5/15 – 10 cm	5/14 – 10 cm	5/23 – 10 cm
Tillage 2	5/13 – 10 cm	5/26 – 10 cm	5/16 – 10 cm	5/16 – 10 cm	5/15 – 10 cm	5/24 – 10 cm
Tillage 3	5/14 – 0 cm	5/27 – 0 cm	5/17 – 0 cm	5/17 – 0 cm	5/16 – 0 cm	5/25 – 0 cm
Tillage 4	10/18 – 5 cm	11/5 – 5 cm	10/21 – 5 cm	10/19 – 5 cm	11/4 – 5 cm	11/18 – 5 cm
Tillage 5	10/19 – 5 cm	11/6 – 5 cm	10/22 – 5 cm	10/20 – 5 cm	11/5 – 5 cm	11/19 – 5 cm
Fertilization 1	5/14 - 114.33 kg N/ha Urea	5/27 - 112.09 kg N/ha Urea	5/17 - 116.57 kg N/ha Urea	5/17 - 121.05 kg N/ha Urea	5/16 - 134.5 kg N/ha Urea	5/25 - 146.83 kg N/ha Urea
	injected to 10 cm	injected to 10 cm	injected to 10 cm	injected to 10 cm	injected to 10 cm	injected to 10 cm
Fertilization 2	6/29 – 168.13 kg N/ha Ammonium Sulfate	7/13 - 168.13 kg N/ha Ammonium Sulfate	7/25 - 168.13 kg N/ha Ammonium Sulfate	-	6/25 - 168.13 kg N/ha Ammonium Sulfate	7/4 – 196.15 kg N/ha Ammonium Sulfate
	applied to surface	applied to surface	applied to surface	-	applied to surface	applied to surface
Fertilization 3	-	-	-	-	7/10 – 196.15 kg N/ha Ammonium Sulfate	7/17 – 168.13 kg N/ha Ammonium Sulfate
	-	-	-	-	applied to surface	applied to surface
Flood Date	5/15/2005	5/27/2006	5/17/2007	6/11/2008	6/20/2009	5/24/2010
Drain Date	9/8/2005	9/24/2006	9/15/2007	9/10/2008	9/22/2009	10/2/2011
Additional Info				two "flushes" this year, entered as single day floods on 5/17 and 6/2	two "flushes" this year, entered as single day floods on 5/23 and 6/7	
Winter Flood Date	12/1/2005	12/1/2006	12/1/2007	12/1/2008	12/1/2009	12/1/2010
Winter Drain Date	2/28/2006	2/28/2007	2/28/2008	2/28/2009	3/15/2010	3/15/2011
Leak Rate	0.08	0.08	0.08	0.08	0.08	0.08
Yield (kg/ha)	9,796	9,097	10,882	8,980	10,087	7,220
Yield (kg C / ha)	3,918	3,639	4,353	3,592	4,035	2,888

Figure C.6 shows crop information for year 1. In this case we have entered crop type (paddy rice), planting dates, and fraction of leaves and stems left in the field (assumed to be all of the crop residue or 100 percent). In addition, in preparation for the crop calibration process we have entered in the maximum biomass for grain based on our measured data (4,353 kg C/ha) and the biomass C/N ratio from field measured data – we have accepted the default values for the rest of the crop parameters for now.

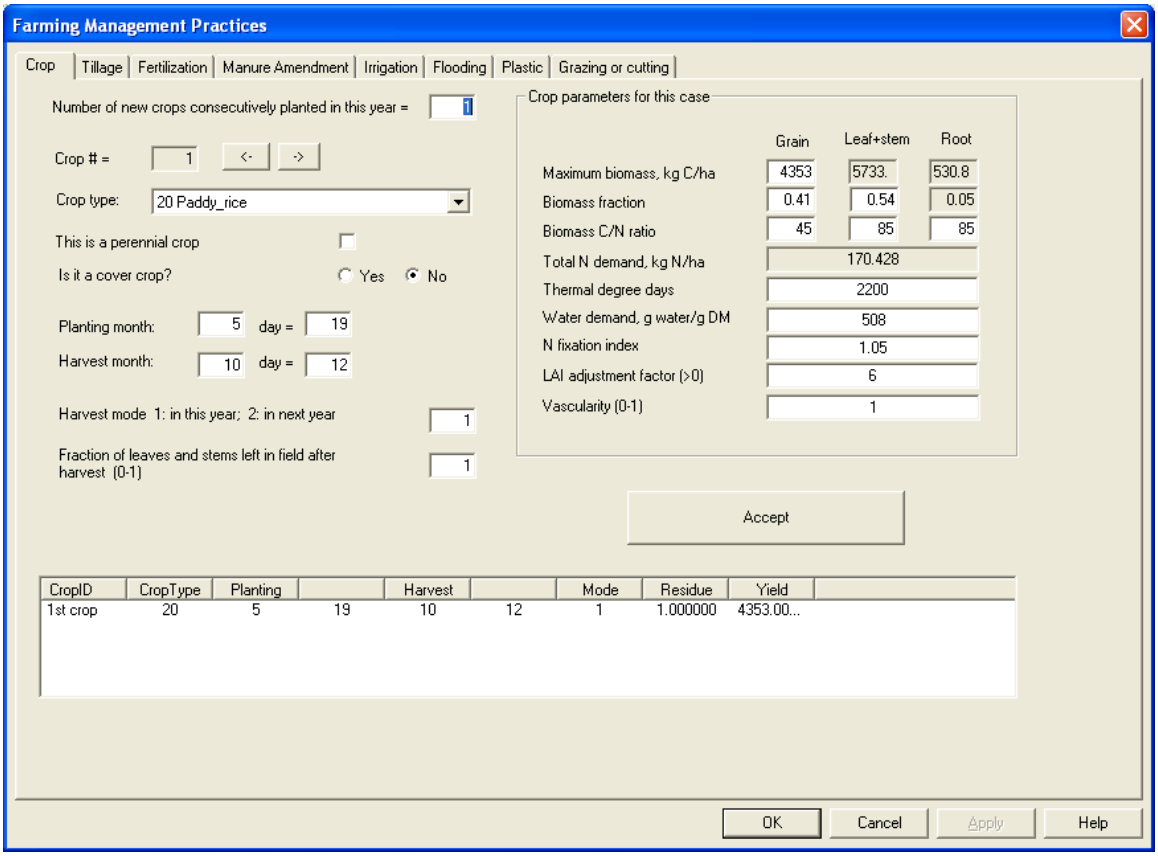

Figure C.6. Rice Farming Management Practices – Crop

Figure C.7 shows tillage practices. We have entered in all five applications and their associated dates and methods.

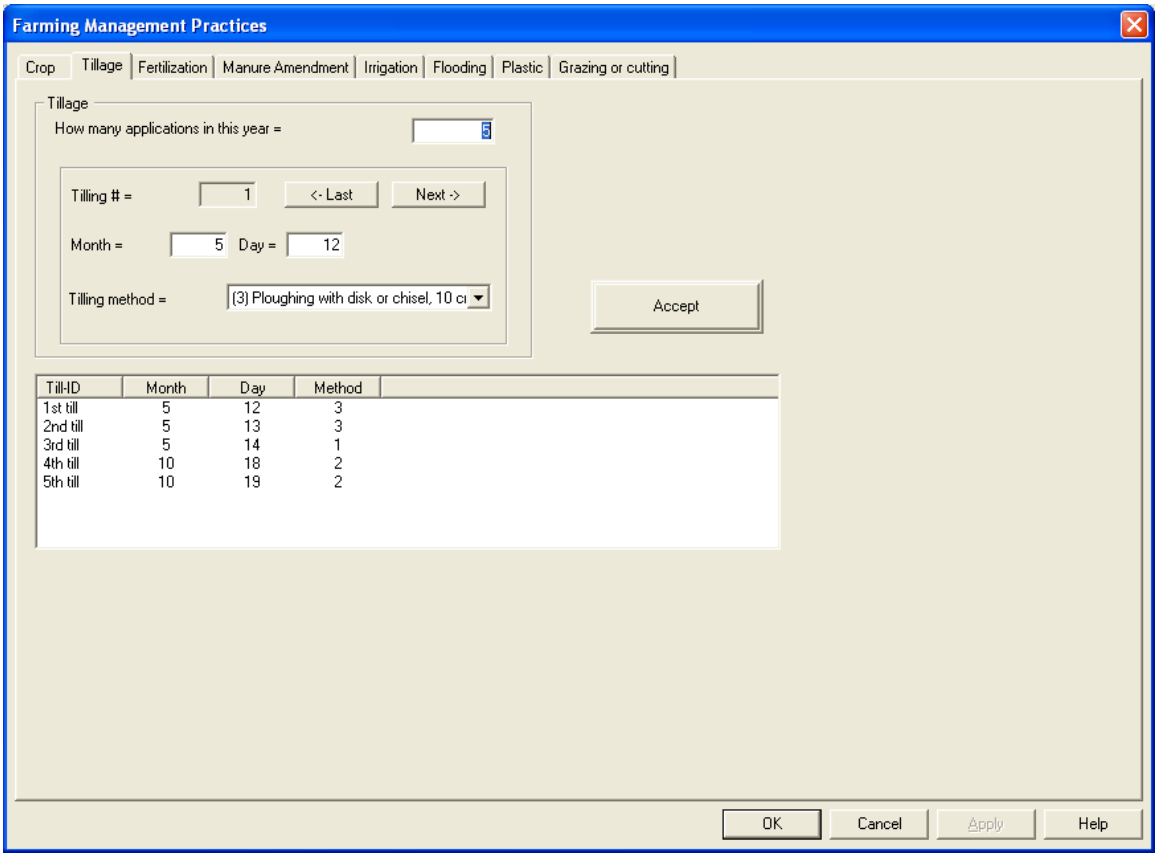

Figure C.7. Rice Farming Management Practices – Tillage

Figure C.8 shows fertilizer applications. We have entered in two applications and their associated dates, depths, and amounts.

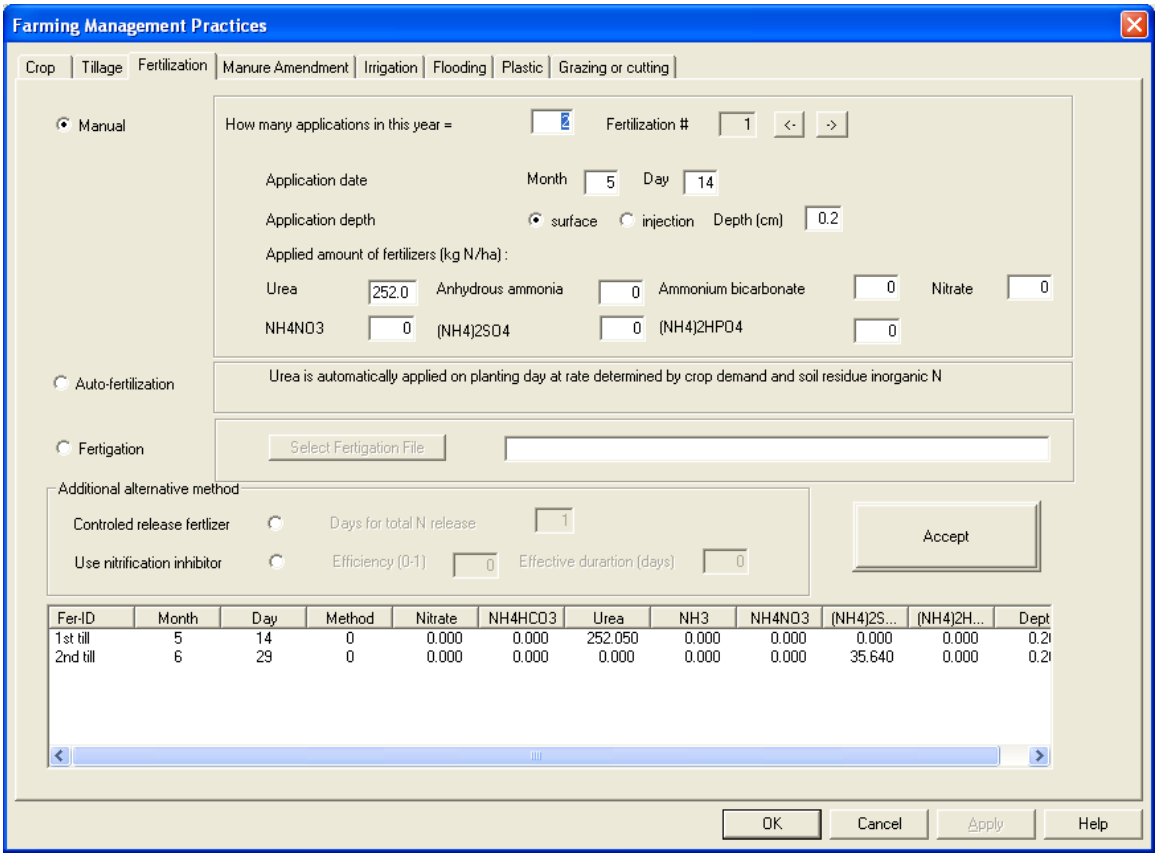

Figure C.8. Rice Farming Management Practices – Fertilization

Figure C.9 shows flooding management. We have entered in two floods (one seasonal and one winter flood) and their associated start and end dates as well as a leak rate of 0.08.

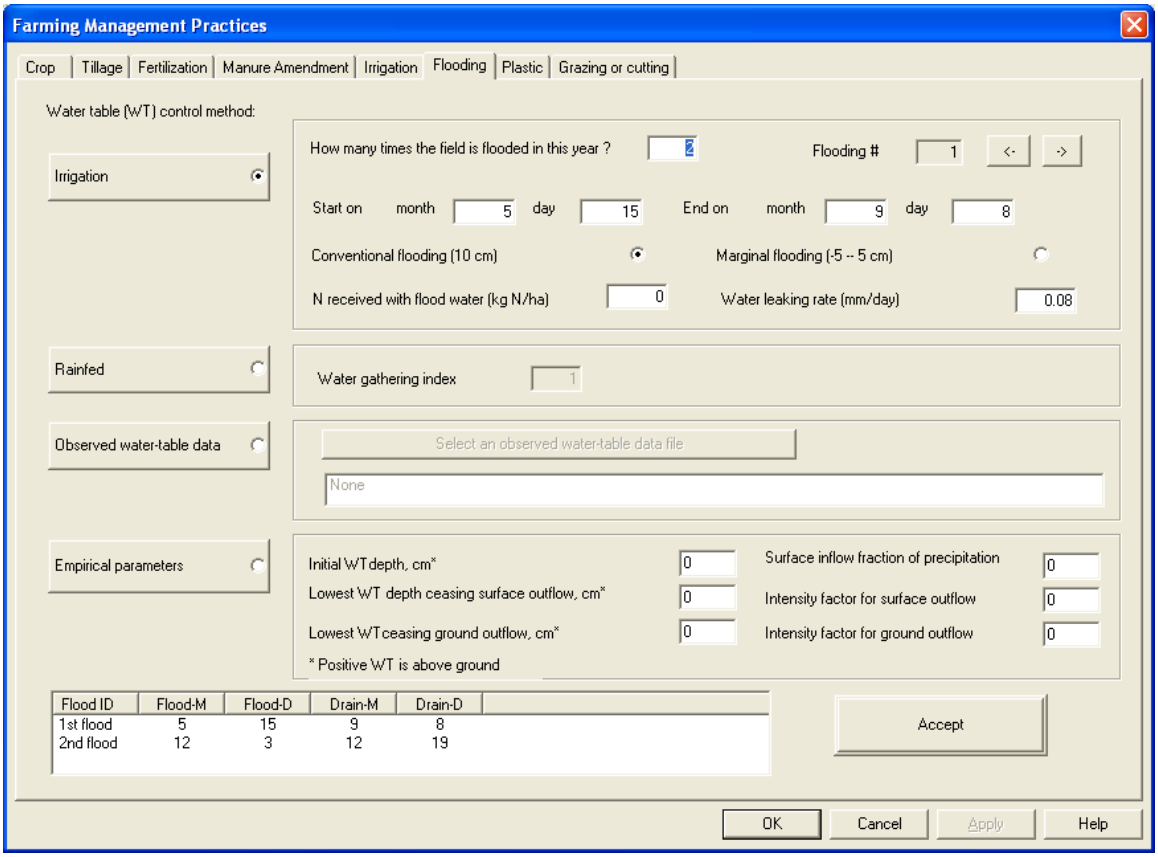

Figure C.9. Rice Farming Management Practices – Flooding

Since the farming management practices for this particular paddy do not involve any manure amendments, irrigation, plastic applications, or grazing/cutting, we will not enter any information on these tabs. The user should ensure that no residual information remains on these tabs from previous model runs.

When all of the information is entered, the user should save the results to a *.dnd file – we will call this “Baseline.dnd”; this file can be used later to set-up alternative management scenarios or to re-run model results.

Crop Model Calibration

The model can now be run to prepare for the crop model calibration – this can be done on the main DNDC screen by clicking the site mode “Run” button. Results are put in the “C:\DNDC\Result\Record\Site” directory.

To review the first iteration of the crop calibration process, we need to compare the modeled yield with measured yield. Modeled yield can be found in “Multi_year_summary.csv” in the “Yield_GrainC” field. These values can be compared with measured yields as in Table C.4. In this case, the maximum absolute difference between measured and modeled yields is large (48 percent) so we will opt to run another iteration with adjusted crop parameters.

Table C.4. Rice Crop Model Calibration – Iteration 1

Year	DNDC Yield (Yield_GrainC)	Measured Yield	Absolute Difference	Absolute Difference Percent
1	4,041	3,918	123	3%
2	4,012	3,639	373	10%
3	4,134	4,353	219	5%
4	3,266	3,592	326	9%
5	3,506	4,035	529	13%
6	4,266	2,888	1,378	48%

We will start the calibration process by modeling a single year: the year with the maximum measured yield (year 3). We will create the run using all of the site characteristics (climate, soil, and known crop parameters), and, as suggested in step 1 of the calibration process, we will use optimal fertilization (i.e. use the auto-fertilization setting). When this iteration is run, grain yield is 4,264 kg C/ha/y; a difference of only two percent. Since this difference is small, we will use the maximum measured yield as the maximum biomass parameter.

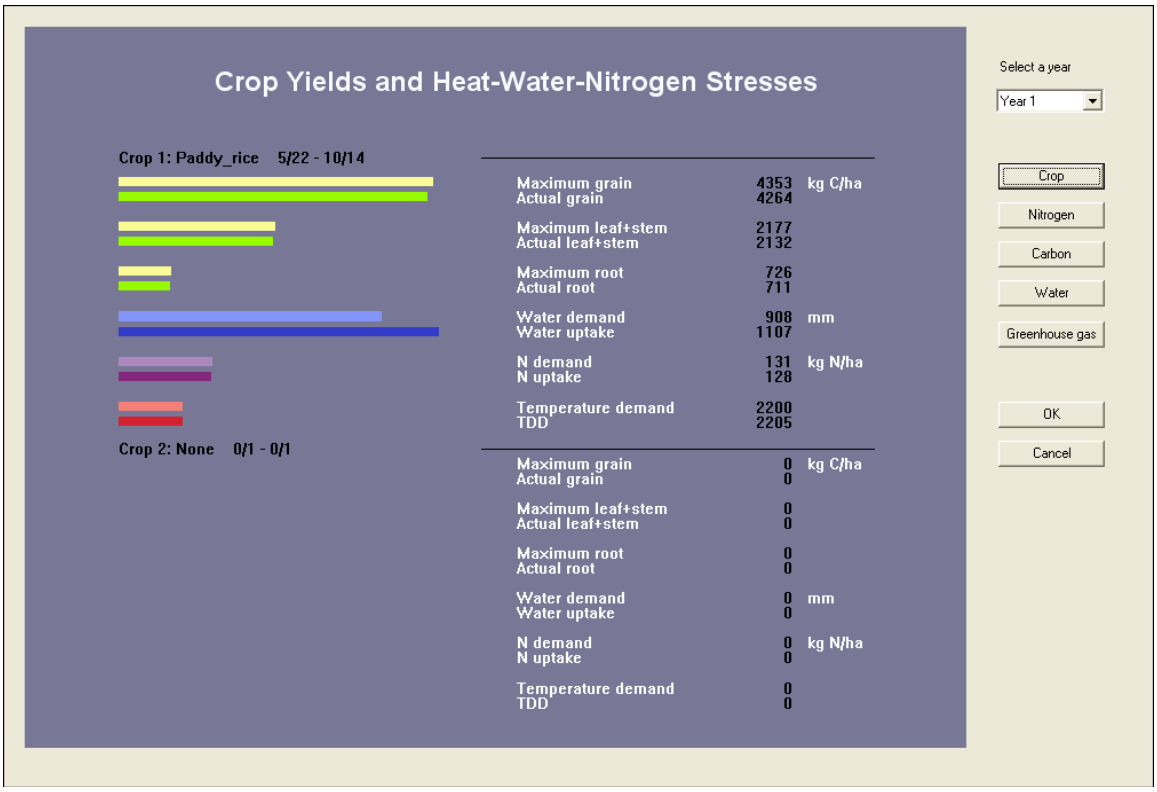

Figure C.10. Rice Crop Yields - Iteration 1

Next, we will check the modeled grain maturity date in the "Day_FieldCrop.csv" file: grain matures on day 238 (August 26) – this appears to be too early as the maturity date should be approximately the same date as the seasonal flood drain date (September 15). By increasing the thermal degree days parameter from 2,200 to 2,700 and re-running the model, we arrive at a more reasonable maturity date (day 260 or September 17).

Since there is no irrigation for paddy rice crops we can skip step 3 of the calibration process. We can now make one minor adjustment to the baseline scenario based on the calibration process: change the crop thermal degree days parameter from 2,200 to 2,700.

Creating Alternative Management Scenarios

For this rice paddy example we will look at two scenarios:

- Water seeded rice with all crop residue left onsite, with a winter flood (the baseline scenario)
- Dry seeded rice with all crop residue left onsite, with a winter flood (the dry seeded scenario)

To do this, we will make a copy of the baseline scenario ("Baseline.dnd") to be adjusted for the alternative scenarios. Each file can be renamed to represent a scenario. We will use the following file names:

- "Baseline.dnd"
- "DrySeeded.dnd"

There are two ways to change the parameters in each *.dnd file. The first is through the DNDC GUI. For a complicated, multi-year run, this is straightforward and a less error-prone method. Users who familiarize themselves with the *.dnd file format (see *DNDC User's Guide*, Section III-1.2) may be able to make these same changes in a text editor.

We will go through the revision process for the above-listed scenarios here ("DrySeeded.dnd").

Here are the key changes to the baseline to create the dry seeded scenario:

- Site name $\longrightarrow$ dry seeded[80]
- Adjust the timing of the flood-up period relative to seeding, shift from May 17 to June 12
- Add two irrigation events (May 23 and June 1)

Open the "DrySeeded.dnd" scenario on the DNDC Input Information dialogue (click on "Open an input data file"). The site name can be changed on the Climate tab of the Input Information dialogue. We will call this scenario "DrySeeded."

For each of the cropping systems (years), we will change the flooding information. Baseline flooding is shown in Figure C.11. And, since we are shifting to dry seeding, we will shift the second flood start date from May 17 to June 12 (see Figure C.12).

[80] Project developers will eventually be running these scenarios in batch mode, so it is important that the site name be changed so that project developers will be able to distinguish the various results from each other.

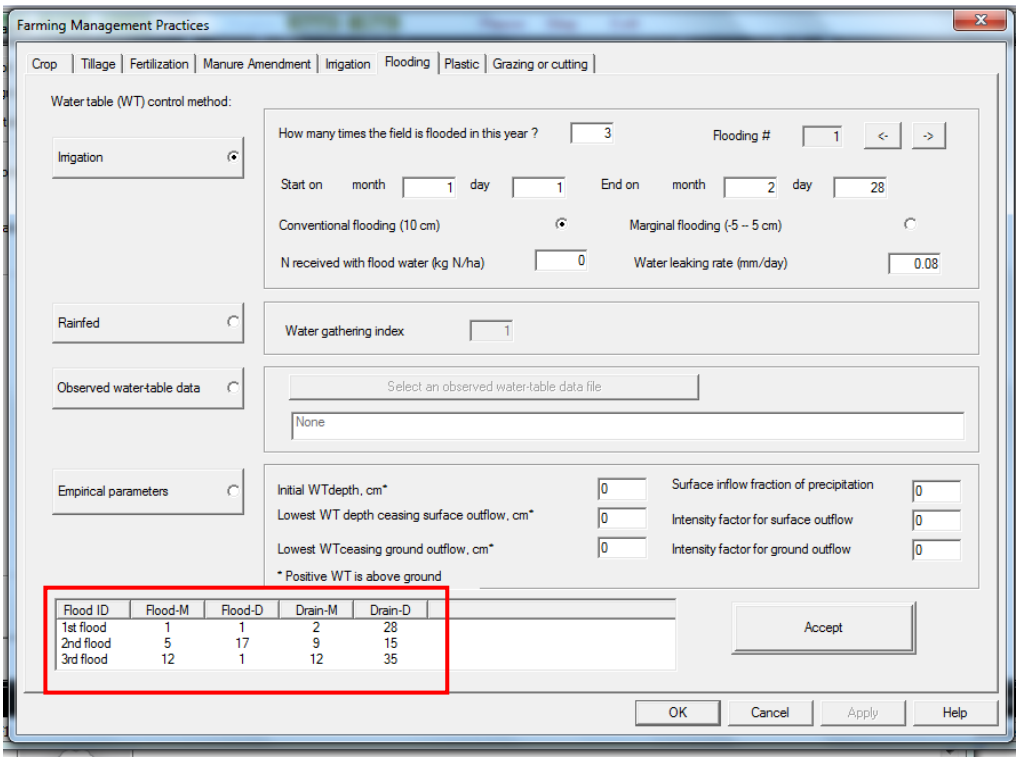

Figure C.11. Baseline to Flooding

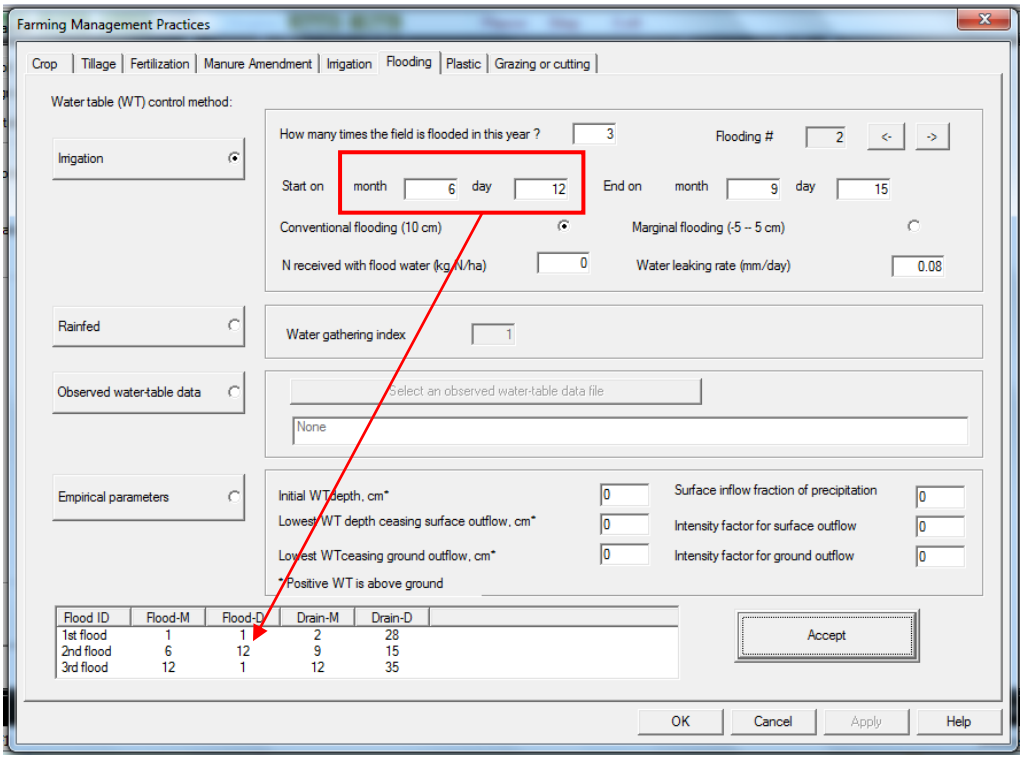

Figure C.12. Dry Seeding Flooding

In addition to a shift in when the fields are flooding for the rice growing season, dry seeding requires irrigation events following seeding to establish a good crop canopy prior to flooding. For this example we illustrate use of two irrigation events (May 23 and June 1) with 10 cm irrigation water for each event. Figure C.13 illustrates the DNDC irrigation tab with these two 10 cm irrigation events scheduled for May 23 and June 1.

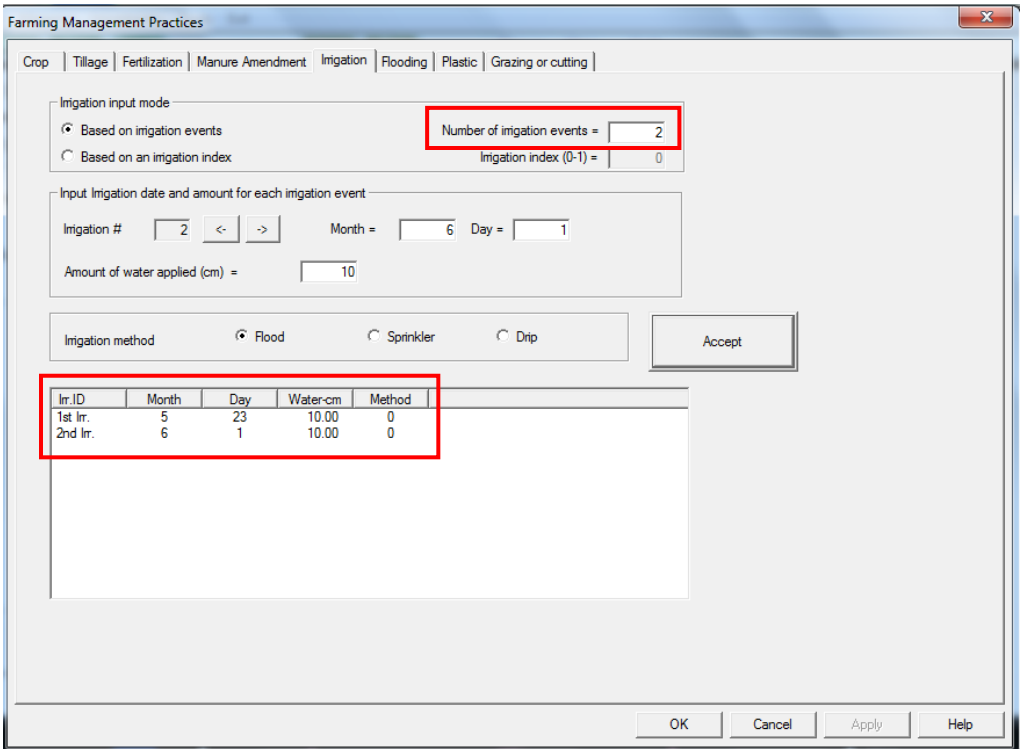

Figure C.13. Irrigation Events for Dry Seeding Scenario

Results for each site run can be examined using the DNDC results tab. Annual emissions for year 20 of a 20-year run for both baseline and dry seeded scenarios are presented in Figure C.14 and Figure C.15, respectively.

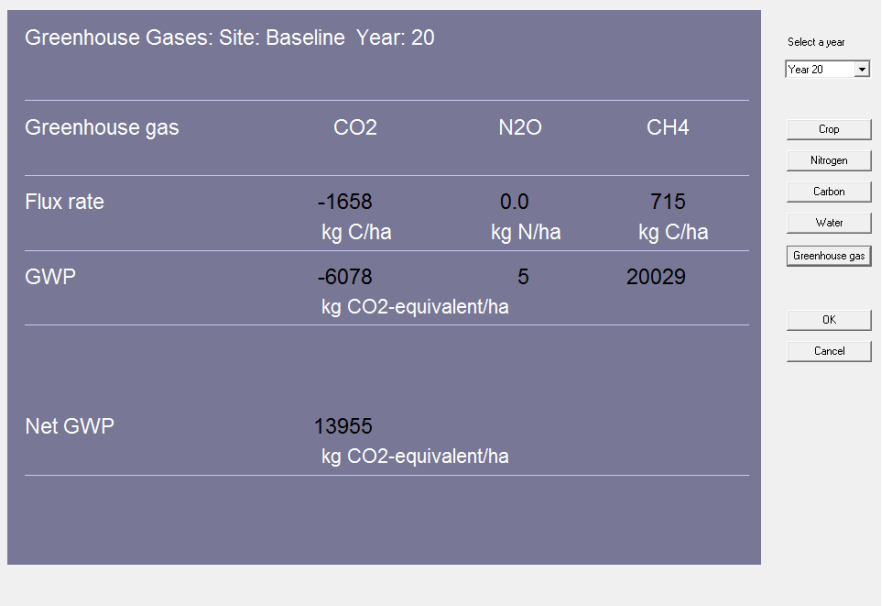

Figure C.14. DNDC Results Panel for Baseline Scenario

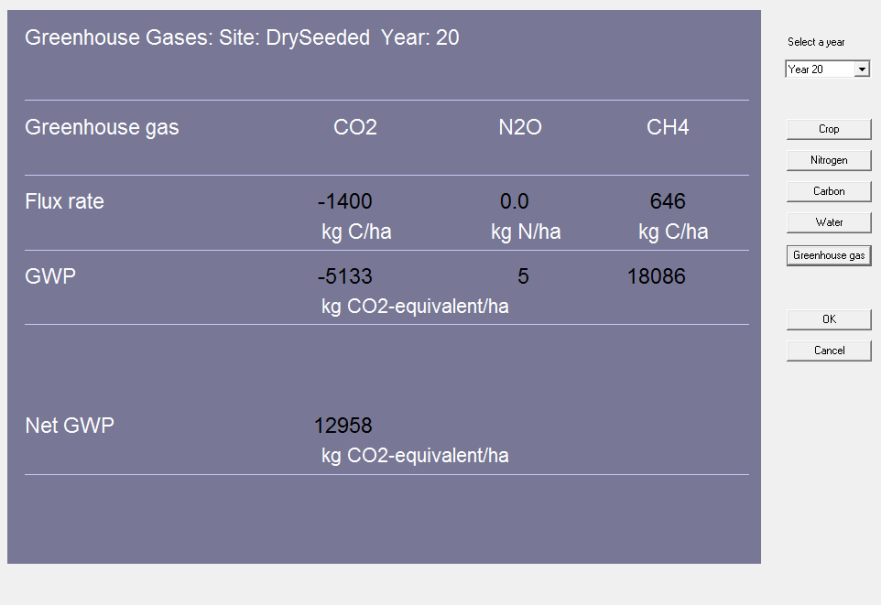

Figure C.15. DNDC Results Panel Dry Seeding Scenario

For this example shift from wet seeded rice to dry seeded, the modeled reduction in GHG emissions was 0.997 tCO_2e/ha.

Once the site level *.dnd files are created for both the baseline and project scenarios, the new software tool for creating all the batch file inputs following the Monte Carlo sampling procedures described in the RCPP can be run. Once the input files are complete, the user can then select batch mode from the tools menu in DNDC (see Figure C.16) and run DNDC in batch mode. A second software tool will then compile all the results from the batch run and provide the model estimates of GHG reductions.

Figure C.16. Batch Mode in DNDC

Appendix D Derivation of Structural Uncertainty Deduction Factors

D.1 Overview

As described in Section 5.4.2 of the protocol, the deduction factor to account for DNDC model structural uncertainty will be published on the Reserve's website (and periodically updated),. This section explains the methodology used by the Reserve to determine the deduction factor.

The structural uncertainty deduction factor will be a function of the total number of fields registering emission reductions with the Reserve in any given cultivation cycle. The procedure described in this appendix will be performed for each region for which the RCPP is applicable in order to determine the appropriate uncertainty deduction factor to be used for each region. For each region, the Reserve will determine the exact deduction factors to be used, and whether the deduction factors are additive or multiplicative (determined as described below). This version of the protocol is applicable to the California Sacramento Valley Region and uses DNDC Version 9.5, for which the structural uncertainty deduction is additive. The structural uncertainty factor is derived based on validation of a specific version of DNDC, and can only be applied to that version. As such, the Reserve will publish structural uncertainty deductions that are specific to a single version of the DNDC model.

The structural uncertainty deduction factor $\boldsymbol{\mu_{struct}}$ is defined such that, after application of the uncertainty deduction factor to the direct emission reductions[81] the following inequality holds in 95 percent of the cases, i.e. with 95 percent confidence.

$$\mathbf{DERs} < \boldsymbol{BE_{meas} - PE_{meas}}$$

The uncertainty deduction can be either added or multiplied to the gross difference between project and baseline emissions, depending on whether the error structure of the residuals is additive or multiplicative.

In the additive case:

$$\mathbf{DERs} = \boldsymbol{\mu_{struct}} + (\boldsymbol{BE_{meas} - PE_{meas}})$$

In the multiplicative case:

$$\mathbf{DERs} = \boldsymbol{\mu_{struct}} \times (\boldsymbol{BE_{meas} - PE_{meas}})$$

Where,

DERs	=	Direct emission reductions
μ_{struct}	=	Structural uncertainty factor
$\mathrm{PE}_{\mathrm{meas}}(\mathrm{i})$	=	Field results for project emissions
$\mathrm{BE}_{\mathrm{meas}}(\mathrm{i})$	=	Field results for baseline emissions

Before the derivation of $\boldsymbol{\mu_{struct}}$ is continued, the lack of bias is confirmed and it is determined whether the error structure of the residuals is additive or multiplicative.

[81] Note that although DNDC is used to model both direct emission reductions and some indirect emission reductions, for simplicity, this guide refers to all modeled emission reductions as direct.

D.2 Confirming the Lack of Bias

The derivation of the structural uncertainty term assumes that no bias exists between measured and modeled results, or that $\langle \boldsymbol{Y_{meas}} \rangle = \langle \boldsymbol{Y_{model}} \rangle$. The DNDC model has been shown to predict greenhouse fluxes without bias, when correctly calibrated. This methodology specifies how model inputs can be set so that the model is calibrated correctly. For each region, it is explicitly tested that the model calibration strategy does not lead to bias by comparing modeled and measured emissions using a paired t-test.

D.3 Verification of the Nature of the Structural Error

The structural error induced by a biogeochemical model such as DNDC is either multiplicative or additional.

In case the error is additive:

$\boldsymbol{Y_{model,i}} = \boldsymbol{Y_{field,i}} + \boldsymbol{\varepsilon_i}$ with $\boldsymbol{\varepsilon} \sim \boldsymbol{\mathcal{N}}(\boldsymbol{0}, \boldsymbol{\sigma})$

In case the error is multiplicative:

$\boldsymbol{Y_{model,i}} = \boldsymbol{Y_{meas,i}} \times \boldsymbol{e^{\varepsilon_i}}$ with $\boldsymbol{\varepsilon} \sim \boldsymbol{\mathcal{N}}(\boldsymbol{0}, \boldsymbol{\sigma})$

For each region, it is explicitly determined whether an additive or multiplicative error model must be assumed. The deviation between modeled and measured results will be multiplicative if residuals increase with increasing modeled values. However, if the deviation between modeled and measured results is additive, the residuals will be constant across modeled values. This is verified by investigating the heteroscedasticity of the residuals or by plotting the residuals versus the model values. In case of doubt, the additive case will lead to more conservative crediting than the multiplicative case and may be used as a default.

D.4 Derivation of the Structural Uncertainty Deduction in Case the Error Term is Additive

If the error is additive and the model is bias-free, the following error model can be assumed for the project and baseline emissions.

$\boldsymbol{PE_{model}} = \boldsymbol{PE_{meas}} + \boldsymbol{\varepsilon_1}$ with $\boldsymbol{\varepsilon_1} \sim \boldsymbol{\mathcal{N}}(\boldsymbol{0}, \boldsymbol{\sigma^2})$
$\boldsymbol{BE_{model}} = \boldsymbol{BE_{meas}} + \boldsymbol{\varepsilon_2}$ with $\boldsymbol{\varepsilon_2} \sim \boldsymbol{\mathcal{N}}(\boldsymbol{0}, \boldsymbol{\sigma^2})$

A correlation between the project and baseline residuals may exist:

$\boldsymbol{\rho} = \mathbf{corr}(\boldsymbol{\varepsilon_1}, \boldsymbol{\varepsilon_2})$

Where,

μ_{struct}	=	Structural uncertainty factor
$\mathrm{PE}_{\mathrm{model}}(\mathrm{i})$	=	Model results for project emissions
$\mathrm{BE}_{\mathrm{model}}(\mathrm{i})$	=	Model results for baseline emissions
$\mathrm{PE}_{\mathrm{meas}}(\mathrm{i})$	=	Field results for project emissions
$\mathrm{BE}_{\mathrm{meas}}(\mathrm{i})$	=	Field results for baseline emissions
ε_1	=	Error term for project emissions

ε_2	=	Error term for baseline emissions
σ	=	Standard deviation of the residuals between modeled and measured values
ρ	=	Correlation between project residuals and baseline residuals

If the direct emission reductions are the difference between project and baseline, one can write:

$$\boldsymbol{DER_{model} = BE_{model} - PE_{model}}$$
$$\boldsymbol{DER_{meas} = BE_{meas} - PE_{meas}}$$

Where:

DER_{model}	=	Direct emission reductions based on modeled emissions
DER_{meas}	=	Direct emission reductions based on measured emissions

Because there is no bias between the model and the measurements, the average of the difference between DER_{model} – DER_{meas} is 0. The variance of this difference is:

$$\begin{aligned} \mathbf{Var}(\boldsymbol{DER_{model} - DER_{meas}}) &= \mathbf{Var}(\boldsymbol{\varepsilon_1}) + \mathbf{Var}(\boldsymbol{\varepsilon_2}) - \mathbf{2Cov}(\boldsymbol{\varepsilon_1, \varepsilon_2}) \\ &= \boldsymbol{\sigma^2 + \sigma^2 - 2\sigma^2\rho} \\ &= \boldsymbol{2\sigma^2(1-\rho)} \end{aligned}$$

In case there are multiple fields **n**, the inequality introduced in the beginning of this section has to hold only for the sum of the direct emission reductions, and for the direct emission reductions of each individual field. In this case, the variance of the sum of the emission reductions is:

$$\begin{aligned} \mathbf{Var}\left(\sum_{i=1}^{n} \boldsymbol{DER_{model,i} - DER_{meas,i}}\right) &= \boldsymbol{n}\cdot\mathbf{Var}(\boldsymbol{\varepsilon_1}) + \boldsymbol{n}\cdot\mathbf{Var}(\boldsymbol{\varepsilon_2}) - \mathbf{2}\boldsymbol{n}\cdot\mathbf{Cov}(\boldsymbol{\varepsilon_1, \varepsilon_2}) \\ &= \boldsymbol{n\sigma^2 + n\sigma^2 - 2n\sigma^2\rho} \\ &= \boldsymbol{2n\sigma^2(1-\rho)} \end{aligned}$$

If s is the standard deviation of the model residuals based on a limited set of k calibration values, the one-sided 95 percent confidence interval around the sum of the differences DER_{model} – DER_{meas} is:

$$\boldsymbol{DER_{model} - DER_{meas}} < s\sqrt{\mathbf{2(1-\rho)}} \times \boldsymbol{t_{inv}(0.95, k)}$$

In other words:

$$\boldsymbol{\mu_{struct}} = \frac{\boldsymbol{s}\sqrt{\mathbf{2(1-\rho)}}}{\sqrt{\boldsymbol{n}}} \times \boldsymbol{t_{inv}(0.95, k)}$$

Where:

μ_{struct}	=	Structural uncertainty factor
s	=	Standard deviation
ρ	=	Correlation between project residuals and baseline residuals
t_{inv}	=	Inverse of the cumulative t-distribution with a specific confidence and degrees of freedom
k	=	Number of pairs of modeled and measured values used for model verification.
n	=	Number of fields within the project "aggregate"

D.5 Derivation of the Structural Uncertainty Deduction in Case the Error Term is Multiplicative

If the error is multiplicative and the model is bias-free, the following error model can be assumed for the project and baseline emissions:

$\boldsymbol{PE_{model} = PE_{meas} \times e^{\varepsilon_1}}$ with $\boldsymbol{\varepsilon_1 \sim \mathcal{N}(0, \sigma^2)}$
$\boldsymbol{BE_{model} = BE_{meas} \times e^{\varepsilon_2}}$ with $\boldsymbol{\varepsilon_2 \sim \mathcal{N}(0, \sigma^2)}$

A correlation between the project and baseline residuals may exist:

$\boldsymbol{\rho = \mathbf{corr}(\varepsilon_1, \varepsilon_2)}$

Where:

$\mathrm{PE}_{\mathrm{model}}(\mathrm{i})$	=	Model results for project emissions
$\mathrm{BE}_{\mathrm{model}}(\mathrm{i})$	=	Model results for baseline emissions
$\mathrm{PE}_{\mathrm{meas}}(\mathrm{i})$	=	Field results for project emissions
$\mathrm{BE}_{\mathrm{meas}}(\mathrm{i})$	=	Field results for baseline emissions
ε_1	=	Error term for project emissions
ε_2	=	Error term for baseline emissions
σ	=	Standard deviation of the residuals between modeled and measured values
ρ	=	Correlation between project residuals and baseline residuals

We will use the same terminology DER_{model} and DER_{meas} as introduced in the additive case in the subsequent derivation. The derivation is similar to the additive case if the following log-transformation is applied:

$$\boldsymbol{\ln\left(\frac{DER_{meas}}{DER_{model}}\right) = \ln(PE_{meas}) + \varepsilon_1 - \ln(BE_{meas}) - \varepsilon_2 - \ln(PE_{meas}) + \ln\,(BE_{meas})}$$

The variance of this ratio can be derived similarly as for the additive case:

$$\boldsymbol{\mathbf{Var}\left(\ln\left(\frac{DER_{meas}}{DER_{model}}\right)\right) = 2\sigma^2(1-\rho)}$$

The quantity **σ** can be estimated by the standard deviation of the difference of the log-transformed project and baseline emissions based on a limited set of **k** calibration values on the condition that a student-t distribution is used in the subsequent one-sided confidence interval:

$$\boldsymbol{\sum_{i=1}^{n} \ln\left(\frac{DER_{meas}}{DER_{model}}\right) < s\frac{\sqrt{2(1-\rho)}}{\sqrt{n}} \times t_{inv}(0.95, k)}$$

Rearranging this equation yields:

$$\boldsymbol{\ln\left(\frac{DER_{meas}}{DER_{model}}\right) < s\frac{\sqrt{2(1-\rho)}}{\sqrt{n}} \times t_{inv}(0.95, k)}$$

$$\boldsymbol{DER_{meas}} < DER_{model} \times e^{s\frac{\sqrt{2(1-\rho)}}{\sqrt{n}} \times t_{inv}(0.95,k)}$$

In other words:

$$\boldsymbol{\mu_{struct}} = e^{-s\frac{\sqrt{2(1-\rho)}}{\sqrt{n}} \times t_{inv}(0.95,k)}$$

D.6 Quantifying the Standard Deviation s and the Correlation ρ

The calculation of μ_{struct} is critically dependent on the standard deviation of the residuals (i.e. the difference between modeled and measured values) **s** and the correlation between the residuals of the project emissions and the residuals of the baseline emissions **ρ**.

These quantities are calculated based on at least 8 pairs of measured and simulated annual emissions that have been measured over at least two growing seasons.

In case only annual fluxes are available, $\boldsymbol{k}$ pairs of $\left(\boldsymbol{Y_{meas}(i), Y_{model}(i)}\right)$ will be available with $\boldsymbol{k \geq 8}$.

In the additive error case, the quantity $\boldsymbol{s}$ can be calculated as the standard deviation of the difference between $\boldsymbol{Y_{meas}(i)}$ and $\boldsymbol{Y_{model}(i)}$. Note that the student-t distribution includes a deduction due to the standard deviation being estimated on a limited set of values. Lower deductions will be achieved if k is higher and more measurements are available.

The quantity ρ can be estimated by dividing the measurements in "baseline" cases, $\boldsymbol{BE_{meas}(i)}$ and "project" cases, $\boldsymbol{PE_{meas}(i)}$. In conventional language, the baseline would be the control or conventional treatment. Subsequently, pairs of measured and simulated emission reductions $\boldsymbol{DER_{meas}(i)}$ and $\boldsymbol{DER_{model}(i)}$ can be calculated as the difference between $\boldsymbol{PE_{meas}(i)}$ and $\boldsymbol{BE_{meas}(i)}$, and $\boldsymbol{PE_{model}(i)}$ and $\boldsymbol{BE_{model}(i)}$, respectively. **ρ** is calculated as the correlation coefficient between $\boldsymbol{DER_{meas}(i)}$ and $\boldsymbol{DER_{model}(i)}$. Smaller correlation coefficients will result in greater uncertainty deductions. Therefore, a set of correlation coefficients is calculated through leave-one-out jackknifing and the correlation coefficient set to the low range of this set of values.

In the multiplicative error case, the quantity s can be calculated as the standard deviation of the difference between $\boldsymbol{\ln Y_{meas}(i)}$ and $\boldsymbol{\ln Y_{meas}(i)}$. Similarly as for the additive case, smaller deductions will be achieved if $\boldsymbol{k}$ is higher and more measurements are available. **ρ** is calculated as the correlation coefficient between $\boldsymbol{\ln\left(\frac{PE_{meas}(i)}{BE_{meas}(i)}\right)}$ and $\boldsymbol{\ln\left(\frac{PE_{model}(i)}{BE_{model}(i)}\right)}$.

However, if a set of daily fluxes are available, the quantities **s** and **ρ** are calculated with more accuracy based on daily values of these quantities as:

$$\boldsymbol{s_{annual} = 365 \times s_{daily}}$$
$$\boldsymbol{\rho_{annual} = \rho_{daily}}$$

Note that any other time period (i.e. 3-daily or weekly) can be used.

Appendix E Summary of Performance Standard Research

This section summarizes research on industry trends in the use of water and residue management practice in rice cultivation that have the potential to reduce methane emissions. The research focused on three practices that had previously been identified in other methodologies as having GHG mitigation potential: dry seeding, reduced winter flooding, and residue management. The outcomes of the research were used to develop performance standards in this protocol.

E.1 Background on Water and Residue Management Practices

Rice is a unique agricultural system due to the use of flooding to meet the plant physiological demands and to control weeds. There are unique advantages of flooding and maintaining a flood throughout the growing season. These advantages include: (1) easier water management and less water use, (2) red rice and grass suppression, (3) less seedling stress from cool weather, (4) elimination of early-season blackbird problems, and (5) reduction in seedling loss due to salt.

Producers' decisions regarding which seeding method to use are targeted at selecting the method that will result in proper seedling emergence that will lead to a uniform canopy. Seeding methods depend on soil type, weather conditions, and producer preferences. Seeding methods for rice production include both water seeding and dry seeding. **Water seeding** describes sowing of dry or soaked seed into a flooded field. It is usually implemented for any or all of the following reasons: red rice control, wet planting season, planting efficiency, and earlier crop maturity. **Dry seeding** simply describes sowing seed into a dry seedbed by drilling or broadcasting. Dry seeding method usually offers more flexibility in planting but may require more time to do so. The flood for dry seeded rice starts approximately 25 to 30 days after seeding. During the dry period, fields are periodically irrigated to promote germination and stand establishment. This system is also weather dependent. A small fraction of the rice acreage is dry seeded in California.

In California, water seeding with continuous flood is predominant during the growing season. Continuous flood regime is used on over 96 percent of the acreage in California. Fields are flooded to a depth of 4 to 5 inches just prior to aerial seeding. While deeper flooding will further reduce weed pressures, it will also lead to poor stand establishment. Once the rice stand is established and the panicle initiation has occurred, many growers will increase the depth of the flood water to 8 inches. This helps with further weed control and protects the rice reproductive organs from cool nighttime temperatures that can lead to reduced yields via blanking. Occasionally, several weeks after seeding, fields are drained for one day to apply herbicide for weed control. This drain is short lived and does not lead to drying of the soil surface. Fields are also drained near the harvest date. The exact timing for draining the fields can vary and can influence total yields.

The University of California Cooperative Extension (UCCE) recommends that growers drain their fields when the panicles are "fully tipped and golden." This is done through visual inspection and is typically two to four weeks prior to anticipated harvest date. According to UCCE, there is a large variability in when growers choose to drain the fields. Some growers choose to drain when the rice is partially or 50 percent "tipped," some wait until 75 percent tipped, and others follow UCCE guidelines of 100 percent or fully tipped.

After the growing season, winter flooding can be used to enhance rice straw decomposition. With a winter flood system, the flood water is introduced to the field shortly after harvest is completed. Growers either maintain flooded conditions until spring by reapplying flood waters or they just use a single flood event. Growers' decisions to flood the field after harvest are influenced by timing of the harvest, habitat goals, and expectations regarding availability of water (Term 91).

E.2 Industry Trends in the Use of GHG Mitigation Practices

Winter Flooding

Two sources of data were used to characterize the use of winter flooding in California rice systems. Site-specific records on the use of winter flooding were collected from the following four irrigation districts: Glen-Colusa, RD 108, Richvale, and Western Canal. In addition, multi-temporal remote sensing data (MODIS and Landsat) were analyzed to map spatial patterns of winter flooding from 2005 to 2010 for the entire California Sacramento Valley.

The data from the Glenn-Colusa Irrigation District (representing over 20 percent of California rice acreage) were analyzed in a GIS to assess acreage of winter flooding from 2007 to 2010 and persistence of winter flooding from one year to the next for each rice field. Approximately 40 percent of the fields did not use winter flooding from 2007 to 2010 (Table D.1). Of the 60 percent of the fields that did use winter flooding at some point, less than one percent of the fields winter flooded for all four years. The data from the other irrigation districts (RD 108, Richvale, and Western Canal) showed similar variability in the fraction of fields with winter flooding.

Table E.1. Presence and Frequency of Winter Flooding in Glenn-Colusa Irrigation District (2007-2010)

Class	Acreage	%
No Floods	42161.9	40.0%
1 Yrs	20314.3	19.3%
2 Yrs	22346.9	21.2%
3 Yrs	17566.9	16.7%
4 Yrs	1912.6	1.8%
Other	977.4	0.9%

In addition, multi-temporal remote sensing data (MODIS and Landsat) was analyzed in order to map spatial patterns of winter flooding for rice growing areas for all of California from 2005 to 2010. These results also indicated that the use of winter flooding varies from one year to the next and there is no clear trend in the extent and frequency of use of winter flooding for all rice growing regions. Details of the spatial analysis of winter flooding are provided in a separate background research paper that will be published on the Reserve website.

The results of this research show that the use of winter flooding every year is virtually non-existent; it is more typical for winter flooding to be used one, two or three years out of every five years with no winter flooding during the other years; and 40 percent of acres appear to never be flooded during the five year interval investigated. Data reported in the background paper[82] affirm these same findings over a longer historical period. Therefore, reduced winter flooding (i.e. the

[82] Background paper will be made available on the Climate Action Reserve website.

absence of winter flooding) is already somewhat common in the California Sacramento Valley. In addition, the intermittent trend in use/non-use of winter flooding, make it difficult to reliably determine what expected levels of reduced winter flooding would be in any given year under "business as usual." These findings, combined with concerns about negative impacts on waterfowl habitat, led to a decision to exclude reduced winter flooding as an eligible project activity in the protocol.

Rice Straw Residue Management

Rice straw represents a significant challenge to rice farmers. Techniques for managing rice straw can be categorized into the following management alternatives: burning, baling, soil incorporation without winter flooding, and soil incorporation with winter flooding for enhanced straw decomposition.

Rice straw may or may not be prepared by chopping or soil-incorporating before flooding. After flooding, many fields are rolled with specially built "cage rollers" which help create soil/straw contact. Decomposition of straw in this system is not limited by moisture and has consistently given more complete decomposition compared to non-flooded systems.

Most potential uses of rice straw can be categorized into energy use, manufacturing and construction, environmental mitigation or livestock use. Environmental mitigation includes the use of rice straw for erosion control on construction areas or for rehabilitation on burned slopes. Small amounts of rice straw are used in composting, mushroom production, and livestock feed and bedding.

There are many potential uses of rice straw, yet few are currently being used. The reasons appear to be related to 1) technical constraints, 2) economic feasibility, particularly related to the cost of removing straw from the field, and 3) supply and storage problems.

Until 1991, burning rice straw was the most common practice. Following the 1991 Rice Straw Burning Reduction Act, burning of rice straw decreased dramatically on an annual basis. By 2001, growing season burning of rice straw was permitted for disease control only with a cap of 25 percent of total rice acreage in the state burned annually. Currently, burning occurs on only 10 to 12 percent of rice acreage in California.[83]

If the straw is not burned, then growers will either retain and incorporate all of the straw on the field or they will bail the rice straw for off-field uses. The current estimate from the California Rice Commission (CalRice) for baling in California is 6 to 8 percent of the acreage per year. This estimate was further corroborated by the Reserve through analysis of previous research,[84] and through the use of a survey of University of California Cooperative Extension (UCCE) rice farm advisors and straw balers in California. Results from the survey suggest that rice baling has declined in recent years due to a loss of demand from the building and construction industry. Estimates from UCCE Rice Farm Advisors ranged from 2 to 6 percent of the California acreage in a given year. This obviously fluctuates a bit with various straw markets. It is also important to note that baling does not remove all of the rice straw following harvest. Due to operational constraints and the market for straw, baling typically removes one to two tons of rice straw per acre out of approximately three tons per acre that is produced. Therefore, anywhere from 50 percent to 33 percent of the rice straw remains on the field. On an annual basis, 80 to 84 percent of all rice fields have 100 percent of the rice straw incorporated into the soil.

[83] Personal communication with Paul Buttner.
[84] Garnache et al., 2011.

Based on the evidence presented by California rice industry experts, the Reserve has concluded that baling of rice straw is not a common practice in California, with a likely adoption rate of between 2 to 7 percent of the acreage. Thus, the Reserve has concluded that switching from rice straw incorporation to baling constitutes an additional GHG reduction practice in California.

Dry Seeding

According to the USDA Economic Research Service ERS data analyzed by Livezey et al. in 2001, a dry seeding method is relatively common in most U.S. rice growing regions; however, it is not common practice in California. In 2001, the estimated acreage of rice that was dry seeded was 5 percent according to the ERS data.[85] To confirm that dry seeding is still not a common practice in California, the Reserve again relied on the estimates provided in survey responses from UCCE Rice Farm Advisors, as well as estimates from the California Rice Commission. According to experts from the UCCE and CalRice, dry seeding is occurring on less than 3 percent of the rice acreage in California.

Based on the evidence presented by California rice industry experts, the Reserve has concluded that dry seeding is not a common practice in California, with a likely adoption rate of less than 3 percent of the acreage. Thus, the Reserve has concluded that switching from water seeding to dry seeding constitutes an additional GHG reduction practice in California.

[85] Livezy et al., 2001, Table 5, pg.10.

Appendix F Wildlife Habitat Conservation and the Rice Industry

In California's Central Valley, approximately 95 percent of the original existing wetlands have been converted from their natural state.[86]

As native wetland habitats have been increasingly degraded, wetland-dependent species, such as waterfowl and shorebirds, have adapted to using flooded rice lands as a substitute for their native habitat. Rice fields may be flooded for up to eight months of the year, mimicking natural wetland conditions and providing surrogate habitat for foraging, breeding, and in the case of migratory birds, wintering.

Though a wide range of species can be observed in each of the U.S. rice growing regions, more species data are available for California's Central Valley than for other U.S. rice growing regions. In California, seven million waterfowl and several hundred thousand shorebirds are supported by rice lands annually,[87] and over 230 species have been identified in the state's rice lands, including waterfowl (e.g. ducks), shorebirds, wading birds, raptors, reptiles, amphibians, and small mammals.[88] Notably, 31 special-status species, such as the federally endangered Giant Garter Snake, have also been identified in California rice lands.

In the U.S., rice lands are considered a leading example of integrating agricultural and natural resource management, with USDA recently honoring the USA Rice Federation with the first national "Legacy of Conservation" award in 2011.

The Reserve's Program Manual explains that generally "projects must have no negative social, economic or environmental consequences and ideally should result in benefits beyond climate change mitigation."

The adoption of dry seeding is expected to result in a delay in winter flooding by a few days, meaning that though there is a slight delay in the provision of surrogate habitat (e.g. flooded rice fields) to wetland-dependent species, the quality of the surrogate habitat will not be affected. The effect of baling on the quality of flooded rice lands as surrogate habitat is somewhat less clear. In one study of species preferences for different rice straw management options, wetland-dependent bird species appeared to have a slight preference for fields where rice straw had been left on the field (whether spread or incorporated) than fields where the rice straw residue had been removed (by baling).[89]

The Reserve will continue to monitor the impacts on wildlife habitat that result from the above two RC management changes, as well as other potential management changes that may be allowed in subsequent versions of this protocol. Should it be determined that a certain activity is resulting in negative impacts, mitigation options and/or changes in approved project activities may be required under subsequent protocol versions.

[86] Petrie, M., & Petrik, K. (May 2010).
[87] Ibid.
[88] Sterling, J., & Buttner, P. (2009).
[89] Elphick, Chris and Lewis Oring, "Conservation implications of flooding rice fields on winter waterbird communities," *Agriculture, Ecosystems, and Environment* 94 (2003).

Rice Cultivation Project Protocol
Version 1.1
ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its Rice Cultivation Project Protocol Version 1.1 (RCPP V1.1) in June 2013. While the Reserve intends for the RCPP V1.1 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the RCPP V1.1.[1]

Per the Reserve's Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered rice cultivation projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the protocol.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact Policy at policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Climate Action Reserve Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications are contained in this single document.

Errata and Clarifications (arranged by protocol section)

Appendix B Step 1.3

1. DNDC Climate Input Data File Formatting (ERRATUM – January 21, 2014)..... 3

Appendix B Step 2.1

2. Missing Climate Data (CLARIFICATION – January 21, 2014)..... 3

Appendix B Step 1.3

1. DNDC Climate Input Data File Formatting (ERRATUM – January 21, 2014)

Section: Appendix B, Step 1.3 DNDC Climate Input Parameters

Context: This step provides background information on the climate input parameters used to run the DNDC model and instructs project developers on how to enter data for these parameters into DNDC. Following an initial description of the climate input parameters and a bulleted list of requirements for determining climate parameter inputs, a paragraph outlines how to enter data into the model, beginning with the words "Data for N concentration in rainfall…" (page 77). The final sentence in that paragraph erroneously lists "Humidity" twice in the data file format. The same mistake is repeated in the example data layout provided in Table B.5. Humidity data should appear once in the series, as the final data input parameter.

Correction: The last sentence on page 77 should be amended to read: "In other words, data needs to be input in text files in the following order: Jday, MaxT, MinT, Precipitation, Wind Speed, Humidity."

Table B.5 on page 78 should be amended to read as follows:

Table B.5. Required Formatting for Climate Input Files

Jday	MaxT (°C)	MinT (°C)	Precipitation (cm)	Wind Speed (m/s)	Humidity (%)
1	12.1	5.2	1.41	2.3	77
2	11.1	6.2	3.01	7.5	80
3	10.1	7.2	0.34	4.3	82
4	11.1	8.2	0.01	2.9	81

*NOTE: Only the format and data itself and not the text of a header row should be entered into the Climate Input files.

Appendix B Step 2.1

2. Missing Climate Data (CLARIFICATION – January 21, 2014)

Section: Appendix B, Step 2.1 Missing Climate or Soil Data

Context: The DNDC model will crash if instructed to run without a full set of data for each input parameter. This step provides a methodology for how to overcome missing climate or soil data. The guidance with respect to missing climate data does not address such instances where climate data are missing for a period not exceeding 14 days, in which a complete and continuous set of data from the 14 day period immediately prior to and following the data gap (for a total of 28 days) are also not available from the same source. In such circumstances, data from another source or the nearest alternative weather station must be used.

Clarification: The following text shall be inserted following the first sentence of the last paragraph on page 82, which begins with the words “For gaps in climate data that do not exceed 14 days…”:

> “If a complete and continuous set of data for the 14 days preceding and following the data gap (for a total of 28 days) cannot be obtained from the same source, project developers must substitute data for the data gap from another source in that same region, and if such data are not available, project developers must then use data from the nearest alternative weather station.”

CLIMATE ACTION RESERVE

Version 1.1 | April 18, 2019

Urban Forest Management

Project Protocol

Climate Action Reserve
www.climateactionreserve.org

Released April 18, 2019

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This workgroup convened for the development of the Urban Tree Planting Project Protocol Version 2.0 and Urban Forest Management Project Protocol Version 1.0. Workgroups are not reconvened for programmatic updates to protocols (e.g., Version 1.1); for additional information, see section 4.3 of the Reserve Program Manual.

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Funding Support

Substantial funding for the development of the Urban Forest Management Project Protocol was provided through a grant from the California Department of Forestry and Fire Prevention.

Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
1.1 About Urban Forests, Carbon Dioxide and Climate Change 2
2 Urban Forest Management Definition and Requirements 4
2.1 Project Definition 4
2.2 Urban Forest Owners 4
2.3 Project Operators 5
2.4 Project Implementation Agreement 5
3 Eligibility Rules 6
3.1 Project Location 6
3.1.1 Project Area 6
3.2 Limits to Site Preparation 7
3.3 Project Start Date 7
3.4 Additionality 8
3.4.1 Legal Requirement Test 8
3.4.2 Performance Standard Test 8
3.4.3 Enhancement Payments 8
3.5 Project Crediting Period 9
3.6 Minimum Time Commitment 9
3.7 Regulatory Compliance 9
3.8 Social and Environmental Co-Benefits 9
3.8.1 Social Co-Benefits 9
3.8.2 Environmental Co-Benefits 10
4 GHG Assessment Boundaries 12
5 Quantifying Net GHG Reductions and Removals 15
5.1 Urban Forest Management Baseline 17
6 Ensuring the Permanence of Credited GHG Reductions and Removals 18
6.1 Contributions to the Buffer Pool 18
6.2 Compensating for Reversals 19
6.2.1 Avoidable Reversals 19
6.2.2 Unavoidable Reversals 19
6.3 Disposition of Projects after a Reversal 20
7 Project Monitoring, Reporting, and Verification 21
7.1 Project Documentation 21
7.1.1 Urban Forest Project Design Document 22
7.2 Monitoring Report 22
7.3 Reporting and Verification Cycles 23
7.3.1 Reporting Period Duration and Cycles 23
7.3.2 Verification Cycles 23

7.3.3 Full Verification Requirements 24
7.3.4 Optional Desk Review Verification 24
7.4 Issuance and Vintage of CRTs....24
7.5 Record Keeping 24
7.6 Transparency....24
8 Verification Guidance....25
8.1 Standard of Verification....25
8.2 Project Verification Activities 26
8.2.1 Initial Verification....26
8.2.2 Full Verification 26
8.2.3 Optional Desk Review Verification 26
8.3 Verifying Urban Forest Management Carbon Estimates 28
8.3.1 Field-Based Inventory Verification Activities....30
8.4 Completing the Verification Process 33
9 Glossary of Terms 34

List of Tables

Table 3.1. Social Co-Benefits of Urban Forest Management Projects 10
Table 3.2. Environmental Co-Benefits of Urban Forest Management Projects 10
Table 4.1. Description of all Sources, Sinks, and Reservoirs 12
Table 7.1. Project Documentation Submittal Requirements 21
Table 8.1. Verification Items and Related Schedules 27
Table 8.2. Verification Guidance 28
Table 8.3. Verification Guidance for Quantification 29
Table 8.4. Verification Guidance for Field Inventories 32

List of Equations

Equation 5.1. Annual Net GHG Reductions and Removals 16

Abbreviations and Acronyms

C	Carbon
CAL FIRE	California Department of Forestry and Fire Protection
CH_4	Methane
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
DBH	Diameter at Breast Height
FIA	Forest Inventory and Analysis Program of the U.S. Forest Service
GHG	Greenhouse gas
GIS	Geographical Information System
ISO	International Organization for Standardization
KML	Keyhole Markup Language (see glossary)
N_2O	Nitrous oxide
PDD	Project Design Document
PIA	Project Implementation Agreement
Reserve	Climate Action Reserve
RPF	Registered Professional Forester (California only)
SSR	Source, sink, or reservoir
UFM	Urban forest management
UFMPP	Urban Forest Management Project Protocol
USFS	United States Forest Service
VOC	Volatile Organic Compound

1 Introduction

The Urban Forest Management Project Protocol (UFMPP) provides requirements and guidance for quantifying the net climate benefits of activities that sequester carbon in woody biomass within an urban environment. The protocol provides project eligibility rules, methods to calculate a project's net effects on greenhouse gas (GHG) emissions and removals of carbon dioxide (CO_2) from the atmosphere ("removals"), procedures for assessing the risk that carbon sequestered by a project may be reversed (i.e., released back to the atmosphere), and approaches for long term project monitoring and reporting.

The goal of this protocol is to ensure that the net GHG reductions and removals caused by a project are accounted for in a complete, consistent, transparent, accurate, and conservative manner[1] and may therefore be reported to the Climate Action Reserve (Reserve) as the basis for issuing carbon offset credits (called Climate Reserve Tonnes, or CRTs). Additionally, it is the goal of the Reserve to ensure the protocol is as efficient and practical as possible for Project Operators.

As the premier carbon offset registry for the North American carbon market, the Reserve encourages action to reduce GHG emissions by ensuring the environmental integrity and financial benefit of emission reduction projects. The Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, issues carbon credits generated from such projects, and tracks the transaction of credits over time in a transparent, publicly-accessible system. The Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California.[2]

Only projects that are eligible under and comply with this UFMPP may be registered with the Reserve. Section 8 of this protocol provides requirements and guidance for verifying the performance of project activities and their associated GHG reductions and removals reported to the Reserve.

1.1 About Urban Forests, Carbon Dioxide and Climate Change

Urban forests have the capacity to both emit and absorb CO_2, a leading greenhouse gas that contributes to climate change. Trees, through the process of photosynthesis, naturally absorb CO_2 from the atmosphere and store the gas as carbon in their biomass, i.e., trunk (bole), leaves, branches, and roots. Carbon may also be stored in the soils that support the urban forest, as well as the understory plants and litter on the urban forest floor. After trees are removed, their wood residue may be converted into mulch, with CO_2 gradually released to the atmosphere through decomposition. Carbon may continue to be sequestered for a substantial amount of time in wood products and in landfills. Carbon from urban forests may also be used to provide fuel for biomass energy. Urban trees can reduce summertime air temperatures and building energy use for air conditioning, thus reducing GHG emissions from electricity generation (Akbari 2002). In winter, trees can increase or decrease GHG emissions associated with energy consumed for space heating, depending on local climate, site features, and building characteristics (Heisler 1986).

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.
[2] For more information, please visit www.climateactionreserve.org.

When trees are disturbed, through events like fire, disease, pests, or harvest, some of their stored carbon may oxidize or decay over time, releasing CO_2 into the atmosphere. The quantity and rate of CO_2 that is emitted may vary, depending on the particular circumstances of the disturbance. Depending on how urban forests are managed or impacted by natural events, they can be a net source of emissions, resulting in a decrease to the reservoir, or a net sink of emissions, resulting in an increase of CO_2 to the reservoir. In other words, urban forests may have a net negative or net positive impact on the climate.

2 Urban Forest Management Definition and Requirements

For the purposes of this protocol, an Urban Forest Management (UFM) Project is a planned set of activities designed to increase removals of CO_2 from the atmosphere, or reduce or prevent emissions of CO_2 to the atmosphere, through increasing and/or conserving urban forest Carbon Stocks.

A glossary of terms used in this protocol is provided in Section 9. Throughout the protocol, important defined terms are capitalized (e.g., "Urban Forest Owner").

2.1 Project Definition

A UFM Project focuses on activities that maintain or increase carbon inventories relative to baseline levels, as defined in this protocol, of carbon within the project boundary. Eligible management activities may include, but are not limited to:

- Increasing the urban forest productivity by removing diseased and suppressed trees
- Reducing emissions by avoiding tree removals
- Planting additional trees on available and appropriate sites
- Monitoring, protecting, and treating trees to avoid premature mortality from stressors such as drought, pests, storm damage, and abiotic agents
- Reducing the vulnerability of trees to impacts of climate change by increasing resilience

2.2 Urban Forest Owners

Credits for a UFM Project must be quantified from carbon that is owned by participating entities. An Urban Forest Owner is a corporation, a legally constituted entity (such as a utility or special district), city, county, state agency, educational campus, individual(s), or a combination thereof that has legal control of any amount of urban forest carbon[3] within the Project Area.

Having legal control of urban forest carbon means that the Urban Forest Owner has the legal authority to effect changes to urban forest carbon quantities (right to plant or remove trees, for example). Legal control of urban forest carbon may be conveyed, for purposes of satisfying this protocol, through fee ownership, perpetual contractual agreements, deeded encumbrances, or other legal provisions. This protocol recognizes the fee owner as the default owner of urban forest carbon where no explicit legal encumbrance exists. Individuals or entities holding mineral, gas, oil, or similar *de minimis*[4] interests without fee ownership are precluded from the definition of Urban Forest Owner.

Only counties, municipalities, educational institutions, and utilities/special districts, or Urban Forest Owners that own a minimum of 50 acres, referred to as Large Urban Forest Owners, may develop a project independently. Urban Forest Owners are able to combine, or aggregate, forest carbon with other Urban Forest Owners to develop a UFM Project at increased scale. Urban Forest Owners must agree to a single Project Operator (see below) who is designated to manage the requirements of the project. A single Project Operator may aggregate projects across multiple areas that they own, if applicable. Aggregated projects may only include the carbon controlled by permission as described in Section 2.3.

[3] See definition of Carbon Stock in the glossary.
[4] *de minimis* control includes access right of ways and residential power line right of ways.

2.3 Project Operators

A Project Operator must be one of the Urban Forest Owners or a legal entity created to represent the Urban Forest Owners. The Project Operator is responsible for undertaking a project and registering it with the Reserve, and is ultimately responsible for all project listing, monitoring, reporting, and verification. The Project Operator is responsible for any Reversals associated with the project and is the entity that executes the Project Implementation Agreement (see below) with the Reserve.

In all cases where multiple Urban Forest Owners participate in a UFM Project, the Project Operator must secure an agreement from all other Urban Forest Owners that assigns authority to the Project Operator to include the carbon they own in the project. Such an agreement must provide any of the Urban Forest Owners the opportunity to opt out of the project.

2.4 Project Implementation Agreement

A Project Implementation Agreement (PIA) is a required agreement between the Reserve and a Project Operator setting forth the Project Operator's obligation (and the obligation of its successors and assigns) to comply with the terms of the protocol. Project Implementation Agreement forms can be found on the Climate Action Reserve's website.

3 Eligibility Rules

In addition to the definitions and requirements described in Section 2, UFM Projects must meet several other criteria and conditions to be eligible for registration with the Reserve, and must adhere to the following requirements related to their duration and crediting periods.

Section 3.1	Project Location	→	*Urban Areas (including Urban Clusters) and Places (including Incorporated Places and Census-Designated Places) within the U.S.*
Section 3.2	Limits to Site Preparation	→	*Disturbance on more than 2% of the Project Area annually not permitted*
Section 3.3	Project Start Date	→	*No more than six months prior to project submission*
Section 3.4	Additionality	→	*Meet legal requirements*
		→	*Meet performance standard*
Section 3.5	Project Crediting Period	→	*25 years*
Section 3.6	Minimum Time Commitment	→	*100 years*
Section 3.7	Regulatory Compliance	→	*Compliance with all applicable laws*
Section 3.8	Social and Environmental Co-Benefits	→	*Projects are encouraged to report on relevant co-benefits*

3.1 Project Location

Only those activities that occur within the Urban Areas[5] and Places[6] boundaries defined by the most recent publication of the United States Census Bureau,[7] are eligible to develop a project under this protocol. Projects must be entirely within defined Urban Area and/or Place boundaries as of Project Commencement.

3.1.1 Project Area

The Project Area is the geographic extent of the project. The Project Area may be made up of consolidated or disaggregated polygons (i.e., parcels, or portions of parcels) within an Urban Area and/or Place polygon established by the U.S Census Bureau. A map layer combining Urban Areas and Places is available on the Urban Forest Project Protocol webpage to assist with identifying eligible Project Areas. When determining the extent of the Project Area at the Project Start Date (see Section 3.3), the most recent Urban Areas and Places GIS layers must be used. These map layers are available from the U.S. Census Bureau website.[8]

[5] Urban Areas are composed of Urbanized Areas (areas with populations ≥50,000 people) and Urban Clusters (populations ≥2,500 and <50,000).

[6] Places are composed of Incorporated Places and Census-Designated Places, and defined by the U.S. Census Bureau. Generally, an Incorporated Place is an area that is legally incorporated under the laws of its respective state, whereas a Census-Designated Place is a community that lacks a separate government but otherwise resembles incorporated places, with a residential core, relatively high population density, and a degree of local identity.

[7] https://www.census.gov/geo/maps-data/

[8] https://www.census.gov/geo/maps-data/data/tiger-line.html

No part of the Project Area can be included if commercial harvesting of timber has occurred in the Project Area in the past 10 years where the canopy cover was reduced by more than 50% within a contiguous acre, excepting where the harvest occurred for safety or forest health purposes. Additionally, the issuance and transaction of credits will be suspended if commercial harvesting of timber products occurs any time during the project. Where the harvesting of commercial timber products is anticipated, the Project Operator should consider the use of a protocol that addresses the carbon stored in harvested wood products, such as the Reserve's Forest Project Protocol or the California Air Resources Board's Compliance Offset Protocol for U.S. Forest Projects. Exceptions to the prohibition are recognized where commercial timber products might be generated from harvests conducted primarily for safety, salvage of material when trees are in decline, and developing improved resilience to wildfire and pests.

A KML file must be submitted with the project to clearly identify the project boundaries. At a minimum, UFM Projects must be at least 25 acres. A project can be made up of one or many participating Urban Forest Owners. Project acreage shall be based on area calculations derived from GIS analysis, such as ArcGIS or Google Earth. GIS data are generally considered to be improvements over strict adherence to county parcel acreages since GIS data are based on aligning property boundaries to geographic characteristics and/or property corners as described in property deeds or official survey notes.

The project must list the county assessor's parcels (APs), the portion of each AP included in the project (as a percentage), the sum of acres derived from the county tax records for all included APs, and the sum of acres derived from the GIS analysis. The sum of acres should be compared between the AP and GIS sources, with the lesser of the two used for the Project Area. If there is a significant discrepancy between AP and GIS acres, the Project Operator may work with the county assessor to resolve any disputed AP acres. The GIS acreage may be used when greater than the AP acreage if the Project Operator provides evidence (e.g., boundary survey) substantiating the accuracy of the GIS acreage.

3.2 Limits to Site Preparation

UFM Projects that plow, till, or rip soils, resulting in the removal of the roots of herbaceous understory in preparation for planting trees where more than 2% of the Project Area is disturbed on an annual basis are not eligible, since soil-related emissions above baseline levels are not quantified in this protocol. Where such plowing, tilling, or ripping of soils occurs as described within an existing project in any one year, the transacting of credits will be suspended until the subsequent years and soil disturbance rates brings the average below the 2% threshold, after which time the 2% threshold in any given year is renewed.

3.3 Project Start Date

The start date for a project is the date at which the Project Operator initiates an activity that will lead to increased GHG reductions or removals with long-term security relative to the project baseline. The start date is initiated by activities that increase carbon inventories and/or decreases emissions relative to the baseline. Evidence of discrete and verifiable activities that justify a start date includes:

- Submitting the project to the Reserve. The Project Start Date is the date of submittal
- Dated planning documents that indicate the date in which the activities were initiated
- Recordation of a conservation easement

To be eligible, the project must be submitted to the Reserve no more than six months after the Project Start Date.[9] Projects may always be submitted for listing by the Reserve prior to their start date.

3.4 Additionality

The Reserve will only register projects that yield surplus GHG emission reductions and removals that are additional to what would have occurred in the absence of a carbon offset market (i.e., under "Business As Usual"). For a general discussion of the Reserve's approach to determining additionality, see the Reserve's Program Manual.[10]

Projects must satisfy the following tests to be considered additional.

3.4.1 Legal Requirement Test

UFM Projects must achieve GHG reductions or removals above and beyond any GHG reductions or removals that would result from compliance with any federal, state, or local law, statute, rule, regulation, or ordinance. Projects must also achieve GHG reductions and removals above and beyond any GHG reductions or removals that would result from compliance with any court order or other legally binding mandates.

Deeded encumbrances, tree planting and management ordinances, provisions of management plans required by law, and contractual agreements, collectively referred to as Legal Agreements, may effectively control urban forest carbon and convey ownership rights to the carbon inventories controlled, affecting which party may claim ownership to any eligible GHG reductions or removals. Similarly, these same controls may have an effect on urban forest carbon inventories beyond the control of any of the Urban Forest Owners and, as such, must be considered to be legal constraints on the project.

The baseline trend for UFM Projects is based on comparison of historic data as described in the Quantification Guidance and includes the effects of legal requirements. This ensures that any GHG reductions or removals achieved by the project are above and beyond any GHG reductions or removals that would result from engaging in Business-As-Usual activities, thereby satisfying the legal requirement test.

3.4.2 Performance Standard Test

UFM Projects must achieve GHG reductions or removals above and beyond any GHG reductions or removals that would result from engaging in Business-As-Usual activities. UFM Projects automatically satisfy the performance standard by maintaining carbon stocks above the baseline.

3.4.3 Enhancement Payments

Enhancement payments provide financial assistance to landowners in order to implement discrete practices that address natural resource concerns and deliver environmental benefits. Examples of relevant enhancement payments include:

- California Climate Investments (CCI), formerly called Greenhouse Gas Reduction Funds (GGRF)
- USFS grants and agreements

[9] Projects are considered submitted when the project developer has completed and uploaded the appropriate project submittal forms to the Reserve software.
[10] Available at http://www.climateactionreserve.org/how/program/program-manual/.

Urban Forest Owner(s) may pursue enhancement payments that support urban forest management carbon project activities. Because every available enhancement payment is not comprehensively addressed by the protocol at this time, the Urban Forest Owner(s) must still disclose any such payments to the verifier and the Reserve on an ongoing basis. The Reserve maintains the right to determine if payment stacking has occurred and whether it would impact project eligibility.

3.5 Project Crediting Period

The crediting period for a UFM Project is 25 years. Projects may be renewed for additional crediting periods with the prospect of incorporating updated technology into the project analysis. The initial baseline can be maintained for the life of the project. There is no limit to the number of times the crediting period may be renewed. Any previously issued credits must be monitored as described below.

3.6 Minimum Time Commitment

Projects must monitor, report, and undergo verification activities for 100 years following the last credit issued to the project.

3.7 Regulatory Compliance

Each time the UFM Project is verified, the Project Operator must attest that the project is in material compliance with all applicable laws relevant to the Project Activity. For this protocol, instances of non-compliance are likely to be considered "material" if they directly pertain to the management of project carbon stocks. Project Operators are required to disclose in writing to the verifier all instances of material non-compliance of the project with any law. If a verifier finds that a project is in a state of material non-compliance, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance. Non-compliance solely due to administrative or reporting issues, or due to "acts of nature," will not affect CRT crediting.

3.8 Social and Environmental Co-Benefits

All UFM Projects will provide climate benefits to the extent in which they generate credits. The ability to achieve additional environmental and social co-benefits depends on consideration of additional factors, some of which are described in this section. Only those projects where public and/or tribal entities participate in direct urban tree management activities (e.g., planting, tree distribution, etc.) are required to include the provisions for social and environmental co-benefits. However, these provisions may serve as suggestions to NGOs and other privately funded projects that may wish to enhance social and environmental co-benefits. Where required, the provisions must be described in the Project Design Document (PDD) and implemented throughout the Project Life. The Reserve has developed a PDD template that outlines elements that need to be addressed.[11]

3.8.1 Social Co-Benefits

Projects can create long-term climate benefits as well as providing other social and environmental benefits. Investment in projects has the potential to improve the quality of life for urban communities in a number of ways. Among other benefits, urban forest projects can improve air quality and reduce storm water runoff, provide shade, and increase property values by creating a more aesthetically pleasing environment. Projects also have the potential to create

[11] Available at http://www.climateactionreserve.org/how/protocols/urban-forest/.

negative social externalities, such as an uneven distribution of project benefits due to an uneven distribution of projects sites throughout a community (e.g., skewed toward more affluent communities). Therefore, social co-benefits should be taken into consideration during project design, in order to prevent these negative social externalities.

Table 3.1. Social Co-Benefits of Urban Forest Management Projects

Social Provisions	Elements to Include in the Project Design Document (PDD)
Equitable distribution of forest resources	Describe how the project will make progress toward achieving relatively equal distribution of tree canopy cover by neighborhood whenever possible.
Public participation	Establish guidelines to ensure adequate notification, opportunities for public participation, and documentation with regards to public activities with urban forest management.

3.8.2 Environmental Co-Benefits

The protocol has a goal of permanently removing greenhouse gases from the atmosphere by sustaining carbon benefits generated from urban forests for at least 100 years. Healthy urban forests can also provide environmental benefits as well as create negative externalities. Projects have the potential to improve air quality and reduce storm water runoff and energy usage. However, they can also contribute to reduced biodiversity, introduce invasive species, and damage infrastructure. Inefficient water usage during maintenance can also put pressure on local and regional water supplies. Projects should employ an evaluation of environmental co-benefits, as well as elements to prevent creating negative environmental externalities.

Table 3.2. Environmental Co-Benefits of Urban Forest Management Projects

Environmental Provisions	Elements to Include in the Project Design Document (PDD)
Biodiversity	Describe how UFM Project activities will maintain and enhance biodiversity, including: 1. Benefits of tree species selection and composition to biodiversity within the Project Area. 2. Use of specific tree species, sizes and/or distributions to support unique habitat elements.
Native species	Describe how UFM Project activities will promote the use of native species, including: 1. Strengths and limitations of using native trees in the project. 2. Preferential treatment of native species.
Non-native species	Describe how UFM Project activities will limit and target the use of any non-native species, including: 1. Strengths and limitations of using non-native trees in the project. 2. Resistance to insects and disease.
Climate change resilience	Describe how UFM Project activities will enhance the resilience of the urban forest to climate change, including: 1. Ability of urban forest to adapt to climate change. 2. Resistance to natural disturbances.

Environmental Provisions	Elements to Include in the Project Design Document (PDD)
Air quality	Describe how UFM Project activities will enhance air quality benefits, including: 1. Tree selection and distribution to reduce air pollutants. 2. Tree selection and distribution to reduce emissions of Biogenic Volatile Organic Compounds (BVOCs). 3. Design tree maintenance activities to reduce fossil fuel emissions.
Physical characteristics	Describe how UFM Project activities will enhance physical characteristics of the urban environment, including: 1. Tree shading. 2. Wind protection. 3. Minimize disturbance to city infrastructure (e.g., sidewalks, power lines, etc.).
Water management	Describe how UFM Project activities will improve water management, including: 1. Increase infiltration and recharge of groundwater. 2. Reduce stormwater runoff. 3. Conserve water from urban forest management.

4 GHG Assessment Boundaries

The quantification of all included sources, sinks, and reservoirs (SSR) (Table 4.1 below) are described in the Urban Forest Management Quantification Guidance on the Reserve's website.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	Type	Gas	Included (I) or Excluded (E)	Justification/Explanation
UF-1	Standing live carbon (carbon in all portions of living trees)	Reservoir / Pool	CO_2	Included	Increases in standing live carbon stocks are likely to be a large Primary Effect of UFM Projects.
UF-2	Shrubs and herbaceous understory carbon	Reservoir / Pool	CO_2	Excluded	For crediting purposes shrubs and herbaceous understory are excluded since changes in this reservoir are unlikely to have a significant effect on total quantified GHG reductions or removals. Furthermore, it is generally not practical to undertake measurements of shrubs and herbaceous understory accurate enough for crediting purposes.
UF-3	Standing dead carbon (carbon in all portions of dead, standing trees)	Reservoir / Pool	CO_2	Included	Standing dead wood is expected to be a small portion of UFM Projects, but may be substantial in rare cases.
UF-4	Lying dead wood carbon	Reservoir / Pool	CO_2	Excluded	For crediting purposes lying dead wood carbon is excluded since changes in this reservoir are unlikely to have a significant effect on total quantified GHG reductions or removals. Changes associated with carbon projects are likely to increase lying dead wood. Furthermore, it is generally not practical to undertake measurements of lying dead wood accurate enough for crediting purposes.
UF-5	Litter and duff carbon (carbon in dead plant material)	Reservoir / Pool	CO_2	Excluded	Litter and duff carbon are excluded since changes in this reservoir are unlikely to have a significant effect on total quantified GHG reductions or removals. Furthermore, it is generally not practical to undertake measurements of litter and duff accurate enough for crediting purposes.
UF-6	Soil carbon	Reservoir / Pool	CO_2	Excluded	Soil carbon is not anticipated to change significantly as a result of UFM Projects.

SSR	Source Description	Type	Gas	Included (I) or Excluded (E)	Justification/Explanation
UF-7	Carbon in in-use forest products	Reservoir / Pool	CO_2	Excluded	Urban forests do not produce significant levels of wood products that persist for long enough periods of time to meet permanence requirements and projects will not substantially change wood product production.
UF-8	Forest product carbon in landfills	Reservoir / Pool	CO_2	Excluded	Urban forests do not produce significant levels of wood products and projects will not substantially change wood product production.
UF-9	Nutrient application	Source	N_2O	Excluded	The use of nitrogen-based fertilizers is not expected to be a significant source of emissions.
UF-10	Biological emissions from site preparation activities	Source	CO_2	Excluded	Biological emissions from site preparation are not quantified since projects that involve intensive site preparation activities are not eligible.
UF-11	Mobile combustion emissions from site preparation activities	Source	CO_2	Excluded	Mobile combustion CO_2 emissions from site preparation are not quantified since projects that involve intensive site preparation activities are not eligible.
			CH_4	Excluded	Changes in CH_4 emissions from mobile combustion associated with site preparation activities are not considered significant.
			N_2O	Excluded	Changes in N_2O emissions from mobile combustion associated with site preparation activities are not considered significant.
UF-12	Mobile combustion emissions from ongoing project operation and maintenance	Source	CO_2	Excluded	Mobile combustion CO_2 emissions from ongoing project operation and maintenance are unlikely to be significantly different from baseline levels and are therefore not included in the GHG Assessment Boundary.
			CH_4	Excluded	CH_4 emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
			N_2O	Excluded	N_2O emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.

SSR	Source Description	Type	Gas	Included (I) or Excluded (E)	Justification/Explanation
UF-13	Stationary combustion emissions from ongoing project operation and maintenance	Source	CO_2	Excluded	Stationary combustion CO_2 emissions from ongoing project operation and maintenance could include GHG emissions associated with electricity consumption or heating/cooling at Urban Forest Owner facilities or at facilities owned or controlled by contractors. These emissions are unlikely to be significantly different from baseline levels and are therefore not included in the GHG Assessment Boundary.
			CH_4	Excluded	CH_4 emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
			N_2O	Excluded	N_2O emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
UF-14	Biological emissions/ removals from changes in urban tree planting and management outside the Project Area	Source	CO_2	Excluded	Emissions due to leakage are unlikely to be significantly different from baseline levels and are considered to be de minimis. Therefore, this SSR is not included in the GHG Assessment Boundary.

5 Quantifying Net GHG Reductions and Removals

This section provides general requirements and guidance for quantifying a UFM Project's net GHG reductions and removals. Detailed methodological approaches to quantifying GHG reductions and removals are provided in the supplemental Quantification Guidance. The Reserve will issue Climate Reserve Tonnes (CRTs) to a project upon confirmation by an accredited and Reserve-approved verification body that the project's GHG reductions and removals have been quantified following the applicable requirements of this section (see Section 8 for verification requirements).

UFM Projects quantify carbon storage based on a relationship between canopy cover and carbon storage. The amount of carbon per acre of canopy cover is referred to as a ratio estimator. Projects may use default ratio estimators published by the Reserve, which have been organized by Assessment Area. Alternatively, projects may choose to sample their forest and generate project-specific ratio estimators. In either case, measuring or estimating project canopy cover is a crucial component of project quantification. This can be done via remote sensing, satellite imagery, and tools like iTree Canopy.[12] An overview of the steps for quantifying urban forest carbon is given below. For more information, refer to the Quantification Guidance document.

1. **Estimating baseline onsite carbon stocks**. The baseline is an estimate of what would have occurred in the absence of a UFM Project. To establish baseline onsite carbon stocks, the Project Operator must apply the appropriate methodology developed according to the guidelines established in the Quantification Guidance. Baseline estimates are developed for a 100-year period. Generally, baselines do not change during the life of the project, absent findings of errors in initial calculation or reconciliation associated with methodological updates.

2. **Determining actual onsite carbon stocks**. Each year, the Project Operator must determine the UFM Project's actual onsite carbon stocks. This must be done by updating the project's canopy estimate for the current year and applying the appropriate ratio estimator, following the guidance in this section and in the Urban Forest Management Quantification Guidance.

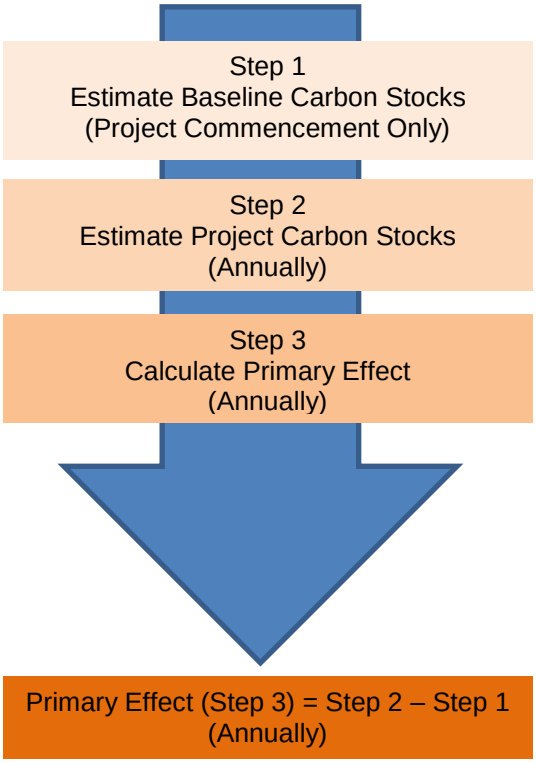
3. **Calculating the project's Primary Effect**. Each year, the Project Operator must quantify the actual change in GHG emissions or removals associated with the project's intended ("primary") effect. For any given year, the Primary Effect is calculated by:
    a. Estimating the change in canopy cover between the current year and prior year.
    b. Extrapolating the change in canopy cover to a change in carbon stocks, using the ratio estimators.
    c. Estimating the difference in baseline carbon stocks between the current year and the prior year.
    d. Subtracting (c) from (b) to establish the change in carbon sequestration between the baseline and project scenarios.

4. **Calculating total net GHG reductions and removals.** For each year, total net GHG reductions and removals are calculated by summing a UFM Project's Primary Effects. If

[12] https://canopy.itreetools.org/

the result is positive, then the project has generated GHG reductions and/or removals in the current year. If the result is negative, this may indicate a Reversal has occurred (see Section 6).[13]

The required formula for quantifying annual net GHG reductions and removals is presented in Equation 5.1. Net GHG reductions and removals must be quantified and reported in units of carbon dioxide-equivalent (CO_2e) metric tons.



Equation 5.1. Annual Net GHG Reductions and Removals

$$\boldsymbol{QR_y = (\Delta AC_{onsite} - \Delta BC_{onsite})}$$

Where, Units

QR_y = Quantified GHG reductions and removals for year y tCO_2e

ΔAC_{onsite} = $(AC_{onsite, y}) - (AC_{onsite, y-1})$ tCO_2e

Where,

$AC_{onsite, y}$ = Actual carbon (CO_2e) as quantified for year y tCO_2e

$AC_{onsite, y-1}$ = Actual carbon (CO_2e) as inventoried for year y-1 tCO_2e

ΔBC_{onsite} = $(BC_{onsite, y}) - (BC_{onsite, y-1})$ tCO_2e

Where,

$BC_{onsite, y}$ = Baseline onsite carbon (CO_2e) as estimated for year y tCO_2e

$BC_{onsite, y-1}$ = Baseline onsite carbon (CO_2e) as estimated for year y-1 tCO_2e

[13] A Reversal occurs only if: (1) total net GHG reductions and removals for the year are negative; and (2) CRTs have previously been issued to the project.

5.1 Urban Forest Management Baseline

To develop a project baseline for a UFM Project, a trend line is developed by calculating a historic estimate of carbon stocks and a recent estimate of carbon stocks. The trend line must pass through at least two historical inventory estimates that are at least 10 years apart and with the earliest point no earlier than 1990. For instance, if a project commences in 2018, the historical estimates may be done using aerial imagery from 2005 and 2015, since the two points pre-date the Project Start Date, are at least 10 years apart from one another, and do not pre-date 1990. Both estimates are developed by first estimating tree canopy area for each date from remotely sensed data and applying the ratio estimators. If historical imagery is not available, more recent images may be used, subject to Reserve approval. The resulting trend is extended 25 years into the future beginning from the Project Start Date, provided legal constraints have not changed substantially (other than changes associated with this protocol) during the 25-year period. The stocking amount is then held steady for the balance of the 100-year projection (75 years following the 25-year trend). A description of how legal constraints affect baseline considerations and technical issues associated with the baseline are described in the Quantification Guidance.

If there are unanticipated changes to legal constraints within the initial 25-year crediting period that will affect carbon stocks in the Project Area, projects are required to disclose the changes. Projects may be eligible to continue for the remaining 25-year crediting period but may not be eligible to renew the crediting period unless the project modifies its baseline to reflect the changes in legal constraints. A review of legal constraints will be performed during each verification, and determination of significance is ultimately subject to the discretion of the Reserve.

6 Ensuring the Permanence of Credited GHG Reductions and Removals

Changes in urban forest management have the potential to enhance the rate of CO_2 absorption, providing removals, and reducing or eliminating emissions associated with the loss of trees (reductions). Reductions may be possible with some UFM Projects. The Reserve requires that credited GHG reductions and removals be effectively "permanent." For UFM Projects, this requirement is met by ensuring that the carbon associated with credited GHG reductions and removals remains stored for at least 100 years.

The Reserve ensures the permanence of GHG reductions and removals through three mechanisms:

1. The requirement for all Project Operators to monitor onsite carbon stocks, submit regular monitoring reports, and submit to regular third-party verification of those reports along with periodic full verifications for the duration of the Project Life.
2. The requirement for all Project Operators to sign a Project Implementation Agreement with the Reserve which obligates Project Operators to retire CRTs to compensate for Reversals of GHG reductions and removals.
3. The maintenance of a Buffer Pool to provide insurance against Reversals of GHG reductions and removals due to unavoidable natural disturbances.

GHG reductions and removals can be "reversed" if the stored carbon associated with them is released (back) to the atmosphere. Many biological and non-biological agents, both natural and human-induced, can cause Reversals. Some of these agents cannot completely be controlled (and are therefore "unavoidable"), such as natural agents like fire, insects, pathogens, drought, and wind. Other agents can be controlled, such as human activities like land conversion. Under this protocol, Reversals due to controllable agents are considered "avoidable". If the quantified GHG reductions and removals in a given year are negative, and CRTs were issued to the UFM Project in any previous year, the Reserve will consider this to be a Reversal regardless of the cause of the decrease.

The Buffer Pool is a holding account for project CRTs, which is administered by the Reserve. All UFM Projects must contribute a percentage of CRTs to a Buffer Pool any time they are issued CRTs for verified GHG reductions and removals. A project that has an Unavoidable Reversal will use Buffer Pool CRTs proportionally from all projects that have contributed to the pool to compensate for the Reversal. Project Operators do not receive payment for their contributions to the Buffer Pool.

If a project experiences an Unavoidable Reversal of GHG reductions and removals (as defined in Section 6.2.2), the Reserve will retire a number of CRTs from the Buffer Pool equal to the total amount of carbon that was reversed (measured in metric tons of CO_2). The Buffer Pool therefore acts as a general insurance mechanism against Unavoidable Reversals for all projects registered with the Reserve.

6.1 Contributions to the Buffer Pool

Projects may be affected by financial risks, management risks, social risks, risks from pollution, and risks from natural disturbances (disease/insects, wildfire, flooding, drought etc.). To compensate for these risks, each project must contribute 6% of their issued CRTs to the Buffer

Pool. The Reserve may determine to re-distribute CRTs to Project Operators in the future, or modify the amount of contributions to the Buffer Pool, if actual Unavoidable Reversals deviate significantly from the current evaluation of risks.

6.2 Compensating for Reversals

The Reserve requires that all Reversals be compensated through the retirement of CRTs. If a Reversal associated with a UFM Project was unavoidable (as defined below), then the Reserve will compensate for the Reversal on the Project Operator's behalf by retiring CRTs from the Buffer Pool. If a Reversal was avoidable (as defined below) then the Project Operator must compensate for the Reversal by surrendering CRTs from its Reserve account, or surrender CRTs from another land use project registered with the Reserve in the event that the Project Operator does not have sufficient CRTs to cover the Reversal.

6.2.1 Avoidable Reversals

An Avoidable Reversal is any Reversal that is due to the Project Operator's negligence, gross negligence, or willful intent, including harvesting, development, and harm to the Project Area due to the Project Operator's negligence, gross-negligence or willful intent. Requirements for Avoidable Reversals are as follows:

1. If an Avoidable Reversal has been identified during annual monitoring, the Project Operator must give written notice to the Reserve within thirty days of identifying the Reversal. Additionally, if the Reserve determines that an Avoidable Reversal has occurred, it shall deliver written notice to the Project Operator.
2. Within thirty days of receiving the Avoidable Reversal notice from the Reserve, the Project Operator must provide a written description and explanation of the Reversal to the Reserve.
3. Within four months of receiving the Avoidable Reversal notice, the Project Operator must retire a quantity of CRTs from its Reserve account equal to the size of the Reversal in CO_2-equivalent metric tons (i.e., QR_y, as specified in Equation 5.1). In addition:
    a. The retired CRTs must be those that were issued to the project, or that were issued to other UFM Projects registered with the Reserve. If no other UFM CRTs are available, the Reserve will approve another appropriate source of credits, with a preference for land use projects.
    b. The retired CRTs must be designated in the Reserve's software system as compensating for the Avoidable Reversal.
4. Within one Reporting Period of receiving the Avoidable Reversal notice, the Project Operator must provide the Reserve with a verified estimate of current onsite carbon stocks and the estimated quantity of the Avoidable Reversal.

6.2.2 Unavoidable Reversals

An Unavoidable Reversal is any Reversal not due to the Project Operator's negligence, gross negligence or willful intent, including, but not limited to, the examples provided in Section 6 above. Requirements for Unavoidable Reversals are as follows:

1. If the Project Operator determines there has been an Unavoidable Reversal, it must notify the Reserve in writing of the Unavoidable Reversal within six months of its occurrence.
2. The Project Operator must explain the nature of the Unavoidable Reversal and provide a verified estimate of onsite carbon stocks within two Reporting Periods so that the Reversal can be quantified (in units of CO_2-equivalent metric tons).

If the Reserve determines that there has been an Unavoidable Reversal, it will retire a quantity of CRTs from the Buffer Pool equal to the size of the Reversal in CO_2-equivalent metric tons.

6.3 Disposition of Projects after a Reversal

If a Reversal lowers the UFM Project's carbon stocks below its approved baseline carbon stocks, the project will be terminated as the original baseline approved for the project would no longer be valid. If a project is terminated due to an Unavoidable Reversal, a new project may be initiated and submitted to the Reserve for registration on the same Project Area. New projects may not be initiated on the same Project Area if the project is terminated due to an Avoidable Reversal.

7 Project Monitoring, Reporting, and Verification

This section provides requirements and guidance on project monitoring, reporting rules, and procedures.

7.1 Project Documentation

Project Operators must provide the following documentation to the Reserve in order to register a UFM Project.

Table 7.1. Project Documentation Submittal Requirements

Document	When Submitted/Required
Project Submittal Form	Once, at project initiation when the Project Operator wishes to submit project concept to Reserve. Must be submitted within 6 months of the Project Start Date.
Project Design Document	Once, prior to initial verification.
Signed Attestation of Title Form	Prior to issuance of credits. Required at initial verification, full verification, and every optional desktop verification.
Signed Attestation of Regulatory Compliance Form	Prior to issuance of credits. Required at initial verification, full verification, and every optional desktop verification.
Signed Attestation of Voluntary Implementation Form	Once, prior to the issuance of credits as part of the initial verification.
Verification Report	Upon completion of verification and prior to issuance of credits. Required at initial verification, full verification, and every optional desktop verification.
Verification Statement	Upon completion of verification and prior to issuance of credits. Required at initial verification, full verification, and every optional desktop verification.
Project Implementation Agreement (PIA) and PIA Amendments	Upon completion of verification and prior to issuance of credits. Required at initial verification, full verification, and every optional desktop verification.

Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

Projects using default ratio estimators need not enlist a Professional Forester, Certified Arborist, or Certified Forester for developing project reports. For projects that develop their own ratio estimators per the Quantification Guidance, all reports that reference carbon stocks must be submitted with the oversight of a Certified Arborist, a Certified Forester, or Professional Forester so that professional standards and project quality are maintained. Any Certified Arborist, a Certified Urban Forester, Professional Forester or Certified Forester preparing a project in an unfamiliar jurisdiction must consult with a Certified Arborist, a Certified Urban Forester, Professional Forester or Certified Forester practicing forestry in that jurisdiction to understand all laws and regulations that govern urban forest practices within the jurisdiction. This requirement does not preclude the project's use of technicians or other unlicensed/uncertified persons working under the supervision of the Professional Forester, Certified Arborist, or Certified Forester.

All projects shall submit a shapefile as a KML that matches the maps submitted to depict the Project Area. The project's reported acres shall be based on the shapefile submitted to the Reserve.

7.1.1 Urban Forest Project Design Document

The Project Design Document (PDD) is a required document for reporting information about a project. The document is submitted at the initial verification. PDDs are intended to serve as the main project document that thoroughly describes how the project meets eligibility requirements, discusses summaries associated with developing data according to quantification requirements, outlines how the project complies with terms for additionality and describes how project Reversal risks are calculated. All methodologies used by Project Operators and descriptions in the PDD must be clear in a way that facilitates review by verifiers, Reserve staff, and the public. PDDs must be of professional quality and free of incorrect citations, missing pages, incorrect project references, etc. A PDD template has been prepared by the Reserve and is available on the Reserve's website.[14] The template is arranged to assist in ensuring that all requirements of the UFMPP are addressed. Use of the Reserve's template is optional, but strongly recommended for ease of verification.

7.2 Monitoring Report

Monitoring is the process of regularly collecting and reporting data related to a project's performance. Annual monitoring of UFM Projects is required to ensure up-to-date estimates of project carbon stocks and provide assurance that GHG reductions or removals achieved by a project have not been reversed. Project Operators must conduct monitoring activities and submit monitoring reports according to the schedule and requirements presented in Section 7.2. Monitoring is required for a period of 100 years following the final issuance of CRTs to a project for quantified GHG reductions or removals.

Monitoring activities consist primarily of updating a project's canopy cover estimates, forest carbon stock estimates, calculating emission reductions for the Reporting Period, and submitting the information in annual monitoring reports to the Reserve at frequencies defined in Section 7.3. CRTs are only issued in years that the project data are verified, as described in Section 7.4.

A monitoring report must be prepared for each Reporting Period. Monitoring reports must be provided to verification bodies whenever a project undergoes verification. The monitoring report must be completed and submitted to the Reserve within 12 months of the end of the Reporting Period. When required verifications must be conducted as explained below, both the verification report and the monitoring report must be completed and submitted to the Reserve within 12 months of the end of the Reporting Period. Monitoring reports must include an update of the project's calculations. The project's calculations must include the following:

1. An updated Project Inventory reflecting estimate of the current year's carbon stocks quantified for the project's Primary Effect. Acceptable methodologies for updating the project's inventory are provided in the Quantification Guidance. The update is determined by:
    a. Including any new forest field inventory data obtained during the Reporting Period (if applicable).
    b. Applying ratio estimators to updated canopy cover estimates.

[14] http://www.climateactionreserve.org/how/protocols/urban-forest/.

   c. Updating estimates for removals and/or disturbances that have occurred during the Reporting Period.
2. The baseline carbon stock estimates for the current Reporting Period, as determined following the requirements in Section 5 and approved at the time of the project's registration.
3. A preliminary calculation of total net GHG reductions and removals (or Reversals) for the Reporting Period, following the requirements in Section 5.
4. A preliminary calculation of the project's Buffer Pool contribution.
5. If a Reversal has occurred during the previous Reporting Period, the report must provide a written description and explanation of the Reversal, whether the Reserve classified the Reversal as Avoidable or Unavoidable, and the status of compensation for the Reversal.

7.3 Reporting and Verification Cycles

This section describes the required reporting and verification cycles. A UFM Project is considered automatically terminated as the result of an Avoidable Reversal (see Section 6.3) if the Project Operator chooses not to report data and undergo verification at required intervals.

7.3.1 Reporting Period Duration and Cycles

Projects must report their initial carbon stock data associated with the Project Start Date. Project Operators must report their project stocks annually with the exception of the Reporting Period immediately following the Project Start Date, which can be any length of time up to one year following the Project Start Date. This enables Project Operators to establish an annual reporting cycle that is convenient for the entity.

Reporting Periods must be contiguous, i.e., there must be no gaps in reporting during the crediting period of a project once the first Reporting Period has commenced.

7.3.2 Verification Cycles

A project must be initially verified within 12 months of the end of its initial Reporting Period which begins based on the Project Start Date. The initial verification must confirm the project's eligibility and confirm that the project's initial carbon stocks and baseline have been established in conformance with the UFMPP. Subsequent verifications may include multiple Reporting Periods, (in which case, the time period covered by the multiple Reporting Periods is referred to as the "Verification Period"). The end date of any Verification Period must correspond to the end date of a Reporting Period.

Verification has both required frequencies and optional frequencies. Required verification is established on a temporal framework to ensure that ongoing monitoring of urban forest carbon stocks are accurate and up-to-date. Optional verification is at the Project Operator's discretion and may be conducted in the years in which verification is not required and the Project Operator wishes to receive credits. Required verifications are referred to as full verifications. Optional verifications are referred to as desk review verifications. Details of verification scheduling requirements are provided within this section.

Verification must be completed within 12 months of the end of the Reporting Period(s) being verified. For required verifications, failure to complete verification within the 12-month time period will result in account activities being suspended until the verification is complete. The project will terminate if the required verification is not completed within 36 months of the end of the Reporting Period(s) being verified. There is no consequence for failure to complete verification activities within 12 months for optional verifications.

7.3.3 Full Verification Requirements

A full verification is a verification in which Project Inventory data are verified through a process that audits data in the office. Site visits are not required if the Reserve's default ratio estimators are used for inventory calculations, but the other components of a full verification must still take place. Projects developing their own ratio estimators must include a site visit as part of the full verification. The Reserve requires that an approved third-party verification body verify all reported data and information for a project and conduct a site visit for projects developing their own ratio estimators. Verification Periods shall comprise no more than five Reporting Periods, excepting the first Reporting Period, which must undergo a full verification.

7.3.4 Optional Desk Review Verification

In between required full verifications, the Project Operator may choose to have an approved third-party verification body conduct a desk review of annual monitoring reports as an optional verification. CRTs may be issued for GHG reductions/removals verified through such desk reviews. The desk review verifications are based on the reported data being within acceptable parameters. If the project has implemented significant changes to the quantification methodology since the last verification, the verification team must perform a full verification. Significant changes to the quantification methodology include, but are not limited to, changes to the ratio estimator value, changes to the Project Area, or a change to the technology used to assess canopy cover. The Reserve will determine whether a change to the quantification methodology rises to this level.

Submission of annual monitoring reports to the Reserve is required even if the Project Operator chooses to forego desk review verification.

7.4 Issuance and Vintage of CRTs

The Reserve will issue Climate Reserve Tonnes (CRTs) for quantified GHG reductions and removals that have been verified through either full verifications or desk reviews. Full verification may determine that earlier desk reviews overestimated full carbon stocks. Any resulting downward adjustment to carbon stock estimates will be treated as a Reversal (see Section 6). In this case, the Project Operator must retire CRTs in accordance with the requirements for compensating for a Reversal (Section 6.2). Vintages are assigned to CRTs based on the proportion of days in a calendar year within a Reporting Period.

7.5 Record Keeping

For purposes of independent verification and historical documentation, Project Operators are required to keep all documents and forms related to the project for a minimum of 100 years after the final issuance of CRTs from the Reserve. This information may be requested by the verification body or the Reserve at any time.

7.6 Transparency

The Reserve requires data transparency for all projects, including data that displays current carbon stocks, Reversals, and verified GHG reductions and removals. For this reason, all non-confidential project data reported to the Reserve will be publicly available on the Reserve's website.

8 Verification Guidance

This section provides guidance to Reserve-approved verification bodies for verifying GHG emission reductions associated with urban forest projects.

This section supplements the Reserve's Verification Program Manual,[15] which provides verification bodies with the general requirements for a standardized approach for independent and rigorous verification of GHG emission reductions and removals. The Verification Program Manual outlines the verification process, requirements for conducting verification, conflict of interest and confidentiality provisions, core verification activities, content of the verification report, and dispute resolution processes. In addition, the Verification Program Manual explains the basic verification principles of ISO 14064-3:2006 which must be adhered to by the verification body.

Verification bodies must read and be familiar with the following International Organization for Standardization (ISO) and Reserve documents and reporting tools:

- Urban Forest Management Project Protocol
- Urban Forest Management Quantification Guidance
- Reserve Program Manual
- Reserve Verification Program Manual
- Reserve software
- ISO 14064-3:2006 Principles and Requirements for Verifying GHG Inventories and Projects

Only Reserve-approved urban forest project verification bodies are eligible to verify UFM Project reports. To become a recognized urban forest project verifier, verification bodies must become accredited under ISO 14065. Information on the accreditation process can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/how-to-become-a-verifier/.

8.1 Standard of Verification

The Reserve's standard of verification for UFM Projects is the Urban Forest Management Project Protocol (this document), Quantification Guidance, the Reserve Program Manual, and the Reserve Verification Program Manual. To verify a Project Operator's initial Project Design Document and annual monitoring reports, verification bodies apply the verification guidance in the Reserve's Verification Program Manual and this section of the UFMPP to the requirements and guidance described in Sections 2 through 7 of the UFMPP.

This section of the protocol provides requirements and guidance for the verification of UFM Projects. This section describes the core verification activities and criteria that must be undertaken and addressed by a verification body in order to provide a reasonable level of assurance that the GHG removals or reductions quantified and reported by Project Operators are materially correct.

Verification bodies will use the criteria in this section to determine if there exists a reasonable assurance that the data submitted on behalf of the Project Operator to the Reserve addresses

[15] Found on the Reserve website at http://www.climateactionreserve.org/how/program/program-manual/.

each requirement in the UFMPP, Sections 2 through 7. Project reporting is deemed accurate and correct if the Project Operator is in compliance with Sections 2 through 7.

Further information about the Reserve's principles of verification, levels of assurance, and materiality thresholds can be found in the Reserve's Verification Program Manual at http://www.climateactionreserve.org/how/program/program-manual/.

8.2 Project Verification Activities

Required verification activities for UFM Projects vary depending on whether the verification body is conducting an initial verification for registration on the Reserve, full verification, or an optional annual verification involving a desk review. The following sections contain guidance for all of these verification activities.

8.2.1 Initial Verification

Verifiers must ensure that the project has met the UFMPP criteria and requirements for eligibility, Project Area definition, additionality, quantification, and calculation of baseline. The verification body must assess and ensure the completeness and accuracy of all required reporting elements submitted in the Project Design Document.

8.2.2 Full Verification

Full verification involves review of the project's eligibility, quantification, relevant attestations, soil carbon emissions associated with management activities, adherence to environmental and social safeguards (if applicable), and buffer pool contribution. Site visits are not required for full verifications of projects that are using default ratio estimator values, as described in the Quantification Guidance.

8.2.3 Optional Desk Review Verification

Full verification is required every five Reporting Periods, at a minimum. Optional desk verifications can occur for interim Reporting Periods according to preferences of the Project Operator. Credits can be verified and registered as the result of an optional desk verification. The main focus of optional desk verifications is to assure that annual monitoring reports are complete, and that project quantification was performed correctly, as described in the Quantification Guidance. If the project has implemented significant changes to the quantification methodology since the last verification, the verification team must perform a full verification. See Section 7.3.4.

Table 8.1 displays the protocol sections that are verified at the initial verification, the full verification, and/or the optional annual verification.

Table 8.1. Verification Items and Related Schedules

Verification Items	Section of UFMPP	Initial	Full	Optional	Apply Professional Judgment[16]?
1. Project Definition	2.1 Urban Forest Management	X			No
2. Urban Forest Owner	2.2 Urban Forest Owners	X	X		No
3. Project Operator	2.3 Project Operators	X	X		No
4. Project Implementation Agreement	2.4 Project Implementation Agreement	X	X	X	No
5. Project Location	3.1 Project Location	X			No
6. Project Area	3.1.1 Project Area	X			No
7. Limits to Site Preparation	3.2 Limits to Site Preparation	X	X		Yes
8. Project Commencement	3.3 Project Commencement	X			Yes
9. Additionality	3.4.1 Legal Requirement Test 3.4.2 Performance Test	X	X		Yes
	3.4.3 Enhancement Payments	X			
10.Project Crediting Period	3.5 Project Crediting Period	X	X		No
11.Minimum Time Commitment	3.6 Minimum Time Commitment	X	X		No
12. Social and Environmental Co-Benefits	3.7 Social and Environmental Co-Benefits	X	X		Yes, for public or tribal entities only
13. Social Co-Benefits	3.8.1 Social Co-Benefits	X	X		Yes, for public or tribal entities only
14. Environmental Co-Benefits	3.8.2 Environmental Co-Benefits	X	X		Yes, for public or tribal entities only
15. GHG Assessment Boundaries	4 GHG Assessment Boundaries	X	X		No
The verification topics below are linked to quantification requirements. The verification of project inventories is described in detail below this table. Verifiers shall assure that requirements associated with the references in this table have been satisfied and implement the specific guidance requirements for verifying inventories below.					
16. Quantifying Net GHG Reductions and Removals	5 Quantifying Net GHG Reductions and Removals Urban Forest Management Quantification Guidance	X	X	X	No
17. Urban Forest Protocol Baselines	5.1 Urban Forest Management Baseline Urban Forest Management Quantification Guidance	X			No
18. Permanence and Buffer Pool Contributions	6.1 Contributions to the Buffer Pool	X	X	X	No
19. Permanence and Compensating for Reversals	6.2 Compensating for Reversals 6.2.1 Avoidable Reversals 6.2.2 Unavoidable Reversals	X	X	X	No

Table 8.1 comprises the full list of verification items required to be part of verification activities. To assist with performing verifications, the Reserve provides Verification Elements tables below (Tables 8.2, 8.3, 8.4) that include additional details on verification standards and periodicity.

[16] Verifiers must use professional judgment to verify protocol criteria which are not quantitative or can be measured completely with objective analysis.

Table 8.2. Verification Guidance

Verification Element	Description	Verification Frequency
I	All items in Table 8.1 have been reviewed and deemed satisfactory by the verifier, both in terms of clear presentation and aligned with the protocol requirements.	Initial full verification only. For projects using project-specific ratio estimators, full site verification is required during the initial verification.
II	Review project Assessment Area(s) or stratum. Verifier shall inspect the project map and determine if the entire Project Area is assigned using the correct Assessment Area(s), or are employing the appropriate methodology per the Quantification Guidance for stratification (if stratifying) for projects developing project-specific ratio estimators. Determination of the appropriateness of the Assessment Area used or stratification will occur during review of evidence provided by the Project Operator (such as aerial imagery) or through a site visit, if applicable.	Initial full verification. For projects using project-specific ratio estimators, full site verification is required during the initial verification, and each time the project opts to update its field-based inventory and ratio estimator(s).
III	Confirm Project Area boundaries are within eligible Project Areas, including evaluation of the accuracy and conservativeness of the project acreage. Determination will occur during review of evidence provided by the Project Operator (such as aerial imagery) or through a site visit, if applicable. A comparison between the acreage of the Project Area identified by AP and GIS sources has been made and the lesser of the two has been used for the final Project Area. However, if the Project Operator opts to use GIS acres, an evaluation of the accuracy of GIS acres must be performed based on a review of supporting documentation (e.g., boundary survey) and ground-truthing activities and will require a site visit.	Initial full verification. For projects using project-specific ratio estimators, full site verification is required during the initial verification, and each time the project opts to update its field-based inventory and ratio estimator(s).
IV	Confirm all aspects of the Quantification Guidance have been implemented correctly.	Each verification.
V	Confirm that the calculation or identification of ratio estimators, expansion to Assessment Area(s) or stratum (for projects developing their own ratio estimators), and expansion to overall Project Area, for historical estimates and current estimates, were implemented correctly.	Each verification.
VI	Confirm that confidence statistics for canopy cover were correctly calculated and meet minimum requirements per the Quantification Guidance.	Each verification.

8.3 Verifying Urban Forest Management Carbon Estimates

The method of verification of carbon estimates varies depending on whether the verification is part of the initial verification, full verification, or an optional desk review verification. The verification elements and their periodicity are explained in this section.

Table 8.3. Verification Guidance for Quantification

Verification Element	Description	Verification Frequency
I (Legal Constraints in the Baseline)	Assess applicable legal constraints that may affect carbon stocks in the Project Area. Confirm that such legal constraints are appropriately modeled into the baseline, per the Quantification Guidance.	Initial full verification.
II (Legal Constraints Review)	Confirm whether there are new, unanticipated legal constraints that may affect carbon stocks in the Project Area.	Each verification.
III (Historical Tree Canopy Area)	Confirming that the methodology for quantifying the historical tree canopy area specified in the Quantification Guidance was implemented correctly as stated in the quantification guidance, as part of the initial full verification. The verifier must independently calculate the canopy area for each applicable Assessment Area (or stratum) using a randomized selection of points used by the Project Operator. The points must be overlaid on the remote sensing image the Project Operator used to generate their estimate/measurement of canopy area. The verifier shall determine if each point 'hits' or 'misses' a tree crown. The verifier shall sample enough points (or plots for projects developing their own ratio estimators) to arrive at a determination of canopy area with +/- 5% at 1 Standard Error for each Assessment Area. The percentage canopy area determined by the verifier must be within 10% of the estimate provided by the Project Operator. The verifier may repeat their effort if the Project Operator is not in conformance with the verifier. Failure to find conformance after three efforts results in failure of the ability to verify the reported canopy area. The Project Operator must resample/re-measure the canopy area and prior to renewing verification activities. The i-Tree Canopy tool may be used to perform the analysis. The Reserve recommends the verifier replicate the approach used by the Project Operator, but verifiers should use professional judgement to determine whether the approach is sound.	Initial full verification.
IV (Current Tree Canopy Area)	Confirming that the methodology for quantifying current tree canopy area specified in the Quantification Guidance was implemented correctly as stated in the quantification guidance. The verifier must independently calculate the canopy area for each Assessment Area if the project spans multiple Assessment Areas, or the Project Area using a randomized or systematic	Each verification.

Verification Element	Description	Verification Frequency
	application of points used by the Project Operator. The points must be overlaid on the remote sensing image the Project Operator used to generate their estimate/measurement of canopy area. The verifier shall determine if each point 'hits' or 'misses' a tree crown. The verifier shall sample enough plots to arrive at a determination of canopy area with +/- 10% at 90% confidence interval. The percentage canopy area determined by the verifier must be within 10% of the estimate provided by the Project Operator. The verifier may repeat their effort if the Project Operator is not in conformance with the verifier. Failure to find conformance after three efforts results in failure of the ability to verify the reported canopy area. The Project Operator must resample/re-measure the canopy area and prior to renewing verification activities. The i-Tree Canopy tool may be used to perform the analysis.	
V (Carbon Estimates for Ratio Estimators)	Confirming that the methodology and requirements for quantifying carbon estimates specified in the Quantification Guidance were implemented correctly.	Each verification.
VI (Ratio Estimators and Summary Calculations)	Confirming that ratio estimators are correctly calculated (or selected, if default ratio estimators are used) and expansions to the Project Area are performed correctly.	Initial full verification.
VII (Updated Project Data)	Confirming that updated emission reduction estimates are accurate, and the project is continuing to use the same ratio estimator as previous verifications.	Each verification following the initial full verification.

8.3.1 Field-Based Inventory Verification Activities

This section applies only to projects that choose to calculate and use their own ratio estimators. For these projects, verification bodies are required to conduct a site visit and verify carbon stock inventory calculations of all sampled and/or measured carbon pools within the Project Area. Inventories of carbon stocks may be used to determine the project baseline and to quantify GHG reductions and removals against the project baseline over time. In these cases, the verification activities must include re-measurement of a randomly selected subset of project data used to calculate the inventory estimate for the project. The data sampled by verifiers are the tree canopy measurements and the ground-based plot measurements. The verification approach for all metrics derived from measured and/or sampled data is based on a randomly selected comparison of verifier data to Project Operator data in a process referred to as sequential sampling.

Verification using the sequential sampling methodology requires the verification body to sequentially sample successive plots. Sequential approaches have stopping rules rather than

fixed sample sizes. Verification is successful after a minimum number of successive plots in a sequence indicate agreement according to the tolerance thresholds established in the sequential sampling workbook provided by the Reserve. The evaluation of the three themes that utilize sequential sampling (CO_2e estimates from plots, current tree canopy area, and historical tree canopy area) shall utilize separate worksheets and include a copy of the results within the verification report.

Where sequential data calculated from the verifier result in a trend of agreement with the Project Operator, verification can proceed toward a finding of accuracy. The minimum number of plots measured by the verifier and the tolerance bounds are established by the Reserve and described in the Quantification Guidance. Where a high level of agreement is found between the Project Operator and the verifier, a finding of acceptable accuracy may be established with the minimal number of plots required by the Reserve. As divergence between verifier estimates and Project Operators increases, the number of plots measured by the verifier must increase in order to work toward establishing a finding of acceptable accuracy. In cases where continued verifier effort does not result in convergence, the Project Operator must decide whether continued investment in verification effort is justified. Alternatively, verification can be suspended while the Project Operator improves the quality of the inventory and revises related project documentation. Verification of measured and/or sampled data must be reinitiated following any modifications to measured and/or sampled data during verification activities.

The sequential sampling workbook provided by the Reserve includes the established stopping rules. Where agreement between the verifier estimates and the Project Operator estimates is within specified tolerance bounds, verification of plot data is successful. Sequential sampling is described in greater detail in the next section.

For the verification of canopy area used to generate ratio estimators, CO_2e estimates from ground-based plots and stratification of urban forest classes, the verifier must randomly select an initial set of 40 ground-based sample plots from the full set of plots measured by the Project Operator, maintaining the order of their selection in sequential order (1 – 40). The verifier must develop an initial strategy to efficiently visit (both in the office and in the field) the first 20 plots (1 – 20) in the list. The plots do not need to be visited and measured sequentially, but they all need to be visited prior to entering the data in the sequential sampling works. The entries of plot summaries into the sequential sampling workbook provided by the Reserve must be in the same order the plots were randomly selected.

The verifier shall visit the same plots in the field to continue verification for the following elements in Table 8.4.

Table 8.4. Verification Guidance for Field Inventories

Verification Element	Description	Verification Frequency
I	If a project has chosen to implement stratification within the Project Area, the verification of accurate stratification must occur simultaneously with the verification of ground-based plots (described below) for carbon estimates. The verifier must determine if the stratum identified for each plot is appropriate or not based on characteristics present during the field visit using professional judgment with the consideration for minimum mapping units described in the Quantification Guidance. The project must achieve a 90% approval rating from the set of the 20 selected plots. **Consequences of failing to meet the accuracy requirements for stratification:** In the event that adequate accuracy cannot be confirmed from the first 20 plots, the verifier must visit and evaluate the second set of 20 randomly selected plots as above. The 90% approval rating must be achieved by the full set of 40 visited plots. If the project does not succeed following evaluation of 40 plots, the Project Operator must refine their stratification and update the plot association with urban forest classes before continuing with verification activities.	Initial full verification. For projects using project-specific ratio estimators, full site verification is required each time the project opts to update its field-based inventory and ratio estimator(s).
II	Ensuring that the CO_2e estimates from individual plots are accurate. The verifier must independently calculate per-acre estimates of CO_2e for each of the 20 plots randomly selected by the verifier, utilizing the sampling methodology described in the Quantification Guidance. The verifier shall measure the trees on each plot, calculating the CO_2e values represented by the trees using the appropriate biomass equations (provided on the Reserve's website), conversion and expansion factors (provided in the Quantification Guidance). The results from the verifier's calculations shall be compared with the Project Operator's estimates for the same 20 plots using the sequential sampling worksheet provided by the Reserve. Measurement standards for verifiers include: a. Measuring every diameter (DBH) to the nearest inch. b. Measuring every height (total height) to the nearest foot. Measuring every tree that is 'borderline' to determine if the tree is either in the plot or out of the plot.	Initial full verification. For projects using project-specific ratio estimators, full site verification is required each time the project opts to update its field-based inventory and ratio estimator(s).

Where the Project Operator and verifier are not in agreement after the verifier data from the 20 initial verification plots has been inputted into the sequential sampling worksheets for each of the themes, additional sets of 20 plots (in 20 plot lots as described for the initial set) may be randomly selected to add to the total set of verification plots. The decision to add additional plots to the total set of verification plots is primarily the Project Operators, based on an assumption

that random chance caused the initial test to fail and convergence towards agreement would occur with additional verification effort.

The results of any additional verification plot may also be inconclusive and require additional verification plots for a determination to be made. For effective application of the sequential sampling statistics in the field, the determination of when the stopping rule is met is done at the end of the measurement of a batch of plots (20 plots) in the field.

Worksheets are provided on the Reserve's website[17] for use by verifiers to assist in verifying sampled data. The Reserve has established a ten percent allowance as an acceptable level of agreement between the verifier and the Project Operator.

8.4 Completing the Verification Process

After completing the core verification activities for a project, the verification body must do the following to complete the verification process:

1. Complete a detailed List of Findings containing both immaterial and material findings (if any) and deliver it to the Project Operator (private document).
2. Exchange correspondence as necessary to resolve issues detailed in the List of Findings, until all material misstatements and nonconformances have been addressed.
3. If a reasonable level of assurance opinion is successfully obtained, complete a Verification Report to be delivered to the Project Operator (public document).
4. Complete the Verification Statement form, detailing the vintage and the number of GHG reductions and removals verified and deliver it to the Project Operator (public document).
5. Verify that the number of GHG reductions and removals, as well as the reversal risk rating, specified in the Verification Report and Statement match the number entered into the Reserve software.
6. Conduct an exit meeting with the Project Operator to discuss the Verification Report, List of Findings, and Verification Statement.
7. Upload electronic copies of the Verification Report, List of Findings, Verification Statement, and Verification Activity Log into the Reserve.

The recommended content for the verification report, list of findings, and verification statement can be found in the Reserve's Verification Program Manual.[18] The Verification Program Manual also provides further guidance on quality assurance, negative verification statements, use of an optional project verification activity log, goals for exit meetings, dispute resolution, and record keeping.

[17] Available at http://www.climateactionreserve.org/how/protocols/urban-forest/.
[18] Available at http://www.climateactionreserve.org/how/program/program-manual/.

9 Glossary of Terms

Additionality	GHG emission reductions should occur as a result of specific GHG mitigation incentives; additionality is achieved when GHG reductions are beyond what would occur under business as usual operation and result from activities that are not mandated by regulation.
Assessment Area	Geographically discrete regions used to identify appropriate default ratio estimators for projects. Such regions are defined by the Reserve based on sampled cities and terrestrial ecoregions. Maps of the Assessment Areas and the associated data may be found on the Reserve's website.
Avoidable Reversal	An avoidable reversal is any reversal that is due to the project operator's negligence, gross negligence, or willful intent, including harvesting, development, and harm to the project area.
Baseline	An estimate of GHG emissions and removals that would have occurred in absence of the project under business as usual operations.
Best Management Practices	Management practices determined by a state or designated planning agency to be the most effective and practicable means (including technological, economic, and institutional considerations) of controlling point and nonpoint source pollutants at levels compatible with environmental quality goals.[19]
Biological Emissions	For the purposes of the Urban Forest Management Project Protocol, biological emissions are GHG emissions that are released directly from forest biomass, both live and dead, including forest soils. Biological emissions are deemed to occur when the reported tonnage of onsite carbon stocks, relative to baseline levels, declines from one year to the next.
Biomass	The amount of living matter comprising, in this case, a tree.
Bole	The trunk or main stem of a tree.
Buffer Pool	The buffer pool is a holding account for urban forest project CRTs administered by the Reserve. It is used as a general insurance mechanism against unavoidable reversals for all UFM projects registered with the Reserve.
Business As Usual	The activities, and associated GHG reductions and removals that would have occurred in the project area in

[19] Helms, J.A. (1998). The dictionary of forestry. Bethesda, MD: Society of American Foresters.

	the absence of incentives provided by a carbon offset market.
Carbon Pool	A reservoir that has the ability to accumulate and store carbon or release carbon. In the case of forests, a carbon pool is the forest biomass, which can be subdivided into smaller pools. These pools may include above-ground or belowground biomass or roots, litter, soil, bole, branches and leaves, among others.
Carbon Sink	A carbon sink is any process, activity or mechanism that removes carbon dioxide from the atmosphere.
Carbon Source	A carbon source is any process or activity that releases carbon dioxide into the atmosphere.
Carbon Stock	A pool of stored carbon. Urban forest carbon stocks include biomass of the project trees. Include living and standing dead vegetation, woody debris and litter, organic matter in the soil, and harvested stocks such as wood for wood products and fuel.
Carbon Stock Change or Carbon Sequestration	The annual incremental change in carbon stocks.
CO_2-equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Certified Arborist	Certified Arborist is the rank of a Registered Consulting Arborist (or above), as certified by the International Society of Arboriculture.
Certified Forester	A professional with certified forester credentials managed by the Society of American Foresters (see www.certifiedforester.org). See also, Professional Forester.
Certified Urban Forester	An urban forester meeting the criteria and having passed the test created by the California Urban Forests Council, and now administered nationally by the Society of American Foresters.
Climate Reserve Tonnes (CRT)	One metric ton (tonne) of verified CO_2 equivalent emission reduction or sequestration.
Entity	The individual, organization, agency or corporation that owns, controls, or manages urban trees.
Global Warming Potential (GWP)	Factors used to convert emissions from GHGs other than carbon dioxide to their equivalent carbon dioxide emissions.

Greenhouse Gas (GHG)	Greenhouse gases mean carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).
GHG Assessment Boundary	The GHG Assessment Boundary defines all the GHG sources, sinks, and reservoirs that must be accounted for in quantifying a project's GHG reductions and removals.
KML	KML (Keyhole Markup Language) is an XML-based file format used to display geographic data in an Earth browser such as Google Earth, Google Maps, and Google Maps for mobile.
Leakage	According to the Intergovernmental Panel on Climate Change: "the unanticipated decrease or increase in greenhouse gas benefits outside of the project's accounting boundary as a result of project activities."
Municipality	A city or town that has corporate status and local government
Permanence	The requirement that GHGs must be permanently reduced or removed from the atmosphere to be credited as carbon offsets. For UFM projects, this requirement is met by ensuring that the carbon associated with credited GHG reductions and removals remains stored for at least 100 years.
Places	Places are defined by the U.S. Census Bureau and are composed of Incorporated Places and Census-Designated Places. Generally, an Incorporated Place is an area that is legally incorporated under the laws of its respective state, whereas a Census-Designated Place is a community that lacks a separate government but otherwise resemble incorporated places, with a residential core, relatively high population density, and a degree of local identity. The most recent definition provided by the U.S. Census Bureau can be found at https://www.census.gov/geo/reference/gtc/gtc_place.html
Primary Effect	The project's intended change in carbon stocks, GHG emissions or removals.
Professional Forester	A professional engaged in the science and profession of forestry. A professional forester is credentialed in jurisdictions that have professional forester licensing laws and regulations. Where a jurisdiction does not have a professional forester law or regulation then a professional forester is defined as having the certified forester credentials managed by the Society of American Foresters (see www.certifiedforester.org).
Project Activity	The carbon storage, emission reductions, and emissions due to an urban forest management project.

Project Area	The area inscribed by the geographic boundaries of a project.
Project Start Date	The start date is initiated by activities that increase carbon inventories and/or decrease emissions relative to the baseline.
Project Life	Refers to the duration of a project and its associated monitoring and verification activities.
Project Inventory	The inventory of trees eligible to generate emission reductions or removals in a project. Developed according to the guidelines in the Quantification Guidance.
Project Operator	One of the urban forest owners or a legally created entity to represent the urban forest owners that is responsible for undertaking a project.
Project Submission Date	The date that a project is submitted for listing in the Reserve program. The Reserve considers a project to be "submitted" when all of the appropriate forms have been uploaded to the Reserve's software system, and the project operator has paid a project submission fee.
Registered Consulting Arborist	An arborist meeting the criteria and having passed all the qualification requirements of the American Society of Consulting Arborists (http://www.asca-consultants.org/about/rca.cfm).
Reporting Period	The time period for which an entity is reporting its project activity and quantifying GHG reductions. This period will typically be 12 months, except for 1) the initial reporting period which begins at the project commencement date and may be more than 12 months, and 2) the second reporting period, which may be less than 12 months.
Reversal	A reversal is a decrease in the stored carbon stocks associated with quantified GHG reductions and removals that occurs before the end of the project life. Under this protocol, a reversal is deemed to have occurred if there is a decrease in the difference between project and baseline onsite carbon stocks from one year to the next, regardless of the cause of this decrease (i.e., if the result of (Δ AC_{onsite} - Δ BC_{onsite}) in Equation 5.1 is negative).
Sampled Cities	Places and urban areas, as defined by the U.S. Census Bureau, that have been discretely sampled for the development of ratio estimators and serve as the basis, along with terrestrial ecoregions, for the definition of Assessment Areas.
Secondary Effects	Unintended changes in carbon stocks, GHG emissions, or GHG removals caused by the project.
Sequestration	The process by which trees remove carbon dioxide from the atmosphere and transform it into biomass.

Terrestrial Ecoregions	Areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources, as delineated by the Commissions for Environmental Cooperation, which serve as the basis, along with sampled cities, for the definition of Assessment Areas.
Tree	A woody perennial plant, typically large and with a well-defined stem or stems carrying a more or less definite crown with the capacity to attain a minimum diameter at breast height of five inches and a minimum height of 15 feet with no branches within three feet from the ground at maturity.[20]
Unavoidable Reversal	An unavoidable reversal is any reversal not due to the project operator's negligence, gross negligence or willful intent, including windstorms or disease that are not the result of the project operator's negligence, gross negligence or willful intent.
Urban Area	Urban areas are defined by the U.S. Census Bureau and are composed of urbanized areas (areas with populations ≥50,000 people) and urban clusters (populations ≥2,500 and <50,000). The most recent urbanized area definition provided by the U.S. Census Bureau can be found at http://www.census.gov/geo/maps-data/maps/2010ua.html.
Urban Forest Management Project (UFM Project, project)	A planned set of activities designed to increase removals of CO_2 from the atmosphere, or reduce or prevent emissions of CO_2 to the atmosphere, through increasing and/or conserving urban forest carbon stocks. An urban forest management (UFM) project focuses on activities that maintain or increase carbon inventories relative to baseline levels of carbon within the project boundary. Eligible activities may include, but are not limited to, increasing the urban forest productivity by removing diseased and suppressed trees, reducing emissions by avoiding tree clearing, and planting additional trees on available and appropriate sites.
Urban Forest Owner	A corporation, legally constituted entity (such as a utility), city, county, state agency, individual(s), or combination thereof that has legal control (e.g., right to plant or remove, etc.) of any amount of urban forest carbon within the project area.
Verification	The process of reviewing and assessing all of a project's reported data and information by an ISO-accredited and Reserve-approved verification body, to confirm that the project operator has adhered to the requirements of this protocol.

[20] Helms, J.A. (1998). The dictionary of forestry. Bethesda, MD: Society of American Foresters.

Verification Cycle	The Reserve requires full verification of projects every five reporting periods, but project operators can choose to have more frequent 'desktop' verifications. In between site visits, desk reviews of project reports can be completed by an approved verification body. The Reserve will only issue CRTs for verified emission reductions.
Verification Period	The period of time over which GHG reductions/removals are verified. A verification period may cover up to five reporting periods. The end date of any verification period must correspond to the end date of a reporting period.

CLIMATE ACTION RESERVE

Version 2.0 | June 25, 2014

Urban Tree Planting

Project Protocol

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Released June 25, 2014

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Substantial funding for the development of the revised Urban Tree Planting Project Protocol was provided through a grant from the California Department of Forestry and Fire Prevention.

Table of Contents

Abbreviations and Acronyms 1

1 Introduction 2
1.1 About Urban Forests, Carbon Dioxide and Climate Change 2
2 Urban Tree Planting Definition and Requirements 4
2.1 Project Definition 4
2.2 Urban Forest Owners 4
2.3 Project Operators 4
2.4 Project Implementation Agreement 5
3 Eligibility Rules 6
3.1 Project Location 6
3.2 Project Area 6
3.3 Project Commencement 6
3.4 Additionality 6
3.4.1 Legal Requirement Test 7
3.4.2 Performance Test 7
3.5 Project Crediting Period 7
3.6 Minimum Time Commitment 7
3.7 Social and Environmental and Co-Benefits 8
3.7.1 Social Co-Benefits 8
3.7.2 Environmental Co-Benefits 8
4 GHG Assessment Boundaries 10
5 Quantifying Net GHG Reductions and Removals 13
5.1 Urban Tree Planting Baseline 15
6 Ensuring the Permanence of Credited GHG Reductions and Removals 16
6.1 Contributions to the Buffer Pool 17
6.2 Compensating for Reversals 17
6.2.1 Avoidable Reversals 17
6.2.2 Unavoidable Reversals 17
6.3 Disposition of Projects after a Reversal 18
7 Project Monitoring, Reporting, and Verification 19
7.1 Project Documentation 19
7.1.1 Urban Forest Project Design Document 20
7.2 Monitoring Report 20
7.3 Reporting and Verification Cycles 21
7.3.1 Reporting Period Duration and Cycles 21
7.3.2 Verification Cycles 22
7.3.3 Requirements of Onsite Verifications 22
7.3.4 Desk Review Verification 22

7.4 Issuance and Vintage of CRTs....23
7.5 Record Keeping....23
7.6 Transparency....23
8 Verification Guidance....24
8.1 Standard of Verification....24
8.2 Project Verification Activities....25
8.2.1 Initial Verification....25
8.2.2 Onsite Verification....25
8.2.3 Optional Annual Verification....25
8.3 Verifying Carbon Inventories....27
8.3.1 Verification of Urban Tree Planting Project Inventories....27
8.4 Completing the Verification Process....29
9 Glossary of Terms....30

List of Tables

Table 3.1. Social Co-Benefits of Urban Tree Planting Projects..... 8
Table 3.2. Environmental Co-Benefits of Urban Tree Planting Projects..... 9
Table 4.1. Description of all Sources, Sinks, and Reservoirs.....10
Table 7.1. Project Documentation Submittal Requirements 19
Table 8.1. Verification Items and Related Schedules 26

List of Figures

Figure 7.1. Urban Tree Planting Reporting Periods.....22

List of Equations

Equation 5.1. Annual Net GHG Reductions and Removals 14

Abbreviations and Acronyms

C	Carbon
CAL FIRE	California Department of Forestry and Fire Protection
CH_4	Methane
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
DBH	Diameter at Breast Height
FIA	Forest Inventory and Analysis Program of the U.S. Forest Service
GHG	Greenhouse gas
GIS	Geographical Information System
ISO	International Organization for Standardization
KML	Keyhole Markup Language (see glossary)
N_2O	Nitrous oxide
PDD	Project Design Document
PIA	Project Implementation Agreement
Reserve	Climate Action Reserve
RPF	Registered Professional Forester (California only)
SSR	Source, sink, or reservoir
UFM	Urban forest management
USFS	United States Forest Service
UTP	Urban tree planting
VOC	Volatile Organic Compound

1 Introduction

The Urban Tree Planting (UTP) Project Protocol provides requirements and guidance for quantifying the net climate benefits of activities that sequester carbon in woody biomass within an urban environment. The protocol provides project eligibility rules, methods to calculate a project's net effects on greenhouse gas (GHG) emissions and removals of carbon dioxide (CO_2) from the atmosphere ("removals"), procedures for assessing the risk that carbon sequestered by a project may be reversed (i.e. released back to the atmosphere), and approaches for long term project monitoring and reporting.

The goal of this protocol is to ensure that the net GHG reductions and removals caused by a project are accounted for in a complete, consistent, transparent, accurate, and conservative manner[1] and may therefore be reported to the Climate Action Reserve (Reserve) as the basis for issuing carbon offset credits (called Climate Reserve Tonnes, or CRTs). Additionally, it is the goal of the Reserve to ensure the protocol is as efficient and practical as possible for Project Operators.

As the premier carbon offset registry for the North American carbon market, the Reserve encourages action to reduce GHG emissions by ensuring the environmental integrity and financial benefit of emission reduction projects. The Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, issues carbon credits generated from such projects, and tracks the transaction of credits over time in a transparent, publicly-accessible system. The Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California.[2]

Only projects that are eligible under and comply with the UTP Project Protocol may be registered with the Reserve. Section 8 of this protocol provides requirements and guidance for verifying the performance of project activities and their associated GHG reductions and removals reported to the Reserve.

1.1 About Urban Forests, Carbon Dioxide and Climate Change

Urban forests have the capacity to both emit and absorb CO_2, a leading greenhouse gas that contributes to climate change. Trees, through the process of photosynthesis, naturally absorb CO_2 from the atmosphere and store the gas as carbon in their biomass, i.e. trunk (bole), leaves, branches, and roots. Carbon may also be stored in the soils that support the urban forest, as well as the understory plants and litter on the urban forest floor. After trees are removed, their wood residue may be converted into mulch, with CO_2 gradually released to the atmosphere through decomposition. Carbon may continue to be sequestered for a substantial amount of time in wood products and in landfills. Carbon from urban forests may also be used to provide fuel for biomass energy. Urban trees can reduce summertime air temperatures and building energy use for air conditioning, thus reducing GHG emissions from electricity generation (Akbari 2002). In winter, trees can increase or decrease GHG emissions associated with energy consumed for space heating, depending on local climate, site features, and building characteristics (Heisler 1986).

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.
[2] For more information, please visit www.climateactionreserve.org.

When trees are disturbed, through events like fire, disease, pests, or harvest, some of their stored carbon may oxidize or decay over time, releasing CO_2 into the atmosphere. The quantity and rate of CO_2 that is emitted may vary, depending on the particular circumstances of the disturbance. Depending on how urban forests are managed or impacted by natural events, they can be a net source of emissions, resulting in a decrease to the reservoir, or a net sink of emissions, resulting in an increase of CO_2 to the reservoir. In other words, urban forests may have a net negative or net positive impact on the climate.

2 Urban Tree Planting Definition and Requirements

For the purposes of this protocol, an Urban Tree Planting (UTP) Project is a planned set of activities designed to increase removals of CO_2 from the atmosphere, or reduce or prevent emissions of CO_2 to the atmosphere, through increasing and/or conserving urban forest carbon stocks.

A glossary of terms used in this protocol is provided in Section 9. Throughout the protocol, important defined terms are capitalized (e.g. "Urban Forest Owner").

2.1 Project Definition

A UTP Project is a project where new trees are planted in areas where trees have not been harvested with a primary commercial interest during the 10 years prior to the Project Commencement Date. Only planted trees and trees that regenerate from planted trees are eligible to be quantified for credits. Benefits from urban tree planting activities occur when the net CO_2e (CO_2e stored minus CO_2e emitted) associated with planted trees exceeds baseline tree planting CO_2e levels.

2.2 Urban Forest Owners

Credits for a UTP Project must be quantified from carbon that is owned by participating entities. An Urban Forest Owner is a corporation, a legally constituted entity (such as a utility or special district), city, county, state agency, educational campus, individual(s), or a combination thereof that has legal control of any amount of urban forest carbon[3] within the Project Area.

Control of urban forest carbon means the Urban Forest Owner has the legal authority to effect changes to urban forest carbon quantities (right to plant or remove, for example). Control of urban forest carbon occurs, for purposes of satisfying this protocol, through fee ownership, perpetual contractual agreements, and/or deeded encumbrances. This protocol recognizes the fee owner as the default owner of urban forest carbon where no explicit legal encumbrance exists. Individuals or entities holding mineral, gas, oil, or similar *de minimis*[4] interests without fee ownership are precluded from the definition of Urban Forest Owner.

2.3 Project Operators

A Project Operator must be one of the Urban Forest Owners or a legally created entity to represent the Urban Forest Owners. The Project Operator is responsible for undertaking a UTP Project and registering it with the Reserve, and is ultimately responsible for all project listing, monitoring, reporting, and verification. The Project Operator is responsible for any reversals associated with the project and is the entity that executes the Project Implementation Agreement (see below) with the Reserve.

In all cases where multiple Urban Forest Owners participate in a UTP Project, the Project Operator must secure an agreement from all other Urban Forest Owners that assigns authority to the Project Operator to include the carbon they own in the project, subject to any conditions imposed by any of the Urban Forest Owners to include or disallow any carbon they control and any provisions to opt out of the project.

[3] See definition of Carbon Stock in the glossary.
[4] *de minimis* control includes access right of ways and residential power line right of ways.

2.4 Project Implementation Agreement

A Project Implementation Agreement (PIA) is a required agreement between the Reserve and a Project Operator setting forth the Project Operator's obligation (and the obligation of its successors and assigns) to comply with the UTP Project Protocol.

3 Eligibility Rules

In addition to the definitions and requirements described in Section 2, projects must meet several other criteria and conditions to be eligible for registration with the Reserve, and must adhere to the following requirements related to their duration and crediting periods.

3.1 Project Location

Only those activities that occur within the Urban Area boundaries, defined by the most recent publication of the United States Census Bureau (http://www.census.gov/geo/maps-data/maps.html), are eligible to develop a project under this protocol. Projects must be entirely within the Urban Area boundary as of Project Commencement.

3.2 Project Area

The Project Area is the geographic extent of the UTP Project. The Project Area may be made up of consolidated or disaggregated polygons. A KML file must be submitted with the project to clearly identify the project boundaries. There are no size limits for UTP Projects.

No part of the Project Area can be included if commercial harvesting of timber has occurred in the Project Area in the past 10 years. Additionally, the issuance and transaction of credits will be suspended if commercial harvesting of timber products occurs any time during the project. Where the harvesting of commercial timber products is anticipated, the OPO should consider the use of a protocol that addresses the carbon stored in harvested wood products, such as the Reserve's Forest Protocol or the California Air Resource's Board Compliance Forest Protocol. Exceptions to the prohibition of harvesting commercial timber products are recognized where the provision of commercial timber products might be generated where harvests are conducted primarily for safety, salvage of material when trees are in decline, and developing improved resilience to wildfire and pests.

3.3 Project Commencement

The commencement date for a project is the date at which the Project Operator initiates an activity that will lead to increased GHG reductions or removals with long-term security relative to the project baseline. The earliest acceptable activity that demonstrates the commencement of project activities is a formal planning process by the Project Operator. Subsequent activities to planning, including the purchase of equipment for tree planting, site preparation, or planting trees, with a plan in place, also demonstrate a project has commenced. Once a UTP Project has commenced, new plantings can occur within the Project Area throughout the Project Life. Discrete and verifiable evidence that acceptable activity has occurred includes signed contracts and/or direct evidence of the recent activity.

To be eligible, the project must be submitted to the Reserve no more than six months after the project commencement date.[5] Projects may always be submitted for listing by the Reserve prior to their start date.

3.4 Additionality

The Reserve will only register projects that yield surplus GHG emission reductions and removals that are additional to what would have occurred in the absence of a carbon offset

[5] Projects are considered submitted when the project developer has completed and uploaded the appropriate project submittal forms to the Reserve software.

market (i.e. under "Business As Usual"). For a general discussion of the Reserve's approach to determining additionality, see the Reserve's Program Manual.[6]

Projects must satisfy the following tests to be considered additional.

3.4.1 Legal Requirement Test

UTP Projects must achieve GHG reductions or removals above and beyond any GHG reductions or removals that would result from compliance with any federal, state, or local law, statute, rule, regulation, or ordinance. Projects must also achieve GHG reductions and removals above and beyond any GHG reductions or removals that would result from compliance with any court order or other legally binding mandates. Deeded encumbrances, tree-planting and management ordinances, and contractual agreements, collectively referred to as Legal Agreements, may effectively control urban forest carbon and possess ownership rights to the carbon inventories controlled. Similarly, deeded encumbrances, tree planting and management ordinances, and contractual agreements may have an effect on urban forest carbon inventories beyond the control of any of the Urban Forest Owners.

Trees planted to fulfill a legal requirement are ineligible under this protocol. Legal requirements include any requirement issued by authority of a federal, state, or local jurisdiction to plant trees for any reason.

3.4.2 Performance Test

Projects must achieve GHG reductions or removals above and beyond any GHG reductions or removals that would result from engaging in Business As Usual activities, as defined by the requirements described below.

3.4.2.1 Performance Standard for Urban Tree Planting Projects

The performance standard metrics are based on the averages of data between the 50th and 100th percentiles. The data are based on the following data:

1. For Municipalities/counties: trees per capita.
2. Educational institutions: trees per acre of maintained landscaping.
3. Utilities: trees per ratepayer

Project Operators must include the performance standard level of planting in their baseline calculations as described in the Quantification Guidance supplemental to this protocol.

3.5 Project Crediting Period

The crediting period for UTP Projects is 25 years. Projects may be renewed for additional crediting periods with the prospect of incorporating updated technology into the project analysis. The initial baseline can be maintained for the crediting period. While the project can be renewed indefinitely, the baseline must be renewed at the end of the crediting period. Any previously issued credits are respected for the life of the project.

3.6 Minimum Time Commitment

Projects must monitor, report, and undergo verification activities for 100 years following the last credit issued to the project.

[6] Available at http://www.climateactionreserve.org/how/program/program-manual/.

3.7 Social and Environmental and Co-Benefits

All projects will provide climate benefits to the extent in which they generate credits. Urban forests provide many additional benefits, including environmental, social, and public health benefits. The ability to achieve additional environmental and social co-benefits depends on consideration of additional factors, some of which are described in this section. Only those projects where public and/or tribal entities participate in direct urban tree management activities (e.g., planting, tree distribution, etc.) are required to include the provisions for social and environmental co-benefits. However, these provisions may serve as suggestions to NGOs and other privately funded projects that may wish to enhance social and environmental co-benefits. Where required, the provisions must be described in the Project Design Document (PDD) and implemented throughout the Project Life. The Reserve has developed a tree-planting template that outlines elements that need to be addressed and provides important considerations that may be helpful in decision-making.[7] The template provides considerations that will enable verifiers to ensure progress is being achieved over time.

3.7.1 Social Co-Benefits

UTP Projects can create long-term climate benefits as well as providing other social and environmental benefits. Investment in projects has the potential to improve the quality of life for urban communities in a number of ways. Among other benefits, tree planting projects can improve air quality and reduce storm water runoff, provide shade, and increase property values by creating a more aesthetically pleasing environment. Projects also have the potential to create negative social externalities such as an uneven distribution of project benefits due to an uneven distribution of projects sites throughout a community (e.g. skewed toward more affluent communities).

Table 3.1. Social Co-Benefits of Urban Tree Planting Projects

Social Provisions	Elements to Include in the Project Design Document (PDD)
Equitable distribution of forest resources	Describe how the project will make progress toward achieving relatively equal distribution of tree canopy cover by neighborhood whenever possible.
Public participation	Establish guidelines to ensure adequate notification, opportunities for public participation, and documentation with regards to public activities with urban forest management.

3.7.2 Environmental Co-Benefits

The protocol has a goal of permanently removing greenhouse gases from the atmosphere by sustaining carbon benefits generated from urban forests for at least 100 years. Healthy urban forests can also provide a number of environmental benefits as well as create negative externalities. Projects have the potential to improve air quality and reduce storm water runoff and energy usage. They can also contribute to reduced biodiversity, introduce invasive species, and damage infrastructure. Inefficient water usage during maintenance can also put pressure on local and regional water supplies.

[7] Available at http://www.climateactionreserve.org/how/protocols/urban-forest/.

Table 3.2. Environmental Co-Benefits of Urban Tree Planting Projects

Environmental Provisions	Elements to Include in the Project Design Document (PDD)
Biodiversity	Describe how UTP Project activities will maintain and enhance biodiversity, including: 1. Benefits of tree species selection and composition to biodiversity within the project area. 2. Use of specific tree species, sizes and/or distributions to support unique habitat elements.
Native species	Describe how UTP Project activities will promote the use of native species, including: 1. Strengths and limitations of using native trees in the UTP Project. 2. Preferential treatment of native species.
Non-native species	Describe how UTP Project activities will limit and target the use of any non-native species, including: 1. Strengths and limitations of using non-native trees in the UTP Project. 2. Resistance to insects and disease.
Climate change resilience	Describe how UTP Project activities will enhance the resilience of the urban forest to climate change, including: 1. Ability of urban forest to adapt to climate change. 2. Resistance to natural disturbances.
Air quality	Describe how UTP Project activities will enhance air quality benefits, including: 1. Tree selection and distribution to reduce air pollutants. 2. Tree selection and distribution to reduce emissions of Biogenic Volatile Organic Compounds (BVOCs). 3. Design tree maintenance activities to reduce fossil fuel emissions.
Physical characteristics	Describe how UTP Project activities will enhance physical characteristics of the urban environment, including: 1. Tree shading. 2. Wind protection. 3. Minimize disturbance to city infrastructure (e.g. sidewalks, power lines, etc.)
Water Management	Describe how UTP Project activities will improve water management, including: 1. Increase infiltration and recharge of groundwater. 2. Reduce stormwater runoff. 3. Conserve water from urban forest management.

4 GHG Assessment Boundaries

The quantification of all included sources, sinks, and reservoirs (SSR) (Table 4.1 below) is described in the supplemental Quantification Guidance available on the Reserve's website.[8]

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	Type	Gas	Included (I) or Excluded (E)	Justification/Explanation
UF-1	Standing live carbon (carbon in all portions of living trees)	Reservoir / Pool	CO_2	Included	Increases in standing live carbon stocks are likely to be a large Primary Effect of UTP Projects
UF-2	Shrubs and herbaceous understory carbon	Reservoir / Pool	CO_2	Excluded	For crediting purposes shrubs and herbaceous understory are excluded since changes in this reservoir are unlikely to have a significant effect on total quantified GHG reductions or removals. Furthermore, it is generally not practical to undertake measurements of shrubs and herbaceous understory accurate enough for crediting purposes.
UF-3	Standing dead carbon (carbon in all portions of dead, standing trees)	Reservoir / Pool	CO_2	Included	Standing dead wood is expected to be a small, but in rare cases substantial, portion of UTP Projects.
UF-4	Lying dead wood carbon	Reservoir / Pool	CO_2	Excluded	For crediting purposes lying dead wood carbon is excluded since changes in this reservoir are unlikely to have a significant effect on total quantified GHG reductions or removals. Changes associated with carbon projects are likely to increase lying dead wood. Furthermore, it is generally not practical to undertake measurements of lying dead wood accurate enough for crediting purposes.
UF-5	Litter and duff carbon (carbon in dead plant material)	Reservoir / Pool	CO_2	Excluded	Litter and duff carbon is excluded since changes in this reservoir are unlikely to have a significant effect on total quantified GHG reductions or removals. Furthermore, it is generally not practical to undertake measurements of litter and duff accurate enough for crediting purposes.

[8] http://www.climateactionreserve.org/how/protocols/urban-forest/

SSR	Source Description	Type	Gas	Included (I) or Excluded (E)	Justification/Explanation
UF-6	Soil carbon	Reservoir / Pool	CO_2	Excluded	Soil carbon is not anticipated to change significantly as a result of UTP Projects.
UF-7	Carbon in in-use forest products	Reservoir / Pool	CO_2	Excluded	Urban forests do not produce significant levels of wood products that persist for long enough periods of time to meet permanence requirements and UTP Projects will not substantially change wood product production.
UF-8	Forest product carbon in landfills	Reservoir / Pool	CO_2	Excluded	Urban forests do not produce significant levels of wood products and UTP Projects will not substantially change wood product production.
UF-9	Nutrient application	Source	N_2O	Excluded	The use of nitrogen-based fertilizers is not expected to be a significant source of emissions.
UF-10	Biological emissions from site preparation activities	Source	CO_2	Excluded	Biological emissions from site preparation are not quantified since projects that involve intensive site preparation activities are not eligible.
UF-11	Mobile combustion emissions from site preparation activities	Source	CO_2	Excluded	Mobile combustion CO_2 emissions from site preparation are not quantified since projects that involve intensive site preparation activities are not eligible.
			CH_4	Excluded	Changes in CH_4 emissions from mobile combustion associated with site preparation activities are not considered significant.
			N_2O	Excluded	Changes in N_2O emissions from mobile combustion associated with site preparation activities are not considered significant.
UF-12	Mobile combustion emissions from ongoing project operation and maintenance	Source	CO_2	Excluded	Mobile combustion CO_2 emissions from ongoing project operation and maintenance are unlikely to be significantly different from baseline levels, and are therefore not included in the GHG Assessment Boundary.
			CH_4	Excluded	CH_4 emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.

SSR	Source Description	Type	Gas	Included (I) or Excluded (E)	Justification/Explanation
			N_2O	Excluded	N_2O emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
UF-13	Stationary combustion emissions from ongoing project operation and maintenance	Source	CO_2	Excluded	Stationary combustion CO_2 emissions from ongoing project operation and maintenance could include GHG emissions associated with electricity consumption or heating/cooling at Urban Forest Owner facilities or at facilities owned or controlled by contractors. These emissions are unlikely to be significantly different from baseline levels, and are therefore not included in the GHG Assessment Boundary.
			CH_4	Excluded	CH_4 emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
			N_2O	Excluded	N_2O emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.

5 Quantifying Net GHG Reductions and Removals

This section provides general requirements and guidance for quantifying a UTP Project's net GHG reductions and removals. Detailed methodological approaches to quantifying GHG reductions and removals are provided in the Quantification Guidance document. The Reserve will issue Climate Reserve Tonnes (CRTs) to a project upon confirmation by an ISO-accredited and Reserve-approved verification body that the project's GHG reductions and removals have been quantified following the applicable requirements of this section (see Section 8 for verification requirements). The Reserve provides an Urban Tree Planting Calculation Tool on its website[9] to assist with the annual calculation of reductions and removals.

Quantification proceeds according to the steps below.

1. **Estimating baseline onsite carbon stocks**. The baseline is an estimate of what would have occurred in the absence of a project. To establish baseline onsite carbon stocks, the Project Operator must apply the appropriate performance test from Section 3.4.2 of this protocol to the Project Onsite Inventory at Project Commencement. The Project Onsite Inventory must have been developed according to the guidelines established in the Quantification Guidance. Baseline estimates are developed for a 100-year period. Generally, baselines do not change during this period absent findings of errors in initial calculation or reconciliation associated with methodological updates.

2. **Determining actual onsite carbon stocks**. Each year, the Project Operator must determine the project's actual onsite carbon stocks. This must be done by updating the UTP Project's forest carbon inventory for the current year, following the guidance in this section and in the Quantification Guidance. The estimate of actual onsite carbon stocks must be adjusted by an appropriate confidence deduction, as described in the Quantification Guidance.

3. **Calculating the project's Primary Effect**. Each year, the Project Operator must quantify the actual change in GHG emissions or removals associated with the project's intended ("primary") effect. For any given year, the Primary Effect is calculated by:
    a. Taking the difference between actual onsite carbon stocks for the current year and actual onsite carbon stocks for the prior year.[10]
    b. Subtracting from (a) the difference between baseline onsite carbon stocks for the current year and baseline onsite carbon stocks for the prior year.

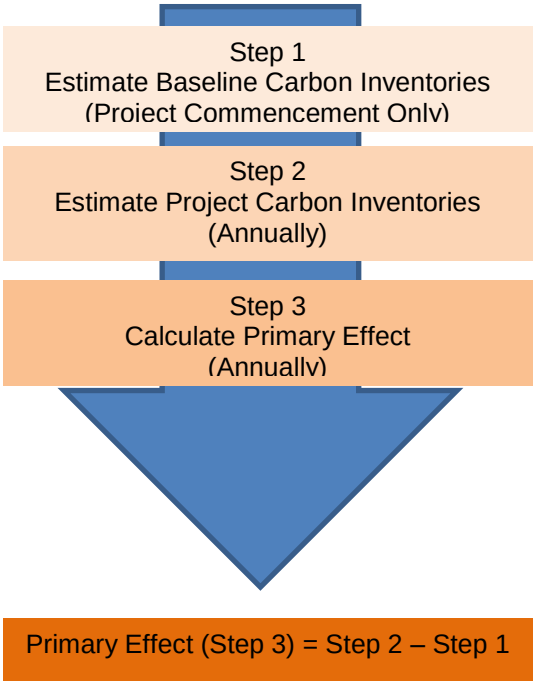
4. Calculating total net GHG reductions and removals. For each year, total net GHG reductions and removals are calculated by summing a project's Primary and Secondary Effects. If the result is positive, then the project has generated GHG reductions and/or removals in the current year. If the result is negative, this may indicate a reversal has occurred (see Section 6).[11]

[9] http://www.climateactionreserve.org/how/protocols/urban-forest/

[10] For the purposes of calculating the project's Primary Effect, actual and baseline carbon stocks prior to the Project Commencement Date are assumed to be zero.

[11] A reversal occurs only if: (1) total net GHG reductions and removals for the year are negative; and (2) CRTs have previously been issued to the UTP Project.

The required formula for quantifying annual net GHG reductions and removals is presented in Equation 5.1. Net GHG reductions and removals must be quantified and reported in units of carbon dioxide-equivalent (CO_2e) metric tons.



Equation 5.1. Annual Net GHG Reductions and Removals

$$\boldsymbol{QR_y = (\Delta AC_{onsite} - \Delta BC_{onsite})}$$

Where, Units

QR_y = Quantified GHG reductions and removals for year y tCO_2e

ΔAC_{onsite} = $(AC_{onsite, y}) - (AC_{onsite, y-1})$ tCO_2e

Where,

$AC_{onsite, y}$ = Actual carbon (CO_2e) as inventoried for year y (y may be less than a year for the first Reporting Period following Project Commencement). tCO_2e

$AC_{onsite, y-1}$ = Actual carbon (CO_2e) as inventoried for year y-1 tCO_2e

ΔBC_{onsite} = $(BC_{onsite, y}) - (BC_{onsite, y-1})$ tCO_2e

Where,

$BC_{onsite, y}$ = Baseline onsite carbon (CO_2e) as estimated for year y (y may be less than a year for the first Reporting Period following Project Commencement). tCO_2e

$BC_{onsite, y-1}$ = Baseline onsite carbon (CO_2e) as estimated for year y-1 tCO_2e

5.1 Urban Tree Planting Baseline

To develop a project baseline for a UTP Project, Project Operators must provide a qualitative characterization of the regulatory framework governing tree planting activities within the Project Area and explain why trees planted as part of the project are outside of any framework requiring the planting of trees.

Projects use a performance standard value which provides guidance to quantifying baselines. The performance standard value is a value that represents the averages of data between the 50th and 100th percentiles for trees planted annually for classes based on the entity type (county, municipality, educational institution, or utility/special district), the entity's size (population, landscaped area, or ratepayer population), and the entity's geo-political region. Project Operators must match their entity with an urban forest class on the Reserve's Urban Forest Project Protocol webpage.

The performance standard value[12] is compared to the actual project trees planted and the resulting proportion is calculated in terms of CO_2e to calculate the baseline contribution. The baseline calculation contains provisions for the potential eventuality that the Project Area is saturated with planted trees. The Reserve's Urban Tree Planting Calculation Tool[13] assists Project Operators with the baseline calculation. A more technical description of the quantification of the UTP Project baseline can be found in the Quantification Guidance supplemental to this protocol.

[12] Available at http://www.climateactionreserve.org/how/protocols/urban-forest/.
[13] Available at http://www.climateactionreserve.org/how/protocols/urban-forest/.

6 Ensuring the Permanence of Credited GHG Reductions and Removals

Changes in urban forest management have the potential to enhance the rate of CO_2 absorption, providing removals, and reducing or eliminating emissions associated with the loss of trees (reductions). Reductions are not possible with UTP Projects. The Reserve requires that credited GHG reductions and removals be effectively "permanent." For UTP Projects, this requirement is met by ensuring that the carbon associated with credited GHG reductions and removals remains stored for at least 100 years.

The Reserve ensures the permanence of GHG reductions and removals through three mechanisms:

1. The requirement for all Project Operators to monitor onsite carbon stocks, submit regular monitoring reports, and submit to regular third-party verification of those reports along with periodic onsite verifications for the duration of the Project Life.
2. The requirement for all Project Operators to sign a Project Implementation Agreement with the Reserve which obligates Project Operators to retire CRTs to compensate for reversals of GHG reductions and removals.
3. The maintenance of a Buffer Pool to provide insurance against reversals of GHG reductions and removals due to unavoidable causes (including natural disturbances such a fires, pest infestations or disease outbreaks).

GHG reductions and removals can be "reversed" if the stored carbon associated with them is released (back) to the atmosphere. Many biological and non-biological agents, both natural and human-induced, can cause reversals. Some of these agents cannot completely be controlled (and are therefore "unavoidable"), such as natural agents like fire, insects, pathogens, drought, and wind.

Other agents can be controlled, such as the human activities like land conversion. Under this protocol, reversals due to controllable agents are considered "avoidable". As described in this section, Project Operators must contribute to the Reserve Buffer Pool to insure against reversals. If the quantified GHG reductions and removals in a given year are negative, and CRTs were issued to the UTP Project in any previous year, the Reserve will consider this to be a reversal regardless of the cause of the decrease.

The Buffer Pool is a holding account for project CRTs, which is administered by the Reserve. All UTP Projects must contribute a percentage of CRTs to a Buffer Pool any time they are issued CRTs for verified GHG reductions and removals. A project that has an Unavoidable Reversal will use Buffer Pool CRTs proportionally from all projects that have contributed to the pool to compensate for the reversal. Project Operators do not receive compensation for their contributions to the Buffer Pool.

If a project experiences an Unavoidable Reversal of GHG reductions and removals (as defined in Section 6.2.2), the Reserve will retire a number of CRTs from the Buffer Pool equal to the total amount of carbon that was reversed (measured in metric tons of CO_2). The Buffer Pool therefore acts as a general insurance mechanism against Unavoidable Reversals for all UTP Projects registered with the Reserve. The Reserve may determine to re-distribute CRTs to Project Operators in the future, or modify the amount of contributions to the Buffer Pool, if actual Unavoidable Reversals fluctuate significantly from the current evaluation of risks.

6.1 Contributions to the Buffer Pool

Projects may be affected by financial risks, management risks, social risks, risks from pollution, and risks from natural disturbances (disease/insects, wildfire, flooding, drought etc.). To compensate for these risks, each project must contribute 6% of their issued CRTs to the Buffer Pool.

6.2 Compensating for Reversals

The Reserve requires that all reversals be compensated through the retirement of CRTs. If a Reversal associated with a UTP Project was unavoidable (as defined below), then the Reserve will compensate for the reversal on the Project Operator's behalf by retiring CRTs from the Buffer Pool. If a reversal was avoidable (as defined below) then the Project Operator must compensate for the reversal by surrendering CRTs from its Reserve account.

6.2.1 Avoidable Reversals

An Avoidable Reversal is any reversal that is due to the Project Operator's negligence, gross negligence, or willful intent, including harvesting, development, and harm to the Project Area due to the Project Operator's negligence, gross-negligence or willful intent. Requirements for Avoidable Reversals are as follows:

1. If an Avoidable Reversal has been identified during annual monitoring, the Project Operator must give written notice to the Reserve within thirty days of identifying the reversal. Additionally, if the Reserve determines that an Avoidable Reversal has occurred, it shall deliver written notice to the Project Operator.
2. Within thirty days of receiving the Avoidable Reversal notice from the Reserve, the Project Operator must provide a written description and explanation of the reversal to the Reserve.
3. Within four months of receiving the Avoidable Reversal notice, the Project Operator must retire a quantity of CRTs from its Reserve account equal to the size of the reversal in CO_2-equivalent metric tons (i.e. QR_y, as specified in Equation 5.1). In addition:
    a. The retired CRTs must be those that were issued to the project, or that were issued to other UTP Projects registered with the Reserve.
    b. The retired CRTs must be designated in the Reserve's software system as compensating for the Avoidable Reversal.
4. Within a year of receiving the Avoidable Reversal notice, the Project Operator must provide the Reserve with a verified estimate of current onsite carbon stocks and the estimated quantity of the Avoidable Reversal.

6.2.2 Unavoidable Reversals

An Unavoidable Reversal is any reversal not due to the Project Operator's negligence, gross negligence or willful intent, including, but not limited to, wildfires or disease that are not the result of the Project Operator's negligence, gross negligence or willful intent. Requirements for Unavoidable Reversals are as follows:

1. If the Project Operator determines there has been an Unavoidable Reversal, it must notify the Reserve in writing of the Unavoidable Reversal within six months of its occurrence.
2. The Project Operator must explain the nature of the Unavoidable Reversal and provide a verified estimate of onsite carbon stocks within one year so that the reversal can be quantified (in units of CO_2-equivalent metric tons).

If the Reserve determines that there has been an Unavoidable Reversal, it will retire a quantity of CRTs from the Buffer Pool equal to size of the reversal in CO_2-equivalent metric tons.

6.3 Disposition of Projects after a Reversal

If a reversal lowers the UTP Project's carbon stocks below its approved baseline carbon stocks, the project will be terminated as the original baseline approved for the project would no longer be valid. If a project is terminated due to an Unavoidable Reversal, a new project may be initiated and submitted to the Reserve for registration on the same Project Area. New projects may not be initiated on the same Project Area if the project is terminated due to an Avoidable Reversal.

7 Project Monitoring, Reporting, and Verification

This section provides requirements and guidance on project monitoring, reporting rules and procedures.

7.1 Project Documentation

Project Operators must provide the following documentation to the Reserve in order to register a UTP Project.

Table 7.1. Project Documentation Submittal Requirements

Document	When Submitted/Required
Project Submittal Form	Once, at project initiation when the Project Operator wishes to submit project concept to Reserve. Must be submitted within 6 months of the Commencement Date.
Project Design Document	Once, prior to initial verification.
Signed Attestation of Title Form	Prior to issuance of credits. Required at initial verification, onsite verification, and every optional desktop verification.
Signed Attestation of Regulatory Compliance Form	Prior to issuance of credits. Required at initial verification, onsite verification, and every optional desktop verification.
Signed Attestation of Voluntary Implementation Form	Once, prior to the issuance of credits as part of the initial verification.
Verification Report	Upon completion of verification and prior to issuance of credits. Required at initial verification, onsite verification, and every optional desktop verification.
Verification Statement	Upon completion of verification and prior to issuance of credits. Required at initial verification, onsite verification, and every optional desktop verification.
Project Implementation Agreement	Upon completion of verification and prior to issuance of credits. Required at initial verification, onsite verification, and every optional desktop verification.

Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

All reports that reference carbon stocks must be submitted with the oversight of a Certified Arborist, a Certified Forester, a Certified Urban Forester, or Professional Forester so that professional standards and project quality are maintained. Any Certified Arborist, Certified Urban Forester, Professional Forester or Certified Forester preparing a project in an unfamiliar jurisdiction must consult with a Certified Arborist, Professional Forester or Certified Forester practicing forestry in that jurisdiction to understand all laws and regulations that govern urban forest practices within the jurisdiction. This requirement does not preclude the project's use of technicians or other unlicensed/uncertified persons working under the supervision of the Professional Forester, Certified Arborist, or Certified Forester.

All projects shall submit a shapefile as a KML that matches the maps submitted to depict the Project Area. The project's reported acres shall be based on the shapefile submitted to the

Reserve. The Reserve will create a file of all verified forest carbon projects on Google Maps for public dissemination.

7.1.1 Urban Forest Project Design Document

The Project Design Document (PDD) is a required document for reporting information about a project. The document is submitted at the initial verification. A PDD template has been prepared by the Reserve and is available on the Reserve's website.[14] The template is arranged to assist in ensuring that all requirements of the UTP Project Protocol are addressed. The template is required to be used by all projects. The template is designed to manage the varying requirements based on project type.

Each project must submit a PDD at the project's first verification. PDDs are intended to serve as the main project document that thoroughly describes how the project meets eligibility requirements, discusses summaries associated with developing data according to quantification requirements, outlines how the project complies with terms for additionality and describes how project reversal risks are calculated. All methodologies used by Project Operators and descriptions in the PDD must be clear in a way that facilitates review by verifiers, Reserve staff, and the public. PDDs must be of professional quality and free of incorrect citations, missing pages, incorrect project references, etc.

7.2 Monitoring Report

Monitoring is the process of regularly collecting and reporting data related to a project's performance. Annual monitoring of UTP Projects is required to ensure up-to-date estimates of project carbon stocks and provide assurance that GHG reductions or removals achieved by a project have not been reversed. Project Operators must conduct monitoring activities and submit monitoring reports according to the schedule and requirements presented in Section 7.2. Monitoring is required for a period of 100 years following the final issuance of CRTs to a project for quantified GHG reductions or removals.

Monitoring activities consist primarily of updating a project's forest carbon inventory, entering the updated inventory into the project's calculation worksheet, and submitting it to the Reserve at frequencies defined in Section 7.3. CRTs are only issued in years that the project data are verified, as described in Section 7.4.

A monitoring report must be prepared for each Reporting Period. Monitoring reports must be provided to verification bodies whenever a project undergoes verification. The monitoring report must be completed and submitted to the Reserve within 12 months of the end of the Reporting Period. When required verifications must be conducted as explained below, both the verification report and the monitoring report must be completed and submitted to the Reserve within 12 months of the end of the Reporting Period. Monitoring reports must include an update of the project's calculation worksheet. The project's calculation worksheet includes:

1. An updated estimate of the current year's carbon stocks in the reported carbon pools. Acceptable methodologies for updating the project's inventory are provided in the Quantification Guidance. The update is determined by:
    a. Including any new forest inventory data obtained during the Reporting Period.
    b. Applying growth estimates to existing inventory.

[14] http://www.climateactionreserve.org/how/protocols/urban-forest/

   c. Updating inventory estimates for removals and/or disturbances that have occurred during the Reporting Period.
2. The baseline carbon stock estimates for the current year, as determined following the requirements in Section 5 and approved at the time of the project's registration.
3. A preliminary calculation of total net GHG reductions and removals (or reversals) for the year, following the requirements in Section 5.
4. *A preliminary calculation of the project's Buffer Pool contribution.

In addition to data reported using the project calculation worksheet, the following must be submitted to the Reserve as part of a monitoring report.

Conditional reporting, as pertinent:

1. If a reversal has occurred during the previous year, the report must provide a written description and explanation of the reversal, whether the Reserve classified the reversal as Avoidable or Unavoidable, and the status of compensation for the reversal.

7.3 Reporting and Verification Cycles

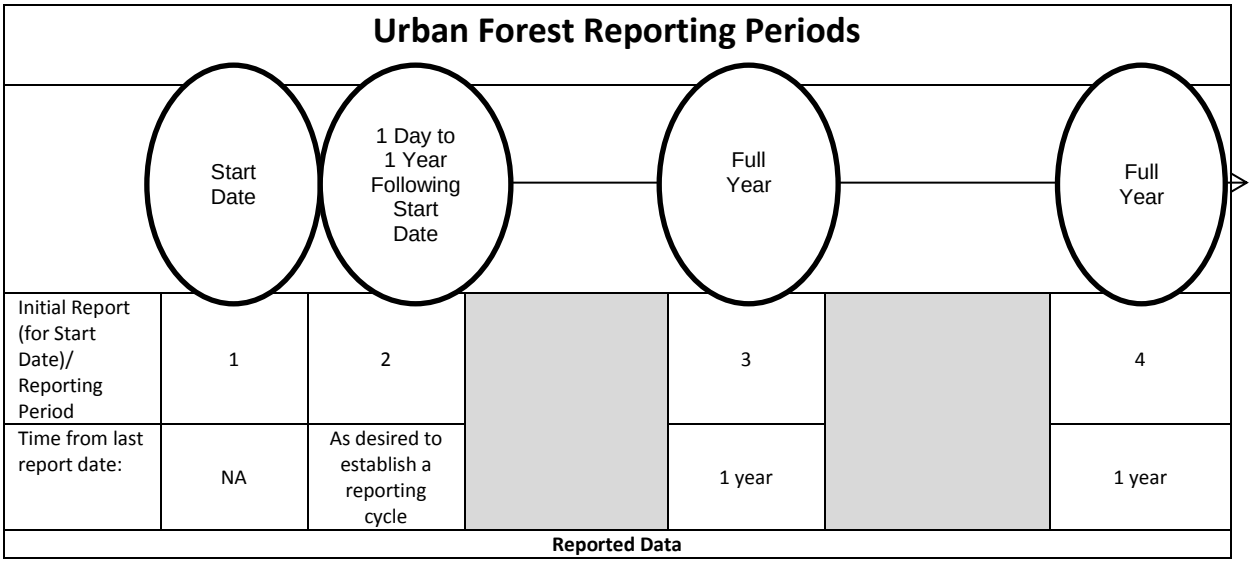
This section describes the required reporting and verification cycles. A UTP Project is considered automatically terminated (see Section 6.3) if the Project Operator chooses not to report data and undergo verification at required intervals.

7.3.1 Reporting Period Duration and Cycles

Projects must report their initial inventory data associated with the Project Commencement Date. Project Operators must report their project inventories annually with the exception of the Reporting Period immediately following Project Commencement, which can be any length of time up to one year. This enables Project Operators to establish an annual reporting cycle that is convenient for the entity.

Figure 7.1 displays the Reporting Periods in graphical form.

Reporting Periods must be contiguous, i.e. there must be no gaps in reporting during the crediting period of a project once the first Reporting Period has commenced.



Project Onsite Carbon Stocks	Yes	Yes		Yes		Yes
CRTs Issued upon Successful Verification?	No	Yes		Yes		Yes

Figure 7.1. Urban Tree Planting Reporting Periods

7.3.2 Verification Cycles

All projects must be initially verified within 30 months of being submitted to the Reserve. The initial verification of all project types must include a site visit, confirm the project's eligibility, and confirm that the project's initial inventory and the baseline have been established in conformance with the UTP Project Protocol. Subsequent verification may include multiple Reporting Periods and is referred to as the "Verification Period." The end date of any Verification Period must correspond to the end date of a Reporting Period.

Verification has both required frequencies and optional frequencies. Required verification is established on a temporal framework to ensure that ongoing monitoring of urban forest carbon stocks are accurate and up-to-date. Optional verification is at the Project Operator's discretion and may be conducted in the years in which verification is not required and the Project Operator wishes to receive credits. Required verifications are referred to as onsite verifications. Optional verifications are referred to as desk review verifications. Details of verification scheduling requirements are provided within this section.

Verification must be completed within 12 months of the end of the Reporting Period(s) being verified. For required verifications, failure to complete verification within the 12 month time period will result in account activities being suspended until the verification is complete. The project will terminate if the required verification is not completed within 36 months of the end of the Reporting Period(s) being verified. There is no consequence for failure to complete verification activities within 12 months for optional verifications.

7.3.3 Requirements of Onsite Verifications

Onsite verification is a verification in which project inventory data are verified through a process that audits data in the office as well as data in the field. The Reserve requires that an approved third-party verification body verify all reported data and information for a project and conduct a site visit for the Verification Period that coincides with Project Commencement and the end of every fifth Reporting Period following the Project Commencement Date. Buffer Pool contributions are also verified during onsite verifications.

7.3.4 Desk Review Verification

In between onsite verifications, the Project Operator may choose to have an approved third-party verification body conduct a desk review of annual monitoring reports as an optional verification. CRTs may be issued for GHG reductions/removals verified through such desk reviews.

Submission of annual monitoring reports to the Reserve is required even if the Project Operator chooses to forego desk review verification.

7.4 Issuance and Vintage of CRTs

The Reserve will issue Climate Reserve Tonnes (CRTs) for quantified GHG reductions and removals that have been verified through either onsite verifications or desk reviews. Onsite verification may determine that earlier desk reviews overestimated onsite carbon stocks. Any resulting downward adjustment to carbon stock estimates will be treated as a reversal (see Section 6). In this case, the Project Operator must retire CRTs in accordance with the requirements for compensating for a reversal (Section 6.2). Vintages are assigned to CRTs based on the proportion of days in a calendar year within a Reporting Period.

7.5 Record Keeping

For purposes of independent verification and historical documentation, Project Operators are required to keep all documents and forms related to the project for a minimum of 100 years after the final issuance of CRTs from the Reserve. This information may be requested by the verification body or the Reserve at any time.

7.6 Transparency

The Reserve requires data transparency for all projects, including data that displays current carbon stocks, reversals, and verified GHG reductions and removals. For this reason, all non-confidential project data reported to the Reserve will be publicly available on the Reserve's website.

8 Verification Guidance

This section provides guidance to Reserve-approved verification bodies for verifying GHG emission reductions associated with urban forest projects.

This section supplements the Reserve's Verification Program Manual,[15] which provides verification bodies with the general requirements for a standardized approach for independent and rigorous verification of GHG emission reductions and removals. The Verification Program Manual outlines the verification process, requirements for conducting verification, conflict of interest and confidentiality provisions, core verification activities, content of the verification report, and dispute resolution processes. In addition, the Verification Program Manual explains the basic verification principles of ISO 14064-3:2006 which must be adhered to by the verification body.

Verification bodies must read and be familiar with the following International Organization for Standardization (ISO) and Reserve documents and reporting tools:

- Urban Tree Planting Project Protocol (this document)
- Reserve Program Manual
- Reserve Verification Program Manual
- Reserve software
- ISO 14064-3:2006 Principles and Requirements for Verifying GHG Inventories and Projects

Only Reserve-approved urban forest project verification bodies are eligible to verify UTP Project reports. To become a recognized urban forest project verifier, verification bodies must become accredited under ISO 14065. Information on the accreditation process can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/how-to-become-a-verifier/.

The verification of reports that reference carbon stocks must be conducted with the oversight of a Certified Arborist, a Professional Forester, or a Certified Forester,[16] managed by the Society of American Foresters, so that professional standards and project quality are maintained. Any Certified Arborist, Professional Forester or Certified Forester who is not currently working with urban forest activities within the Project Area must consult with a Certified Arborist, a Professional Forester, Certified Forester, or planning agency familiar with the practice of urban forestry in that jurisdiction to understand all laws and regulations that govern urban forest practice within the jurisdiction. The Reserve may evaluate and approve alternative professional credentialing requirements if requested, but only for jurisdictions where laws or regulations that govern professional urban forest management do not exist.

8.1 Standard of Verification

The Reserve's standard of verification for UTP Projects is the Urban Tree Planting Project Protocol, the Reserve Program Manual, and the Reserve Verification Program Manual. To verify a Project Operator's initial Project Design Document and annual monitoring reports, verification bodies apply the verification guidance in the Reserve's Verification Program Manual and this

[15] Found on the Reserve website at http://www.climateactionreserve.org/how/program/program-manual/.
[16] See www.certifiedforester.org.

section of the UTP Project Protocol to the requirements and guidance described in Sections 2 through 7 of the UTP Project Protocol.

This section of the protocol provides requirements and guidance for the verification of UTP Projects. This section describes the core verification activities and criteria that must be undertaken and addressed by a verification body in order to provide a reasonable level of assurance that the GHG removals or reductions quantified and reported by Project Operators are materially correct.

Verification bodies will use the criteria in this section to determine if there exists a reasonable assurance that the data submitted on behalf of the Project Operator to the Reserve addresses each requirement in the UTP Project Protocol, Sections 2 through 7. Project reporting is deemed accurate and correct if the Project Operator is in compliance with Sections 2 through 7.

Further information about the Reserve's principles of verification, levels of assurance, and materiality thresholds can be found in the Reserve's Verification Program Manual at http://www.climateactionreserve.org/how/program/program-manual/.

8.2 Project Verification Activities

Required verification activities for UTP Projects vary depending on whether the verification body is conducting an initial verification for registration on the Reserve, onsite verification, or an optional annual verification involving a desk review. The following sections contain guidance for all of these verification activities.

8.2.1 Initial Verification

Verifiers must ensure that the project has met the UTP Project Protocol criteria and requirements for eligibility, Project Area definition, additionality, quantification and calculation of baseline. The initial verification must include onsite verification. The verification body must assess and ensure the completeness and accuracy of all required reporting elements submitted in the Project Design Document.

8.2.2 Onsite Verification

Onsite verification involves review of the UTP Project's quantification, relevant attestations, soil carbon emissions associated with management activities, adherence to environmental and social safeguards (if applicable), and risk of reversal ratings. After a project's initial verification, subsequent site visits must assess and assure accuracy in measurement and monitoring techniques and onsite record keeping practices. Onsite verifications must be completed during the initial verification and for every fifth subsequent reporting cycle. That is, onsite verification is required every 5-years.

8.2.3 Optional Annual Verification

Optional annual verifications can occur according to preferences of the Project Operator. Credits can be verified and registered as the result of an optional annual verification. Optional annual verification occurs in the interim years between onsite verifications. The main focus of optional annual verifications is to assure that annual monitoring reports are complete and that reported project carbon inventories are within acceptable bounds, as described in the Quantification Guidance.

Table 8.1 displays the protocol sections that are verified at the initial verification, the onsite verification, and/or the optional annual verification.

Table 8.1. Verification Items and Related Schedules

Verification Items	Section of UTP Project Protocol	Initial	Site	Optional	Apply Professional Judgment[17]?
1. Project Definition	2.1 Urban Tree Planting	X			Yes
2. Urban Forest Owner	2.2 Urban Forest Owners	X	X		Yes
3. Project Operator	2.3 Project Operators	X	X		No
4. Project Implementation Agreement	2.4 Project Implementation Agreement	X	X	X	No
5. Project Location	3.1 Project Location	X			No
6. Project Area	3.2 Project Area	X			No
8. Project Commencement	3.3 Project Commencement	X			Yes
9. Additionality	3.4.1 Legal Requirement Test 3.4.2 Performance Test	X	X		Yes
	3.4.2.1 Performance Standard for Urban Tree Planting Projects	X			
10.Project Crediting Period	3.5 Project Crediting Period	X	X		No
11.Minimum Time Commitment	3.6 Minimum Time Commitment	X	X		No
12. Social and Environmental Co-Benefits	3.7 Social and Environmental Co-Benefits	X	X		Yes for public entities only
13. Social Co-Benefits	3.7.1 Social Co-Benefits	X	X		Yes for public entities only
14. Environmental Co-Benefits	3.7.2 Environmental Co-Benefits	X	X		Yes for public entities only
15. GHG Assessment Boundaries	4 GHG Assessment Boundaries	X	X		No
The verification topics below are linked to quantification requirements. The verification of project inventories is described in detail below this table. Verifiers shall assure that requirements associated with the references in this table have been satisfied and implement the specific guidance requirements for verifying inventories below.					
16. Quantifying Net GHG Reductions and Removals	5 Quantifying Net GHG Reductions and Removals 8.3 Verifying Carbon Inventories Urban Tree Planting Quantification Guidance	X	X	X	No
17. Urban Forest Protocol Baselines	5.1 Urban Tree Planting Baseline Urban Tree Planting Quantification Guidance: Baseline Development for Urban Tree Planting Projects	X			No
18. Permanence and Buffer Pool Contributions	6.1 Contributions to the Buffer Pool	X	X		No
19. Permanence and Compensating for Reversals	6.2 Compensating for Reversals 6.2.1 Avoidable Reversals 6.2.2 Unavoidable Reversals	X	X	X	No

[17] Verifiers must use professional judgment to verify protocol criteria which are not quantitative or can be measured completely with objective analysis.

8.3 Verifying Carbon Inventories

Verification bodies are required to verify carbon stock inventory calculations of all sampled and/or measured carbon pools within the Project Area. Inventories of carbon stocks are used to determine the project baseline and to quantify GHG reductions and removals against the project baseline over time. The method of verification of carbon inventories varies depending on whether the verification is part of the initial verification, onsite verification, or an optional verification. The verification elements and their periodicity are explained in this section.

Verification Item	Description	Verification Frequency
1 – Quantification of Carbon Estimates	Confirming that the methodology and requirements for quantifying carbon estimates specified in the Urban Tree Planting Quantification Guidance were implemented correctly and that the field measurements, use of biomass equations, and summary of project data meet minimum tolerance standards for accuracy, as part of onsite verification.	Initial onsite verification and every subsequent 5 years following initial onsite verification.
2 – Updated Data	Confirming that updated data are within acceptable bounds.	Optional, in years in between onsite verifications.

8.3.1 Verification of Urban Tree Planting Project Inventories

8.3.1.1 Office-Based Inventory Verification Activities

The verifier must progress through each successive step according to the guidance below. Verification activities may only proceed to field verification activities once the following items have been successfully verified:

1. Prior to verification of project inventories, **items 1 – 16** in Table 8.1 must be reviewed and deemed satisfactory by the verifier, both in terms of clear presentation and aligned with the protocol requirements.
2. Confirm that the **tree records** used in producing the project-level estimate of CO_2e are in a database, have latitude and longitude for each tree, and that the sum of individual CO_2e estimates for each tree equals the reported value for the project.
3. Confirm that the **confidence statistics** for canopy cover were correctly calculated and meet minimum requirements.

8.3.1.2 Field-Based Inventory Verification Activities

The verification effort must include a re-measurement of a subset of project data used to calculate the inventory estimate for the project. The data sampled by verifiers are individual trees. The verification strategy for all measured data is based on a comparison of randomly selected verifier measurements to Project Operator measurements in a process referred to as sequential sampling. Individual diameters (DBH) and total height must be measured for each tree. The minimum standards of measurement for verifiers are:

1. To the nearest inch for DBH measurements. DBH must be measured per the Urban Tree Planting Quantification Guidance.
2. To the nearest foot for height measurements.

Verification using the sequential sampling methodology requires the verification body to sequentially sample successive plots. Sequential approaches have stopping rules rather than fixed sample sizes. Verification is successful after a minimum number of successive plots in a sequence indicate agreement according to the tolerance thresholds established in the sequential sampling workbook. The evaluation of the three themes that utilize sequential sampling (CO_2e estimates from plots, current tree canopy area, and historical tree canopy area) shall utilize separate worksheets and include a copy of the results within the verification report.

Where sequential measurements from the verifier result in a trend of agreement with the Project Operator's data, as defined by established tolerance bounds, verification can proceed toward a finding of adequate accuracy. The number of trees measured by the verifier is based on stopping rules established by the Reserve. Where a high level of agreement is found between the Project Operator and the verifier, a finding of accuracy may be established with the minimal number of trees required by the Reserve. As variation between verifier estimates and Project Operators increases, the number of trees measured by the verifier must increase in order to work toward establishing a finding of accuracy. In cases where continued verifier effort does not result in agreement, the Project Operator must decide whether continued investment in verification effort is justified. Alternatively, verification can be suspended while the Project Operator improves the quality of the inventory and revises related project documentation.

The worksheet provided by the Reserve includes the established stopping rules. Where agreement between the verifier and the Project Operator is within specified tolerance bounds, verification of plot data is successful. For the field-based verification activities, the verifier must randomly select an initial set of 40 individual trees sampled by the Project Operator, maintaining the order of their selection in sequential order (1 – 40).

Verification Element	Description	Verification Frequency
1	**Measurement of Field Data**: The verifier must develop an initial strategy to efficiently visit the first 20 trees (1-20) in the list. The trees to not need to be visited and measured sequentially, but they all need to be visited prior to entering the data in the sequential sampling works. The verifier must measure the individual trees and calculate the CO_2e associated with each tree. The entries of tree summaries into the sequential sampling worksheet provided by the Reserve must be in the same order the trees were randomly selected.	Initial verification and each subsequent 5-year onsite verification.
2	**Data Quality Control**: Confirm that the tree records used in producing the project-level estimate of CO_2e are in a database, have latitude and longitude for each tree, and that the sum of individual CO_2e estimates for each tree equals the reported value for the project.	Initial verification and each subsequent 5-year onsite verification.
3	Confirm that the **confidence statistics** for canopy cover were correctly calculated and meet minimum requirements.	Initial verification and each subsequent 5-year onsite verification.

8.3.1.3 Optional Verification for Interim Years between Onsite Verifications

In the interim years between onsite verifications, OPOs can optionally have project stocks verified and receive credits. Verifiers shall compare current reported data with previously verified data and calculate if the reported data are within acceptable tolerance bounds. The tolerance bound is defined within 5% of the previous year's reported carbon stocks. Projects that utilize the optional verification must provide contribute 20% of the credits generated during the optional verification to a holding account. The holding account is reconciled to the project accounting in the reporting year that the project undergoes onsite verification. Data that are not within tolerance bounds must undergo the requirements for a 5-year onsite verification.

8.4 Completing the Verification Process

After completing the core project verification activities for a UTP Project, the verification body must do the following to complete the verification process:

1. Complete a verification report to be delivered to the Project Operator (public document).
2. Complete a detailed list of findings containing both immaterial and material findings (if any), and deliver it to the Project Operator (private document).
3. Prepare a concise verification statement detailing the vintage and the number of CRTs verified, and deliver it to the Project Operator (public document).
4. Verify that the number of CRTs specified in the verification report and statement match the number entered into the Reserve software.
5. Conduct an exit meeting with the Project Operator to discuss the verification report, list of findings, and verification statement and determine if material misstatements (if any) can be corrected. If so, the verification body and Project Operator should schedule a second set of verification activities after the Project Operator has revised the project submission.
6. If a reasonable level of assurance opinion is successfully obtained, upload electronic copies of the verification report, list of findings, verification statement, and verification activity log into the Reserve.
7. Return important records and documents to the Project Operator for retention.

The recommended content for the verification report, list of findings, and verification statement can be found in the Reserve's Verification Program Manual.[18] The Verification Program Manual also provides further guidance on quality assurance, negative verification statements, use of an optional project verification activity log, goals for exit meetings, dispute resolution, and record keeping.

[18] Available at http://www.climateactionreserve.org/how/program/program-manual/.

9 Glossary of Terms

Additionality	GHG emission reductions should occur as a result of specific GHG mitigation incentives; additionality is achieved when GHG reductions are beyond what would occur under business as usual operation and result from activities that are not mandated by regulation.
Allometric Equation	An equation that utilizes the genotypical relationship among tree components to estimate characteristics of one tree component from another. Allometric equations allow the below ground root volume to be estimated using the above-ground bole volume.
Avoidable Reversal	An avoidable reversal is any reversal that is due to the project operator's negligence, gross negligence, or willful intent, including harvesting, development, and harm to the project area.
Baseline	An estimate of GHG emissions and removals that would have occurred in absence of the project under business as usual operations.
Best Management Practices	Management practices determined by a state or designated planning agency to be the most effective and practicable means (including technological, economic, and institutional considerations) of controlling point and nonpoint source pollutants at levels compatible with environmental quality goals.[19]
Biological Emissions	For the purposes of the UTP Project Protocol, biological emissions are GHG emissions that are released directly from forest biomass, both live and dead, including forest soils. Biological emissions are deemed to occur when the reported tonnage of onsite carbon stocks, relative to baseline levels, declines from one year to the next.
Biomass	The amount of living matter comprising, in this case, a tree.
Bole	The trunk or main stem of a tree.
Buffer Pool	The buffer pool is a holding account for urban forest project CRTs administered by the Reserve. It is used as a general insurance mechanism against unavoidable reversals for all UTP projects registered with the Reserve.
Business As Usual	The activities, and associated GHG reductions and removals that would have occurred in the project area in the absence of incentives provided by a carbon offset market.

[19] (Helms, 1998)

Carbon Pool	A reservoir that has the ability to accumulate and store carbon or release carbon. In the case of forests, a carbon pool is the forest biomass, which can be subdivided into smaller pools. These pools may include above-ground or belowground biomass or roots, litter, soil, bole, branches and leaves, among others.
Carbon Sink	A carbon sink is any process, activity or mechanism that removes carbon dioxide from the atmosphere.
Carbon Source	A carbon source is any process or activity that releases carbon dioxide into the atmosphere.
Carbon Stock	A pool of stored carbon. Urban forest carbon stocks include biomass of the project trees. Include living and standing dead vegetation, woody debris and litter, organic matter in the soil, and harvested stocks such as wood for wood products and fuel.
Carbon Stock Change or Carbon Sequestration	The annual incremental change in carbon stocks.
C_{emis}	CO_2 and other GHG emissions from project maintenance activities, for example, due to vehicular or equipment use.
C_{proj}	Project carbon, i.e. carbon stored annually in project trees, reported as CO_2.
Certified Arborist	An arborist meeting the criteria having passed the test given by the International Society of Arboriculture (http://www.isa-arbor.com/certification/index.aspx).
Certified Forester	A professional with certified forester credentials managed by the Society of American Foresters (see www.certifiedforester.org). See also, Professional Forester.
Certified Urban Forester	An urban forester meeting the criteria and having passed the test created by the California Urban Forests Council, and now administered nationally by the Society of American Foresters.
Climate Reserve Tonnes (CRT)	One metric ton (tonne) of verified CO_2 equivalent emission reduction or sequestration.
CO_2-equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Dry Weight (DW) Biomass	The weight of aboveground tree biomass when dried to 0% moisture content. Also known as oven-dry and bone-dry biomass. Convert from green biomass to dry weight biomass by multiplying by 0.56 for hardwoods or 0.48 for softwoods.

Entity	The individual, organization, agency or corporation that owns, controls, or manages urban trees.
Freshweight or Green Biomass	The weight of aboveground tree biomass when fresh (or green), which includes the moisture present at the time the tree was cut. The moisture content of green timber varies greatly among different species. The Reserve assumes that the moisture content of fresh weight biomass is 30%.
Global Warming Potential (GWP)	Factors used to convert emissions from GHGs other than carbon dioxide to their equivalent carbon dioxide emissions.
Greenhouse gas (GHG)	Greenhouse gases mean carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).
GHG Assessment Boundary	The GHG Assessment Boundary defines all the GHG sources, sinks, and reservoirs that must be accounted for in quantifying a project's GHG reductions and removals.
Inherent Uncertainty	The scientific uncertainty associated with calculating carbon stocks and greenhouse gas emissions.
KML	KML (Keyhole Markup Language) is an XML based file format used to display geographic data in an Earth browser such as Google Earth, Google Maps, and Google Maps for mobile.
Leakage	According to the Intergovernmental Panel on Climate Change: "the unanticipated decrease or increase in greenhouse gas benefits outside of the project's accounting boundary as a result of project activities."
Permanence	The requirement that GHGs must be permanently reduced or removed from the atmosphere to be credited as carbon offsets. For UTP projects, this requirement is met by ensuring that the carbon associated with credited GHG reductions and removals remains stored for at least 100 years.
Primary Effects	The project's intended changes in carbon stocks, GHG emissions or removals.
Professional Forester	A professional engaged in the science and profession of forestry. A professional forester is credentialed in jurisdictions that have professional forester licensing laws and regulations. Where a jurisdiction does not have a professional forester law or regulation then a professional forester is defined as having the certified forester credentials managed by the Society of American Foresters (see www.certifiedforester.org).
Project Activity	The carbon storage, emission reductions and emissions

	due to an urban tree planting project.
Project Area	The area inscribed by the geographic boundaries of a project.
Project Commencement (Project Commencement Date)	The commencement date is initiated by activities that increase carbon inventories and/or decrease emissions relative to the baseline.
Project Life	Refers to the duration of a project and its associated monitoring and verification activities.
Project Onsite Inventory	The inventory of trees eligible to generate emission reductions or removals in a project. Developed according to the guidelines in the Quantification Guidance.
Project Operator	One of the urban forest owners or a legally created entity to represent the urban forest owners that is responsible for undertaking a project.
Project Submission Date	The date that a project is submitted for listing in the Reserve program. The Reserve considers a project to be "submitted" when all of the appropriate forms have been uploaded to the Reserve's software system, and the project operator has paid a project submission fee.
Registered Consulting Arborist	An arborist meeting the criteria and having passed all the qualification requirements of the American Society of Consulting Arborists (http://www.asca-consultants.org/about/rca.cfm).
Reporting Uncertainty	The level of uncertainty associated with an entity's chosen method of sampling and/or inventorying carbon stock and calculation methodologies. Contrast with inherent uncertainty.
Reporting Period	The time period for which an entity is reporting its project activity and quantifying GHG reductions. This period will typically be 12 months, except for 1) the initial reporting period which begins at the project commencement date and may be more than 12 months, and 2) the second reporting period, which may be less than 12 months.
Reversal	A reversal is a decrease in the stored carbon stocks associated with quantified GHG reductions and removals that occurs before the end of the project life. Under this protocol, a reversal is deemed to have occurred if there is a decrease in the difference between project and baseline onsite carbon stocks from one year to the next, regardless of the cause of this decrease (i.e. if the result of (Δ AC_{onsite} - Δ BC_{onsite}) in Equation 5.1 is negative).
Secondary Effects	Unintended changes in carbon stocks, GHG emissions, or GHG removals caused by the project.
Sequestration	The process by which trees remove carbon dioxide from

	the atmosphere and transform it into biomass.
Start Date	See Project Commencement.
Tree	A woody perennial plant, typically large and with a well-defined stem or stems carrying a more or less definite crown with the capacity to attain a minimum diameter at breast height of five inches and a minimum height of 15 feet with no branches within three feet from the ground at maturity.[20]
Tree Residue	Aboveground biomass from urban trees (as distinguished from construction debris) that can be salvaged for reuse, such as mulch, wood products, or fuel for biomass power plant.
Unavoidable Reversal	An unavoidable reversal is any reversal not due to the project operator's negligence, gross negligence or willful intent, including windstorms or disease that are not the result of the project operator's negligence, gross negligence or willful intent.
Urban Area	The most recent Urbanized Area definition provided by the United States Census Bureau at http://www.census.gov/geo/maps-data/maps/2010ua.html.
Urban Forest Owner	A corporation, legally constituted entity (such as a utility), city, county, state agency, individual(s), or combination thereof that has legal control (e.g. right to plant or remove, etc.) of any amount of urban forest carbon within the project area.
Urban Tree Planting Project (UTP Project, project)	A planned set of activities designed to increase removals of CO_2 from the atmosphere, or reduce or prevent emissions of CO_2 to the atmosphere, through increasing and/or conserving urban forest carbon stocks. An urban tree planting (UTP) project involves new trees being planted in areas where trees have not been harvested with a primary commercial interest over the past 10 years prior to project commencement. This does not include harvesting where the primary concern is for human safety or forest health. Only planted trees and trees that regenerate from planted trees are eligible to be quantified for credits. Benefits from urban tree planting activities occur when the CO_2e associated with planted trees exceeds baseline tree planting CO_2e levels.
Verification	The process of reviewing and assessing all of a project's reported data and information by an ISO-accredited and Reserve-approved verification body, to confirm that the project operator has adhered to the requirements of this protocol.

[20] (Helms 1998)

Verification Cycle	The Reserve requires onsite verification of projects every five years, but project operators can choose to have more frequent 'desktop' verifications. In between site visits, desk reviews of project reports can be completed by an approved verification body. The Reserve will only issue CRTs for verified emission reductions.
Verification Period	The period of time over which GHG reductions/removals are verified. A verification period may cover multiple reporting periods. The end date of any verification period must correspond to the end date of a reporting period.

CLIMATE ACTION RESERVE

Version 5.0 | April 24, 2019

Landfill

Project Protocol

Climate Action Reserve
www.climateactionreserve.org

Released April 24, 2019

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Table of Contents

1 Introduction 2
2 The GHG Reduction Project 3
2.1 Background 3
2.2 Project Definition 3
2.3 The Project Developer 4
3 Eligibility Rules 5
3.1 Location 5
3.2 Project Start Date 5
3.3 Project Crediting Period 5
3.4 Additionality 6
3.4.1 The Performance Standard Test 6
3.4.2 Limits on Credit Stacking 7
3.4.3 The Legal Requirement Test 8
3.5 Regulatory Compliance 10
4 The GHG Assessment Boundary 11
5 Quantifying GHG Emission Reductions 16
5.1 Quantifying Baseline Emissions 18
5.2 Quantifying Project Emissions 24
6 Project Monitoring 27
6.1 Monitoring Requirements 27
6.1.1 Indirect Monitoring Alternative 30
6.2 Instrument QA/QC 31
6.3 Missing Data 33
6.4 Monitoring Parameters 33
7 Reporting Parameters 42
7.1 Project Documentation 42
7.2 Record Keeping 42
7.3 Reporting Period and Verification Cycle 43
7.3.1 Reporting Periods 43
7.3.2 Verification Periods 43
7.3.3 Verification Site Visit Schedule 44
8 Verification Guidance 45
8.1 Standard of Verification 45
8.2 Monitoring Plan 45
8.3 Verifying Project Eligibility 45
8.4 Core Verification Activities 46
8.5 Landfill Project Verification Items 47
8.5.1 Project Eligibility and CRT Issuance 47
8.5.2 Quantification of GHG Emission Reductions 48
8.5.3 Risk Assessment 49
8.6 Completing Verification 50
9 Glossary of Terms 51
10 References 55
Appendix A Development of the Performance Standard Threshold 57
A.1 2007 Performance Standard Analysis 57
A.2 2011 Performance Standard Test: Size Threshold for LFGE Projects 58
A.3 Protocol Version 5.0 Performance Standard Analysis 60
Appendix B Emission Factor Tables 65

B.1 Destruction Efficiencies for Destruction Devices 67
Appendix C Baseline Monitoring and Calculation of LFG_{B1}, LFG_{B2}, and B_{CH4} 68
C.1 Baseline Monitoring 68
C.2 Monitoring 68
C.3 Passive Flare Configuration 69
C.4 Calculation 69
C.5 Example 71
Appendix D Data Substitution Guidelines 73

List of Tables

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs 13
Table 6.1. Monitoring Data to be Collected and Used to Estimate Emission Reductions....34
Table 8.1. Summary of Eligibility Criteria....46
Table 8.2. Eligibility Verification Items....47
Table 8.3. Quantification Verification Items....49
Table 8.4. Risk Assessment Verification Items....49
Table A.1. Summary of Information on U.S. Landfills (NSPS/EG and Non-NSPS/EG) (2007)...57
Table A.2. Summary of Non-NSPS/EG Landfills Under Assumption that Flare-Only Landfills Are Already Regulated (2007) 58
Table A.3. WIP Values for 5% Market Penetration of LFGE Projects 59
Table B.1. CO_2 Emission Factors for Fossil Fuel Use 65
Table B.2. Default Destruction Efficiencies for Destruction Devices 67
Table C.1. Example Dataset and Calculation of $Closed_{discount}$ or $NQ_{discount}$ 72

List of Figures

Figure 4.1. General Illustration of the GHG Assessment Boundary....12
Figure 5.1. Organizational Chart for Equations in Section 5 17
Figure 6.1. Suggested Arrangement of LFG Metering Equipment 29
Figure A.1. Precipitation Zones of the United States, by County 59
Figure A.2. New LFGE Installations 60
Figure A.3. New LFGE Installations and Marginal Power Input Costs 61

List of Equations

Equation 5.1. Calculating GHG Emission Reductions 18
Equation 5.2. Adjusting the Landfill Gas Flow for Temperature and Pressure 18
Equation 5.3. Calculating Baseline Emissions....20
Equation 5.4. Total Methane Emissions Destroyed 21
Equation 5.5. Baseline Adjustment for Destruction in the Baseline Scenario....22
Equation 5.6. Calculating Baseline Adjustment for Destruction in a Qualifying Flare at a Closed Landfill 22
Equation 5.7. Calculating Baseline Adjustment for Non-Qualifying Devices 23
Equation 5.8. Calculating Baseline Adjustment for Qualifying Devices....23
Equation 5.9. Calculating Project Emissions 25
Equation 5.10. Calculating Project Emissions from Fossil Fuel Use 25
Equation 5.11. Calculating Project Emissions from Electricity Use 25
Equation 5.12. Calculating Project Emissions from the Use of Supplemental Natural Gas....26
Equation C.1. Calculation of Baseline Discount for Flares at a Closed Landfill....70
Equation C.2. Calculation of Baseline Discount for a Non-Qualifying Device 71

Abbreviations and Acronyms

ACF	Actual cubic feet
BAU	Business as usual
CAA	Clean Air Act
CARB	California Air Resources Board
CEQA	California Environmental Quality Act
CH_4	Methane
CNG	Compressed natural gas
CO_2	Carbon dioxide
EG	Emission Guidelines
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
GCCS	Gas Collection and Control System
IPCC	Intergovernmental Panel on Climate Change
LFG	Landfill gas
LFGE	Landfill gas-to-energy
LMOP	Landfill Methane Outreach Program
LNG	Liquefied natural gas
Mg	Mega gram (1,000,000 grams, or one tonne or “t”)
MMg	Million mega grams
MSW	Municipal solid waste
MWh	Megawatt hour
N_2O	Nitrous oxide
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NG	Natural gas
NMOC	Non-methane organic compounds
NPV	Net Present Value
NSPS	New Source Performance Standards
NSR	New Source Review
PSD	Prevention of Significant Deterioration
QA/QC	Quality Assurance/Quality Control
RCRA	Resources Conservation and Control Act
Reserve	Climate Action Reserve
SCF	Standard cubic feet (60°F and 1 atm)
tCO_2e	Metric ton of carbon dioxide equivalent
VOC	Volatile organic compound
WIP	Waste in place

1 Introduction

The Climate Action Reserve (Reserve) Landfill Project Protocol provides guidance to account for and report greenhouse gas (GHG) emission reductions associated with installing a landfill gas collection and destruction system at a landfill.

The Climate Action Reserve is an environmental nonprofit organization that promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. A pioneer in carbon accounting, the Reserve serves as an approved Offset Project Registry (OPR) for the State of California's Cap-and-Trade Program and plays an integral role in supporting the issuance and administration of compliance offsets. The Reserve also establishes high quality standards for offset projects in the North American voluntary carbon market and operates a transparent, publicly-accessible registry for carbon credits generated under its standards.

Project developers that install landfill gas capture and destruction technologies use this document to register GHG reductions with the Reserve. This protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Verification Program Manual[1] and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification of GHG emission reductions associated with a landfill project.[2]

[1] Available online at http://www.climateactionreserve.org/how/verification/verification-program-manual/

[2] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG accounting principles.

2 The GHG Reduction Project

2.1 Background

Most MSW in the United States is deposited in landfills, where bacteria decompose the organic material. A product of both the bacterial decomposition and oxidation of solid waste is landfill gas, which is composed of methane (CH_4) and carbon dioxide (CO_2) in approximately equal concentrations, as well as smaller amounts of non-methane organic compounds (NMOC), nitrogen (N_2), oxygen (O_2) and other trace gases. If not collected and destroyed, over time, this landfill gas is released to the atmosphere. In the United States, the Environmental Protection Agency (EPA) has concluded that landfills are the largest source of anthropogenic emissions of CH_4, accounting for 16 percent of total CH_4 emissions.[3] However, the solid waste industry has made significant efforts to reduce their GHG emissions, with an almost 40% reduction in CH_4 emissions since 1990.[4]

There is considerable uncertainty regarding the actual amount of fugitive methane emissions from landfills. Therefore, this protocol does not address fugitive landfill methane emissions. Instead, it addresses the methane that is captured and destroyed in excess of any regulatory requirements. Landfill operations that utilize bioreactor technologies are not eligible to use this protocol, as it is unclear what effects the bioreactor may have on the baseline fugitive methane emissions and the timing of their release from the landfill.

2.2 Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the collection of methane gas from one or more specified cells at an eligible landfill, and the destruction of such methane gas in one or more eligible destruction devices. The expansion of an existing Gas Collection and Control System (GCCS) to a new cell or cells can optionally be included within an existing landfill project or submitted as a new project. If any cells are to be considered as a new project, those cells must be engineered in such a way that LFG cannot migrate between cells in the proposed new project and cells in the existing project. Where a single landfill contains multiple cells, across multiple landfill projects, those projects may share common destruction devices, provided the flow of methane from each project is metered separately.

Qualifying destruction devices may include utility flares, enclosed flares, engines, turbines, microturbines, boilers, pipelines, leachate evaporators, kilns, sludge dryers, burners, furnaces, or fuel cells. Devices not specifically listed here may still be eligible under this protocol, provided written approval is obtained from the Reserve. All destruction devices require an appropriate default or site-specific destruction efficiency value.[5]

An eligible landfill is one that:

1. Is not subject to regulations or other legal requirements requiring the destruction of methane gas; and
2. Is not a bioreactor, as defined by the U.S. EPA: “a MSW landfill or portion of a MSW landfill where any liquid other than leachate (leachate includes landfill gas condensate)

[3] U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016, EPA-430-R-18-003 (April 2018).
[4] Ibid, *Table 7-3: CH_4 Emissions from Landfills (MMR CO_2 Eq.)*.
[5] See Table B.2 and the guidance in Section B.1 for biogas destruction efficiency defaults and site-specific values.

is added in a controlled fashion into the waste mass (often in combination with recirculating leachate) to reach a minimum average moisture content of at least 40 percent by weight to accelerate or enhance the anaerobic (without oxygen) biodegradation of the waste"[6]; and

3. Does not add any liquid other than leachate into the waste mass in a controlled manner.

Captured landfill gas may be destroyed onsite or transported for offsite use. Regardless of how project developers use the captured landfill gas, for the project to be eligible to register with the Reserve under this protocol, the ultimate fate of the methane must be destruction.[7]

Landfill gas collection and destruction systems typically consist of wells, pipes, blowers, caps and other technologies that enable or enhance the collection of landfill gas and convey it to a destruction technology. At some landfills, a flare will be the only device where landfill gas is destroyed. For projects that utilize energy or process heat technologies to destroy landfill gas, such as turbines, reciprocating engines, fuel cells, boilers, heaters, or kilns, these devices will be where landfill gas is destroyed. Most projects that produce energy or process heat also include a flare to destroy gas during periods when the gas utilization project is down for repair or maintenance. Direct use arrangements which entail the piping of landfill gas to be destroyed by an industrial end user at an offsite location are also an eligible approach to destruction of the landfill gas. For instances of direct use, agreements between the project developer and the end user of the landfill gas (e.g., an industrial client purchasing the landfill gas from the project developer), must include a legally binding agreement to assure that the GHG reductions will not be claimed by more than one party. Direct use project developers must also be able to identify the specific destruction technology at the receiving end of the pipeline.

Projects that utilize landfill methane for energy generation may avoid GHG emissions associated with fossil fuel combustion. However, under this protocol such projects do not receive credit for fossil fuel displacement. Although the Reserve does not issue CRTs for fossil fuel displacement, it strongly supports using landfill methane for energy production.

2.3 The Project Developer

The "project developer" is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be landfill owners, landfill operators, GHG project financiers, utilities, or independent energy companies. The project developer must have clear ownership of the project's GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership by signing the Reserve's Attestation of Title form.[8]

[6] 40 CFR 63.1990 and 40 CFR 258.28a.

[7] It is possible that at some point landfill gas may be used in the manufacture of chemical products. However, given that these types of projects are few, if any, these projects are not addressed in this protocol.

[8] Attestation of Title form available at http://www.climateactionreserve.org/how/program/documents/.

3 Eligibility Rules

Projects that meet the definition of a GHG reduction project in Section 2.2 must fully satisfy the following eligibility rules in order to register with the Reserve.

Eligibility Rule I:	Location	→	*U.S. and its tribal lands and territories*
Eligibility Rule II:	Project Start Date	→	*No more than 12 months prior to project submission*
Eligibility Rule III:	Project Crediting Period	→	*Emission reductions may only be reported during the crediting period; the crediting period may be renewed one time*
Eligibility Rule IV:	Additionality	→	*Meet performance standard*
		→	*Avoid exceeding limits on credit stacking*
		→	*Exceed legal requirements*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Under this protocol, only projects located at landfills in the United States and its tribal lands and territories are eligible to register with the Reserve.[9]

3.2 Project Start Date

The project start date shall be defined by the project developer, but must be no more than 90 days after landfill gas is first destroyed in a project destruction device, regardless of whether sufficient monitoring data are available to report reductions. The start date is defined in relation to the commencement of methane destruction, not other activities that may be associated with project initiation or development.

To be eligible, the project must be submitted to the Reserve no more than twelve months after the project start date.[10] Projects may always be submitted for listing by the Reserve prior to their start date. For projects that are transferring to the Reserve from other offset registries, start date guidance can be found in the Program Manual.

3.3 Project Crediting Period

The Reserve will issue CRTs for GHG reductions quantified and verified using this protocol for an initial crediting period of ten years following the project start date. However, the Reserve will cease to issue CRTs for GHG reductions if at any point landfill gas destruction becomes legally required at the landfill. If an eligible project has begun operation at a landfill that later becomes subject to a regulation, ordinance, or permitting condition that would call for the installation and operation of a landfill gas control system, the Reserve will issue CRTs for GHG reductions achieved up until the date that the landfill gas control system is legally required to be operational.

[9] Refer to Appendix A for information on the performance standard analysis supporting application of this protocol in the United States.

[10] Projects are considered submitted when the project developer has fully completed and filed the appropriate Project Submittal Form, available at: http://www.climateactionreserve.org/how/program/documents/.

The project crediting period begins at the project start date regardless of whether sufficient monitoring data are available to verify GHG reductions. Projects will be eligible to apply for a second crediting period, provided the project meets the eligibility requirements of the most current version of the protocol at the time of such application. If a project developer wishes to apply for eligibility under a second, 10-year crediting period, they must do so no sooner than six months before the end date of the initial crediting period.

A project may be eligible for a second crediting period even if the project has failed to maintain continuous reporting up to the time of applying for a second crediting period, provided the project developer elects to take a zero-credit reporting period for any period for which continuous reporting was not maintained.[11] The second crediting period shall begin on the day following the end date of the initial crediting period.

3.4 Additionality

The Reserve registers only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The performance standard test
2. The legal requirement test

3.4.1 The Performance Standard Test

Projects pass the performance standard test by meeting a performance threshold, i.e., a standard of performance applicable to all landfill projects, established on an *ex ante* basis by this protocol.[12]

If a project upgrades to a newer version of the protocol for a subsequent verification, it must meet the performance standard test requirements of that version of the protocol, applied as of the original project start date. If a project is submitted for a second crediting period, it is subject to the performance standard test in the most current version of the protocol at that time, applied as of the original project start date.

For this protocol, the Reserve uses a practice-change threshold that focuses on the baseline scenario and changes made in the project scenario. A project passes the performance standard test if it involves one of the following activities:

1. Installation of a landfill gas collection system and a new qualifying destruction device at an eligible landfill where landfill gas has never been collected and destroyed prior to the project start date.

2. Installation of a new qualifying destruction device at an eligible landfill where landfill gas is currently collected and vented, but has never been destroyed in any manner prior to the project start date.

[11] See zero-credit reporting period guidance and requirements in the Reserve Program Manual, http://www.climateactionreserve.org/how/program/program-manual/.

[12] The Reserve defined the performance standard based upon an evaluation of landfill practices in the United States. A summary of the performance standard analysis is provided in Appendix A.

3. Installation of a new qualifying destruction device at an eligible landfill where landfill gas was collected and destroyed at any time prior to the project start date using:
    a. A non-qualifying destruction device (e.g., passive flare); or
    b. A destruction device that is not otherwise eligible under the protocol (e.g., a destruction device installed prior to the earliest allowable project start date).

4. Installation of a new gas collection system on a physically-distinct[13] cell (or cells) where neither gas collection nor destruction has previously occurred, and connection of this new collection system to an existing landfill gas destruction system. The new collection system must have its own metering that satisfies the requirements of this protocol. In this scenario, more than one project may exist at a single landfill. The start date for this project shall be no more than 90 days following the first flow of landfill gas from the new collection system to the destruction system, regardless of the presence of adequate metering for crediting.

Destruction devices that were installed temporarily and utilized only for pilot or testing purposes specifically in anticipation of the GHG project shall not be considered in determining project eligibility or quantification. Devices may only be excluded under this provision if they were installed as a direct precursor to the project activity in order to gather information or determine project viability. Verifiable evidence of this intent must be presented. Changes in landfill ownership, or in the ownership of destruction devices, are not considered in determining prior landfill gas management practices. If landfill gas was previously collected and destroyed (in the given cells of the project) by a party other than the project developer, it still qualifies as "prior" collection and destruction.

Under scenarios (1), (2), and (3) above, expanding a well-field (either in conjunction with, or subsequent to, installing a new destruction device) may constitute a system expansion rather than a separate project. Expanding a well-field is eligible as a new, separate project only if it meets the conditions described in scenario (4). In these scenarios, expanding a well-field initiates a new crediting period.

The practice-change threshold is applied as of the project start date and is evaluated at the project's initial verification.

The Reserve will periodically re-evaluate the appropriateness of the performance standard criteria by updating the analysis in Appendix A. As part of its periodic assessments of the performance threshold, the Reserve will use a stakeholder process to evaluate whether implementation of this protocol has resulted in negative environmental effects, such as increased emissions of criteria pollutants and/or methane. Projects under this protocol are expected to have positive environmental effects. If it is determined that negative environmental effects have occurred, the Reserve will identify and implement revisions to the protocol to prevent such effects from occurring in the future, or may suspend implementation of the protocol if necessary.

3.4.2 Limits on Credit Stacking

When multiple forms of incentive credits are sought for a single activity at a single facility or on a single piece of land, with some temporal overlap between the different credits or payments, it is referred to as "credit stacking". Under this protocol, credit stacking is defined as receiving both

[13] The landfill cell must be engineered in such a way that landfill gas cannot migrate between that cell and other landfill cells.

offset credits and other types of mitigation credits for the same activity on spatially overlapping areas (i.e., in the same landfill). Mitigation credits are any instruments issued for the purpose of offsetting the environmental impacts of another entity, such as emissions of GHGs, or the displacement of fossil fuel emissions from transport applications, to name a few.

Any type of mitigation credit received for activities on the project area must be disclosed by the project developer to the verification body and the Reserve on an ongoing basis.

The Reserve has identified market opportunities for the upgrade of landfill gas into high-Btu fuels, that provide an incentive sufficient to raise additionality concerns. Such opportunities include the federal Renewable Fuel Standard (RFS) and the California Low Carbon Fuel Standard (LCFS), where the carbon incentive is often orders of magnitude greater than that provided by the sale of offset credits. Analysis reveals that the strength of these incentives is driving investment in landfill gas projects at present, and that such projects can be considered "business as usual", without the additional presence of carbon offset revenues.[14] Therefore, projects that receive mitigation credits for upgrading landfill gas into high-Btu fuels will not be eligible to receive offset credits for the same period of time under this protocol.

3.4.3 The Legal Requirement Test

All projects are subject to a legal requirement test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. Projects pass the legal requirement test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the destruction of landfill gas methane at the project site.[15] To satisfy the legal requirement test, project developers must submit a signed Attestation of Voluntary Implementation form[16] prior to the commencement of verification activities each time the project is verified. In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the legal requirement test.

As of the project start date, landfills collecting and destroying landfill gas to comply with regulations or other legal mandates – or that are required by regulation or legal mandate to install a landfill gas control system in the future – are not eligible to register new projects with the Reserve. Landfills collecting and destroying landfill gas to comply with regulations or other legal mandates are not eligible to register GHG reductions associated with the early installation of gas control systems during landfill expansion into new cells.

If an eligible project begins operation at a landfill that later becomes subject to a regulation, ordinance, or permitting condition that calls for the installation of a landfill gas control system, GHG reductions may be reported to the Reserve up until the date that the installation of a landfill gas control system is legally required to be operational. If the landfill's methane emissions are included under an emissions cap (e.g., under a state or federal cap-and-trade program), emission reductions may likewise be reported to the Reserve until the date that the emissions cap takes effect.

[14] Further information about the Reserve's performance standard analysis is available in Section A.3.
[15] A project may pass the legal requirement test if a landfill gas control system is installed to treat landfill gas for NMOC in order to comply with a regulation, ordinance, or permitting condition, but destruction of the landfill gas is not the only compliance mechanism available to the landfill operator, and the total mass flow of NMOC for the landfill gas control system is less than the applicable NMOC threshold (see Section 3.4.3.1).
[16] Form available at http://www.climateactionreserve.org/how/program/documents/.

3.4.3.1 Federal Regulations

There are several EPA regulations for MSW landfills that have a bearing on the eligibility of methane collection and destruction projects as voluntary GHG reduction projects. These regulations include:

- New Source Performance Standards (NSPS) for MSW Landfills, codified in 40 CFR 60 subpart WWW – Targets landfills that commenced construction or made modifications after May 1991
- New Source Performance Standards (NSPS) for MSW Landfills, codified in 40 CFR 60 subpart XXX – Targets landfills that commenced construction, reconstruction, or modification after July 17, 2014
- Emission Guidelines (EG) for MSW Landfills, codified in 40 CFR 60 subpart Cc. – Targets existing landfills that commenced construction before May 30, 1991, but accepted waste after November 8, 1987
- The National Emission Standards for Hazardous Air Pollutants (NESHAP), codified in 40 CFR 63 subpart AAAA – Regulates new and existing landfills

These regulations require control of non-methane organic compounds (NMOC) from landfills according to certain size and emission thresholds. In most cases, activities to reduce NMOC will also lead to a reduction in CH_4 emissions, as gas collection and destruction is a common NMOC management technique employed at regulated landfills. If the project start date occurs prior to the date of an NMOC test that crosses the regulatory threshold, the project may continue to receive credits for landfill gas destruction up until the date that the system is required to be operational by the regulation. If the project start date occurs after the date of an NMOC test that crosses the regulatory threshold, the landfill is not eligible to register as a project.

Landfills smaller than 2.5 million megagrams or 2.5 million cubic meters of waste, and those landfills not defined as MSW landfills such as landfills that contain only construction and demolition material or industrial waste, are not usually subject to NSPS, EG or NESHAP.

The list of regulations above should not be considered exhaustive, and the onus will be on project developers and verification bodies to ensure all applicable laws have been considered, when demonstrating that the legal requirement test has been met.

3.4.3.2 State and Local Regulations, Ordinances, and Permitting Requirements

All states are required by the Clean Air Act (CAA) and Subtitle D of the Resource Conservation and Recovery Act (RCRA Subtitle D) to promulgate rules for landfills. Some landfills that exceed applicable emission thresholds will require site-specific permits requiring controls under the New Source Review (NSR) or Prevention of Significant Deterioration (PSD) permitting program authorized by the CAA and implemented by states. These state-level rules generally follow federal guidelines. However, the state rules can be more stringent, or require the installation of a gas collection and destruction system, or the destruction of volatile organic compounds (VOC), NMOC, or CH_4 earlier, or at smaller facilities, than the federal regulations would require.

For example, on June 17, 2010, California Air Resources Board (CARB) approved a discrete early action measure to reduce methane emissions from landfills. The control measure applies to landfills with greater than 450,000 Mg WIP. The regulation reduces methane emissions from landfills by requiring gas collection and control systems where these systems were not

previously required and establishes statewide performance standards to maximize methane capture efficiencies.[17]

In recent years the inclusion of air quality, water quality and even GHG emission control measures in permitting requirements (CEQA, NEPA, etc.) has become more prevalent. State and local governments may regulate MSW landfills by putting in place nuisance laws or requiring solid waste facilities smaller than the facilities regulated by the CAA or RCRA Subtitle D to control landfill gas. Other regulations or ordinances may require minimal gas collection to prevent lateral migration of the landfill gas to neighboring properties. Collection and destruction activities required under NSPS, EG, NESHAP, CAA and other state and local regulations, ordinances or permitting requirements are not eligible as GHG reduction projects.[18]

The Reserve acknowledges that non-CAA programs such as RCRA Subtitle D, water quality regulations and other state and local regulations, ordinances or permitting requirements do not always dictate the installation of a landfill gas collection system as the only compliance mechanism to manage NMOC emissions or VOC water contamination, but that the installation of a landfill gas collection system is commonly the most effective and least demanding compliance mechanism available. Therefore, the installation of a landfill gas collection and destruction system for compliance with non-CAA regulations will not qualify as a GHG reduction project under this protocol unless these projects also meet the eligibility requirements discussed below.

Some water quality, explosive gas mitigation, and local nuisance regulations and ordinances allow for passive landfill gas control systems, which collect and vent landfill gas to the atmosphere, but are not required to treat or destroy the vented gases. Project activities that add a destruction device to a landfill that is only required to implement a passive landfill gas control system pass the legal requirement test.

3.5 Regulatory Compliance

As a final eligibility requirement, project developers must attest that the project is in material compliance with all applicable laws (e.g., air, water quality, safety, etc.) prior to verification activities commencing each time a project is verified. Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a project is in a state of recurrent non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance. Non-compliance solely due to administrative or reporting issues, or due to “acts of nature,” will not affect CRT crediting.

Where projects are co-located at a single landfill, and in particular where projects share common equipment or infrastructure, the onus will be on the project developer(s) to demonstrate that a regulatory violation at the site is not relevant to all projects.

[17] California Air Resources Board, Landfill Methane Control Measure webpage: http://www.arb.ca.gov/cc/landfills/landfills.htm.

[18] The Reserve acknowledges that the third-party verifier will need to exercise some discretion when reviewing permits that require the installation of a landfill gas control system or any portion thereof. Permits tend to include strong language, such as “must” or “shall” install a landfill gas control system, even in the case that a landfill chooses to voluntarily install a landfill gas control system but is required to obtain a permit to do so.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers in order to determine the total net change in GHG emissions caused by a landfill project.

This protocol does not account for carbon dioxide emission reductions associated with displacing grid-delivered electricity or fossil fuel use.

CO_2 emissions associated with the generation and destruction of landfill gas are considered biogenic emissions[19] (as opposed to anthropogenic) and are not be included in the GHG Assessment Boundary. This is consistent with the Intergovernmental Panel on Climate Change's (IPCC) guidelines for captured landfill gas.[20]

Figure 4.1 below provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the boundary. All SSRs within the dashed line are accounted for under this protocol.

Table 4.1 provides greater detail on each SSR and provides justification for the inclusion or exclusion of SSRs and gases from the GHG Assessment Boundary.

[19] The rationale is that carbon dioxide emitted during combustion represents the carbon dioxide that would have been emitted during natural decomposition of the solid waste. Emissions from the landfill gas control system do not yield a net increase in atmospheric carbon dioxide because they are theoretically equivalent to the carbon dioxide absorbed during plant growth.

[20] *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; p.5.10, ftnt.

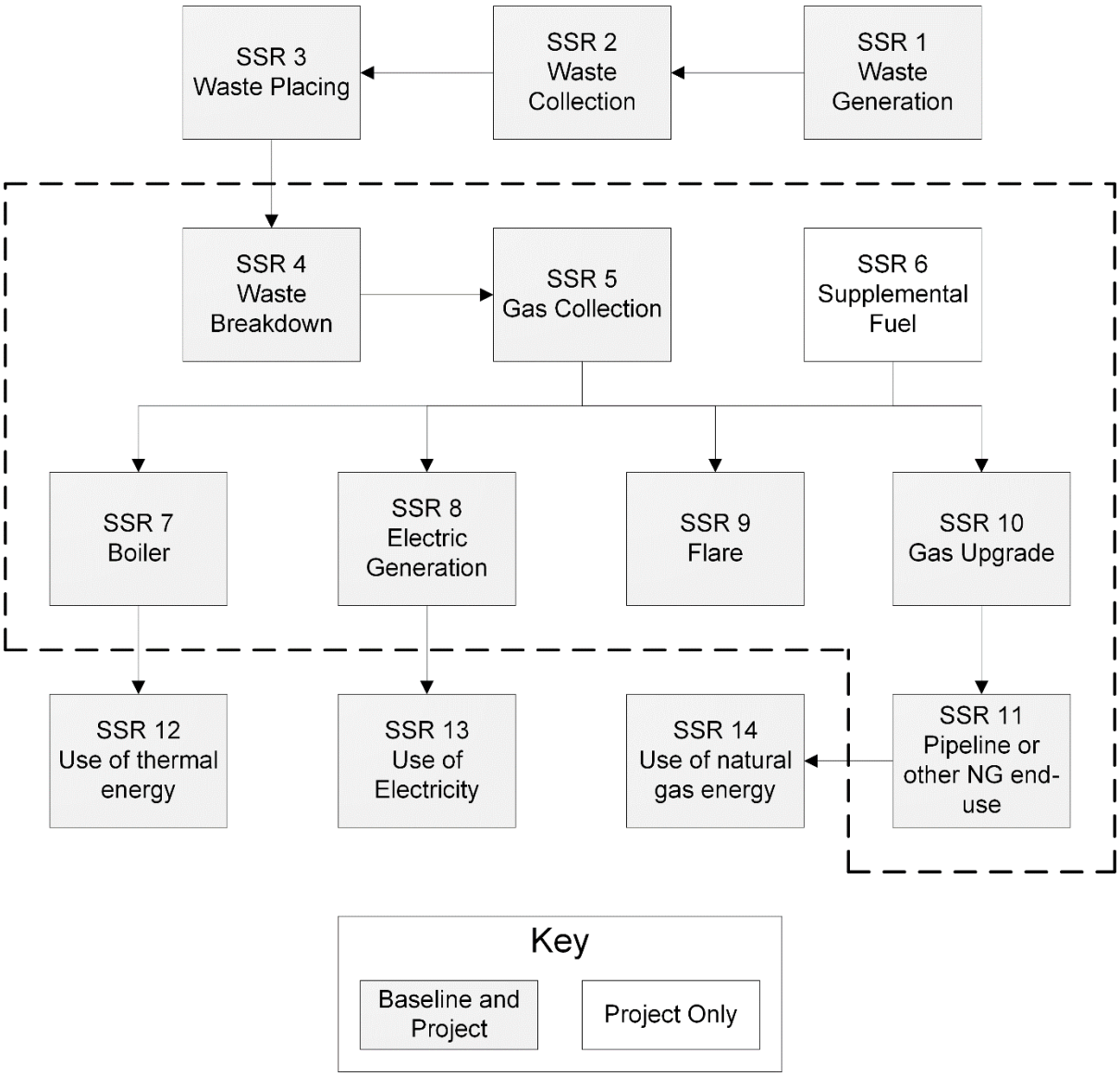


Figure 4.1. General Illustration of the GHG Assessment Boundary

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
1	Emissions from Waste Generation	N/A	B,P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
2	Emissions from Waste Collection prior to landfilling	CO_2	B,P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		CH_4		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		N_2O		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios s
3	Emissions from Waste Placing Activities	CO_2	B,P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		CH_4		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		N_2O		Excluded	This emission source is assumed to be equal in the baseline and project scenarios
4	Emissions from Waste Breakdown in Landfill	CO_2	B,P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Primary source of GHG emissions in baseline. Calculated based on destruction in baseline and project destruction devices.
5	Emissions from Gas Collection System	CO_2	P	Included	Landfill projects result in CO_2 emissions associated with the energy used for collection and processing of landfill gas
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline Gas Collection System	CO_2	B	Excluded	This emission source is assumed to be very small
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small
6	Emissions from Supplemental Fuel	CO_2	P	Included	Landfill projects may require use of supplemental fossil fuel, resulting in significant new GHG emissions
		CH_4		Included	Calculated based on destruction efficiency of destruction device
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline Supplemental Fuel Use	CO_2	B	Excluded	This emission source is assumed to be very small
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small
7		CO_2	P	Excluded	Biogenic CO_2 emissions are excluded

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
	Emissions from Project LFG Boiler Destruction	CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline LFG Boiler Destruction	CO_2	B	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
8	Emissions from Project LFG Electricity Generation	CO_2	P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline LFG Electricity Generation	CO_2	B	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
9	Emissions from Project LFG Flare Destruction	CO_2	P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline LFG Flare Destruction	CO_2	B	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
10	Emissions from Upgrade of LFG	CO_2	B,P	Included	Landfill projects may result in GHG emissions from additional energy used to upgrade landfill gas
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small
11	Emissions from Project LFG Pipeline or other NG end-use	CO_2	P	Excluded	Biogenic emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	Assumed to be very small
	Emissions from Baseline LFG Pipeline or other NG end-use	CO_2	B	Excluded	Biogenic emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
12	Use of Project Generated Thermal Energy	CO_2	P	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG-generated thermal energy
	Use of Baseline Generated Thermal Energy	CO_2	B	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG-generated thermal energy

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
13	Use of Project Generated Electricity	CO_2	P	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG-generated electricity.
	Use of Baseline Generated Electricity	CO_2	B	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG-generated electricity.
14	Use of Natural Gas Energy	CO_2	P	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG delivered through pipeline or other end uses
	Use of Baseline Natural Gas Energy	CO_2	B	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG delivered through pipeline or other end uses

5 Quantifying GHG Emission Reductions

GHG emission reductions from a landfill project are quantified by comparing actual project emissions to baseline emissions at the landfill. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the landfill project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

GHG emission reductions must be quantified and reported on at least an annual basis. Such reports must be verified on a schedule in accordance with the requirements of Section 7.3. Project developers may choose to quantify and verify GHG emission reductions on a more frequent basis if they desire. The length of time over which GHG emission reductions are quantified and reported is called the "reporting period".

The calculations provided in this protocol are derived from internationally accepted methodologies.[21] Project developers shall use the calculation methods provided in this protocol to determine baseline and project GHG emissions in order to quantify GHG emission reductions.

[21] The Reserve's GHG reduction calculation method is derived from the Kyoto Protocol's Clean Development Mechanism (ACM0001 V.6 and AM0053 V.1), the EPA's Climate Leaders Program (Draft Landfill Offset Protocol, October 2006), the GE AES Greenhouse Gas Services Landfill Gas Methodology V.1, and the RGGI Model Rule (January 5, 2007).

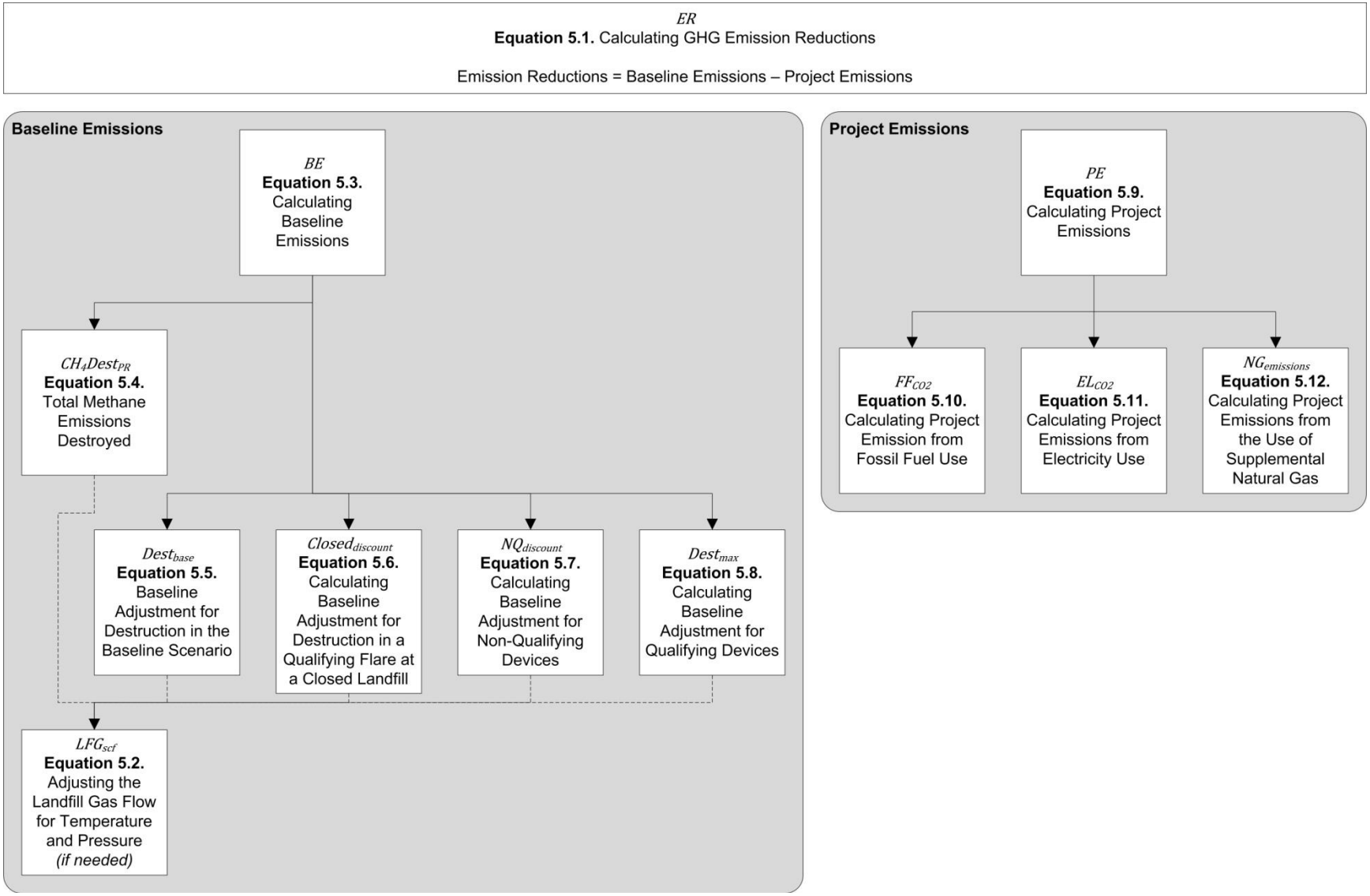


Figure 5.1. Organizational Chart for Equations in Section 5

Equation 5.1. Calculating GHG Emission Reductions

$$ER = BE - PE$$

Where,			Units
ER	=	GHG emission reductions of the project activity during the reporting period	tCO_2e
BE	=	Baseline emissions during the reporting period	tCO_2e
PE	=	Project emissions during the reporting period	tCO_2e

If any of the landfill gas flow metering equipment does not internally correct for the temperature and pressure of the landfill gas, separate pressure and temperature measurements must be used to correct the flow measurement. Corrected values must be used in all of the equations of this section. Apply Equation 5.2 only if the landfill gas flow metering equipment does not internally correct for temperature and pressure.

Equation 5.2. Adjusting the Landfill Gas Flow for Temperature and Pressure

$$LFG_{i,t} = LFG_{unadjusted} \times \frac{520}{T} \times \frac{P}{1}$$

Where,			Units
$LFG_{i,t}$	=	Adjusted volume of landfill gas fed to the destruction device *i*, in time interval *t*	scf
$LFG_{unadjusted}$	=	Unadjusted volume of landfill gas collected for the given time interval	acf
T	=	Measured temperature of the landfill gas for the given time period (°R = °F + 459.67)	°R
P	=	Measured pressure of the landfill gas in for the given time interval	atm

5.1 Quantifying Baseline Emissions

Traditional baseline emission calculations are not required for this protocol for the quantification of methane reductions. The baseline scenario assumes that all uncontrolled methane emissions are released to the atmosphere except for the portion of methane that would be oxidized by bacteria in the soil of uncovered landfills absent the project,[22] or destroyed by a baseline destruction device. Therefore, with the exception of the deductions outlined below, baseline emissions are equal to the sum of all methane destroyed by eligible destruction devices.

As noted in Section 3.4.1, projects may fall into five categories based on the baseline state of the landfill and level of landfill gas management. Each of these categories requires a slightly different methodology for calculating relevant baseline emissions.

1. Landfills where no previous collection or destruction took place prior to the project start date must deduct the following from baseline emissions:
    a. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

2. Landfills where previous collection and/or destruction took place in a non-qualifying destruction device must deduct the following from baseline emissions:
    a. The amount of methane destroyed by the non-qualifying destruction device.

[22] A small portion of the methane generated in landfills (around 10%) is naturally oxidized to carbon dioxide by methanotrophic bacteria in the cover soils of well managed landfills. The 10% factor is based on Intergovernmental Panel on Climate Change (IPCC) guidelines (2006).

   b. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

3. Landfills where previous collection and destruction took place in a qualifying destruction device must deduct the following from baseline emissions:
   a. The amount of methane that could have been destroyed if the baseline destruction device was operating at full capacity.
   b. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

4. Closed landfills where previous collection and destruction took place in a qualifying flare must deduct the following from baseline emissions:
   a. The amount of methane collected by baseline landfill gas wells and destroyed in the qualifying flare.
   b. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

5. Projects where an existing GCCS is connected to a new landfill cell that was previously not affected by the GCCS must deduct the following from baseline emissions:
   a. If previous collection and destruction of methane from this cell (other than in the project GCCS), then the appropriate amount of methane shall be deducted according to the guidance in items 2-4, above, depending on which is relevant.
   b. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

These conditions ensure that the reductions resulting from the GHG project can be accounted for separately from collection and destruction that would have occurred from the baseline equipment. Only the landfill gas destroyed beyond what would have been destroyed by the baseline collection and destruction system is considered eligible for crediting.

Baseline emissions shall be calculated using Equation 5.3. Both the OX discount factor and the DF discount factor shall only be applied to periods of time during the reporting period for which each factor is applicable. The OX discount factor shall only be applied for the number of days during the reporting period when the landfill did not incorporate a synthetic liner throughout the entire area of the final cover system. The DF discount factor shall only be applied for the number of days during the reporting period when methane concentration values were taken at a frequency that is less than continuous (every 15 minutes). Thus, Equation 5.3 may be calculated separately for different portions of the reporting period, with the results summed to provide a total BE value for the entire reporting period.

Equation 5.3. Calculating Baseline Emissions

$$\boldsymbol{BE = CH_4Dest_{PR} \times GWP \times (1 - OX) \times (1 - DF) - Dest_{base} \times (1 - OX)}$$

Where,			Units
BE	=	Baseline emissions during the reporting period	tCO_2e
CH_4Dest_{PR}	=	Total methane destroyed by the project landfill gas collection and destruction system during the reporting period (see Equation 5.4)	tCH_4
GWP	=	Global warming potential factor of methane to carbon dioxide equivalent, equal to 25 at the time of publication[23]	tCO_2e/tCH_4
OX	=	Factor for the oxidation of methane by soil bacteria. Equal to 0.10 for all landfills except those that incorporate a synthetic liner throughout the entire area of the final cover system, where OX = 0	
DF	=	Discount factor to account for uncertainties associated with the monitoring equipment. (See Section 6.1.) Equal to zero if using continuous methane monitoring	
$Dest_{base}$	=	Adjustment to account for baseline LFG destruction device (see Equation 5.5). Equal to zero if no baseline LFG destruction system is in place prior to project implementation	tCO_2e

The term CH_4Dest_{PR} represents the amount of methane destroyed by the project. This term is calculated according to Equation 5.4.

[23] At time of publication, landfill projects are instructed to use GWP values from the IPCC 4th Assessment Report. This value may be updated in the future via guidance from the Reserve.

Equation 5.4. Total Methane Emissions Destroyed

$$\boldsymbol{CH_4Dest_{PR} = \sum_i (CH_4Dest_i) \times (0.0423 \times 0.000454)}$$

Where,			Units
CH_4Dest_{PR}	=	Total methane destroyed by the project landfill gas collection and destruction system during the reporting period	tCH_4
$CH_4 Dest_i$	=	The net quantity of methane destroyed by destruction device *i* during the reporting period	scf CH_4
0.0423	=	Density of methane	lb CH_4/scf CH_4
0.000454	=	Conversion factor from pounds to metric tonnes	tCH_4/lb CH_4

And,

$$\boldsymbol{CH_4Dest_i = Q_i \times DE_i}$$

Where,			Units
$CH_4 Dest_i$	=	The net quantity of methane destroyed by device *i* during the reporting period	scf
Q_i	=	Total quantity of landfill methane sent to destruction device *i* during the reporting period	scf
DE_i	=	Methane destruction efficiency for device *i*. See Appendix B for guidance	

And,

$$\boldsymbol{Q_i = \sum_t \left(LFG_{i,t} \times PR_{CH_4,t}\right)}$$

Where,			Units
Q_i	=	Total quantity of landfill methane sent to destruction device *i* during the reporting period	scf
$LFG_{i,t}$	=	Adjusted volume of landfill gas fed to the destruction device *i*, in time interval *t*	scf
t	=	Time interval for which LFG flow and concentration measurements are aggregated. See Table 6.1 for guidance	
$PR_{CH4,t}$	=	The average methane fraction of the landfill gas in time interval *t*	scf CH_4/ scf LFG

For projects where methane was destroyed in the baseline, Equation 5.5 must be applied. This equation accounts for the methane emissions calculated in Equation 5.4 that would have been destroyed in the absence of the project activity.

Any project at a landfill where methane was collected and destroyed at any time prior to the project start date – even if the prior collection and/or destruction system was removed or has been dormant for an extended period of time – must apply the baseline deduction. The time period over which the value of $Dest_{base}$ is to be aggregated, using Equation 5.5, may be chosen by the project developer, but cannot be less than weekly, and must be consistent throughout the reporting period.

Equation 5.5. Baseline Adjustment for Destruction in the Baseline Scenario

$$\boldsymbol{Dest_{base} = (Closed_{discount} + NQ_{discount} + Dest_{max}) \times 0.0423 \times 0.000454 \times GWP}$$

Where,			Units
$Dest_{base}$	=	Adjustment to account for the baseline methane destruction associated with a baseline destruction device. Equal to zero if there is no baseline installation	tCO_2e
$Closed_{discount}$	=	Adjustment to account for the methane that would have been combusted in the baseline flare from baseline wells at a closed landfill. Equal to zero if the project is not a flare project at a closed landfill	scf CH_4
$NQ_{discount}$	=	Adjustment to account for the methane that would have been combusted in the baseline, non-qualifying combustion device. Equal to zero if there is no non-qualifying combustion device	scf CH_4
$Dest_{max}$	=	Deduction of the un-utilized capacity of the baseline destruction device. This deduction is to be applied only when a new destruction device is used during project activity. See Box 5.1 below for an example of the application of the $Dest_{max}$ adjustment	scf CH_4
0.0423	=	Density of methane	lb CH_4/ scf CH_4
0.000454	=	Conversion factor	tCH_4/ lb CH_4
GWP	=	Global warming potential factor of methane to carbon dioxide equivalent, equal to 25 at the time of publication[24]	tCO_2e/tCH_4

Equation 5.6. Calculating Baseline Adjustment for Destruction in a Qualifying Flare at a Closed Landfill

$$\boldsymbol{Closed_{discount} = LFG_{B1} \times B_{CH_4,closed}}$$

Where,			Units
$Closed_{discount}$	=	Adjustment to account for the methane that would have been combusted in the baseline flare from baseline wells at a closed landfill. Equal to zero if the project is not a flare project at a closed landfill	scf CH_4
LFG_{B1}	=	Landfill gas from the baseline landfill gas wells that would have been destroyed by the qualifying destruction system during the reporting period. See Appendix C for guidance on calculating LFG_{B1}	scf
$B_{CH4,closed}$	=	Methane fraction of landfill gas destroyed by the collection system during the reporting period. See Appendix C for guidance on calculating $B_{CH4,closed}$	scf CH_4/ scf LFG

$NQ_{discount}$, may be determined using either of the following options.

1. $NQ_{discount}$ shall be equal to the measured quantity of methane recovered through an active gas collection system installed into the corresponding cell or waste mass of the landfill in which the baseline devices operated. The landfill gas flow from these active wells shall be determined using Equation 5.4 above for a minimum of one month.[25]

[24] At time of publication, landfill projects are instructed to use GWP values from the IPCC 4th Assessment Report. This value may be updated in the future via guidance from the Reserve.

[25] For the purpose of using Equation 5.4 to determine $NQ_{discount}$, the quantity of landfill gas would be only that which is being metered from the corresponding cell or waste mass in which the baseline devices had operated, and not necessarily all of the landfill gas being destroyed by the destruction system.

2. $NQ_{discount}$ shall be monitored and calculated per Equation 5.7 and Appendix D.

Equation 5.7. Calculating Baseline Adjustment for Non-Qualifying Devices

$$\boldsymbol{NQ_{discount} = LFG_{B2} \times B_{CH_4,NQ}}$$

Where,			Units
$NQ_{discount}$	=	Adjustment to account for the methane that would have been combusted in the baseline, non-qualifying combustion device. Equal to zero if there is no non-qualifying combustion device	scf CH_4
LFG_{B2}	=	Landfill gas that would have been destroyed by the original, non-qualifying destruction system during the reporting period. See Appendix C for guidance on calculating LFG_{B2}	scf
$B_{CH4,NQ}$	=	Methane fraction of landfill gas destroyed by non-qualifying devices in the baseline. Equal to average methane concentration over the reporting period if maximum capacity is used for LFG_{B2}. See Appendix C for further guidance on calculating $B_{CH4,NQ}$	scf CH_4/ scf LFG

Equation 5.8. Calculating Baseline Adjustment for Qualifying Devices

$$\boldsymbol{Dest_{max} = \sum_{t}\left[\left(LFG_{Bmax,t} - LFG_{B3,t}\right) \times PR_{CH_4,t}\right]}$$

Where,			Units
$Dest_{max}$	=	Deduction of the un-utilized capacity of the baseline destruction device. This deduction is to be applied only when a new destruction device is used during project activity. See Box 5.1 below for an example of the application of the $Dest_{max}$ adjustment	scf CH_4
$LFG_{Bmax,t}$	=	The maximum landfill gas flow capacity of the baseline methane destruction device in time interval *t*	scf
$LFG_{B3,t}$	=	The actual landfill gas flow of the baseline methane destruction device in time interval *t*	scf
$PR_{CH4,t}$	=	The average methane fraction of the landfill gas in time interval *t* as measured	scf CH_4 /scf LFG
t	=	Time interval for which LFG flow and concentration measurements are aggregated. See Table 6.1 for guidance	

Box 5.1. Applying the $Dest_{max}$ Adjustment

This adjustment was designed to help differentiate system upgrades from additional projects, while encouraging project developers to use their landfill gas beneficially. In short, this methodology assumes that any gas that *could* have been destroyed in the baseline qualifying device is not additional; diversion of that gas to a new destruction device represents an upgrade. Therefore, this term deducts from calculated project reductions that portion of gas that, in the absence of the new destruction device, still could have been destroyed.

Example:
A flare with a capacity of 1000 cfm was installed at a landfill in 1998. Therefore, because this flare was operational before 2001, the landfill gas control system is ineligible as a project under this protocol. However, in 2005, an electric generator with a 2000 cfm capacity was installed, and all landfill gas was diverted to this device. The addition of the electric generator meets the eligibility requirements of this protocol, and therefore qualifies as a new project. Because the baseline flare is a qualifying destruction device under this protocol and is not eligible as a project due to other eligibility criteria (i.e., operational date), it must be accounted for using $Dest_{max}$.

In 2005, 900 cfm was sent to generator, and 0 cfm was sent to the flare. In the year 2006, due to landfill expansion and installation of additional wells, the generator destroyed 1400 cfm while the flare was non-operational. In 2007, further well expansion allowed the generator to operate at full capacity and the flare was used to destroy an additional 300 cfm of landfill gas.

Calculations:

Year	Generator Destruction (cfm)	Flare Capacity (cfm)	Flare Destruction (cfm)	Deduction (cfm)	Project Reductions (cfm)
2005	900	1000	0	1000	-100 (0)
2006	1400	1000	0	1000	400
2007	1800	1000	300	700	1100

Note: this example and the calculations are significantly simplified for illustrative purposes. The example values are calculated on a cubic feet per minute of landfill gas basis. Reporters are actually required to report the cumulative value of methane gas sent to the destruction device for each time interval *t*.

5.2 Quantifying Project Emissions

Project emissions must be quantified at a minimum on an annual, *ex post* basis. As shown in Equation 5.9, project emissions equal:

- Total indirect carbon dioxide emissions resulting from consumption of electricity from the grid related to project activities
- Total carbon dioxide emissions from the onsite destruction of fossil fuel related to project activities
- Total carbon dioxide emissions from the combustion of supplemental natural gas
- Total methane emissions from the incomplete combustion of supplemental natural gas

Project emissions shall be calculated using Equation 5.9.

Equation 5.9. Calculating Project Emissions

$$PE = FF_{CO_2} + EL_{CO_2} + NG_{emissions}$$

Where,			Units
PE	=	Project emissions during the reporting period	tCO_2e
FF_{CO2}	=	Total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	tCO_2
EL_{CO2}	=	Total carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	tCO_2
$NG_{emissions}$	=	Total quantity of emissions from supplemental natural gas, including both uncombusted methane and carbon dioxide emissions during the reporting period	tCO_2e

Equation 5.10. Calculating Project Emissions from Fossil Fuel Use

$$FF_{CO_2} = \frac{\sum_j (FF_{PR,j} \times EF_{FF,j})}{1000}$$

Where,			Units
FF_{CO2}	=	Total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	tCO_2
$FF_{PR,j}$	=	Total fossil fuel consumed by the project landfill gas collection and destruction system during the reporting period, by fuel type *j*	volume fossil fuel
$EF_{FF,j}$	=	Fuel specific emission factor. See Appendix B	kg CO_2/volume fossil fuel
1000	=	Conversion factor	kg CO_2/tCO_2

Equation 5.11. Calculating Project Emissions from Electricity Use

$$EL_{CO_2} = \frac{(EL_{PR} \times EF_{EL})}{2204.62}$$

Where,			Units
EL_{CO2}	=	Total carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	tCO_2
EL_{PR}	=	Total electricity consumed by the project landfill gas collection and destruction system during the reporting period	MWh
EF_{EL}	=	CO_2 emission factor for electricity used[26]	lb CO_2/ MWh
2204.62	=	Conversion factor	lb CO_2/ tCO_2

[26] Refer to the most version of the U.S. EPA eGRID most closely corresponding to the time period during which the electricity was used. Projects shall use the annual total output emission rates for the subregion where the project is located, not the annual non-baseload output emission rates. The eGRID tables are available from the U.S. EPA website: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

Equation 5.12. Calculating Project Emissions from the Use of Supplemental Natural Gas

$$NG_{emissions} = \sum_{i}\left[NG_i \times NG_{CH_4} \times 0.0423 \times 0.000454 \times \left[\left((1 - DE_I) \times GWP\right) + \left(DE_i \times \frac{12}{16} \times \frac{44}{12}\right)\right]\right]$$

Where,			Units
$NG_{emissions}$	=	Total emissions from supplemental natural gas during the reporting period, including both uncombusted methane and carbon dioxide emissions	tCO_2e
NG_i	=	Total quantity of supplemental natural gas delivered to the destruction device *i* during the reporting period	scf
DE_i	=	Methane destruction efficiency of destruction device *i*. See Appendix B	
NG_{CH4}	=	Average methane fraction of the supplemental natural gas as provided for by fuel vendor	scf CH_4/scf NG
0.0423	=	Density of methane	lb CH_4/scf CH_4
0.000454	=	Conversion factor	tCH_4/lb CH_4
GWP	=	Global warming potential factor of methane to carbon dioxide equivalent, equal to 25 at the time of publication[27]	tCO_2e/tCH_4
12/16	=	Carbon ratio of methane	C/CH_4
44/12	=	Carbon ratio of carbon dioxide	CO_2/C

[27] At time of publication, landfill projects are instructed to use GWP values from the IPCC 4th Assessment Report. This value may be updated in the future via guidance from the Reserve.

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verifiers to confirm that the stipulations of this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of instrument cleaning, inspection, field check and calibration activities; and the role of the individual performing each specific monitoring activity, as well as QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision. The Monitoring Plan shall also contain a detailed diagram of the landfill gas collection and destruction system, including the placement of all meters and equipment that affect SSRs within the GHG Assessment Boundary (see Figure 4.1).

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the legal requirement test (Section 3.4.3).

Project developers are responsible for monitoring the performance of the project and operating the landfill gas collection and destruction system in a manner consistent with the manufacturer's recommendations for each component of the system.

6.1 Monitoring Requirements

Methane emission reductions from landfill gas capture and control systems must be monitored with measurement equipment that directly meters:

- The flow of landfill gas delivered to each destruction device, measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure

- The fraction of methane in the landfill gas delivered to the destruction device, measured continuously and recorded every 15 minutes and averaged at least daily (measurements taken at a frequency that is less than continuous and more than weekly may be used with the application of a 10% discount in Equation 5.3). Projects may not be eligible for crediting if methane concentration is not measured and recorded at least weekly

- The operational activity of the destruction device(s), monitored and documented at least hourly to ensure landfill gas destruction

If discontinuous CH_4 concentration monitoring is to be employed, then the project developer shall develop a prescriptive methodology for how such monitoring is to be carried out. The method should be reasonable in the circumstances of the project and shall be consistently applied throughout the reporting period. Any such methodology, and adherence to the methodology (or otherwise), should be clearly set out in the project monitoring report.

Methane fraction of the landfill gas is to be measured on a wet/dry basis, depending on the basis of measurement for flow, temperature, and pressure (must be measured on same basis as flow, temperature, and pressure). The methane analyzer and flow meter should be installed in the same relative placement to any moisture-removing components of the landfill gas system (there should not be a moisture-removing component separating the measurement of flow and methane fraction). The meters themselves should also operate on the same basis (i.e., if one meter internally dries the sample prior to measurement, the same should occur at other meters). An acceptable variation to this arrangement would be in the case where flow is measured on a dry basis, while the methane concentration is measured on a wet basis. The opposite arrangement is not permissible. No separate monitoring of temperature and pressure is necessary when using flow meters that automatically correct for temperature and pressure, expressing LFG volumes in normalized cubic meters.

A single flow meter may be used for multiple destruction devices under certain conditions. If all destruction devices are of identical efficiency and verified to be operational, no additional steps are necessary for project registration. Otherwise, the destruction efficiency of the least efficient destruction device shall be used as the destruction efficiency for all destruction devices monitored by this meter.

If there are any periods when not all destruction devices measured under a single flow meter are operational, methane destruction during these periods will be eligible provided that the verifier can confirm all of the following conditions are met:

1. The destruction efficiency of the least efficient destruction device in operation shall be used as the destruction efficiency for all destruction devices monitored by this meter; and

2. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and

3. For any period where one or more destruction devices within this arrangement is not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period. For devices other than flares, it must be shown that the output corresponds to the flow of gas.

These means for allowing a single device to monitor operational activity at multiple destruction devices shall not be construed to relax the requirement for hourly operational data for all destruction devices. Rather, this arrangement permits a specific metering arrangement during periods when one or more devices are *known* to not be operating. In order to know the operational status of a device, it must be monitored. All destruction devices must have their operational status monitored and recorded at least hourly. In other words, the project dataset will include an indication of operational status corresponding to each hour of landfill gas data. If these data are missing or never recorded for a particular device, that device will be assumed to be not operating and no emission reductions may be claimed for landfill gas destroyed by that device during the period when data are missing.

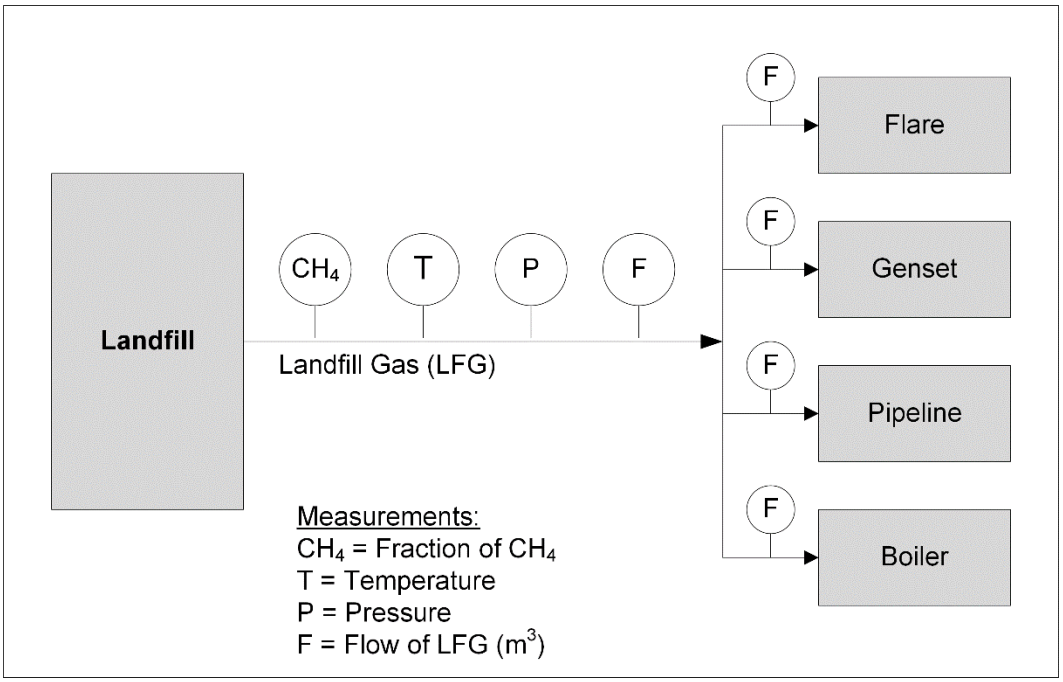
All flow data collected must be corrected for temperature and pressure at 60^{o} F and 1 atm. If any of the landfill gas flow metering equipment does not internally correct for the temperature and pressure of the landfill gas, separate pressure and temperature measurements must be

used to correct the flow measurement. The temperature and pressure of the landfill gas must be measured continuously. Corrected values must be used in all of the equations of this section.

Apply Equation 5.2 only if the landfill gas flow metering equipment does not internally correct for temperature and pressure.

The continuous methane analyzer should be the preferred option for monitoring methane concentrations, as the methane content of landfill gas captured can vary by more than 20% during a single day due to gas capture network conditions (dilution with air at wellheads, leakage on pipes, etc.).[28] When using the alternative approach of discontinuous methane concentration measurement using a calibrated portable gas analyzer, project developers must account for the uncertainty associated with these measurements by applying a 10% discount factor to the total quantity of methane collected and destroyed in Equation 5.3.

Figure 6.1 represents the suggested arrangement of the landfill gas flow meters and methane concentration metering equipment.



Note: The number of flow meters must be sufficient to track the total flow as well as the flow to each combustion device. The above scenario includes one more flow meter than would be necessary to achieve this objective.
Source: Consolidated baseline methodology for landfill gas project activities, Clean Development Mechanism, Version 07, Sectoral Scope 13 (2007).

Figure 6.1. Suggested Arrangement of LFG Metering Equipment

The operational activity of the landfill gas collection system and the destruction devices shall be monitored and documented at least hourly to ensure actual landfill gas destruction. GHG reductions will not be accounted for during periods that the destruction device was not operational. For flares, operation is defined as thermocouple readings above 500° F. For all other destruction devices, the means of demonstration shall be determined by the project developer and subject to verifier review. If relying on the difference between ambient

[28] Consolidated baseline methodology for landfill gas project activities, Clean Development Mechanism, Version 07, Sectoral Scope 13 (2007).

temperatures and temperatures recorded by a thermocouple to demonstrate operational activity (instead of using a fixed temperature threshold), then a temperature difference of at least 200° F shall be used. If any destruction device is equipped with a safety shut off valve, that prevents biogas flow to the destruction device when not operational, then demonstrating the presence and operability of the shut off valve will be sufficient to demonstrate operational activity of that device.

In "direct use" scenarios where landfill gas is delivered offsite to a third-party end user (not to a commercial natural gas transmission and distribution system or to a facility under management control of the project operator), reasonable efforts must be made to obtain data demonstrating the operational status of the destruction device(s). If it is not possible to obtain such data, the verifier must use their professional judgment to confirm that there has been no significant release of project landfill gas and that the project developer is using the destruction efficiency value appropriate for the end use. Evidence that may assist a verifier in making a determination to that effect may include, but is not limited to, one or more of the following:

- A signed attestation from the third-party operator of the destruction device that no catastrophic failure of destruction or significant release of landfill gas occurred during the reporting period, and that the safety features and/or design of the destruction equipment are such that the destruction device does not allow landfill gas to pass through it when non-operational and/or that the project developer is able to switch off the flow of landfill gas offsite in the event of emergencies (and has rigorous procedures in place to ensure such shutoff occurs immediately)
- The verifier confirming the same via a first-person interview with the third-party operator
- Examination of the safety features and/or design of the destruction equipment, such that the destruction device does not allow landfill gas to pass through it when non-operational and/or that the project developer is able to switch off the flow of landfill gas offsite in the event of emergencies (and has rigorous procedures in place to ensure such shutoff occurs immediately)
- Records that can corroborate the type and level of operation of the destruction device during the reporting period, such as engine output data, etc.

If the verifier is reasonably assured that no significant release of landfill gas has occurred offsite during the reporting period, the project can use the destruction efficiency appropriate to that offsite destruction device, despite the lack of hourly data from a monitoring device confirming operational status.

6.1.1 Indirect Monitoring Alternative

As an alternative to the direct measurement of LFG, projects may instead choose to demonstrate volumes of CH_4 destroyed using output data for their destruction device. Where the output of destruction devices (such as gensets) is measured via the use of a commercial transfer meter (i.e., a meter whose output is used as the basis for the quantification under an energy delivery contract), which is subject to regular, professional maintenance, the project may use such data as the basis for determining the volume of CH_4 destroyed. The meter output shall be subjected to an appropriate conversion methodology to calculate the volume of CH_4 destroyed during the reporting period. One example of a methodology that may be suitable is brake-specific fuel consumption calculations. Projects may also be able to use results of performance testing mandated under 40 CFR Part 60 Subpart IIII, Subpart JJJJ, and Subpart KKKK, to develop an appropriate conversion methodology. If using the indirect monitoring alternative, the commercial meter must be maintained by appropriately-trained professionals, in

accordance with manufacturer requirements. In scenarios where projects are able to control the maintenance of such meters, the QA/QC requirements in Section 6.2 apply. In scenarios where projects are not able to control the maintenance of such meters, reasonable efforts must be made to obtain documentation demonstrating manufacturer maintenance requirements have been met during the reporting period.

The monitoring methodology to be employed must be clearly set out in the project monitoring report, it must be applied consistently throughout the reporting period, and it must be demonstrated to the satisfaction of the project's verifier and the Reserve that the use of such data and methodology is reasonable under the circumstances, and results in a conservative estimation of the volume of CH_4 destroyed.

6.2 Instrument QA/QC

Monitoring instruments shall be inspected and calibrated according to the following schedule.

All gas flow meters[29] and continuous methane analyzers must be:

- Cleaned and inspected on a regular basis, as specified in the project's Monitoring Plan, with activities and results documented by site personnel. Cleaning and inspection procedures and frequency must, at a minimum, follow the manufacturer's recommendations
- Field checked for calibration accuracy by a third-party technician with the percent drift documented, using either a portable instrument (such as a pitot tube) or manufacturer specified guidance, at the end of – but no more than two months prior to or after – the end date of the reporting period[30]
- Calibrated by the manufacturer or a certified third-party calibration service per manufacturer's guidance or every 5 years when calibration frequency is not specified by the manufacturer

Conformance with the factory calibration requirement is only required during periods of time where data gathered by the meter are used for emission reduction quantification. Periods where the meter did not meet this requirement will not cause the project to fail this requirement, provided the meter was not being used for project emission reduction quantification during such periods, and provided the meter was brought back into conformance before being employed to gather project data.

If a stationary meter that was in use for 60 days or more is removed and not reinstalled during a reporting period, that meter shall either be field-checked for calibration accuracy prior to removal or calibrated (with percent drift documented) by the manufacturer or a certified calibration service (with as-found results recorded) prior to quantification of emission reductions for that reporting period.

If the required calibration or calibration check is not performed and properly documented, no GHG credits may be generated for that reporting period. Flow meter calibrations shall be documented to show that the meter was calibrated to a range of flow rates corresponding to the

[29] Field checks and calibrations of flow meters shall ensure that the meter accurately reads volumetric flow, and has not drifted outside of the prescribed +/-5% accuracy threshold.

[30] Instead of performing field checks, the project developer may instead have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but no more than two months prior to or after the end date of the reporting period to meet this requirement.

flow rates expected at the landfill. Methane analyzer calibrations shall be documented to show that the calibration was carried out to the range of conditions (temperature and pressure) corresponding to the range of conditions as measured at the landfill.

The as-found condition (percent drift) of a field check must always be recorded. If the meter is found to be measuring outside of the +/- 5% threshold for accuracy, the data must be adjusted for the period beginning with the last successful field check or calibration event up until the meter is confirmed to be in calibration (unless the last event occurred during the prior reporting period, in which case adjustment is made back to the beginning of the current reporting period). If, at the time of the failed field check, the meter is cleaned and checked again, with the as-left condition found to be within the accuracy threshold, a full calibration is not required for that piece of equipment. This shall be considered a failed field check, followed by a successful field check. The data adjustment shall be based on the percent drift recorded at the time of the failed field check. However, if the as-left condition remains outside of the +/- 5% accuracy threshold (whether or not additional cleaning and accuracy testing occurs), calibration is required by the manufacturer or a certified service provider for that piece of equipment.

For the interval between the last successful field check and any calibration event confirming accuracy outside of the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated.

1. For calibrations that indicate under-reporting (lower flow rates, or lower methane concentration), the metered values must be used without correction.

2. For calibrations that indicate over-reporting (higher flow rates, or higher methane concentration), the metered values must be adjusted based on the greatest calibration drift recorded at the time of calibration.

For example, if a project conducts field checks quarterly during a year-long reporting period, then only three months of data will be subject at any one time to the adjustments above. However, if the project developer feels confident that the meter does not require field checks or calibration on a greater than annual frequency, then failed events will accordingly require the penalty to be applied to the entire year's data. Frequent calibration may minimize the total accrued drift (by zeroing out any error identified) and result in smaller overall deductions. Additionally, strong equipment inspection practices that include checking all probes and internal components will minimize the risk of meter and analyzer inaccuracies and the corresponding deductions. If it is not possible to determine the accrued drift and/or an appropriate method for scaling the data (e.g., drift is recorded in milliwatts, which cannot be directly translated into a drift percentage), the project developer should seek guidance from the instrument manufacturer to confirm when the 5% drift threshold has been reached and how to appropriately scale the relevant data.

Additional field checks carried out during the reporting period at the project developer's discretion may be performed by an individual that is not a third-party technician. In this case, the competency of the individual and the accuracy of the field check procedure must be assessed and approved by the verification body. Furthermore, if the field check reveals accuracy outside of the +/- 5% threshold, calibration is required and the data must be scaled as detailed above. In order to provide flexibility in verification, data monitored up to two months after a field check may be verified. As such, the end date of the reporting period must be no more than two months after the latest successful field check.

If a portable instrument either:

1. acquires project data (e.g., a handheld methane analyzer is used to take weekly methane concentration measurements), or

2. is used to field check the calibration accuracy of equipment that acquires project data and the portable instrument produces a data output that is or could be used in emission reduction calculations (i.e., flow or concentration); then,

the portable instrument shall be maintained and calibrated per the manufacturer's specifications, and calibrated at least annually by the manufacturer, by a laboratory approved by the manufacturer, or at an ISO 17025 accredited laboratory. Other pieces of equipment used for QA/QC of monitoring instruments shall be maintained according to the manufacturer's specifications, including calibration where specified. Portable methane analyzers must also be field calibrated to a known sample gas prior to each use.

6.3 Missing Data

In situations where the flow rate or methane concentration monitoring equipment is missing data, the project developer shall apply the data substitution methodology provided in Appendix D. If for any reason the destruction device monitoring equipment is inoperable (for example, the thermocouple on the flare), then no emission reductions can be registered for the period of inoperability.

6.4 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Monitoring Data to be Collected and Used to Estimate Emission Reductions

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
		Regulatory compliance	Project developer attestation to compliance with regulatory requirements relating to landfill gas project	Each reporting period		Must be monitored and determined for each reporting period. The project developer shall document all federal, state, and local regulations, ordinances, and permit requirements (and compliance status for each) that apply to the GHG reduction project. The project developer shall provide a signed attestation to their compliance status for the above mentioned federal, state, and local regulations, ordinances, and permit requirements
		Legal requirement test	Project developer attestation of voluntary implementation	Each reporting period		Must be monitored and determined for each reporting period. The project developer shall document
		Operation of destruction device		Hourly	o	Required for each destruction device. For flares, operation is defined as thermocouple readings above 500° F. The presence and operability of a safety shut off valve will be sufficient to demonstrate operational activity of the given device.
Equation 5.1	ER	GHG emission reductions during the reporting period	tCO_2e	Per reporting period	c	
Equation 5.1 Equation 5.3	BE	Baseline emissions during the reporting period	tCO_2e	Per reporting period	c	

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.1 Equation 5.9	PE	Project emissions during the reporting period	tCO_2e	Per reporting period	c	
Equation 5.2 Equation 5.4	$LFG_{i,t}$	Adjusted volume of landfill gas fed to the destruction device *i*, in time interval *t*	scf	Continuous	m/c	Measured continuously by a flow meter and recorded at least once every 15 minutes. Data to be aggregated by time interval t (this parameter is calculated in cases where the metered flow must be corrected for temperature and pressure)
Equation 5.2	$LFG_{unadjusted}$	Unadjusted volume of landfill gas collected for the given time interval	acf	Continuous	m	Used only in cases where the flow meter does not automatically correct to 60° F and 1 atm
Equation 5.3 Equation 5.4	CH_4Dest_{PR}	Total methane destroyed by the project landfill gas collection and destruction system during the reporting period	tCH_4		c	
Equation 5.3	DF	Discount factor to account for uncertainties associated with the monitoring equipment	0-1.0	Continuous	r	Equal to zero if using continuous methane monitor (see Section 6.1)
Equation 5.3	OX	Factor for the oxidation of methane by soil bacteria	0, 0.1		r	Equal to 0.10 for all landfills except those that incorporate a synthetic liner throughout the entire area of the final cover system where OX = 0

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.3	GWP	100-year global warming potential for CH_4	tCO_2e/tCH_4	Per reporting period	r	As of publication, the value is 25.[31] This may be updated in the future via guidance from the Reserve
Equation 5.3 Equation 5.5	$Dest_{base}$	Adjustment to account for the baseline methane destruction associated with a baseline destruction device	tCO_2e		c	Equal to zero if no baseline LFG destruction system is in place prior to project implementation
Equation 5.4	CH_4Dest_i	The net quantity of methane destroyed by destruction device *i* during the reporting period	scf CH_4		c	
Equation 5.4	Q_i	Total quantity of landfill methane sent to destruction device *i* during the reporting period	scf CH_4	Daily/Weekly	c	Calculated daily if methane is continuously metered or weekly if methane is measured weekly
Equation 5.4 Equation 5.12	DE_i	Methane destruction efficiency for device *i*	%	Once	r/m	See Appendix B for guidance and default values
Equation 5.4	*t*	Time interval for which LFG flow and concentration measurements are aggregated	week, day, or smaller interval	Continuous/ Daily/Other	r	The interval employed is contingent upon the interval of data acquisition.

[31] Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (2007).

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.4 Equation 5.8	$PR_{CH4,t}$	The average methane fraction of the landfill gas in time interval *t*	scf CH_4 / scf LFG	Continuous/ Other	m	Measured by continuous gas analyzer or a calibrated portable gas analyzer. Data to be averaged by time interval *t*.
Equation 5.5 Equation 5.6	$Closed_{discount}$	Adjustment to account for the methane which would have been combusted in the baseline flare from baseline wells at a closed landfill	scf CH_4	Yearly	c	Calculated per year, but may be scaled for project reporting periods less than one year
Equation 5.5 Equation 5.7	$NQ_{discount}$	Adjustment to account for the methane which would have been combusted in the baseline, non-qualifying combustion device	scf CH_4	Yearly	c	Calculated per year, but may be scaled for project reporting periods less than one year
Equation 5.5 Equation 5.8	$Dest_{max}$	Deduction of the un-utilized capacity of the baseline destruction device	scf CH_4	Weekly, Monthly, or Per reporting period (no more than weekly)	c	This deduction is to be applied only when a new destruction device is used during project activity
Equation 5.6	LFG_{B1}	Landfill gas from the baseline landfill gas wells that would have been destroyed by the qualifying destruction system during the reporting period	scf LFG	Yearly	c	Calculated using Appendix D. Calculated per year, but may be scaled for project reporting periods less than one year

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.6	$B_{CH4,closed}$	Methane fraction of landfill gas destroyed by baseline flares at a closed landfill	scf CH_4 / scf LFG	Continuously/ Other	m	Measured by continuous gas analyzer or a calibrated portable gas analyzer.
Equation 5.7	LFG_{B2}	Landfill gas that would have been destroyed by the original, non-qualifying destruction system during the reporting period	scf LFG / yr	Yearly	c	Calculated per Section 5, or according to guidance provided in Appendix D. Calculated per year, but may be scaled for project reporting periods less than one year
Equation 5.7	$B_{CH4,NQ}$	Methane fraction of landfill gas destroyed by non-qualifying devices in the baseline	scf CH_4 / scf LFG	Continuously/ Other	m	Measured by continuous gas analyzer or a calibrated portable gas analyzer
Equation 5.8	$LFG_{Bmax,t}$	The maximum landfill gas flow capacity of the baseline methane destruction device in time interval *t*	scf	At beginning of first reporting period	c	Calculated based on manufacturer's and/or engineer specifications for the destruction device and blower system. The maximum capacity of the limiting component, either the destruction device or blower, shall be used
Equation 5.8	$LFG_{B3,t}$	The actual landfill gas flow of the baseline methane destruction device in time interval *t*	scf	Continuous	m	Measured continuously by a flow meter and recorded at least once every 15 minutes
Equation 5.9 Equation 5.10	FF_{CO2}	Total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	tCO_2	Per reporting period	c	

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.9 Equation 5.11	EL_{CO2}	Total carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	tCO_2		c	
Equation 5.9 Equation 5.12	$NG_{emissions}$	Total quantity of emissions from supplemental natural gas, including both uncombusted methane and carbon dioxide emissions during the reporting period	tCO_2	Per reporting period	c	Includes both uncombusted methane and carbon dioxide emissions
Equation 5.10	$FF_{PR,j}$	Total fossil fuel consumed by the project landfill gas collection and destruction system during the reporting period, by fuel type *j*	volume fossil fuel	Monthly	o	Calculated from monthly record of fossil fuel purchased and consumed
Equation 5.10	$EF_{FF,j}$	Fuel specific emission factor	kg CO_2 / volume fossil fuel	Per reporting period	r	See Appendix C

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.11	EL_{PR}	Total electricity consumed by the project landfill gas collection and destruction system during the reporting period	MWh		m/o	Obtained from either onsite metering or utility purchase records. Required to determine CO_2 emissions from use of electricity to operate the project activity
Equation 5.11	EF_{EL}	Carbon emission factor for electricity used	$lbCO_2$ / MWh	Per reporting period	r	See the most up to date version available of the U.S. EPA eGRID[32]
Equation 5.12	NG_i	Total quantity of supplemental natural gas delivered to the destruction device *i* during the reporting period	scf	Continuous	m	Metered prior to delivery to destruction device
Equation 5.12	NG_{CH4}	Average methane fraction of the supplemental natural gas as provided for by fuel vendor	scf CH_4 / scf NG		r	Refer to purchase records
	T	Temperature of the landfill gas	°C	Continuous	m	No separate monitoring of temperature is necessary when using flow meters that automatically adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized cubic feet

[32] Available at: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
	P	Pressure of the landfill gas	atm	Continuous	m	No separate monitoring of pressure is necessary when using flow meters that automatically measure adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized cubic feet

7 Reporting Parameters

This section provides guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit verified emission reduction reports to the Reserve annually at a minimum.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register a landfill gas destruction project:

- Project Submittal form
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Detailed system diagram from Monitoring Plan
- Verification Report
- Verification Statement

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form

At a minimum, the above project documentation will be available to the public via the Reserve's online reporting tool of the same name, the Climate Action Reserve. Further disclosure and other documentation may be made available on a voluntary basis. Project submittal forms and project registration information can be found at: http://www.climateactionreserve.org/how/program/documents/.

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of GHG reductions
- Copies of all solid waste, air, water, and land use permits; Notices of Violations (NOVs); and any administrative or legal consent orders dating back at least 3 years prior to the project start date, and for each subsequent year of project operation
- Project developer attestation of compliance with regulatory requirements relating to the landfill gas project
- Collection and control device information (installation dates, equipment list, etc.)

- LFG flow meter information (model number, serial number, manufacturer's calibration procedures)
- Methane monitor information (model number, serial number, calibration procedures)
- Destruction device monitor information (model number, serial number, calibration procedures)
- LFG flow data (for each flow meter)
- LFG flow meter calibration data (for each flow meter)
- Methane monitoring data
- Methane monitor calibration data
- Destruction device monitoring data (for each destruction device)
- Destruction device monitor calibration data (for each destruction device)
- CO_2e monthly and annual tonnage calculations
- Copies of the results of the NSPS/EG Tier 1 and/or Tier 2 NMOC emission rate estimates and the projected date when system start-up will be required by NSPS
- Initial and annual verification records and results
- All maintenance records relevant to the LFG control system, monitoring equipment, and destruction devices
- Operational records of the landfill relating to the amount of waste placed onsite (scalehouse records, etc.), or most recent documented WIP report accepted by a regulatory agency

Calibrated portable gas analyzer information that the project developer should retain includes:

- Date, time, and location of methane measurement
- Methane content of LFG (% by volume) for each measurement
- Methane measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.3 Reporting Period and Verification Cycle

7.3.1 Reporting Periods

The reporting period is the length of time over which GHG emission reductions from project activities are quantified. Project developers must report GHG reductions resulting from project activities during each reporting period. A reporting period may not exceed 12 months in length, except for the initial reporting period, which may cover up to 24 months. The Reserve accepts verified emission reduction reports on a sub-annual basis, should the project developer choose to have a sub-annual reporting period and verification schedule (e.g., monthly, quarterly, or semi-annually). Reporting periods must be contiguous; there must be no gaps in reporting during the crediting period of a project once the first reporting period has commenced.

7.3.2 Verification Periods

The verification period is the length of time over which GHG emission reductions from project activities are verified. The initial verification period for a landfill project is limited to one reporting period (i.e., up to 24 months). Subsequent verification periods may cover up to two reporting periods. CRTs will not be issued for reporting periods that have not been verified. For any reporting period that ends prior to the end of the verification period (i.e., year 1 of a 2-year verification period), an interim monitoring report must be submitted to the Reserve no later than six months following the end of the relevant reporting period. The interim monitoring report shall contain a summary of emission reductions, description of QA/QC activities, and description of

any potential nonconformances, data errors, metering issues, or material changes to the project.[33] All mandatory sections of interim monitoring reports must be verified in the subsequent verification.

To meet the verification deadline, the project developer must have the required verification documentation (see Section 7.1) submitted within 12 months of the end of the verification period. The end date of any verification period must correspond to the end date of a reporting period.

7.3.3 Verification Site Visit Schedule

A site visit must occur during the initial verification, and at least once every two reporting periods thereafter. A reporting period may be verified without a new site visit if the following requirements are met:

1. A new site visit occurred in conjunction with the verification of the previous reporting period;
2. The current verification is being conducted by the same verification body that conducted the site visit for the previous verification; and
3. There have been no significant changes in data management systems, equipment, or personnel since the previous site visit.

The above requirements apply regardless of whether the verification period contains one or two reporting periods. The Reserve maintains the discretion to require a new site visit for a reporting period despite satisfaction of the above requirements. For example, the approval of a significant variance during the reporting period could be considered grounds for denial of the option to forego a site visit for the verification.

[33] A template monitoring report is available at: http://www.climateactionreserve.org/how/program/documents/.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions from landfill gas projects developed to the standards of this protocol. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities in the context of landfill gas destruction projects.

Verification bodies trained to verify landfill gas projects must conduct verifications to the standards of the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Landfill Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify landfill projects. Verification bodies approved under other project protocol types are not permitted to verify landfill projects. Information about verification body accreditation and Reserve project verification training can be found in the Verification Program Manual.

8.1 Standard of Verification

The Reserve's standard of verification for landfill projects is the Landfill Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify a landfill project developer's project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Section 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm a landfill project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for a landfill project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Location	United States and its territories	Once during first verification
Start Date	Projects must be submitted for listing within six months of the project start date	Once during first verification
Project Crediting Period	Ensure the project is within its first or second crediting period	Once during each crediting period
Performance Standard Test	Installation of a qualifying destruction device where not required by law (see Section 3.4.1 for other requirements)	Once during first verification
Limits on Credit Stacking	Ensure no credits are issued to the project for transport fuel incentive programs, or other programs with overlapping GHG boundaries	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures that lay out procedures for ascertaining and demonstrating that the project passes the legal requirement test	Every verification
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws	Every verification
Exclusions	▪ Bioreactors ▪ Landfills that re-circulate a liquid other than leachate in a controlled manner ▪ Indirect emissions from the displacement of grid electricity or natural gas	Every verification

8.4 Core Verification Activities

The Landfill Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with the destruction of landfill methane. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a landfill project, but verification bodies shall also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emissions sources, sinks and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as system energy use, fuel consumption, combustion and destruction from various qualifying and non-qualifying destruction devices, and soil oxidation.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the landfill project uses to gather data on methane collected and destroyed and to calculate baseline and project emissions.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.5 Landfill Project Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a landfill project. The tables include references to the section in the protocol where requirements are further described. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to landfill projects that must be addressed during verification.

8.5.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for landfill projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of a landfill project and is properly defined per Section 2.2	No
2.3	Verify ownership of the reductions by reviewing Attestation of Title	No
2.3	For direct use agreements between the project developer and the end user of the landfill gas (i.e., an industrial client purchasing the landfill gas from the project developer), verify that a legally binding mechanism is built into the agreement language to assure that the GHG offset credits will not be double counted	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that project is within its first or second 10-year crediting period	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
3.4.1	Verify that the project meets the appropriate performance standard test for the project type per Section 3.4.1	No
3.4.2	Verify no credits are issued to the project for transport fuel incentive programs, or other programs with overlapping GHG boundaries	No
3.4.3	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the legal requirement test	No
3.4.3	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
4	Confirm all baseline non-qualifying devices have been properly accounted for within project's GHG Assessment Boundary	No
4	Confirm all baseline qualifying devices have been properly accounted for within project's GHG Assessment Boundary	No
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No
6	Verify that the project monitoring plan contains procedures for ascertaining and demonstrating that the project passes the legal requirement test at all times	Yes
6	Verify that the landfill gas control system operated in a manner consistent with the design specifications	Yes
6	Verify that there is an individual responsible for managing and reporting GHG emissions, and that individual properly trained and qualified to perform this function	Yes
6.2	Verify that all gas flow meters and methane analyzers adhered to the inspection, cleaning, and calibration schedule specified in the protocol. If they do not, verify that a variance has been approved for monitoring variations or that adjustments have been made to data per the protocol requirements	No
6.2	If any piece of equipment failed a calibration check, verify that data from that equipment was scaled according to the failed calibration procedure for the appropriate time period	No
6.3	If used, verify that data substitution methodology was properly applied	No
7.1	Verify that appropriate documents are created to support and/or substantiate activities related to GHG emission reporting activities, and that such documentation is retained appropriately	Yes
	If any variances were granted, verify that variance requirements were met and properly applied	Yes
	If any zero-credit reporting periods were taken, verify that zero-credit reporting period requirements were met	Yes

8.5.2 Quantification of GHG Emission Reductions

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project	No
5	Verify that the project developer correctly accounted for baseline methane destruction in the baseline scenario	No
5	Verify that the project developer correctly monitored, quantified and aggregated the amount of methane collected from the landfill and destroyed by the project landfill gas control system?	No
5	Verify that the project developer correctly quantified and aggregated electricity use	Yes
5	Verify that the project developer correctly quantified and aggregated fossil fuel use	Yes
5	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5	Verify that the project developer applied the correct methane destruction efficiencies	No
Appendix B	If the project developer used source test data in place of the default destruction efficiencies (Appendix B), verify accuracy and appropriateness of data and calculations	Yes

8.5.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project monitoring plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that equipment calibrations have been carried out to satisfy the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6.2	Verify that the methane destruction equipment was operated and maintained according to manufacturer specifications	Yes
7.2	Verify that all required records have been retained by the project developer	No

8.6 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verification body	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Landfill management practices that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e., fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Bioreactor	Any landfill which: a. Meets the EPA definition of a bioreactor: "a MSW landfill or portion of a MSW landfill where any liquid other than leachate (leachate includes landfill gas condensate) is added in a controlled fashion into the waste mass (often in combination with recirculating leachate) to reach a minimum average moisture content of at least 40 percent by weight to accelerate or enhance the anaerobic (without oxygen) biodegradation of the waste."[34] b. Has been designated by local, state, or federal regulators as a bioreactor. c. Has received grants or funding to operate as a bioreactor.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
Closed landfill	A landfill that has ceased waste acceptance, and has submitted a closure report to EPA or the state indicating that it will no longer accept waste.
CO_2-equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Direct Use Project	A Landfill Gas to Energy Project where the landfill gas is used for its thermal capacity. Direct use projects offer a cost-effective alternative for fueling combustion or heating equipment at facilities located near a

[34] 40 CFR 63.1990 and 40 CFR 258.28a.

	landfill. Qualifying destruction devices include boilers, leachate evaporators, kilns, sludge dryers, burners, furnaces.
Eligible landfill	An "eligible landfill" is a landfill that: 1. Is not subject to regulations or other legal requirements requiring the destruction of methane gas 2. Is not a bioreactor 3. Does not add any liquid other than leachate into the waste mass in a controlled manner
Electricity Project	A Landfill Gas to Energy Project for the generation of electricity. Technologies include engines, turbines, microturbines and fuel cells.
Emission factor (EF)	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Emission guidelines (EG)	Guidelines for State regulatory plans that have been developed by the U.S. EPA. For landfills, emission guidelines are codified in 40 CFR 60 Subpart CC.
Flare	A destruction device that uses an open flame to burn combustible gases with combustion air provided by uncontrolled ambient air around the flame.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Emissions that are a consequence of the actions of a reporting entity, but are produced by sources owned or controlled by another entity.
Landfill	A defined area of land or excavation that receives or has previously received waste that may include household waste, commercial solid waste, non-hazardous sludge and industrial solid waste.
Landfill gas (LFG)	Gas resulting from the decomposition of wastes placed in a landfill. Typically, landfill gas contains methane, carbon dioxide and other trace organic and inert gases.
Landfill gas project	Installation of infrastructure that in operating causes a decrease in GHG emissions through destruction of the methane component of landfill gas.

Landfill gas-to-energy (LFGE)	A LFGE project is one where the LFG destruction involves a destruction device that generates energy (engine, turbine, microturbine, fuel cell, boiler, upgrade to pipeline, upgrade to CNG/LNG, etc.). This does not include small-scale, non-commercial applications, such as leachate drying.
Medium-Btu project	See Direct Use project definition.
Metric ton or "tonne" (t, Mg)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g., cars, trucks, tractors, dozers, etc.).
National Emission Standards for Hazardous Air Pollutants (NESHAP)	Federal emission control standards codified in 40 CFR 63. Subpart AAAA of Part 63 prescribes emission limitations for MSW landfills.
New Source Performance Standards (NSPS)	Federal emission control standards codified in 40 CFR 60. Subpart WWW of Part 60 prescribes emission limitations for MSW landfills.
Non-methane organic compounds (NMOC)	Non-methane organic compounds as measured according to the provisions of 40 CFR 60.754.
Non-qualifying destruction device	A passive flare or other combustion system that results in the destruction of methane, but which cannot serve as the primary destruction device for a methane destruction project under this protocol.
Nitrous oxide (N_2O)	A GHG consisting of two nitrogen atoms and a single oxygen atom.
Project baseline	A business-as-usual GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a project activity, as identified in the Landfill Project Protocol. A project developer may be an independent third party or the landfill operating entity.
Qualifying destruction device	Includes but is not limited to a utility flare, enclosed flare, engine, turbine, microturbine, boiler, pipeline, vehicle, fuel cells, leachate evaporators,

	kilns, sludge dryers, burners, furnaces which can serve as the primary destruction device for a methane destruction project under this protocol.
Renewable Energy Certificates (RECs)	As defined by the U.S. EPA Green Power Partnership, a REC represents the property rights to the environmental, social, and other non-power qualities of renewable electricity generation. For a landfill project this is represented by the existence of a REC contract or participation of the landfill in a REC tracking system. The RECs may be sold as bundled (green power) or unbundled from the associated energy that is generated.
Reporting period	Specific time period of project operation for which the project developer has calculated and reported emission reductions and is seeking verification and issuance of credits. The reporting period must be no longer than 12 months.
Resource Conservation and Recovery Act (RCRA)	Federal legislation under which solid and hazardous waste disposal facilities are regulated.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
Upgraded Landfill Gas Project	A Landfill Gas to Energy Project where the landfill gas is cleaned to a level similar to natural gas. Three common types of projects are RNG (Renewable Natural Gas), CNG (Compressed Natural Gas) or LNG (Liquefied Natural Gas).
Verification	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	An ISO-accredited and Reserve-approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Verification period	The period of time over which GHG emission reductions are verified. Landfill projects may verify up to two reporting periods at a time.
Waste in place	The cumulative amount of solid waste, measured in metric tons, that has been permanently placed into the landfill.

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Appendix A Development of the Performance Standard Threshold

The initial performance standard for the Landfill Project Protocol Version 1.0 was adopted in 2007. This analysis used as its primary data source the database of nearly 2,400 landfills in the United States developed and maintained by the U.S. EPA's Landfill Methane Outreach Program (LMOP).[35] This database does not represent all U.S. landfills, but rather a subset of all landfills that have been identified as having current landfill gas to energy (LFGE) projects or where potential opportunities exist for such projects. This database is updated on an ongoing basis by LMOP staff. Landfill gas projects take time to move from conception to operation (often two years or more) so the database does not see rapid, significant changes. The original analysis conducted in 2007 concluded that any new installation of a landfill gas collection system and/or qualifying destruction device where gas had not previously been collected and destroyed (or was destroyed using a non-qualifying destruction device) could be considered additional.

In the years following the 2007 analysis, there was a significant increase in the market penetration of landfill gas to energy systems. Hence in 2011 the performance standard underwent a significant update, with the release of Version 4.0 of the Landfill Project Protocol. The focus on the original performance standard test and the 2011 update were landfills not required to collect and control gas emissions by NSPS/EG, either because they are under the landfill design size that would make them subject to the regulation or because they were still below the NMOC emissions per year threshold to trigger gas destruction obligations. The purpose of the 2011 analysis was to identify whether new criteria were necessary to continue to ensure that only additional landfill gas destruction projects are eligible to register with the Reserve, and if so, what those criteria should be.

A.1 2007 Performance Standard Analysis

Table A.1 and Table A.2 provide the summary conclusions of the Reserve's 2007 performance standard analysis, using the LMOP database available at that time. The original analysis excluded all landfills that were closed prior to 2001, since their methane production was assumed to have already dropped off significantly and they would therefore be poor candidates for landfill gas projects.

Table A.1. Summary of Information on U.S. Landfills (NSPS/EG and Non-NSPS/EG) (2007)

	Number of Landfills	Percent of Landfills	Number w/ LFG Collection	Percent w/ LFG Collection
Landfills in Analysis				
NSPS/EG	697	37.35	697	100
Non-NSPS/EG	1169	62.65	261	22.33
Subtotal	1866	100	958	51.34
Landfills Excluded from Analysis	518			
Total U.S. Landfills	2384			

[35] LMOP is a voluntary partnership program that was created to reduce methane emissions from landfills by encouraging the use of landfill gas for energy. LMOP tracks whether or not specific landfills are required to reduce landfill gas emissions under the New Source Performance Standards and Emission Guidelines for Municipal Solid Waste Landfills (NSPS/EG), promulgated March 1996. Because LMOP is not a regulatory program, it cannot make an official EPA designation regarding any landfill's NSPS/EG status. Information relating to NSPS/EG was obtained by voluntary submittal and is subject to change over time. Therefore, LMOP cannot guarantee the validity of this information.

Table A.2. Summary of Non-NSPS/EG Landfills Under Assumption that Flare-Only Landfills Are Already Regulated (2007)

	Flares Included		Flares Excluded	
Non-NSPS/EG Landfills	**Number of Landfills**	**Percentage**	**Number of Landfills**	**Percentage**
Flare-Only	166	14.2	Excluded	Excluded
Electricity	67	5.7	67	6.7
Gas Projects	28	2.4	28	2.8
Subtotal	261	22.3	95	9.5
No LFG collection	908	77.7	908	90.5
Total	1169	100.0	1003	100.0
Estimated Market Penetration of LFG Collection Projects at Unregulated Landfills		**22.3%**		**9.5%**

A.2 2011 Performance Standard Test: Size Threshold for LFGE Projects

In the 2011 performance standard analysis, the Reserve sought to identify characteristics or conditions that could distinguish between additional and non-additional projects. The analysis was based on the premise that in the absence of any incentives provided by GHG offsets or RECs, the feasibility of installing a LFGE project at an unregulated landfill depended largely on the amount of methane produced at the landfill. Landfills that produce more methane are more likely to be better candidates for such projects. The Reserve identified two key factors in methane production potential, first the amount of waste in place (WIP) and second, annual precipitation at the landfill.

Having identified two key factors in methane production potential, the next step in the Reserve's analysis was to examine the market penetration of voluntary LFGE projects at unregulated landfills as a function of the size of the landfill (measured as WIP at the time the project was installed) and annual precipitation.

The Reserve identified a WIP threshold for each precipitation zone that effectively screened out a majority of non-additional LFGE projects. The objective of excluding non-additional projects, however, had to be balanced against concerns about unfairly excluding landfills from eligibility where no projects currently exist. The result was to target a WIP threshold for each zone such that the percentage of unregulated landfills with LFGE projects was 5% or less (i.e., the "natural" market penetration of LFGE projects at landfills below the threshold was no more than 5%). For landfills in the arid precipitation zone, this threshold was determined to be 2.17 million metric tons (MMg). For landfills in the non-arid precipitation zone, this threshold was determined to be 0.72 MMg (Table A.3).

The percentage of incorrectly excluded landfills at these thresholds differs markedly for the arid and non-arid zones. For the arid zone, only 10% of unregulated landfills without LFGE projects are incorrectly excluded. For the non-arid zone, however, nearly 60% of unregulated landfills without LFGE projects are incorrectly excluded. Although that was a high rate of incorrect exclusions, the Reserve believed it was important to strike a balance strongly in favor of ensuring that projects that *did* pass an additionality screen were likely to be additional. In the absence of alternative characteristics or conditions that could be used to screen for additional projects, the Reserve believed it was necessary to adopt a stringent WIP threshold.

Table A.3. WIP Values for 5% Market Penetration of LFGE Projects[36]

	Arid Counties (<25" Annual Precipitation)	Non-Arid Counties (>25" Annual Precipitation)
WIP Threshold for 5% Market Penetration of LFGE Projects at Unregulated Landfills (metric tons)	2,165,000	715,000
Percentage of Landfills with No LFG Collection Excluded by this WIP Threshold	10%	58%

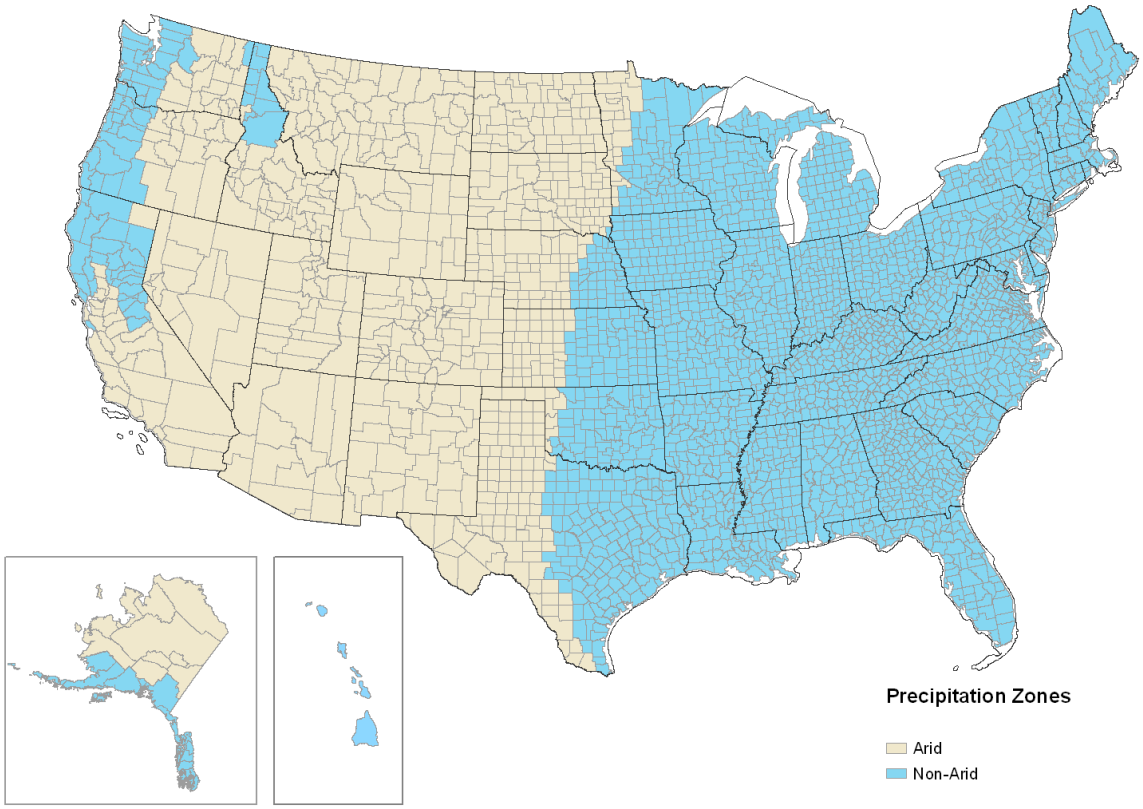

Figure A.1. Precipitation Zones of the United States, by County

Based on the USGS Hydrologic Zones of the United States (2003). Arid counties average less than 25 inches of precipitation annually, and non-arid counties average 25 inches or greater precipitation annually.

[36] It is likely that some of the LFGE projects at landfills not subject to NSPS/EG and below the size thresholds presented here are in fact required by local regulations. Thus, the actual "natural" market penetration below these thresholds is likely to be below 5%, and may be significantly below 5%. The analysis conservatively assumes that none are legally required.

A.3 Protocol Version 5.0 Performance Standard Analysis

Since the 2011 performance standard analysis, there have been significant changes in the U.S. domestic energy landscape and thus landfill gas market conditions. A review of updated LMOP data reveals that the market penetration of LFGE projects has remained steady (with relatively few LFGE project closures), but that the uptake of new LFGE projects has fallen off significantly in recent years. LMOP data are used in Figure A.2 below to depict the number of new LFGE projects installed per year from 2000 through 2017. These data indicate a significant decline in new LFGE project installations per year over the past few years; this is projected to continue beyond 2018.

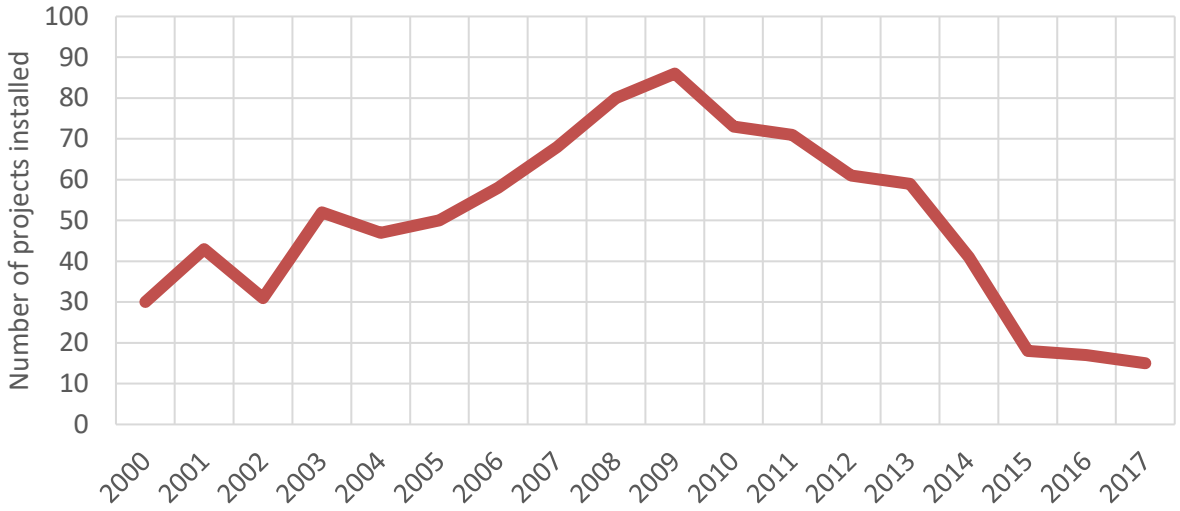

Figure A.2. New LFGE Installations

The number of new LFGE projects installed per year from the year 2000 to 2017.

Given that this declining trend of new LFGE project uptake occurred while the U.S. was experiencing a boom in domestic energy production, in particular natural gas (NG), Reserve staff sought to explore the nexus between NG pricing and LFGE project uptake. Reserve staff examined Energy Information Administration data on U.S. energy costs, including coal, petroleum, and natural gas. As landfill gas and natural gas can be effectively substituted in the production of marginal electrical demand, Reserve staff wanted to determine if the price of natural gas could be a useful means to predict LFGE project uptake.

Figure A.3 below indicates that a correlation can be drawn between declining costs of inputs for marginal electricity generation and the decline in the development of new LFGE projects. This data suggests a strong correlation between declining costs of energy inputs competing with LFG, in particular NG, and the installation of new LFGE projects.

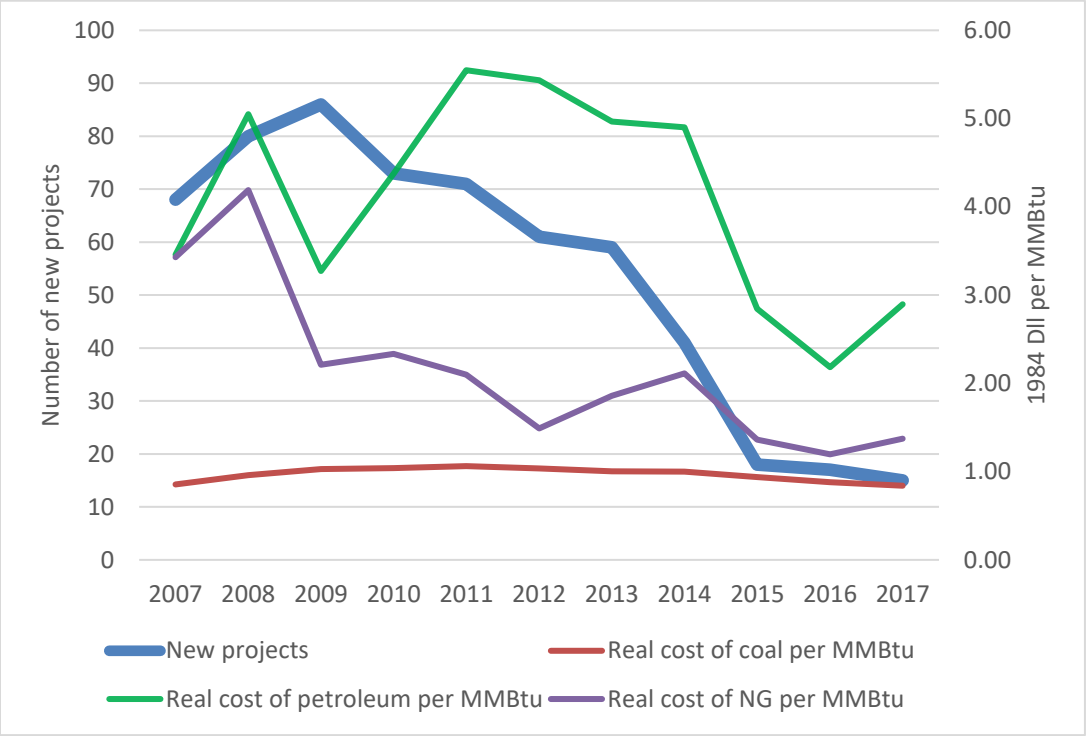

Figure A.3. New LFGE Installations and Marginal Power Input Costs

The number of new LFGE projects installed per year from the year 2007 to 2017 (both regulated and unregulated landfills), and marginal power generation fuel input costs (coal, petroleum, and NG).

Despite the strong observed correlation between NG pricing and new LFGE project development, Reserve staff and workgroup members were cautious not to assume causality. Expert guidance from the workgroup, literature, and Reserve staff suggested that NG pricing alone is insufficient to capture the complexities of LFGE market conditions. Instead, Reserve staff sought to look more broadly at the financial feasibility of LFGE projects, and examine other potentially key contributing factors, including regulatory conditions, LFGE incentives, availability of infrastructure such as NG pipelines, availability of end-use buyers, tax rates, as well as the underlying size and gassiness of landfills.

To more accurately distinguish the projects that would be financially feasible given current market conditions, the Reserve focused on three market factors: 1) landfill gas energy end-use categories; 2) market penetration per end-use category; and 3) LFGE project's financial feasibility (including the impacts of incentives other than offsets). Following expert guidance, the Reserve split LFGE projects into three categories for this assessment: high-Btu projects (RNG, CNG, or LNG projects injecting compressed gas into pipelines), medium-Btu projects (projects where gas is piped directly to a nearby customer or used onsite for its thermal capacity), and electricity generation projects.

The analysis of high-Btu projects reveals that they are not common practice (less than 1% of LMOP landfills have a high-Btu project in place[37]), however, some 39 new high-Btu projects are

[37] Penetration rate is defined as the number of landfills with at least one operational project divided by the total number of landfills in the LMOP database.

either currently in their planning stages or under construction (almost 60% of all LMOP planned or under construction projects for 2019 onwards[38]). Discussions with industry experts indicate that as of the end of 2018, some 50 existing high-Btu projects currently receive incentives under the federal Renewable Fuel Standard (RFS) program, and that RFS incentives are currently providing revenues equivalent to approximately \$58/tCO_2e. Analysis also reveals that as of March 2019, some 110 landfills receive incentives under the California Low Carbon Fuel Standard (LCFS) for provision of renewable landfill gas as a transport fuel in California. This analysis suggests that if a landfill is able to support an RNG/CNG/LNG project, it will potentially be eligible for RFS RIN or LCFS revenues and if it is able to secure such transport fuel incentives, it will thus be feasible without offset revenues. Such projects are also very likely to trigger NSPS/EG size thresholds and be excluded pursuant to the legal requirement test. The analysis therefore suggests that projects receiving such incentives could reasonably be deemed non-additional.

As with any incentives created purely by regulation, these incentives are subject to significant risk that regulations may change or some other regulatory barrier may prevent the project from receiving such incentives. These risks are often referred to as 'stroke of the pen' risks. Given that investment in high-Btu projects is largely being driven by renewable transport fuel incentives, that such projects are subject to significant 'stroke of the pen' regulatory risks, and that such projects are likely to be excluded by the legal requirement test, the Reserve deems that landfill projects producing high-Btu fuels that do not receive transport fuel incentives do not need to be excluded via the limits on credit stacking to ensure additionality. Therefore, any high-Btu projects that do not receive transport fuel incentives, such as federal RFS or California LCFS incentives, will be considered to have met the requirements related to credit stacking. Any high-Btu projects that receive transport fuel incentives, such as the federal RFS or California LCFS, will not be eligible under this protocol, pursuant to the credit stacking provisions in Section 3.4.2. Project developers are required under Section 3.4.2 to disclose the issuance of any type of mitigation credit to the Reserve, and the Reserve will assess additionality with respect to each program.

In contrast to high-Btu projects, medium-Btu projects remain uncommon (landfills with at least one operational medium-Btu project represent less than 3% of all landfills in the LMOP database). Similarly, medium-Btu projects face stiff competition from natural gas as they are both typically used for thermal heating applications. Natural gas prices are currently very competitive relative to medium-Btu LFGE projects. In addition, the most limiting factor for the feasibility of a medium-Btu project is the availability of an end-use buyer of the landfill gas that is within close enough proximity to make the development of local transmission pipelines feasible (typically, such facilities must be within a 10-mile radius for the project to be feasible).[39] Given that these projects remain uncommon, and continue to face significant barriers, these projects can reasonably be deemed additional.

With a total number of 459 operational projects by September 2018, electricity projects represented close to 75% percent of all operational LFGE projects in the LMOP database. In other words, 14% of all landfills in the LMOP database have at least one active electricity project making this technology type fairly common. While electricity projects currently represent the vast

[38] Landfill Methane Outreach Program. "Webinar: Renewable Natural Gas from LFG and Sustainability at L'Oreal (PDF)". United States Environmental Protection Agency. December 12, 2018. Available at https://www.epa.gov/lmop/webinar-renewable-natural-gas-landfill-gas-and-sustainability-loreal

[39] Landfill Methane Outreach Program. "LFG Energy Project Development Handbook." United States Environmental Protection Agency. 2017. Available at: https://www.epa.gov/lmop/landfill-gas-energy-project-development-handbook

majority of LFGE projects, LMOP data reveals that the majority of new planned and in-construction LFGE projects are now set to utilize RNG/CNG. Furthermore, expert guidance indicated that despite electricity LFGE projects being common practice, new electricity LFGE projects currently face unfavorable market conditions, as reflected by the low numbers of projected and planned electricity LFGE projects.[40] Some unfavorable market conditions are low wholesale electricity purchase prices, lack of attractive incentives, and the upcoming expiration of state's Renewable Portfolio Standard goals.

To expand on the understanding of the downward trend for electricity projects, the Reserve sought to identify under which conditions projects would be additional. To do this, the Reserve evaluated the electricity generation capacity at which projects were likely to reach financial feasibility in the absence of GHG offset revenue. It was assumed that a project reaches the point of financial feasibility when it achieves a positive Net Present Value (NPV). The financial feasibility of 32 landfill scenarios was assessed using the LMOP Landfill Gas to Energy Cost Model (LFGcost-Web). The LFGcost-Web is an Excel-based tool that allows users to estimate the financial feasibility of a wide range of LFGE projects, based on specific landfill and project characteristics.[41] Once the Reserve input the set of assumptions for a given scenario in the model, the project design flow rate was gradually increased to evaluate the NPV that the model returned. If the NPV became positive, then landfills under the mix of assumptions for that specific scenario were considered non-additional at or above the given flow rate.

The Reserve retained a number of LFGcost model default assumptions and edited several, following expert consultation. The LFGcost input factors that most affected modeled results were the projects' regulatory status under NSPS, landfill ownership types (private or public), and revenue streams. Below is a summary of assumptions underlying how these specific factors were modeled:

1. Regulatory status: Smaller unregulated projects were assumed to not have an LGCC in place prior to installing an electricity project; thus, the costs of installing the piping, collection, and flaring systems are included in the modeling of these scenarios. Regulated (larger) projects, on the other hand, were assumed to have an LGCC system in place prior to assessing the feasibility of an electricity project, and therefore the costs of installing an LGCC system was not included in the modeling of those scenarios.

2. Landfill ownership status: The assumption as to whether a landfill was owned by a public or private entity was critical, in that it determined the tax rates imposed on the project. Projects funded and developed by local governments were given a 0% tax rate, while private projects were given a 25% tax rate. The Reserve developed the 25% private tax rate as a combination of the 21% federal tax rate plus an assumed average 4% state tax rate. A review of state tax rates revealed a simple average rate of 6% nationally, but the Reserve chose to use a 4% tax rate,[42] as this would more readily return positive NPV rates and conservatively exclude more projects.

3. Revenue streams: Project revenue streams modeled in the various scenarios were a mix of energy tax credits, RECs, and, most critically, electricity sales price. These assumptions were differentiated based on the availability of incentives and revenues

[40] LMOP, 2018.
[41] A copy of the LFGcost-Web tool and background information can be accessed here: https://www.epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model.
[42] A table of state tax rates produced by the Tax Foundation was used for this analysis, which was accessed here: https://taxfoundation.org/state-corporate-rates-brackets-2019/.

across different regions in the United States. The assumption with respect to the electricity sales price warrants specific discussion, as it had the single largest effect on project NPV. The LFGcost tool used a default electricity sales price of $0.06/kWh. Expert guidance indicated that this price was not representative of wholesale prices paid to LFGE project operators and was too high. Therefore, the Reserve's analysis replaced this value with a price representing the national average historical wholesale 'high' price for 2018.[43] The Reserve then identified any pricing regions for which the average historical 2018 price was higher than the national average, and for those areas, the Reserve used the regional average, as this ensures the resulting NPV is more representative and conservative. In two regions, the Reserve used an electricity sales price which was above the national average historical 2018 wholesale price. In Vermont, an electricity price of $0.09/kWh[44] was used, representing the feed-in tariff available under their Standard Offer program. The average price in New England was set at $0.058/kWh, reflecting the average 2018 wholesale electricity price there (specifically at the Nepool MH DA LMP Peak).[45]

Four of the modeled scenarios returned a positive NPV, indicating that financial feasibility is strong without offsets, and they should therefore be excluded for not being additional. All four of these scenarios shared the following characteristics:

- They were large enough to be considered 'regulated' (so the cost of a mandatory GCCS was not included in the analysis);
- REC incentives were available; and
- Electricity sales prices were higher than the national average wholesale price.

The assumption regarding the costs of installing a collection and flaring system was most critical to all scenarios. The added cost of installing a GCCS as part of an electricity project was high enough to make any unregulated project infeasible even with the availability of incentives. Given that no unregulated project scenarios returned a positive NPV, the Reserve believes that the legal requirement test is enough to address the additionality of electricity projects. In the case of the four scenarios that returned positive NPV values, the landfill itself was large enough to trigger the legal requirement test to make it ineligible. For this reason, the Reserve has not included these four scenarios in the performance standard test itself, as such projects will effectively be excluded from eligibility via the legal requirement test.

[43] Energy Information Administration and Intercontinental Exchange (ICE). Wholesale Electricity and Natural Gas Market Data. Accessed in Jan 30, 2019. Available at https://www.eia.gov/electricity/wholesale/.
[44] VEPP Inc. Standard Offer Program Request for Proposals. 2019 RFP Coming January 2019. Available at: http://www.vermontstandardoffer.com/2019-rfp-informationa/.
45 EIA and ICE, 2019.

Appendix B Emission Factor Tables

Table B.1. CO_2 Emission Factors for Fossil Fuel Use[46]

Fuel Type	Default High Heat Value	Default CO_2 Emission Factor	
Coal and coke	mmBtu/ short ton	kg CO_2/ mmBtu	kg CO_2/ short ton
Anthracite	25.09	103.69	2601.582
Bituminous	24.93	93.28	2325.470
Subbituminous	17.25	97.17	1676.183
Lignite	14.21	97.72	1388.601
Coal Coke	24.8	113.67	2819.016
Mixed (Commercial sector)	21.39	94.27	2016.435
Mixed (Industrial coking)	26.28	93.9	2467.692
Mixed (Industrial sector)	22.35	94.67	2115.875
Mixed (Electric Power sector)	19.73	95.52	1884.610
Natural gas	mmBtu/ scf	kg CO_2/ mmBtu	kg CO_2/ scf
(Weighted U.S. Average)	0.001026	53.06	0.054
Petroleum products	mmBtu/ gallon	kg CO_2/ mmBtu	kg CO_2/ gallon
Distillate Fuel Oil No. 1	0.139	73.25	10.182
Distillate Fuel Oil No. 2	0.138	73.96	10.206
Distillate Fuel Oil No. 4	0.146	75.04	10.956
Residual Fuel Oil No. 5	0.14	72.93	10.210
Residual Fuel Oil No. 6	0.15	75.1	11.265
Used Oil	0.138	74	10.212
Kerosene	0.135	75.2	10.152
Liquefied petroleum gases (LPG)[1]	0.092	61.71	5.677
Propane[1]	0.091	62.87	5.721
Propylene[2]	0.091	67.77	6.167
Ethane[1]	0.068	59.6	4.053
Ethanol	0.084	68.44	5.749
Ethylene[2]	0.058	65.96	3.826
Isobutane[1]	0.099	64.94	6.429
Isobutylene[1]	0.103	68.86	7.093
Butane[1]	0.103	64.77	6.671
Butylene[1]	0.105	68.72	7.216
Naphtha (<401 deg F)	0.125	68.02	8.503
Natural Gasoline	0.11	66.88	7.357
Other Oil (>401 deg F)	0.139	76.22	10.595
Pentanes Plus	0.11	70.02	7.702
Petrochemical Feedstocks	0.125	71.02	8.878
Petroleum Coke	0.143	102.41	14.645
Special Naphtha	0.125	72.34	9.043
Unfinished Oils	0.139	74.54	10.361

[46] 40 CFR Part 98 Subpart C Table C-1: Default CO_2 Emission Factors and High Heat Values for Various Types of Fuel.

Fuel Type	Default High Heat Value	Default CO_2 Emission Factor	
Heavy Gas Oils	0.148	74.92	11.088
Lubricants	0.144	74.27	10.695
Motor Gasoline	0.125	70.22	8.778
Aviation Gasoline	0.12	69.25	8.310
Kerosene-Type Jet Fuel	0.135	72.22	9.750
Asphalt and Road Oil	0.158	75.36	11.907
Crude Oil	0.138	74.54	10.287
Other fuels—solid	mmBtu/ short ton	kg CO_2/ mmBtu	kg CO_2/ short ton
Municipal Solid Waste	9.953	90.7	902.737
Tires	28	85.97	2407.160
Plastics	38	75	2850.000
Petroleum Coke	30	102.41	3072.300
Other fuels—gaseous	mmBtu/ scf	kg CO_2/ mmBtu	kg CO_2/ scf
Blast Furnace Gas	0.000092	274.32	0.025
Coke Oven Gas	0.000599	46.85	0.028
Propane Gas	0.002516	61.46	0.155
Fuel Gas[4]	0.001388	59	0.082
Biomass fuels—solid	mmBtu/ short ton	kg CO_2/ mmBtu	kg CO_2/ short ton
Wood and Wood Residuals (dry basis)[5]	17.48	93.8	1639.624
Agricultural Byproducts	8.25	118.17	974.903
Peat	8	111.84	894.720
Solid Byproducts	10.39	105.51	1096.249
Biomass fuels—gaseous	mmBtu/ scf	kg CO_2/ mmBtu	kg CO_2/ scf
Landfill Gas	0.000485	52.07	0.025
Other Biomass Gases	0.000655	52.07	0.034
Biomass Fuels—Liquid	mmBtu/ gallon	kg CO_2/ mmBtu	kg CO_2/ gallon
Ethanol	0.084	68.44	5.749
Biodiesel (100%)	0.128	73.84	9.452
Rendered Animal Fat	0.125	71.06	8.883
Vegetable Oil	0.12	81.55	9.786

[1] The HHV for components of LPG determined at 60°F and saturation pressure with the exception of ethylene.
[2] Ethylene HHV determined at 41°F (5°C) and saturation pressure.
[3] Use of this default HHV is allowed only for: (a) Units that combust MSW, do not generate steam, and are allowed to use Tier 1; (b) units that derive no more than 10 percent of their annual heat input from MSW and/or tires; and (c) small batch incinerators that combust no more than 1,000 tons of MSW per year.
[4] Reporters subject to subpart X of this part that are complying with §98.243(d) or subpart Y of this part may only use the default HHV and the default CO_2 emission factor for fuel gas combustion under the conditions prescribed in §98.243(d)(2)(i) and (d)(2)(ii) and §98.252(a)(1) and (a)(2), respectively. Otherwise, reporters subject to subpart X or subpart Y shall use either Tier 3 (Equation C-5) or Tier 4.
[5] Use the following formula to calculate a wet basis HHV for use in Equation C-1: $HHV^w = ((100 - M)/100)*HHV^d$ where HHV^w = wet basis HHV, M = moisture content (percent) and HHV^d = dry basis HHV from Table C-1.

B.1 Destruction Efficiencies for Destruction Devices

If available, the official source tested methane destruction efficiency shall be used in Equation 5.4 in place of the default methane destruction efficiency. Device-specific source testing shall be conducted annually, by a state or local agency accredited service provider, and include at least three test runs, with the accepted final value being one standard deviation below the mean of the measured efficiencies. If neither the state nor locality relevant to the project site offer accreditation for source testing service providers, projects may use an accredited service provider from another U.S. state or domestic locality. Alternatively, projects may choose a non-accredited service provider, under the following conditions: 1) the service provider must provide verifiable evidence of prior testing that was accepted for compliance by a domestic regulatory agency, and 2) the prior testing procedures must be substantially similar to the procedures used for determining methane destruction efficiency for the project destruction device(s).

If site-specific source test results conforming with the above paragraph are not available, project developers shall use the default methane destruction efficiencies provided below.

Table B.2. Default Destruction Efficiencies for Destruction Devices

Destruction Device	Destruction Efficiency (DE)
Open Flare	0.96
Enclosed Flare	0.995
Lean-burn Internal Combustion Engine	0.936
Rich-burn Internal Combustion Engine	0.995
Boiler	0.98
Microturbine or large gas turbine	0.995
Upgrade and use of gas as CNG/LNG fuel	0.95
Upgrade and injection into natural gas transmission and distribution pipeline	0.98*
Offsite use of gas under direct-use agreement	Per corresponding destruction device factor (not pipeline)

Source: The default destruction efficiencies for enclosed flares and electricity generation devices are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data is made available to the Reserve.

***** The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH_4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH_4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH_4/PJ, which is 0.8%. These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations. [47]

[47] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

Appendix C Baseline Monitoring and Calculation of LFG_{B1}, LFG_{B2}, and B_{CH4}

This appendix shall be used to calculate LFG_{B2} and $B_{CH4,NQ}$ for use in Equation 5.7. Much of the discussion here is concerned with accommodating the added complexity of monitoring passive flares and other non-qualifying devices. However, the methodology described is also applicable for measuring and documenting LFG_{B1} and $B_{CH4,closed}$ for calculating $Closed_{discount}$ in Equation 5.6.

C.1 Baseline Monitoring

Passive flares and other non-qualifying destruction devices are often installed at landfills for purposes other than methane destruction, and therefore are not amenable to simple monitoring. For example, flares installed for odor control may be used intermittently and without any instrumentation tracking gas flow and methane concentration. This makes assessing baseline methane destruction from passive flares extremely difficult to quantify. Quantification is further exacerbated by the fact that passive flares are not necessarily designed to accommodate metering equipment; for example, in many cases passive flares do not have sufficient straight pipe length to control for turbulence. These limitations, combined with the low flow rates generally seen at passive flares, greatly limit the number and type of metering equipment that can be used. Monitoring destruction of landfill gas from baseline landfill gas wells at closed landfill flares will face fewer obstacles.

Constraints on monitoring landfill gas from passive flares are unique to each landfill. The Reserve has attempted to make this methodology as flexible as possible to make it widely applicable. Any deviations from this methodology will require a formal request for variance.

C.2 Monitoring

Non-qualifying destruction devices (e.g., passive flares) and qualifying flares at closed landfills must be monitored for a period of at least three months. This period must occur prior to the project start date to ensure that the measured gas flow is not decreased by the addition of project wells or pressure changes that result from the project activity. Methane destruction from the chosen period must be extrapolated to one year based on the 90% upper confidence limit of the methane destruction identified in this period. Therefore, monitoring for more than three months, or with greater than weekly frequency, may lessen statistical uncertainty and reduce the required $NQ_{discount}$ or $Closed_{discount}$.

Gas flow must be measured weekly at a minimum and must be normalized to maximum flow capacity (scfm, 60°F and 1 atm). If gas flow falls below the measurable range for the chosen metering device, the minimum flow value of the chosen metering device must be applied to that time interval. Methane concentration must also be measured at least weekly.

One measurement should be entered on each day for which readings were taken. If continuous measurements were taken, these should be averaged. If a single measurement was taken, then this value should be used. Therefore, if a daily monitoring plan is chosen for the three-month period, a total of 90 data points will be available (one per day). However, if weekly measurements are taken, then only 13 data points will be available for the analysis (one per week). Alternatively, irregular measurement intervals (for example, if someone is onsite three consecutive days) or bi-weekly measurements can be used as well, allowing for anywhere

between 13 and 90 data points for any 90-day period. However, no more than one data point per calendar day may be applied and all collected data must be used.

All metering equipment used in baseline monitoring is subject to the same maintenance, calibration, and QA/QC requirements outlined previously for project metering equipment. In the case where a project does not meet the baseline monitoring maintenance, calibration, and QA/QC requirements of this protocol version, it shall be acceptable for that project to have its baseline monitoring, maintenance, calibration, and QA/QC verified against the requirements of a previous version of this protocol, so long as it is the version that was in force at the beginning date of the project's baseline monitoring period.

C.3 Passive Flare Configuration

As the configuration of passive flares will be unique to each landfill, it is not possible to dictate a single monitoring methodology. Rather, the following options have been devised as acceptable configurations.

1. Each passive flare will be monitored individually for both flow and methane concentration according to the schedule outlined in Section C.2.
2. Wells from two or more passive flares may be connected to a single flare with a single set of meters for both flow and methane concentration. Additional engineering may be required to ensure that the altered pressure characteristics of the system do not decrease total gas flow. The flow characteristics of this system will require substantiation from engineering documents and calculations and will be assessed by the verification body.
3. Wells from two or more passive flares may be connected with the active collection system and monitored separately from the new project wells while under vacuum from the blower.

C.4 Calculation

Please use Equation C.1 to calculate the $Closed_{discount}$ and Equation C.2 to calculate the $NQ_{discount}$.

Equation C.1. Calculation of Baseline Discount for Flares at a Closed Landfill

$$Closed_{discount} = 525,600 \times CH_{4_{min}}$$

$$LFG_{B1} = 525,600 \times 90\%UCL(LFG_{scfm})$$

Where,			Units
LFG_{B1}	=	Landfill gas from the baseline landfill gas wells that would have been destroyed by the qualifying destruction system during the reporting period	scf LFG
90%UCL(LFG_{scfm})	=	90% upper confidence limit of the average flow rate in the metered period (must be >3 months)	scfm LFG
525,600	=	Minutes in one year	min/yr

$$B_{CH_4,closed} = 90\%UCL(B_{CH_4,closed,t})$$

Where,			Units
$B_{CH4,closed,t}$	=	Methane concentration for baseline calculations	scf CH_4/ scf LFG
90%UCL($B_{CH4,closed,t}$)	=	90% upper confidence limit of the average methane concentration in the metered period (must be >3 months)	scf CH_4/ scf LFG

$$90\%UCL = mean + t_{value} \times \left(\frac{SD}{\sqrt{n}}\right)$$

Where,			Units
mean	=	Sample mean (of $B_{CH4,closed,t}$ or LFG_{scfm})	scf or %
t_{value}	=	90% t-value coefficient for data set with degrees of freedom *df* (use Excel feature: =TINV(0.1,df)	
SD	=	Standard deviation of the sample (of $B_{CH4,closed,t}$ or LFG_{scfm})	scf or %
n	=	Sample size	
df	=	Degrees of freedom (= n-1)	

Equation C.2. Calculation of Baseline Discount for a Non-Qualifying Device

$$NQ_{discount} = 525,600 \times CH_{4_{min}}$$

$$LFG_{B2} = 525,600 \times 90\%UCL(LFG_{scfm})$$

Where,			Units
LFG_{B2}	=	Landfill gas that would have been destroyed by the original, non-qualifying destruction system during the reporting period	scf LFG
90%UCL(LFG_{scfm})	=	90% upper confidence limit of the average flow rate in the metered period (must be >3 months)	scfm LFG
525,600	=	Minutes in one year	min/yr

$$B_{CH_4,NQ} = 90\%UCL(B_{CH_4,NQ,t})$$

Where,			Units
$B_{CH4,NQ,t}$	=	Methane concentration for baseline calculations	scf CH_4/ scf LFG
90%UCL($B_{CH4,NQ,t}$)	=	90% upper confidence limit of the average methane concentration in the metered period (must be >3 months)	scf CH_4/ scf LFG

$$90\%UCL = mean + t_{value} \times \left(\frac{SD}{\sqrt{n}}\right)$$

Where,			Units
mean	=	Sample mean (of $B_{CH4,NQ,t}$ or LFG_{scfm})	scf or %
t_{value}	=	90% t-value coefficient for data set with degrees of freedom *df* (use Excel feature: =TINV(0.1,df)	
SD	=	Standard deviation of the sample (of $B_{CH4,NQ,t}$ or LFG_{scfm})	scf or %
n	=	Sample size	
df	=	Degrees of freedom (= n-1)	

C.5 Example

The following example (Table C.1) demonstrates the necessary calculation for determining $Closed_{discount}$ or $NQ_{discount}$. The calculations outlined above in Section C.4 are represented by the first three columns of data. The final conversions to tCO_2e/yr are done using Equation 5.5.

Note that although the measurements had average values yielding a deduction of 5,961 tCO_2e/yr, due to the limited data and variability of the measurements, the appropriate deduction is 7,830 tCO_2e/yr. If, instead of weekly data there was daily data over this three month period that yielded the exact same mean and standard deviation, the additional data alone would have lowered the deduction to only 6,807 tCO_2/yr. Alternately, if the data had been more consistent and showed a standard deviation for the flow data of only 6 with the same mean, then the deduction with 14 samples would have been only 6,689 tCO_2/yr. Therefore, the added uncertainty deduction of this method is directly related to the level of variability in the data and the number of samples.

Table C.1. Example Dataset and Calculation of $Closed_{discount}$ or $NQ_{discount}$

	Calculated According to Equations C.1 and C.2				Calculated According to Equation 5.5	
	CH_4 (%)	**Flow (scfm)**	**Flow CH_4 (scfm)**	**CH_4/year (scf/yr)**	**CH_4/year (t/yr)**	**tCO_2e/year**
6/1/2008	56.7	48	27	14,304,703	274	5,760
6/8/2008	55.3	75	41	21,799,260	418	8,778
6/15/2008	58.1	21	12	6,412,846	123	2,582
6/22/2008	54.0	90	49	25,544,160	490	10,286
6/29/2008	55.6	47	26	13,734,979	263	5,531
7/6/2008	56.3	23	13	6,805,994	131	2,741
7/13/2008	57.2	70	40	21,045,024	404	8,475
7/20/2008	58.0	15	9	4,572,720	88	1,841
7/27/2008	52.3	89	47	24,465,103	469	9,852
8/3/2008	55.7	42	23	12,295,886	236	4,951
8/10/2008	54.8	51	28	14,689,469	282	5,915
8/17/2008	62.1	19	12	6,201,554	119	2,497
8/24/2008	59.3	66	39	20,570,933	394	8,284
8/31/2008	57.6	70	40	21,192,192	406	8,534
Mean	**56.6**	**51.86**	**28**	**14,803,281**	**284**	**5,961**
SD	0.02	25.70				
n	14	14				
df	13	13				
90% t-value	1.77	1.77				
UCL at 90%	**57.8**	**64.02**	**37**	**19,443,275**	**373**	**7,830**

Appendix D Data Substitution Guidelines

This appendix provides guidance on calculating emission reductions when data integrity has been compromised due to missing data points. No data substitution is permissible for equipment such as thermocouples, which monitor the proper functioning of destruction devices. Rather, the methodologies presented below are to be used only for the methane concentration and flow metering parameters.

The Reserve expects that projects will have continuous, uninterrupted data for the entire verification period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously. If data is missing for both parameters, no reductions can be credited.

Further, substitution may only occur when two other monitored parameters corroborate proper functioning of the destruction device and system operation within normal ranges. These two parameters must be demonstrated as follows:

1. Proper functioning can be evidenced by thermocouple readings for flares, energy output engines, etc.
2. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
3. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology maybe applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours immediately before and following the outage
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness
Greater than one week	No data may be substituted, and no credits may be generated

The lower confidence limit should be used for both methane concentration and flow readings for landfill projects, as this will provide the greatest conservativeness.

For weekly measured methane concentration, the lower of the measurement before and the measurement after must be used. This substitution may only be used to substitute data for one consecutive missing weekly measurement.

CLIMATE ACTION RESERVE

Version 4.0 | January 23, 2013

U.S. Livestock

Project Protocol

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Released January 23, 2013

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Acknowledgements

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Derik Broekhoff
Rachel Tornek
Heather Raven
Anna Schmitz

The Reserve would like to thank SAIC and Kathryn Bickel Goldman for their work on the performance standard analysis.

The Reserve also recognizes the workgroup for their generous contribution of time and expertise, as well as other members of the public who actively participated in the protocol development process.

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Table of Contents

Abbreviations and Acronyms 1

1 Introduction 2
2 The GHG Reduction Project 3
2.1 Project Definition 3
2.2 The Project Developer 3
3 Eligibility Rules 4
3.1 Location 4
3.2 Project Start Date 4
3.3 Project Crediting Period 4
3.4 Uncontrolled Anaerobic Baseline 5
3.5 Additionality 6
3.6 Regulatory Compliance 7
4 The GHG Assessment Boundary 8
5 Quantifying GHG Emission Reductions 13
5.1 Required Parameters for Modeling Baseline and Project Emissions 14
5.2 Modeling Baseline Methane Emissions 18
5.3 Calculating Project Methane Emissions 23
5.4 Metered Methane Destruction Comparison 29
5.5 Calculating Baseline and Project Carbon Dioxide Emissions 29
6 Project Monitoring 32
6.1 Site-Specific Determination of Maximum Methane Potential (B_0) 32
6.2 Biogas Control System Monitoring Requirements 34
6.3 Biogas Measurement Instrument QA/QC 36
6.4 Monitoring Parameters 38
7 Reporting Parameters 45
7.1 Project Documentation 45
7.2 Record Keeping 45
7.3 Reporting and Verification Cycle 46
8 Verification Guidance 50
8.1 Standard of Verification 50
8.2 Monitoring Plan 50
8.3 Verifying Project Eligibility 50
8.4 Core Verification Activities 51
8.5 Verification Period 52
8.6 Livestock Verification Items 53
8.7 Completing Verification 55
9 Glossary of Terms 56
10 References 59

Appendix A Associated Environmental Impacts 61
Appendix B Emission Factor Tables 62
Appendix C Summary of Performance Standard Development 72
Appendix D Data Substitution 80
Appendix E Development of the B_0 Sampling and Analysis Methodology 81
Appendix F Sample Livestock Project Diagram 85

List of Tables

Table 4.1. Description of all Sources, Sinks, and Reservoirs....10
Table 6.1. Project Monitoring Parameters....38
Table 7.1. Sample Verification Cycle under Option 2....48
Table 7.2. Sample Verification Cycle under Option 3....49
Table 8.1. Summary of Eligibility Criteria for a Livestock Project....51
Table 8.2. Eligibility Verification Items....53
Table 8.3. Quantification Verification Items....54
Table 8.4. Risk Assessment Verification Items....55

List of Figures

Figure 4.1. General Illustration of the GHG Assessment Boundary.... 9
Figure 5.1. Organization of Equations in Section 5....17
Figure 6.1. Suggested Arrangement of Biogas Metering Equipment....35
Figure E.1. Monthly Milk Production Trends as a Percent Change Over Annual Average Monthly Milk Production (1998-2011)....82

List of Equations

Equation 5.1. GHG Reductions from Installing a Biogas Control System....18
Equation 5.2. Modeled Baseline Methane Emissions....19
Equation 5.3. Modeled Baseline Methane Emissions from Anaerobic Storage/Treatment Systems....20
Equation 5.4. Modeled Baseline Methane for Non-Anaerobic Storage/Treatment Systems....23
Equation 5.5. Project Methane Emissions....24
Equation 5.6. Project Methane Emissions from the Biogas Control System....25
Equation 5.7. Methane Emissions from Venting Events....26
Equation 5.8. Modeled Project Methane Emissions from Anaerobic Treatment of BCS Effluent26
Equation 5.9. Modeled Project Methane Emissions from Non-Anaerobic Treatment of BCS Effluent....28
Equation 5.10. Project Methane Emissions from *Non*-BCS Related Sources....28
Equation 5.11. Metered Methane Destruction....29
Equation 5.12. Increased Carbon Dioxide Emissions....31

List of Appendix Tables

Table B.1. Manure Management System Components....62
Table B.2. Livestock Categories and Typical Animal Mass....63
Table B.3. Volatile Solids and Maximum Methane Potential by Livestock Category....63
Table B.4. Biogas Collection Efficiency by Digester Type....63
Table B.5a. 2010 Volatile Solid Default Values for Dairy Cows, Heifers, Heifers-Grazing and Cows-Grazing by State (kg/day/1000 kg mass)....64
Table B.6. IPCC 2006 Methane Conversion Factors by Manure Management System Component/Methane Source 'S'....67
Table B.7. Biogas Destruction Efficiency Default Values by Destruction Device....69
Table B.8. CO_2 Emission Factors for Fossil Fuel Use....70
Table B.9. Volatile Solids Removed Through Solids Separation....71
Table B.10. Baseline Assumptions for Greenfield Projects....71
Table C.1. Dairy and Swine Operations in the U.S. by Manure Management System (2006)....73

Table C.2. Dairy and Swine Operations in the U.S. by Manure Management System (2012)....73
Table C.3. Dairy and Swine Operations by Size and Manure Management System (2006) 74
Table C.4. Dairy and Swine Operations by Size and Manure Management System (2012) 74
Table C.5. Dairy and Swine Operations by Size and Manure Management System (2012) 75
Table C.6. Dairy and Swine Operations by Size and Manure Management System (2012) 76
Table C.7. Dairy and Swine Operations Utilizing Liquid Manure Management, by Size and Manure Management System (2012).....77
Table E.1. Effects of Relative Population Size on Composite B_0 Value……..83

Abbreviations and Acronyms

BCS	Biogas control system
CARB	California Air Resources Board
CH_4	Methane
CNG	Condensed natural gas
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
GWP	Global warming potential
IPCC	Intergovernmental Panel on Climate Change
lb	Pound
LNG	Liquefied natural gas
MCF	Methane conversion factor
MT	Metric ton or tonne
N_2O	Nitrous oxide
NG	Natural gas
QA/QC	Quality Assurance/Quality Control
Reserve	Climate Action Reserve
scf	Standard cubic foot at 1 atm pressure and 60°F temperature
SSR	Sources, sinks, and reservoirs
t	Metric ton or tonne
TAM	Typical animal mass
VS	Volatile solids

1 Introduction

The Climate Action Reserve's (Reserve) Livestock Project Protocol provides guidance to account for and report greenhouse gas (GHG) emission reductions associated with the installation of a biogas control system (BCS) for manure management on dairy cattle and swine farms. The protocol focuses on quantifying the change in methane emissions, but also accounts for potential increases in carbon dioxide emissions.

The Climate Action Reserve is the most experienced, trusted and efficient offset registry to serve the California cap-and-trade program and the voluntary carbon market. With deep roots in California and a reach across North America, the Reserve encourages actions to reduce greenhouse gas emissions and works to ensure environmental benefit, integrity and transparency in market-based solutions to address global climate change. It operates the largest accredited registry for the California compliance market and has played an integral role in the development and administration of the state's cap-and-trade program. For the voluntary market, the Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies and issues and tracks the transaction of carbon credits (Climate Reserve Tonnes) generated from such projects in a transparent, publicly-accessible system. The Reserve program promotes immediate environmental and health benefits to local communities and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California.

Project developers that install manure biogas capture and destruction technologies use this document to register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Verification Program Manual and Section 8 of this protocol.

This project protocol facilitates the creation of GHG emission reductions determined in a complete, consistent, transparent, accurate, and conservative manner, while incorporating relevant sources.[1]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG accounting principles.

2 The GHG Reduction Project

Manure treated and stored under anaerobic conditions decomposes to produce methane, which, if uncontrolled, is emitted to the atmosphere. This predominantly occurs when livestock operations manage waste with anaerobic, liquid-based systems (e.g. in lagoons, ponds, tanks, or pits). Within the livestock sector, the primary drivers of methane generation include the amount of manure produced and the fraction of volatile solids (VS) that decompose anaerobically. Temperature and the retention time of manure during treatment and storage also affect methane production.

2.1 Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the installation and operation of a biogas control system[2] that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities on livestock operations. The biogas control system must destroy methane gas that would otherwise have been emitted to the atmosphere in the absence of the project from uncontrolled anaerobic treatment and/or storage of manure.

Captured biogas can be destroyed on-site, or transported for off-site use (e.g. through gas distribution or transmission pipeline), or used to power vehicles. Regardless of how project developers take advantage of the captured biogas, the ultimate fate of the methane must be destruction.

"Centralized digesters" that integrate waste from more than one livestock operation also meet the definition of a GHG reduction project.

Note that the protocol does not preclude project developers from co-digesting organic matter in the biogas control system. However, the additional organics could impact the nutrient properties of digester effluent; project developers should consider this when assessing the project's associated water quality impacts. The Reserve has also developed the Organic Waste Digestion Project Protocol that provides a quantification methodology for crediting the co-digestion of eligible waste streams with livestock manure. The protocol is available at http://www.climateactionreserve.org/how/protocols/adopted/organic-waste-digestion/current/.

2.2 The Project Developer

The "project developer" is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers could be livestock facility owners and operators, GHG project financiers, or other entities. The project developer must have clear ownership of the project's GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership each time the project is verified by signing the Reserve's Attestation of Title form.[3]

Under this protocol, the project developer is the only party required to be involved with project implementation.

[2] Biogas control systems encompass anaerobic digester systems – which may be designed and operated in a variety of ways, from ambient temperature covered lagoons to heated lagoons to mesophilic plug flow or complete mix concrete tank digesters—as well as methane destruction systems, such as flares or engines.

[3] Attestation of Title form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

3 Eligibility Rules

Project developers using this protocol must satisfy the following eligibility rules to register reductions with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project.

Eligibility Rule I:	Location	→	*U.S., its territories, and tribal lands*
Eligibility Rule II:	Project Start Date	→	*No more than 6 months prior to project submission*
Eligibility Rule III:	Anaerobic Baseline	→	*Demonstrate anaerobic baseline conditions*
Eligibility Rule IV:	Additionality	→	*Meet performance standard*
		→	*Exceed regulatory requirements*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Only projects located in the United States and its territories, or on U.S. tribal lands, are eligible to register reductions with the Reserve under this protocol. Livestock projects located in Mexico must use the Mexico Livestock Project Protocol if seeking to register GHG reductions with the Reserve.

3.2 Project Start Date

The start date for a livestock project is defined as the date on which the project's biogas control system becomes operational. For the purposes of this protocol, a BCS is considered *operational* on the date that the system begins producing and destroying methane gas following an initial start-up period. This date can be selected by the project developer within the 6 month period following the date on which manure is first loaded into the digester or on the date that the cover installation was completed (for a covered lagoon digester where the lagoon already contained manure).

Projects must be submitted to the Reserve no more than six months after the project start date.

3.3 Project Crediting Period

Project developers are eligible to register GHG reductions with the Reserve according to this protocol for a period of ten years following the project's start date. All projects that initially pass the eligibility requirements set forth in this protocol are eligible to register GHG reductions with the Reserve for the duration of the project's first crediting period (ten years), even if a regulatory agency with authority over a livestock operation passes a rule obligating the installation of a BCS during this initial crediting period.

If a project developer wishes to apply for eligibility under a second crediting period, they must do so within the final six months of the initial crediting period. Thus, the Reserve may issue CRTs for GHG reductions quantified and verified according to the U.S. Livestock Project Protocol for a maximum of two ten year crediting periods after the project start date. Section 3.5.1 and 3.5.2 describe the requirements to qualify for a second crediting period. Deadlines and requirements

for reporting and verification, as laid out in this protocol, the Program Manual, and the Verification Program Manual, will continue to apply without interruption.

3.4 Uncontrolled Anaerobic Baseline

The installation of a BCS at a livestock operation where the primary manure management system is aerobic (produces little to no methane) may result in an increase of the amount of methane emitted to the atmosphere. Thus, the BCS must digest manure that would primarily be treated in an anaerobic system in the absence of the project in order for the project to meet the definition of a GHG reduction project. Sections 3.4.1, 3.4.2, and 3.4.3 explain the specific baseline scenario options. Under any one of these scenarios, the uncontrolled anaerobic baseline requirement may be temporarily disrupted for the purposes of construction of the project digester. In these cases, the verifier may use professional judgment to confirm that the requirements of this section have been met.

3.4.1 Existing Livestock Facilities

For livestock facilities that have been in operation for more than five years, developers of livestock projects must demonstrate that an uncontrolled anaerobic manure management system was in place for the five years immediately prior to the date that manure was first loaded into the project digester. That anaerobic system may include a lagoon or a pond as long as the depth of the system was sufficient to prevent algal oxygen production and create an oxygen-free bottom layer (i.e. greater than 1 meter in liquid depth).[4]

For livestock facilities that have been in operation for more than two years, but less than five years, developers of livestock projects must demonstrate that an uncontrolled anaerobic manure management system was in place at all times up until the project's start date.

3.4.2 New Livestock Facilities (Greenfields)

Greenfield livestock projects (i.e. projects that are implemented at livestock facilities that have been in operation for less than two years at a site that had no prior manure management infrastructure) are eligible only if the project developer can demonstrate that there are no restrictions to the construction and operation of an open, uncontrolled, anaerobic manure storage system. Since a greenfield project will not have an existing manure management system that can be used to model the baseline methane emissions, all greenfield projects shall utilize a set of standardized baseline management assumptions (see Table B.10).

3.4.3 Centralized Digesters

For projects that employ a centralized digester that will be accepting manure from more than one livestock operation, each individual source of manure (identified by livestock facility) must meet the anaerobic baseline requirements above as of the project start date. In other words, if a new facility begins sending manure to the project digester after the project start date, the anaerobic baseline of that manure must still be assessed as of the project start date.

[4] This is consistent with the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) methodology ACM00010 (available at: http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html). For additional information on the design and maintenance of anaerobic wastewater treatment systems, see U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Storage Facility, No. 313; and U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Treatment Lagoon, No. 359.

3.5 Additionality

The Reserve will only accept projects that yield surplus GHG reductions that are additional to what would have otherwise occurred. That is, the reductions are above and beyond business-as-usual operation.

Project developers satisfy the "additionality" eligibility rule by passing two tests:

1. The Performance Standard Test
2. The Legal Requirement Test

3.5.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a program-wide performance threshold – i.e. a standard of performance applicable to all manure management projects, established on an *ex-ante* basis. The performance threshold represents "better than business-as-usual" manure management. If the project meets the threshold, then it exceeds what would happen under the business-as-usual scenario and generates surplus/additional GHG reductions.

For this protocol, the Reserve uses a technology-specific threshold; sometimes also referred to as a practice-based threshold, where it serves as "best-practice standard" for managing livestock manure. By installing a BCS, a project developer passes the Performance Standard Test.

The Reserve defined this performance standard by evaluating manure management practices in California and the United States. A summary of the study to establish the threshold is provided in Appendix C.

The Performance Standard Test is applied at the time of the project's start date. All projects that pass this test at the project's start date are eligible to register reductions with the Reserve for the duration of the first project crediting period, even if the Reserve revises the Performance Standard Test in subsequent versions of this protocol during that period. As stated in Section 3.3, the project crediting period is ten years.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol at the time of the submittal for the second crediting period, including any updates to the Performance Standard Test.

3.5.2 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the installation of a BCS at the livestock operation.

The Legal Requirement Test is applied at the time of a project's start date. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[5] prior to the commencement of verification activities for the first verification

[5] Attestation forms are available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

period. All projects that pass this test at the project's start date are eligible to register reductions with the Reserve for the duration of their first crediting period, even if legal requirements change or new legal requirements are enacted during that period.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Legal Requirement Test. Furthermore, during a project's second crediting period, it must demonstrate that it passes the Legal Requirement Test during each reporting period. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form prior to the commencement of verification activities for each verification period. If project activities become legally required during a project's second crediting period, the project will only be eligible to receive CRTs up to the date that the system is required to be operational.

The Reserve's analysis of manure management practices in the U.S. identified no regulations that obligate livestock owners to invest in a manure BCS. The analysis looked most closely at recent, stringent California air quality regulations (e.g. SJVAPCD Rule 4570 and Sacramento AQMD Rule 496), and found that installing an anaerobic digester is one of several compliance options, although high capital costs appear to prohibit the use of anaerobic digesters as a practical compliance mechanism for these air quality regulations.

3.6 Regulatory Compliance

As a final eligibility requirement, project developers must attest that project activities do not cause material violations of applicable laws (e.g. air, water quality, safety, etc.). To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form[6] prior to the commencement of verification activities each time the project is verified. Project developers are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project or project activities.

A violation should be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the project developer shall disclose the violation to the verifier.

If a verifier finds that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurrent administrative violations directly related to project activities may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

[6] Attestation forms are available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers to determine the net change in emissions associated with installing a BCS. This protocol's assessment boundary captures sources from waste production to disposal, including off-site manure disposal.

CH_4 emissions from the land application of manure and digester effluent are excluded from the GHG Assessment Boundary. As these emission sources will either remain the same or decrease from the baseline to the project scenario, this exclusion is considered to be conservative.

N_2O emissions associated with manure management and disposal are also excluded from the GHG Assessment Boundary. Again, as these emission sources will either remain the same or decrease from the baseline to the project scenario, this exclusion is also considered to be conservative. Significant uncertainty remains regarding the quantification of potential N_2O changes. While some projects may result in a significant decrease in N_2O emissions, at this time there is no project-level methodology available to appropriately account for this uncertainty.

CO_2 emissions associated with the capture and destruction of biogas are considered biogenic emissions[7] (as opposed to anthropogenic) and are not included in the GHG Assessment Boundary.

This protocol does not account for CO_2 emission reductions associated with displacing grid-delivered electricity or fossil fuel use. However, project developers may reduce the project emissions associated with increased use of grid-connected electricity by utilizing project-generated electricity for project equipment.

Figure 4.1 provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the boundary. All SSRs within the dashed line are accounted for under this protocol.

Table 4.1 provides greater detail on each SSR and provides justification for the inclusion or exclusion of SSRs and gases from the GHG Assessment Boundary.

[7] The rationale is that carbon dioxide emitted during combustion represents the carbon dioxide that would have been emitted during natural decomposition of the manure. Emissions from the biogas control system do not yield a net increase in atmospheric carbon dioxide because they are theoretically equivalent to the carbon dioxide absorbed during plant/feed growth.

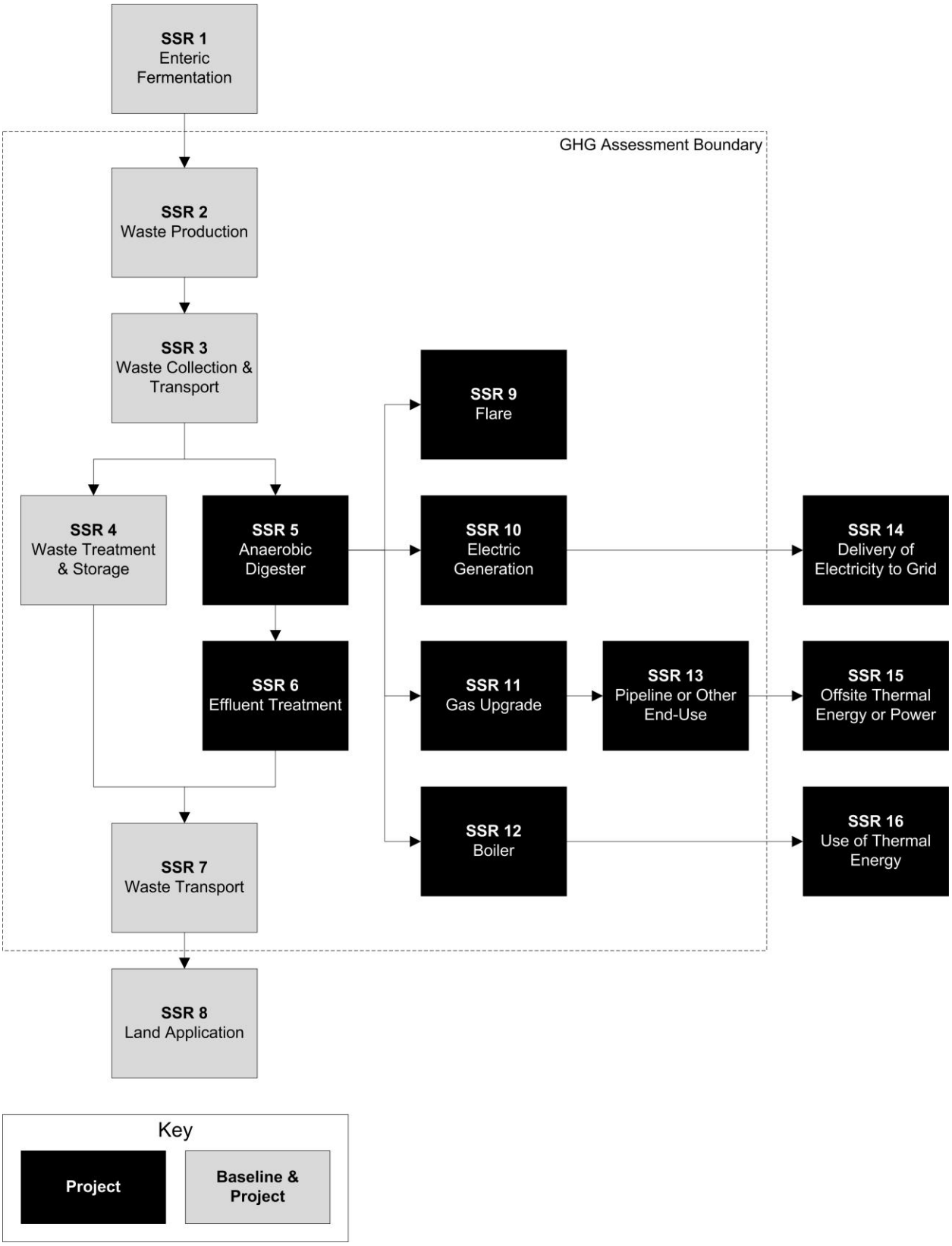


Figure 4.1. General Illustration of the GHG Assessment Boundary

Table 4.1 relates GHG source categories to sources and gases, and indicates inclusion in the calculation methodology. It is intended to be illustrative – GHG sources are indicative for the source category, GHGs in addition to the main GHG are also mentioned, where appropriate.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
1	Emissions from enteric fermentation	CH_4	B, P	*Excluded*	It is very unlikely that a livestock operation would change its feeding strategy to maximize biogas production from a digester; thus impacting enteric fermentation emissions from ruminant animals.
2	Emissions from waste deposits in barn, milking parlor or pasture/corral	N_2O	B, P	*Excluded*	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the project scenario, see page 8 for further explanation.
	Emissions from mobile and stationary support equipment	CO_2	B, P	*Included*	If any additional vehicles or equipment are required by the project beyond what is required in the baseline, emissions from such sources shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
3	Emissions from mechanical systems used to collect and transport waste (e.g. engines and pumps for flush systems; vacuums and tractors for scrape systems)	CO_2	B, P	*Included*	If any additional vehicle or equipment use is required by the project beyond what is required in the baseline, emissions from such sources shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
	Vehicle emissions (e.g. for centralized digesters)	CO_2		*Included*	If any additional vehicles or fuel use is required by the project beyond what is required in the baseline, emissions from such equipment shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
4	Emissions from waste treatment and storage including: anaerobic lagoons, dry lot deposits, compost piles, solid storage piles, manure settling basins, aerobic treatment, storage ponds, etc.	CO_2	B, P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions in the baseline.
		N_2O		*Excluded*	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the project scenario, see page 8 for further explanation.
	Emissions from support equipment	CO_2		*Included*	If any additional equipment is required by the project beyond what is required in the baseline, emissions from such equipment shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
5	Emissions from the anaerobic digester due to biogas collection inefficiencies and venting events	CH_4	P	*Included*	Project may result in leaked emissions from anaerobic digester.
6	Emissions from effluent treatment system	CH_4	P	*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	See page 8.
7	Vehicle emissions for land application and/or off-site transport	CO_2	B, P	*Included*	If any additional vehicle use is required by the project beyond what is required in the baseline, associated additional emissions shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
8	Emissions from land application	CH_4	B, P	*Excluded*	Project activity is unlikely to increase emissions relative to baseline activity.
		N_2O	B, P	*Excluded*	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the project scenario, see page 8 for further explanation

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
9	Emissions from combustion during flaring, including emissions from incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
10	Emissions from combustion during electric generation, including incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
11	Emissions from upgrading biogas for pipeline injection or use as CNG/LNG fuel	CO_2	P	*Included*	Emissions resulting from on-site fossil fuel use and/or grid electricity may be significant.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
12	Emissions from combustion at boiler, including emissions from incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
13	Emissions from combustion of biogas by end user of pipeline or CNG/LNG, including incomplete combustion	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
14	Use of project-generated electricity	CO_2	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas-generated electricity.
		CH_4			
		N_2O			
15	Off-site use of project-generated thermal energy or power	CO_2	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas delivered through pipeline or other end uses.
		CH_4			
		N_2O			
16	Use of project-generated thermal energy	CO_2	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas-generated thermal energy.
		CH_4			
		N_2O			
	Project construction and decommissioning emissions	CO_2	P	*Excluded*	Emission source is assumed to be very small.
		CH_4			
		N_2O			

5 Quantifying GHG Emission Reductions

GHG emission reductions from a livestock project are quantified by comparing actual project emissions to baseline emissions at the project site. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the livestock project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary during the reporting period. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

GHG emission reductions are generally quantified and verified on an annual basis. Project developers may choose to verify GHG emission reductions on a more frequent or less frequent basis if they desire (see Section 7.3). The length of time over which GHG emission reductions are quantified and reported to the Reserve is called the "reporting period." The length of time over which GHG reductions are verified is called a "verification period." Under this protocol, a verification period may cover multiple reporting periods (see Section 7.3.4). Project developers should take note that some equations to calculate baseline and project emissions are run on a month-by-month basis and activity data monitoring takes place at varying levels of frequency. As applicable, monthly emissions data (for baseline and project) are summed together to calculate emission reductions over a given reporting period. Projects whose reporting periods begin or end with incomplete calendar months shall only quantify the baseline and project emissions for the portion of the month that is included within the reporting period.
The calculations provided in this protocol are derived from internationally accepted methodologies.[8] Project developers shall use the calculation methods provided in this protocol to determine baseline and project GHG emissions in order to quantify GHG emission reductions.

To support project developers and facilitate consistent and complete emissions reporting, the Reserve has developed an Excel-based calculation tool. This tool is available to all Reserve account holders and their designated representatives. Instructions for obtaining the most recent version of this tool are available on the U.S. Livestock Project Protocol webpage. The Reserve *recommends* the use of the Livestock Calculation Tool for all project calculations and emission reduction reports. Only the most recent version of this tool should be used, unless otherwise recommended by Reserve staff. In any case where there is potential disagreement between guidance provided in the protocol and guidance provided in the calculation tool, the protocol shall take precedence.

The current methodology for quantifying the GHG impact associated with installing a BCS requires the use of both modeled reductions (following Equation 5.2 to Equation 5.4 and Equation 5.6 to Equation 5.9) as well as the utilization of *ex-post* metered data from the BCS to be used as a check on the modeled reductions.

The Reserve recognizes that there can be material differences between modeled methane emission reductions and the actual metered quantity of methane that is captured and destroyed by the BCS due to digester start-up periods, venting events, and other BCS operational issues.

[8] The Reserve's GHG reduction calculation method is derived from the Kyoto Protocol's Clean Development Mechanism (ACM0010 V.5), the EPA's Climate Leaders Program (Manure Offset Protocol, August 2008), and the RGGI Model Rule (January 5, 2007).

These operational issues have the potential to result in substantially less methane destruction than is modeled, leading to an overestimation of GHG reductions in the modeled case.

To address this issue and maintain consistency with international best practice, the Reserve requires the modeled methane emission reduction results to be compared to the *ex-post* metered quantity of methane that is captured and destroyed by the BCS. The lesser of the two values will represent the total methane emission reductions for the reporting period. Equation 5.1 below outlines the quantification approach for calculating the emission reductions from the installation of a BCS.

5.1 Required Parameters for Modeling Baseline and Project Emissions

The following parameters must be determined for the modeling of baseline and project emissions:

Population – P_L

The procedure requires project developers to differentiate between livestock categories (*L*) (e.g. lactating dairy cows, non-milking dairy cows, heifers, etc.). This accounts for differences in methane generation across livestock categories. See Appendix B, Table B.2 for methane generation values. The population of each livestock category shall be monitored on a monthly basis, and for Equation 5.4 is averaged for an annual total population.

Volatile solids – VS_L

This value represents the daily organic material in the manure for each livestock category and consists of both biodegradable and non-biodegradable fractions. The VS content of manure is a combination of excreted fecal material (the fraction of a livestock category's diet consumed and not digested) and urinary excretions, expressed in a dry matter weight basis (kg/animal).[9] This protocol requires that the VS value for all livestock categories be determined as outlined in Box 5.1.

$Mass_L$

This value is the annual average live weight of the animals, per livestock category. These data are necessary because default VS values are supplied in units of kg/day/1000kg mass, therefore the average mass of the corresponding livestock category is required in order to convert the units of VS into kg/day/animal. Site specific livestock mass is preferred for all livestock categories. If site-specific data are unavailable, Typical Animal Mass (TAM) values may be used (see Appendix B, Table B.2).

Maximum methane production – $B_{0,L}$

This value represents the maximum methane-producing capacity of the manure, differentiated by livestock category (*L*) and diet. Project developers shall use the default B_0 factors from Appendix B, Table B.3. Alternatively, project developers may follow the sampling and testing procedure contained in Section 6.1 in order to determine a site-specific B_0 value for a particular animal category.

[9] IPCC 2006 Guidelines volume 4, chapter 10, p. 10.42.

MS_S

The MS value apportions manure from each livestock category to appropriate manure management system component (*S*), and is a critical factor in determining a project baseline, as well as project emissions from effluent treatment. It reflects the reality that waste from the operation's livestock categories are not managed uniformly. The MS value accounts for the operation's multiple types of manure management systems. It is expressed as a percent (%), relative to the total amount of VS produced by the livestock category. As waste production is normalized for each livestock category, the percentage shall be calculated as percent of population for each livestock category. For example, a dairy operation might send 85% of its milking cows' waste to an anaerobic lagoon and 15% could be deposited in a corral. In this situation, an MS value of 85% would be assigned to Equation 5.3 and 15% to Equation 5.4.

Importantly, the MS value indicates where the waste would have been managed in the baseline scenario. If a portion of the VS was removed from the waste stream through some sort of separation procedure, the MS value shall be adjusted to accurately reflect the baseline treatment of the VS. To account for VS removal from solids separation equipment, project developers may use a default value for the particular type of separation mechanisms employed (Table B.9), or a site-specific value based on the removal efficiency of the baseline system.

MS_{BCS}, which represents the fraction of manure that is sent to the BCS in the project scenario, follows the same logic as above, but is used to accurately quantify the project methane emissions from effluent treatment (see Equation 5.8).

MGS_{BCS}

The MGS_{BCS} value represents the maximum biogas storage capacity of the BCS system. This value is needed only in the case of a venting event during the reporting period, which is quantified using Equation 5.7. If the BCS consists of multiple digester tanks or covered lagoons, the project only need quantify the maximum storage (MGS_{BCS}) and biogas flow (F_{pw}) of the component(s) of the BCS that experienced the venting event.

Methane conversion factor – MCF

This method to calculate methane emissions reflects the site-specific monthly biological performance of the operation's baseline anaerobic manure management systems, as predicted using the van't Hoff-Arrhenius equation and farm-level data on temperature, as well as VS loading and system VS retention time.[10]

Each manure management system component has a volatile solids-to-methane conversion efficiency that represents the degree to which maximum methane production (B_0) is achieved. Methane production is a function of the extent of anaerobic conditions present in the system, the temperature of the system, and the retention time of organic material in the system.[11]

Default MCF values for non-anaerobic baseline manure management system components (as well as certain project BCS effluent treatment and Non-BCS sources) are available in Appendix B. These are used in Equation 5.4 and Equation 5.9.

Contrastingly, site-specific calculations of volatile solids-to-methane conversion efficiency are required for anaerobic baseline manure management system components and for the anaerobic

[10] The method is derived from Mangino et al., "Development of a Methane Conversion Factor to Estimate Emissions from Animal Waste Lagoons" (2001).
[11] IPCC 2006 Guidelines volume 4, chapter 10, p. 10.43.

treatment of project BCS effluent. For anaerobic lagoons, storage ponds, liquid slurry tanks etc., project developers perform a site-specific calculation of the mass of volatile solids degraded by the anaerobic storage/treatment system. This is expressed as "degraded volatile solids" or VS_{deg} in Equation 5.3, which equals the system's monthly available volatile solids multiplied by '*f*', the van't Hoff-Arrhenius factor. The '*f*' factor effectively converts total available volatile solids in the anaerobic manure storage/treatment system to methane-convertible volatile solids, based on the monthly temperature of the system. The multiplication of VS_{deg} by B_0 quantifies the maximum potential methane emissions that would have been produced for each livestock category's contribution of manure to that system.

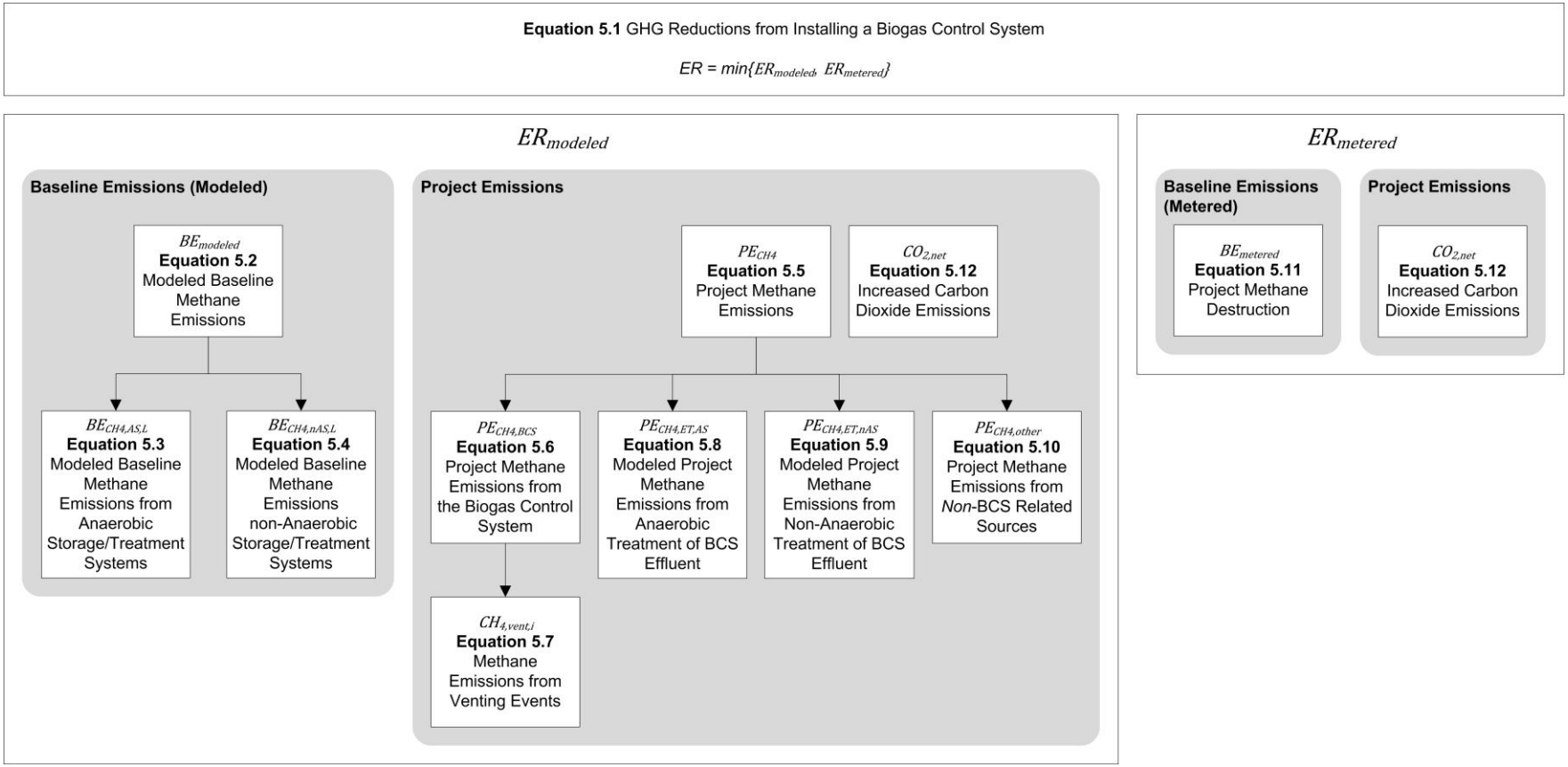


Figure 5.1. Organization of Equations in Section 5

Equation 5.1. GHG Reductions from Installing a Biogas Control System

$$ER = \min\{ER_{modeled}, ER_{metered}\}$$

$$ER_{modeled} = BE_{modeled} - PE_{CH_4} - CO_{2,net}$$

Where,			Units
$ER_{modeled}$	=	Avoided methane emissions associated with the project during the reporting period, quantified using a modeled baseline scenario	tCO_2e
$BE_{modeled}$	=	Modeled baseline emissions from the baseline scenario (Equation 5.2)	tCO_2e
PE_{CH4}	=	Total project methane emissions during the reporting period (Equation 5.5)	tCO_2e
$CO_{2,net}$	=	Net increase in anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources resulting from project activity (Equation 5.12)	tCO_2e

$$ER_{metered} = BE_{metered} - CO_{2,net}$$

Where,			Units
$ER_{metered}$	=	Avoided methane emissions associated with the project during the reporting period, quantified using metered methane destruction data	tCO_2e
$BE_{metered}$	=	Aggregated quantity of methane collected and destroyed during the reporting period (Equation 5.11)	tCO_2e
$CO_{2,net}$	=	Net increase in anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources resulting from project activity (Equation 5.12)	tCO_2e

5.2 Modeling Baseline Methane Emissions

Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that would have occurred if not for the installation of the BCS. For the purposes of this protocol, project developers calculate their baseline emissions according to the manure management system in place prior to installing the BCS. Baseline emissions are then recalculated for each reporting period to reflect what the emissions would have been had the previous management system continued to function under current conditions. For Greenfield projects, as defined in Section 3.4.2, the baseline manure management practices shall be modeled according to the default values provided in Table B.10.

The procedure to determine the modeled baseline methane emissions follows Equation 5.2, which combines Equation 5.3 and Equation 5.4. The calculation procedures use a combination of site-specific values and default factors.

Box 5.1. Daily Volatile Solids for All Livestock Categories

Consistent with international best-practice, it is recommended that appropriate VS_L values for dairy livestock categories be obtained from the state-specific lookup tables (Tables B.5.a – B.5.f) provided in Appendix B. When possible, use the year corresponding to the appropriate emission year. If the current year's table is not included in the protocol, use the most current year that is available from the Reserve. Updated tables will be provided in the Livestock Calculation Tool, as well as the Reserve website.[12]

VS_L values for all other livestock can be found in Appendix B, Table B.3.

Important – Units provided for all VS values in Appendix B are in (kg/day/1000kg), In order to get VS_L in the appropriate units (kg/animal/day), the following equation must be used:

$$\boldsymbol{VS_L = VS_{Table} \times \frac{Mass_L}{1000}}$$

Where,

			Units
VS_L	=	Volatile solid excretion on a dry matter weight basis	kg/animal/day
VS_{Table}	=	Volatile solid excretion from lookup table (Table B.3 and Table B.5a - B.5d)	kg/day/1000kg
$Mass_L$	=	Average live weight for livestock category *L*. If site specific data are unavailable, use values from Appendix B, Table B.2 corresponding to the appropriate emission year (or the most current year that is available from the Reserve)	kg

Equation 5.2. Modeled Baseline Methane Emissions

$$\boldsymbol{BE_{modeled} = \sum_{S,L} \left(BE_{CH_4,AS,L} + BE_{CH_4,nAS,L}\right)}$$

Where,

			Units
$BE_{modeled}$	=	Total baseline methane emissions during the reporting period, summed for each baseline treatment system *S* and livestock category *L*	tCO_2e
$BE_{CH4,AS,L}$	=	Total monthly baseline methane emissions from anaerobic storage/treatment system *AS* by livestock category *L*, aggregated for the reporting period. See Equation 5.3	tCO_2e
$BE_{CH4,nAS,L}$	=	Total baseline methane emissions for the reporting period from non-anaerobic storage/treatment systems by livestock category *L.* See Equation 5.4	tCO_2e

[12] http://www.climateactionreserve.org/how/protocols/us-livestock/

Equation 5.3. Modeled Baseline Methane Emissions from Anaerobic Storage/Treatment Systems

$$BE_{CH_4,AS,L} = \left(VS_{deg,AS,L} \times B_{0,L} \times days_{mo} \times 0.68 \times 0.001 \times 21\right) \times \left(\frac{rd_{mo}}{days_{mo}}\right)$$

Where,			Units
$BE_{CH4,AS,L}$	=	Total monthly baseline methane emissions from anaerobic manure storage/treatment system *AS* from livestock category *L*	tCO_2e/yr
$VS_{deg,AS,L}$	=	Monthly volatile solids degraded in anaerobic manure storage/treatment system *AS* from livestock category *L*	kg dry matter
$B_{0,L}$	=	Maximum methane producing capacity of manure for livestock category *L* – see Appendix B, Table B.3 for default values or Section 6.1 for guidance on determining a site-specific value	m^3 CH_4/kg of VS
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion factor from kg to metric tons	
21	=	Global Warming Potential of methane as carbon dioxide equivalent	tCO_2e/tCH_4
$days_{mo}$	=	Calendar days per month	days
rd_{mo}	=	Reporting days during the current month (see Box 5.2)	days

$$VS_{deg,AS,L} = \sum_{AS,L} \left(VS_{avail,AS,L} \times f\right)$$

Where,			Units
$VS_{deg,AS,L}$	=	Monthly volatile solids degraded by anaerobic manure storage/ treatment system *AS* by livestock category *L*	kg dry matter
$VS_{avail,AS,L}$	=	Monthly volatile solids available for degradation from anaerobic manure storage/treatment system *AS* by livestock category *L*	kg dry matter
f	=	The van't Hoff-Arrhenius factor = "the proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system" [13]	

Equation 5.3 continued on next page.

[13] Mangino, et al.

Equation 5.3. Continued

$$VS_{avail,AS,L} = \left(VS_L \times P_L \times MS_{AS,L} \times days_{mo} \times 0.8\right) + \left(VS_{avail-1,AS} - VS_{deg-1,AS}\right)$$

Where,			Units
$VS_{avail,AS,L}$	=	Monthly volatile solids available for degradation in anaerobic storage/treatment system *AS* by livestock category *L*	kg dry matter
VS_L	=	Volatile solids produced by livestock category *L* on a dry matter basis. Refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/day
P_L	=	Average population of livestock category *L* (based on population data for the current month)	
$MS_{AS,L}$	=	Percent of manure sent to (managed in) anaerobic manure storage/treatment system *AS* from livestock category *L* [14]	%
$days_{mo}$	=	Calendar days per month	days
0.8	=	Management and design practices factor[15]	
$VS_{avail-1,AS}$	=	Previous month's volatile solids available for degradation in anaerobic system *AS*[16]	kg
$VS_{deg-1,AS}$	=	Previous month's volatile solids degraded by anaerobic system *AS*	kg

$$f = exp\left[\frac{E\left(T_{mo} - T_{ref}\right)}{(R)\left(T_{ref}\right)(T_{mo})}\right]$$

Where,			Units
f	=	The van't Hoff-Arrhenius factor	
E	=	Activation energy constant (15,175)	cal/mol
T_{mo}	=	Monthly average ambient temperature (K = °C + 273). If T_{mo} < 5°C then *f* = 0.104. If T_{mo} > 29.5°C then *f* = 0.95	Kelvin
T_{ref}	=	303.16; Reference temperature for calculation	Kelvin
R	=	Ideal gas constant (1.987)	cal/Kmol

[14] The MS value represents the percent of manure that would be sent to (managed by) the anaerobic manure storage/treatment systems in the baseline case – as if the biogas control system was never installed.

[15] Mangino, et al. This factor was derived to "account for management and design practices that result in the loss of volatile solids from the management system." This reflects the difference between the theoretical modeled biological activity and empirical measurement of biological activity due to removal of liquid or other management practices that result in loss of VS from the treatment system. This does not account for removal of solids prior to the treatment system.

[16] IPCC 2006 Guidelines (Volume 4, Chapter 10, p. 42); ACM0010 (V2, p.8); and EPA Climate Leaders Manure Offset Protocol (August 2008).

Box 5.2. Calculating the Number of Reporting Days for a Reporting Period

For some projects, it may be necessary to exclude a number of days from the calculation of emission reductions. If the reporting period begins or ends mid-way through a month, the calculation shall be prorated to only include the number of days for each month that fall within the reporting period by setting *nrd* equal to the number of days that fall outside the reporting period. If the project is not eligible to report emission reductions for a certain period of time for other reasons (e.g. regulatory compliance issues, missing data), those days may also be included in the determination of *nrd*.

For example, if a reporting period begins on March 10, then nrd_{March} = 9. If the same reporting period ends on December 31st of the same year, then nrd_{rp} = 9, and *rd* = (306 – 9) = 297.

The following equation is used to determine the number of reporting days for the current period. This is to be applied for individual months for those equations that are run monthly, and for the entire reporting period for those equations that are run once per reporting period.

$$\boldsymbol{rd = days - nrd}$$

Where,

rd	=	Number of reporting days in the current period (month, reporting period, etc.)
days	=	Number of calendar days in the current period (e.g. equal to 30 for June)
nrd	=	Non-reporting days in the current period

Retention of Volatile Solids

Equation 5.3 calculates methane emissions from anaerobic manure storage/treatment systems based on site-specific information on the mass of volatile solids degraded by the anaerobic storage/treatment system and available for methane conversion.[17] It incorporates the effects of temperature through the van't Hoff-Arrhenius (*f*) factor and accounts for the retention of volatile solids through the use of monthly assumptions of baseline conditions. Each month, a certain quantity of VS is converted into methane (VS_{deg}). The VS that is available for conversion each month (VS_{avail}) is the sum of VS that enters the manure management system, as well as VS that remains in the system from the previous month ($VS_{avail-1} – VS_{deg-1}$).

Project developers shall not carry over volatile solids from one month to the next when modeling baseline anaerobic treatment systems where the retention time was 30 days or less. For these systems ($VS_{avail-1} – VS_{deg-1}$) = 0 in Equation 5.3 for every month.

Depending on the accumulation of sludge in the baseline manure storage system, it may have been necessary to drain and clean the system on a periodic basis. This cleaning removes the non-degraded VS that has accumulated in the system. For anaerobic lagoons with a retention time greater than 30 days, project developers shall zero out the VS retained in the system following the month when the system would have been completely drained and sludge removed under baseline operating conditions. For the month following the sludge removal, ($VS_{avail-1} – VS_{deg-1}$) = 0 in Equation 5.3. For projects where a BCS is being retrofit into existing operations, baseline anaerobic system management practices should reflect actual pre-project manure management practices on that farm.

[17] These system components must meet the Anaerobic Baseline requirement in Section 3.4.

If the farm utilized solids separation in the baseline (thus preventing or delaying sludge accumulation), this removal and alternative treatment of VS should be reflected in the MS values, as explained earlier in this section.

The removal of supernatant liquids for spraying on fields at agronomic rates does not affect the monthly carryover of VS, as long as the system maintains at least one meter of liquid depth. Projects therefore do not need to account for regular field spraying activities that meet this description.

Equation 5.4 applies to non-anaerobic storage/treatment systems. Both Equation 5.3 and Equation 5.4 reflect basic biological principles of methane production from available volatile solids, determine methane generation for each livestock category, and account for the extent to which the waste management system handles each category's manure.

Equation 5.4. Modeled Baseline Methane for Non-Anaerobic Storage/Treatment Systems

$$BE_{CH_4,nAS,L} = \left(P_L \times MS_{L,nAS} \times VS_L \times days_{rp} \times MCF_{nAS} \times B_{0,L}\right) \times 0.68 \times 0.001 \times 21 \times \left(\frac{rd_{rp}}{days_{rp}}\right)$$

Where,			Units
$BE_{CH4,nAS,L}$	=	Total baseline methane emissions during the reporting period from non-anaerobic storage/treatment systems	tCO_2e
P_L	=	Average population of livestock category *L* during the reporting period (based on monthly population data)	
$MS_{L,nAS}$	=	Percent of manure from livestock category *L* managed in non-anaerobic storage/treatment systems	%
VS_L	=	Volatile solids produced by livestock category *L* on a dry matter basis. Refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/day
$days_{rp}$	=	Number of days in the reporting period	days
MCF_{nAS}	=	Methane conversion factor for non-anaerobic storage/treatment system. See Appendix B	%
$B_{0,L}$	=	Maximum methane producing capacity for manure for livestock category *L*. See Appendix B, Table B.3 for default values, or Section 6.1 for determining a site-specific value	m^3 CH_4/kg of VS dry matter
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion factor from kg to metric tons	
21	=	Global Warming Potential of methane as carbon dioxide equivalent	tCO_2e/tCH_4
rd_{rp}	=	Reporting days during the reporting period	days

5.3 Calculating Project Methane Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary after the installation of the BCS. Project emissions are calculated on an annual, *ex-post* basis. Like baseline emissions, some parameters are monitored on a monthly basis. Unlike baseline emission calculations, methane emissions from the BCS are calculated from metered data, rather than modeled projections. Methane emissions from manure storage and/or treatment systems other than the BCS are modeled much the same as in the baseline scenario.

As shown in Equation 5.5, project methane emissions equal:

- The amount of methane created by the BCS that is not captured and destroyed by the control system, plus
- Methane from the digester effluent treatment systems (where applicable), plus
- Methane from sources in the waste treatment and storage category other than the BCS and associated effluent treatment systems. This includes all other manure treatment systems such as compost piles, solids storage etc.

Consistent with this protocol's baseline methane calculation approach, the formula to account for project methane emissions incorporates all potential sources within the waste treatment and storage category. Non-BCS-related sources follow the same calculation approach as provided in the baseline methane equations. Several activity data for the variables in Equation 5.9 will be the same as those in Equation 5.2 to Equation 5.4.

If the project elects to install an impermeable cover on an effluent pond (potentially creating an additional anaerobic digester) and the biogas generated in this covered pond is collected and destroyed by the project BCS, then this covered pond shall be considered part of the project digester system. If the biogas generated by this covered pond is not destroyed, it must be quantified as project methane emissions using Equation 5.8.

Although not common under normal digester operation, it is possible that a venting event may occur due to catastrophic failure of digester cover materials, the digester vessel, or the gas collection system. In the event that a catastrophic system failure results in the venting of biogas, the quantity of methane released to the atmosphere shall be estimated according to Equation 5.7 below.

Equation 5.5. Project Methane Emissions

$$\boldsymbol{PE_{CH_4} = \left(PE_{CH_4,BCS} + PE_{CH_4,ET,AS} + PE_{CH_4,ET,nAS} + PE_{CH_4,other}\right) \times 21}$$

Where,			Units
PE_{CH4}	=	Total project methane emissions for the reporting period,	tCO_2e
$PE_{CH4,BCS}$	=	Methane emissions from the BCS during the reporting period (Equation 5.6)	tCH_4
$PE_{CH4,ET,AS}$	=	Monthly methane emissions from the BCS effluent anaerobic treatment systems, aggregated for the reporting period (Equation 5.8)	tCH_4
$PE_{CH4,ET,nAS}$	=	Methane emissions from the BCS effluent non-anaerobic treatment systems during the reporting period (Equation 5.9)	tCH_4
$PE_{CH4,other}$	=	Methane emissions from sources in the waste treatment and storage category other than the BCS and associated effluent treatment systems, during the reporting period (Equation 5.10)	tCH_4
21	=	Global warming potential of methane as carbon dioxide equivalent	tCO_2e/tCH_4

Equation 5.6. Project Methane Emissions from the Biogas Control System

$$PE_{CH_4,BCS} = \sum_i \left[\left[CH_{4,metered,i} \times \left(\left(\frac{1}{BCE} \right) - BDE_{i,weighted} \right) \right] + CH_{4,vent,i} \right]$$

Where,

			Units
$PE_{CH4,BCS}$	=	Methane emissions from the BCS, to be summed for each reporting period	tCH_4
$CH_{4,metered,i}$	=	Quantity of methane collected and metered in month *i*	tCH_4
BCE	=	Methane collection efficiency of the BCS. Project developers shall use the appropriate default value provided in Table B.4	fraction
$BDE_{i,weighted}$	=	Weighted average of all destruction devices used in month i	fraction
$CH_{4,vent,i}$	=	Quantity of methane that is vented to the atmosphere due to BCS venting events in month *i*, as quantified in Equation 5.7 below	tCH_4

$$CH_{4,metered,i} = F \times \frac{520}{T_b} \times \frac{P}{1} \times CH_{4,conc} \times 0.0423 \times 0.000454$$

Where,

			Units
$CH_{4,metered,i}$	=	Wuantity of methane collected and metered in month *i*[18]	tCH_4
F	=	Measured volumetric flow of biogas in month *i*	scf
T_b	=	Temperature of the biogas flow (°R = °F + 459.67)	°R
P	=	Pressure of the biogas flow	atm
$CH_{4,conc}$	=	Measured methane concentration of biogas for month *i*	fraction
0.0423	=	Density of methane gas (1 atm, 60°F)	lb CH_4/scf
0.000454	=	Conversion factor from lb to metric ton	

** The terms ($520/T_b$) and ($P/1$) should be omitted if the continuous flow meter internally corrects for temperature and pressure to 60°F and 1 atm.*

$$BDE_{i,weighted} = \frac{\sum_{DD}(BDE_{DD} \times F_{i,DD})}{F_i}$$

Where,

			Units
$BDE_{i,weighted}$	=	Monthly weighted average of all destruction devices used in month *i*	fraction
BDE_{DD}	=	Default methane destruction efficiency of a particular destruction device 'DD'. See Appendix B for default destruction efficiencies[19]	fraction
$F_{i,DD}$	=	Monthly flow of biogas to a particular destruction device 'DD'	scf/month
F_i	=	Total monthly measured volumetric flow of biogas to all destruction devices	scf/month

[18] This value reflects directly measured biogas mass flow and methane concentration in the biogas to the combustion device.

[19] Project developers have the option to use either the default methane destruction efficiencies provided, or site specific methane destruction efficiencies, for each of the combustion devices used in the project. Site-specific values must be provided by an independent air emissions testing body that is accredited by a state or local agency, or the Stack Testing Accreditation Council (STAC). See Appendix B for more information. Where a state/region does not have an appropriate accreditation system or accredited service providers, the project developer may look to another state/region to find suitably qualified service providers.

Equation 5.7. Methane Emissions from Venting Events

$$CH_{4,vent,i} = \left(MGS_{BCS} + \left(F_{pw} \times t\right)\right) \times CH_{4,conc} \times 0.0423 \times 0.000454$$

Where,			Units
$CH_{4,vent,i}$	=	Quantity of methane that is vented to the atmosphere due to BCS venting events in month *i*	tCH_4
MGS_{BCS}	=	Maximum biogas storage of the BCS system[20]	scf
F_{pw}	=	Average total daily flow of biogas from the digester for the entire week prior to the venting event[20]	scf/day
t	=	Number of days of the month that biogas is venting uncontrolled from the BCS system (can be a fraction)	days
$CH_{4,conc}$	=	Measured methane concentration of biogas prior to the venting event	fraction
0.0423	=	Density of methane gas (1 atm, 60°F)	lb CH_4/scf
0.000454	=	Conversion factor from lb to metric ton	

Equation 5.8, along with Equation 5.9, shall be used to account for all treatment systems associated with the BCS effluent. The factor ETF_i shall be estimated by the project developer to determine what fraction of the VS in the effluent is sent to each treatment system, and is represented as a fraction (e.g. if 85% of the BCS effluent is sent to an effluent pond, then ETF_i for that system is equal to 0.85). Anaerobic effluent treatment systems are those which store liquid effluent in a lagoon, pond, or tank. This includes liquid storage systems that employ non-airtight covers (i.e. biogas is freely vented to the atmosphere) as long as the entire system is managed as a passive storage system, rather than an actively-managed treatment system (i.e. no heating, mixing, etc.).

Equation 5.8. Modeled Project Methane Emissions from Anaerobic Treatment of BCS Effluent

$$PE_{CH_4,ET,AS} = \sum_i \left(VS_{ET,i} \times B_{0,ET} \times days_{mo} \times 0.8 \times f \times 0.68 \times 0.001\right) \times \frac{rd_{mo}}{days_{mo}}$$

Where,			Units
$PE_{CH4,ET,AS}$	=	Monthly methane emissions from anaerobic effluent treatment systems	tCH_4
$VS_{ET,i}$	=	Volatile solids to anaerobic effluent treatment system *i* (see below)	kg/day
$B_{0,ET}$	=	Maximum methane producing capacity (of VS dry matter)[21]	m^3CH_4/kg VS
$days_{mo}$	=	Calendar days in the current month	days
0.8	=	Management and design practices factor[15]	fraction
f	=	The van't Hoff-Arrhenius factor, as calculated in Equation 5.3	
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion from kg to metric tons	t/kg
rd_{mo}	=	Reporting days in the current month	days

Equation 5.8 continued on next page

[20] If the BCS consists of multiple digester tanks or covered lagoons, the project only need quantify the maximum storage (MGS_{BCS}) and biogas flow (F_{pw}) of the component(s) of the BCS that experienced the venting event.

[21] The B_0 value for the project effluent pond is not differentiated by livestock category. Project developers shall use the B_0 value that corresponds with a weighted average of the operation's livestock categories that contribute manure to the BCS (weighted by the kg of VS contributed by each livestock category). Supporting laboratory data and documentation per Section 6.1 needs to be supplied to the verifier to justify an alternative value.

Equation 5.8. Continued

$$VS_{ET,i} = \left[\left(\sum_{L}\left(VS_L \times P_L \times MS_{L,BCS}\right)\right) \times 0.3\right] \times ETF_i$$

Where,			Units
$VS_{ET,i}$	=	Volatile solids to anaerobic effluent treatment system *i*	kg/day
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis. *Important* – refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/ day
P_L	=	Average population of livestock category *L* during the reporting period (based on monthly population data)	
$MS_{L,BCS}$	=	Fraction of manure from livestock category *L* that is managed in the BCS	fraction
0.3	=	Default value representing the amount of VS that exits the digester as a fraction of the VS entering the digester[22]	fraction
ETF_i	=	Fraction of the effluent that exits the digester and is sent to effluent treatment system *i*	fraction

If the effluent from the project digester is directed to a covered liquid effluent storage system, and the biogas from this storage system is not collected and destroyed, then the following scenarios apply:

1. If the effluent from this system is applied directly to land and biogas flow and methane concentration are monitored in accordance with Section 6, then $PE_{CH4,ET,AS}$ for this system shall be determined using Equation 5.6, assuming a BCE value of 0.95 and a BDE value of 0.

   For any periods where biogas flow and/or methane concentration data from this system are missing (and not replaceable through data substitution) or not in conformance with Section 6, Equation 5.8 shall be used to determine the quantity of project methane emissions from this system component.

2. If the effluent from the covered liquid effluent storage system is directed to another treatment system (i.e. not land-applied), then an additional calculation is required. The methane released from the covered liquid effluent system shall be quantified using the guidance in Scenario 1 above, but the additional methane released by the further treatment system must also be quantified. Equation 5.9 shall be used to calculate the methane released from the additional treatment system using the default assumptions that 30% of the $VS_{ET,i}$ from the effluent storage system enters the additional treatment system.

[22] Per ACM0010 (V2 Annex I).

Equation 5.9. Modeled Project Methane Emissions from Non-Anaerobic Treatment of BCS Effluent[23]

$$PE_{CH_4,ET,nAS} = \sum_i \left(VS_{ET,i} \times B_{0,ET} \times rd_{rp} \times 0.68 \times MCF_{ET,i} \times 0.001\right)$$

Where,			Units
$PE_{CH4,ET,nAS}$	=	Project methane emissions from non-anaerobic effluent treatment systems during the reporting period	tCH_4
$VS_{ET,i}$	=	Volatile solids to non-anaerobic effluent treatment system *i* (see Equation 5.8)	kg/day
$B_{0,ET}$	=	Maximum methane producing capacity (of VS dry matter)[24]	m^3CH_4/kg
rd_{rp}	=	Number of reporting days in the current reporting period	days
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
$MCF_{ET,i}$	=	Methane conversion factor for effluent treatment system *i* (Table B.6)	fraction
0.001	=	Conversion factor from kg to metric tons	

Equation 5.10. Project Methane Emissions from *Non*-BCS Related Sources[25]

$$PE_{CH_4,other} = \sum_L \left(P_L \times VS_L \times B_{0,L} \times MCF_{non-BCS} \times rd_{rp} \times 0.68 \times 0.001\right)$$

Where,			Units
$PE_{CH4,other}$	=	Methane from sources in the waste treatment and storage category other than the BCS and associated effluent treatment systems during the reporting period	tCH_4
P_L	=	Average population of livestock category *L* during the reporting period	
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis. Refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/ animal/ day
$B_{0,L}$	=	Maximum methane producing capacity of VS dry matter for manure for livestock category *L*, (Appendix B, Table B.3)	m^3 CH_4/kg
$MCF_{non-BCS}$	=	Management-weighted methane conversion factor for waste treatment and storage systems other than the BCS and associated effluent treatment systems	fraction
rd_{rp}	=	Number of reporting days in the current reporting period	days
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion factor from kg to metric tons	

$$MCF_{non-BCS} = \sum_S \left(MCF_S \times MS_{L,S}\right)$$

Where,			Units
$MCF_{non-BCS}$	=	Management-weighted methane conversion factor for waste treatment and storage systems other than the BCS and associated effluent treatment systems	fraction
MCF_S	=	Methane conversion factor for system component *S* (Table B.9)	fraction
$MS_{L,S}$	=	Fraction of manure from livestock category *L* that is managed in non-BCS system component *S*	fraction

[23] Non-anaerobic effluent treatment systems are those which manage effluent in solid form, or those which manage liquid effluent in a way that would be considered aerobic (e.g. a pond with effective aeration equipment).

[24] The B_o value for the project effluent pond is not differentiated by livestock category. Project developers shall use the B_o value that corresponds with a weighted average of the operation's livestock categories that contribute manure to the BCS (weighted by the kg of VS contributed by each livestock category). Supporting laboratory data and documentation per Section 6.1, need to be supplied to the verifier to justify an alternative value.

[25] According to this protocol, non-BCS-related sources means manure management system components (system component 'S') other than the biogas control system and the BCS effluent treatment systems (if used).

5.4 Metered Methane Destruction Comparison

As described above, the Reserve requires all projects to compare the modeled methane emission reductions for the reporting period, as calculated in Equation 5.2 to Equation 5.4 and Equation 5.6 to Equation 5.9, with the actual metered amount of methane that is destroyed in the BCS over the same period. The lesser of the two values is to be used as the total methane emission reductions for the reporting period in question.

In order to calculate the metered methane reductions, the monthly quantity of biogas that is metered and destroyed by the BCS must be aggregated over the reporting period. In the event that a project developer is reporting reductions for a period of time that is less than a full year, the total modeled methane emission reductions would be aggregated over this time period and compared with the metered methane that is destroyed in the BCS over the same period of time. Similarly, projects whose reporting periods begin or end with incomplete calendar months shall only quantify the baseline and project emissions for the portion of the month that is included within the reporting period. For example, if a project is reporting and verifying only 6 months of data (e.g. July to December), then the modeled emission reductions over this 6 month period would be compared to the total metered biogas destroyed over the same six month period, and the lesser of the two values would be used as the total methane emission reduction quantity for this six month period. See Equation 5.1 for calculation guidance.

Equation 5.11 below details the metered methane destruction calculation.

Equation 5.11. Metered Methane Destruction

$$BE_{metered} = \sum_{i} \left(CH_{4,metered,i} \times BDE_{i,weighted} \right) \times 21$$

Where,			Units
$BE_{metered}$	=	Aggregated quantity of methane collected and destroyed during the reporting period	tCO_2e
$CH_{4,metered,i}$	=	Quantity of methane collected and metered in month $_i$. See Equation 5.6 for calculation guidance	tCH_4/month
$BDE_{i,weighted}$	=	Weighted average of all destruction devices used in month *i*.[26] See Equation 5.6 for calculation guidance	fraction
21	=	Global warming potential of methane as carbon dioxide equivalent	tCO_2e/tCH_4

5.5 Calculating Baseline and Project Carbon Dioxide Emissions

Sources of carbon dioxide emissions associated with a project may include electricity use by pumps and equipment, fossil fuel generators used to power pumping systems or milking parlor equipment, tractors that operate in barns or free-stalls, on-site manure hauling trucks, or vehicles that transport manure off-site. Per Table 4.1, the carbon dioxide emissions from any additional equipment, vehicles, or fuel use that is required by the project beyond what is required in the baseline shall be accounted for. In practice, project developers shall account for the emissions from any new electric- or fuel-powered equipment or vehicles purchased and

[26] Project developers have the option to use either the default methane destruction efficiencies provided, or site specific methane destruction efficiencies, for each of the combustion devices used in the project. Site-specific values must be provided by an independent air emissions testing body that is accredited by a state or local agency, or the Stack Testing Accreditation Council (STAC). See Appendix B for more information.

installed/operated specifically for the purpose of implementing the project, as well as any additional fuel used by old or new vehicles to collect or transport waste.

Project developers may either use Equation 5.12 below to calculate the net increase in carbon dioxide emissions, or, if they can demonstrate during verification that project carbon dioxide emissions are estimated to be equal to or less than 5% of the total baseline emissions, then the project developer may estimate baseline and project carbon dioxide emissions. If an estimation method is used, verifiers shall confirm based on professional judgment that project carbon dioxide emissions are equal to or less than 5% of the total baseline emissions based on documentation and the estimation methodology provided by the project developer. If emissions cannot be confirmed to be below 5%, then Equation 5.12 shall be used. Regardless of the method used, all estimates or calculations of anthropogenic carbon dioxide emissions within the GHG Assessment Boundary must be verified and included in emission reduction calculations.[27]

If calculations or estimates indicate that the project results in a net decrease in carbon dioxide emissions from grid-delivered electricity, mobile and stationary sources, then for quantification purposes the net increase in these emissions must be specified as zero (i.e. $CO_{2,net} = 0$ in Equation 5.12).

Carbon dioxide emissions from the combustion of biogas are considered biogenic emissions and are excluded from the GHG Assessment Boundary.

Equation 5.12 below calculates the net increase in anthropogenic carbon dioxide emissions resulting from the project activity.

[27] This is consistent with guidance in WRI's GHG Project Protocol regarding the treatment of significant secondary effects.

Equation 5.12. Increased Carbon Dioxide Emissions

$$CO_{2,net} = BE_{CO_2,MSC} - PE_{CO_2,MSC}$$

Where,			Units
$CO_{2,net}$	=	Net increase in anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources resulting from project activity during the reporting period. If result is <0, use a value of 0	tCO_2
$BE_{CO2,MSC}$	=	Total baseline CO_2 emissions from electricity consumption and mobile and stationary combustion sources during the reporting period (see equation below)	tCO_2
$PE_{CO2,MSC}$	=	Total project CO_2 emissions from electricity consumption and mobile and stationary combustion sources during the reporting period (see equation below)	tCO_2

All CO_2 emissions associated with electricity consumption and stationary and mobile combustion are calculated using the equation:

$$CO_{2,MSC} = \left(\sum_c QE_c \times EF_{CO_2,e}\right) + \left[\left(\sum_c QF_c \times EF_{CO_2,f}\right) \times 0.001\right]$$

Where,			Units
$CO_{2,MSC}$	=	Anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources	tCO_2
QE_c	=	Quantity of grid-connected electricity consumed for each emissions source 'c'[28] during the reporting period	MWh
$EF_{CO2,e}$	=	CO_2 emission factor for electricity used[29]	tCO_2/MWh
QF_c	=	Quantity of fuel consumed for each mobile and stationary emission source 'c' during the reporting period	MMBtu or gallons
$EF_{CO2,f}$	=	Fuel-specific emission factor *f* from Appendix B	kg CO_2/MMBtu or kg CO_2/gallon
0.001	=	Conversion factor from kg to metric tons	

[28] Emissions from electricity generated by the BCS and consumed onsite, do not need to be reported, as the resulting CO_2 emissions are considered biogenic, CH_4 is captured by the BDE calculation and N_2O emissions are excluded as negligible.

[29] Refer to the version of the U.S. EPA eGRID most closely corresponding to the time period during which the electricity was used. Projects shall use the annual total output emission rates for the subregion where the project is located, not the annual non-baseload output emission rates. The eGRID tables are available from the U.S. EPA website: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of instrument field check and calibration activities; and the role of individuals performing each specific monitoring activity, as well as QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision. The Monitoring Plan shall also contain a detailed diagram of the BCS, including the placement of all meters and equipment that affect SSRs within the GHG Assessment Boundary (see Figure 4.1 and Appendix F).

For a project's second crediting period, the Monitoring Plan must also include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.5.2).

Project developers are responsible for monitoring the performance of the project and operating each component of the biogas collection and destruction system in a manner consistent with the manufacturer's recommendations.

6.1 Site-Specific Determination of Maximum Methane Potential (B_0)[30]

The determination of a site-specific value for maximum methane potential (B_0) is optional for manure from dairy facilities. Swine facilities must use the default values. For projects that choose this option for the quantification of emission reductions related to one or more manure streams being digested in the project's BCS, or the BCS effluent, the following criteria must be met in order to ensure accuracy and consistency of the site-specific B_0 values:

1. Manure samples for each eligible livestock category must be sampled prior to mixing with manure from other animal categories or any other waste streams. These samples shall be taken from the manure collection system, rather than from an individual animal.
    a. Scrape systems: Samples shall be collected from the freshly scraped manure.
    b. Flush systems: Samples shall be collected at the point that the flushed manure leaves the barn. Additional samples must be collected of the flush water prior to mixing with manure.
    c. BCS effluent: Samples shall be collected after the effluent has exited the digester and prior to any further treatment.

2. Sampling events shall occur during the time period between August and October, inclusive.
    a. Manure samples: For each eligible animal category, there shall be one single-day sampling event. A total of at least six samples of at least one half liter each must

[30] Background information on the development of this section can be found in Appendix E.

be taken during the event. Samples shall be taken one to three hours apart, and all samples of the same type shall be combined (i.e. dairy cow manure samples in one container). The composite sample shall be delivered to the testing laboratory as soon as possible following the collection of the final sample.[31]

b. Flush water samples: If the farm utilizes a flush system for manure collection, the flush water must be sampled prior to mixing with manure. Two samples of at least one liter shall be collected, one to three hours apart, during the manure sampling event. These samples shall be combined into one container and delivered to the testing laboratory as soon as possible.
c. Effluent samples: Two samples of at least one liter shall be collected, one to three hours apart, during the manure sampling event. These samples shall be combined into one container and delivered to the testing laboratory as soon as possible.[32]

3. All samples must be analyzed using a Biochemical Methane Potential (BMP) Assay procedure at an independent, third-party laboratory that is familiar and experienced with this test and ISO 11734.[33] The laboratory must be able to document at least three years of experience with the BMP assay, and must have procedures in place to maintain a consistent inoculum. The laboratory must maintain and follow a standard operating procedure that outlines the process used in undertaking BMP analysis at that laboratory, and which can be made available to the verifier upon request.

4. At least six test runs shall be conducted using material from the mixed manure sample (i.e. split the sample into two and test each in triplicate). Tests shall report the weight of VS for the sample (as kg of dry matter) as well as the volume of methane produced, in order to determine the maximum methane potential as m^3 CH_4/kg VS. If applicable, the flush water sample and effluent sample shall each be used for one test run in triplicate. The laboratory shall conduct an assay on the seed inoculum itself in order to control for its contribution to the methane potential of the manure samples. The laboratory shall also conduct a control assay with a substrate of known methane potential (such as glucose or cellulose) to verify correct procedures were followed and that the inoculum was viable. If the control assay differs from its established expected value by greater than 15%, all results from that batch of assays shall be discarded. Measurement of gas flow shall be corrected to standard temperature and pressure (60°F and 1 atm). Devices used to measure gas flow and methane content shall be properly installed and calibrated, such that they can provide results within +/- 5% accuracy.

5. After the manure sample has been analyzed, there should be at least six estimates for the methane potential. The site specific value for B_0 shall equal the 90% lower confidence limit of all assay results. For flush systems, the mean methane potential of the flush water results must be subtracted from the calculated methane potential of the flushed manure sample. For BCS effluent, the mean methane potential of the test results

[31] Note, while there is no prescribed timeline regarding how quickly samples must be delivered to a laboratory, the longer a sample is retained before testing, the lower the methane generating potential will be. This loss can be mitigated by storing and transporting samples at temperatures below 5°C.
[32] *Ibid*.
[33] For more information on BMP Assay analysis and procedures, see: Moody et al. "Use of Biochemical Methane Potential (BMP) Assays for Predicting and Enhancing Anaerobic Digester Performance." (2009) http://sa.pfos.hr/sa2009/radovi/pdf/Radovi/r10-009.pdf

shall be used for the quantification. Additional sampling and assays may be carried out, and will reduce uncertainty and result in a final value that is closer to the mean.

Site-specific B_0 values determined using this procedure shall be valid for the reporting period during which the sampling occurred. Projects may elect to determine a site-specific B_0 value for only a subset of the eligible manure streams and utilize default values for the remainder. The verifier must confirm that sampling procedures conform to this section and that the personnel responsible for the sampling are trained and competent.

6.2 Biogas Control System Monitoring Requirements

The methane capture and control system must be monitored with measurement equipment that directly meters:

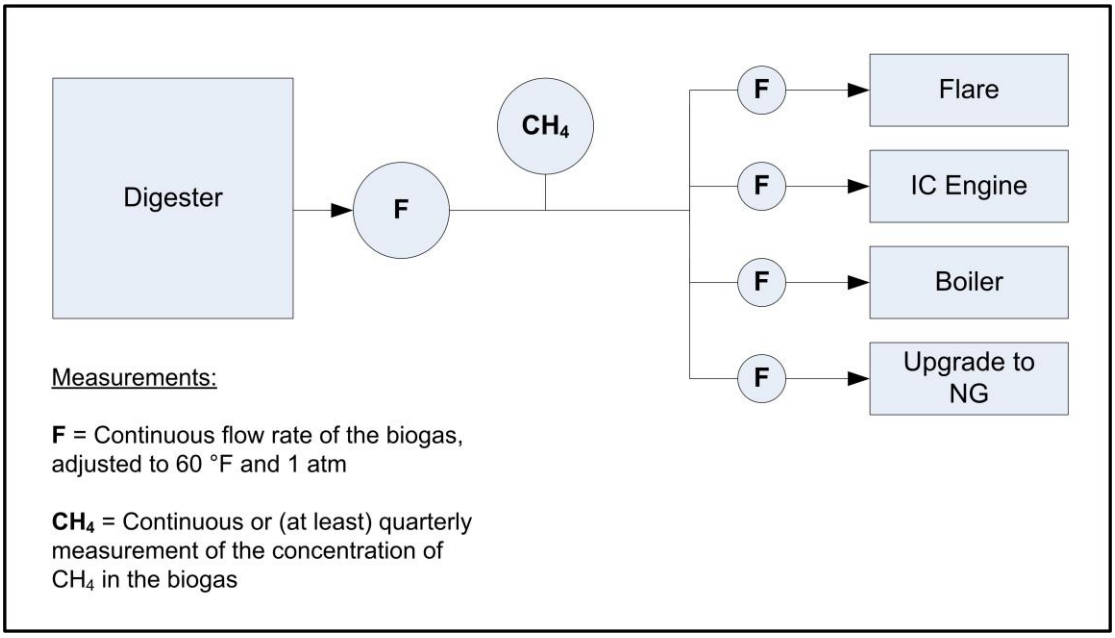
- The total flow of biogas, measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure, prior to delivery to the destruction device(s).
- The flow of biogas delivered to each destruction device (except as described below), measured continuously and recorded at least every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure.
- The fraction of methane in the biogas, measured with a continuous analyzer or, alternatively, with at least quarterly measurements.
- The operational status of each destruction device (except as described below), measured and recorded at least hourly.

Flow data must be corrected for temperature and pressure at 60^{o}F and 1 atm, either internally or by following the guidance in Equation 5.6.

A single flow meter may be used to monitor the flow of gas to multiple destruction devices under certain conditions. If all destruction devices are of identical methane destruction efficiency (as described in Table B.7) and verified to be operational (i.e. there is recorded evidence of destruction), no additional steps are necessary for project registration. One example of this scenario would be a single meter used for a bank of multiple, identical engines that are in constant operation. If the destruction devices are not of identical efficiency, then the destruction efficiency of the least efficient device shall be applied to the flow data for this meter.
If there are any periods where the operational data show that one or more devices were not destroying methane, these periods are eligible for crediting, provided that the verifier can confirm all of the following conditions are met:

a. The destruction efficiency of the least efficient destruction device in operation shall be used as the destruction efficiency for all destruction devices monitored by this meter; and
b. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and
c. For any period where one or more destruction device(s) within this arrangement is not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period. For devices other than flares, it must be shown that the output corresponds to the flow of gas.

Figure 6.1 represents the suggested arrangement of the biogas flow meters and methane concentration metering equipment.



Note: The number of flow meters must be sufficient to track the total flow as well as the flow to each combustion device. The above example includes one more flow meter than would be necessary to achieve this objective.

Figure 6.1. Suggested Arrangement of Biogas Metering Equipment

Operational activity of the destruction devices shall be monitored and documented at least hourly to ensure actual methane destruction.

If for any reason the destruction device or the operational monitoring equipment (for example, the thermocouple on the flare) is inoperable, then all metered biogas going to the particular device shall be assumed to be released to atmosphere during the period of inoperability. In other words, during the period of inoperability, the destruction efficiency of the device must be assumed to be zero. In Equation 5.10, the monthly destruction efficiency (BDE) value shall be adjusted accordingly. See Box 6.1 below for an example BDE adjustment.

Box 6.1. Example BDE Adjustment

As an example, consider a situation where the primary destruction device is an open flare with a BDE of 96%, and it is found to be inoperable for a period of 5 days of a 30 day month. Assume that the total flow of biogas to the flare for the month is 3,000,000 scf, and that the total flow recorded for the 5 day period of inoperability is 500,000 scf. In this case the monthly BDE would be adjusted as follows:

$$BDE = \frac{[(0.96 \times 2{,}500{,}000) + (0.0 \times 500{,}000)]}{3{,}000{,}000} = 80\%$$

6.3 Biogas Measurement Instrument QA/QC

All gas flow meters[34] and continuous methane analyzers must be:

- In calibration (accurate to +/- 5% of the true value being measured) at time of installation. Calibration accuracy can be demonstrated through either a recent field check (as installed) or calibration by the manufacturer or a certified calibration service.

- Maintained per manufacturer's guidance, as well as cleaned and inspected on a quarterly basis, with the activities performed and as found/as left condition of the equipment documented.

- Field checked for calibration accuracy by an appropriately trained individual or a third-party technician with the percent drift documented, using either a portable instrument (such as a pitot tube)[35] or manufacturer specified guidance, at the end of but no more than 60 days prior to or after the end date of the reporting period.[36]

- Calibrated by the manufacturer or a certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent. Meters shall be calibrated to the range of conditions expected on site (e.g. pipe diameter, flow rate, temperature, pressure, gas composition) and as found/as left condition of the equipment documented.

If a stationary meter that was in use for 60 days or more is removed and not reinstalled during a reporting period, that meter shall either be field-checked for calibration accuracy prior to removal or calibrated (with percent drift documented) by the manufacturer or a certified calibration service prior to quantification of emission reductions for that reporting period.

If the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment, with as found/as left condition of the equipment documented.

For the interval between the last successful field check and any calibration event confirming accuracy below the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated and re-installed.

- For calibrations that indicate the flow meter was outside the +/- 5% accuracy threshold, the project developer shall estimate total emission reductions using i) the metered values without correction, and ii) the metered values adjusted based on the greatest calibration drift recorded at the time of calibration. The lower of the two emission reduction estimates shall be reported as the scaled emission reduction estimate.

[34] Field checks and calibrations of flow meters shall assess the volumetric output of the flow meter in SCF at 1 atm pressure and 60°F temperature.

[35] It is recommended that a professional third party calibration service be hired to perform flow meter field checks if using pitot tubes or other portable instruments, as these types of devices require professional training in order to achieve accurate readings.

[36] Instead of performing field checks, the project developer may instead have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but no more than 60 days prior to or after the end date of the reporting period to meet this requirement.

For example, if a project conducts field checks quarterly during a year-long verification period, then only three months of data will be subject at any one time to the penalties above. However, if the project developer feels confident that the meter does not require field checks or calibration on a greater than annual basis, then failed events will accordingly require the penalty to be applied to the entire year's data. Further, frequent calibration may minimize the total accrued drift (by zeroing out any error identified), and result in smaller overall deductions.

If a portable instrument is used (such as a handheld methane analyzer), the portable instrument shall be calibrated at least annually – or per the manufacturer's guidance, whichever is more frequent – by the manufacturer or at an ISO 17025 accredited laboratory. Portable methane analyzers shall be calibrated to a known reference gas prior to each use.

6.3.1 Missing Data

In situations where the flow rate or methane concentration monitoring equipment is missing data, the project developer shall apply the data substitution methodology provided in Appendix D. This methodology may also be used for periods where the project developer can show that the data are available but known to be corrupted (and where this corruption can be verified with reasonable assurance). If for any reason the monitoring equipment on any given destruction device is inoperable (for example, the thermocouple on the flare), then the destruction efficiency of that device must be assumed to be zero. For periods when it is not possible to use data substitution to fill data gaps, no emission reductions may be claimed. The methane flow volume for these days shall be zero, and the number of reporting days for that month shall be reduced to exclude the days of missing data (see Box 5.2).

During any period where the project is not claiming emission reduction credits and is not classifying the period as a venting event, the project developer must be able to demonstrate that project emissions were not greater than baseline emissions.

6.4 Monitoring Parameters

Provisions for monitoring other variables to calculate baseline and project emissions are provided in Table 6.1. The parameters are organized by general project factors then by the calculation methods.

Table 6.1. Project Monitoring Parameters

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
	Regulations	Project developer attestation to compliance with regulatory requirements relating to the manure digester project	All applicable regulations	n/a	Every verification period	Information used to demonstrate compliance with associated regulations and rules, e.g. criteria pollutant and effluent discharge limits.
	L	Type of livestock categories on the farm	Livestock categories	o	Monthly	See Appendix B, Table B.2.
Equation 5.1	$ER_{modeled}$	Avoided methane emissions associated with the project during the reporting period	tCO_2e	c	Every reporting period	Quantified using a modeled baseline scenario.
Equation 5.1	$BE_{modeled}$	Modeled baseline emissions during the reporting period	tCO_2e	c	Every reporting period	Quantified using a modeled baseline scenario.
Equation 5.1 Equation 5.5	PE_{CH4}	Total project methane emissions during the reporting period	tCO_2e	c	Every reporting period	Quantified using a modeled project scenario and metered methane destruction data.
Equation 5.1 Equation 5.12	$CO_{2,net}$	Net increase in anthropogenic CO_2 emissions from electricity and mobile/stationary combustion	tCO_2e	c	Every reporting period	
Equation 5.1	$ER_{metered}$	Avoided methane emissions associated with the project during the reporting period	tCO_2e	c	Every reporting period	Quantified using metered methane destruction data.
Equation 5.1 Equation 5.11	$BE_{metered}$	Aggregated quantity of methane collected and destroyed during the reporting period	tCO_2e	c	Every reporting period	Quantified using metered methane destruction data.

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.2	$BE_{CH4,AS,L}$	Total baseline methane emissions from anaerobic storage/treatment systems by livestock category, aggregated for reporting period	tCO_2e	c	Monthly	
Equation 5.2 Equation 5.4	$BE_{CH4,nAS,L}$	Total baseline methane emissions for the reporting period from non-anaerobic storage/treatment systems by livestock category	tCO_2e	c	Every reporting period	
Equation 5.3	$VS_{deg,AS,L}$	Monthly volatile solids degraded in each anaerobic storage system *AS*, for each livestock category *L*	kg	c, o	Monthly	Calculated value from operating records. Recommend Reserve Livestock Calculation Tool for all calculations.
Equation 5.3 Equation 5.4 Equation 5.10	$B_{0,L}$	Maximum methane producing capacity for manure by livestock category	(m^3 CH_4/ kg VS)	r	Every reporting period	See Appendix B, Table B.3.
Equation 5.3 Equation 5.8	$days_{mo}$	Calendar days per month	days	r	Monthly	See Box 5.2.
Equation 5.3 Equation 5.8	rd_{mo}	Reporting days during the current month	days	o	Monthly	See Box 5.2.
Equation 5.3	$VS_{avail,AS,L}$	Monthly volatile solids available for degradation in each anaerobic storage system, for each livestock category	kg	c, o	Monthly	Calculated value from operating records. Recommend Reserve Livestock Calculation Tool for all calculations.
Equation 5.3 Equation 5.8	*f*	van't Hoff-Arrhenius factor	n/a	c	Monthly	The proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system. Recommend Reserve Livestock Calculation Tool for all calculations.
Equation 5.3 Equation 5.4 Equation 5.8 Equation 5.10	VS_L	Daily volatile solid production for each livestock category	(kg/animal/ day)	r, c	Every reporting period	Appendix B, Table B.3 and Table B.5a-d; see Box 5.1 for guidance on converting units from (kg/day/1000kg) to (kg/animal/day).

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.3 Equation 5.4 Equation 5.8 Equation 5.10	P_L	Average number of animals for each livestock category	population (# head)	o	Monthly	
Equation 5.3	$MS_{AS,L}$	Fraction of manure from each livestock category managed in the anaerobic waste handling system	%	o	Every reporting period	Reflects the percent of waste handled by the system components *S* pre-project. Each system component must have an MS value per livestock category. Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 100%. See Appendix B, Table B.1.
Equation 5.3	$VS_{avail-1,AS}$	Previous month's volatile solids available for degradation in anaerobic system	kg	c	Monthly	
Equation 5.3	$VS_{deg-1,AS}$	Previous month's volatile solids degraded by anaerobic system	kg	c	Monthly	
Equation 5.3	E	Activation energy constant	cal/mol	r		15,175 cal/mol
Equation 5.3	T_{mo}	Average monthly temperature at location of the operation	°C	m/o	Monthly	Used for van't Hoff calculation and for choosing appropriate MCF value.
Equation 5.3	T_{ref}	Reference temperature	K	r		303.16 Kelvins
Equation 5.3	R	Ideal gas constant	cal/Kmol	r		1.987 cal/Kmol
Equation 5.4	$MS_{L,nAS}$	Fraction of manure from each livestock category *L* managed in the non-anaerobic waste handling system	%	o	Every reporting period	Reflects the percent of waste handled by the system components *S* pre-project. Each system component must have an MS value per livestock category. Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 100%. See Appendix B, Table B.1.
Equation 5.4	$days_{rp}$	Number of days in the reporting period	days	o	Every reporting period	See Box 5.2.
Equation 5.4	MCF_{nAS}	Methane conversion factor for non-anaerobic storage/treatment system	%	r	Every reporting period	From Appendix B. Differentiate by livestock category.

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.4 Equation 5.9 Equation 5.10	rd_{rp}	Reporting days during the reporting period	days		Every reporting period	See Box 5.2.
Equation 5.5 Equation 5.6	$PE_{CH4,BCS}$	Methane emissions from the BCS	tCH_4	m, c	Every reporting period	Calculated for each month and summed for the reporting period.
Equation 5.5 Equation 5.8	$PE_{CH4,ET,AS}$	Methane emissions from the BCS effluent anaerobic treatment systems	tCH_4	m, c	Every reporting period	Calculated for each month and summed for the reporting period.
Equation 5.5 Equation 5.9	$PE_{CH4,ET,nAS}$	Methane emissions from the BCS effluent non-anaerobic treatment systems	tCH_4	m, c	Every reporting period	Calculated for the reporting period.
Equation 5.5 Equation 5.10	$PE_{CH4,other}$	Methane emissions from sources in the waste treatment and storage category other than the BCS and associated effluent treatment systems	tCH_4	m, c	Every reporting period	Calculated for the reporting period.
Equation 5.6 Equation 5.11	$CH_{4,metered,i}$	Metered amount of methane collected and destroyed by the BCS in month *i*	tCH_4	m, c	Monthly calculation from continuous data	Calculated from biogas flow and methane fraction meter readings (See *F* and $CH_{4,conc}$ parameters below).
Equation 5.6	BCE	Biogas capture efficiency of the anaerobic digester, accounts for fugitive emissions	fraction	r	Every reporting period	Use default value from Table B.4.
Equation 5.6 Equation 5.11	$BDE_{i,weighted}$	Methane destruction efficiency of destruction device(s)	fraction	r, c	Monthly	Actual efficiency of the system to destroy captured methane gas – accounts for different destruction devices.
Equation 5.6 Equation 5.7	$CH_{4,vent,i}$	Quantity of methane that is vented to the atmosphere due to BCS venting events	scf	c	Monthly	Calculated from average total flow of biogas from the digester and the number of days biogas is venting.
Equation 5.6	F	Volume of biogas from digester to destruction devices	scf	m	Continuously, aggregated monthly	Measured continuously from flow meter and recorded every 15 minutes or totalized and recorded at least once daily. Data to be aggregated monthly.

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.6	T_b	Temperature of the biogas	°R (Rankine)	m	Continuously, averaged monthly	Measured to normalize volume flow of biogas to STP. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic feet.
Equation 5.6	P	Pressure of the biogas	atm	m	Continuously, averaged monthly	Measured to normalize volume flow of biogas to STP. No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic feet.
Equation 5.6 Equation 5.7	$CH_{4,conc}$	Methane concentration of biogas	fraction	m	At least quarterly	Samples to be taken at least quarterly. See Section 6.2 for metering guidance.
Equation 5.6	BDE_{DD}	Default methane destruction efficiency of a particular destruction device	%	r	Monthly	See Appendix B for default destruction efficiencies by device.
Equation 5.6	$F_{i,DD}$	Flow of biogas to a particular destruction device	scf	m	Monthly	See Section 6.2 for metering guidance.
Equation 5.6	F_i	Total volumetric flow of biogas to all destruction devices	scf	m	Monthly	See Section 6.2 for metering guidance.
Equation 5.7	MGS_{BCS}	Maximum biogas storage of the BCS system	scf	r	Every reporting period	Obtained from digester system design plans. Necessary to quantify the release of methane to the atmosphere due to an uncontrolled venting event.
Equation 5.7	F_{pw}	Average total daily flow of biogas from the digester for the entire week prior to the uncontrolled venting event	scf/day	m	Weekly	Average flow of biogas can be determined from the daily records from the previous week.
Equation 5.7	t	Number of days of the month that biogas is venting uncontrolled from the BCS system	days	m, o	Monthly	

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.8 Equation 5.9	$VS_{ET,i}$	Volatile solids to effluent treatment system *i*	kg/day	r, c	Every reporting period	If project uses effluent pond, equals 30% of the average daily VS entering the digester.
Equation 5.8 Equation 5.9	$B_{0,ET}$	Maximum methane producing capacity of VS dry matter	(m^3 CH_4/ kg VS)	c	Every reporting period	An average of the $B_{0,EF}$ value of the operation's livestock categories that contributes manure to the BCS.
Equation 5.8	$MS_{L,BCS}$	Fraction of manure from each livestock category managed in the BCS	fraction	o	Every reporting period	Used to determine the total VS entering the digester. The fraction should be tracked in operational records.
Equation 5.8	ETF_i	Fraction of the effluent that exits the digester that is sent to effluent treatment system		o, r	Every reporting period	Used to determine the amount of VS for each effluent treatment system. The percentage should be tracked in operational records, or the project developer may provide a technical reference to support this fraction.
Equation 5.9	$MCF_{ET,i}$	Methane conversion factor for effluent treatment system	%	r	Every reporting period	See Appendix B. Project developers should use the *liquid slurry* MCF value.
Equation 5.10	$MCF_{non\text{-}BCS}$	Management-weighted methane conversion factor for waste treatment and storage systems other than the BCS and associated effluent treatment systems	%	r	Every reporting period	Referenced from Appendix B.
Equation 5.10	MCF_S	Methane conversion factor for system component		r		See Table B.9.
Equation 5.10	$MS_{L,S}$	Manure from each livestock category managed in the baseline waste handling system	fraction	o	Every reporting period	Fraction of waste handled by the system component *S* pre-project. Each system component must have an MS value per livestock category. Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 1. See Appendix B, Table B.1.
Equation 5.12	$BE_{CO2,MSC}$	Total baseline CO_2 emissions from electricity and mobile/stationary combustion during reporting period	tCO_2	c	Every reporting period	

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.12	$PE_{CO2,MSC}$	Total project CO_2 emissions from electricity and mobile/stationary combustion during reporting period	tCO_2	c	Every reporting period	
Equation 5.12	$CO_{2,MSC}$	Anthropogenic CO_2 emissions from electricity and mobile/stationary combustion	tCO_2	c	Every reporting period	
Equation 5.12	QE_c	Quantity of electricity consumed	MWh	o, c	Every reporting period	Electricity used by project for manure collection, transport, treatment/storage, and disposal.
Equation 5.12	$EF_{CO2,e}$	Emission factor for electricity used by project	tCO_2/MWh	r	Every reporting period	See Appendix B. If biogas produced from digester is used to generate electricity consumed, the EF is zero.
Equation 5.12	QF_c	Quantity of fuel used for mobile/stationary combustion sources	MMBtu or gallons	o, c	Every reporting period	Fuel used by project for manure collection, transport, treatment/storage, and disposal, and stationary combustion sources including supplemental fossil fuels used in combustion device.
Equation 5.12	$EF_{CO2,f}$	Fuel-specific emission factor for mobile/stationary combustion sources	kg CO_2/ MMBtu or kg CO_2/ gallon	r	Every reporting period	Refer to EPA eGRID for emission factors. If biogas produced from digester is used as an energy source, the EF is zero.

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit either a project monitoring report or a verified emission reduction report to the Reserve annually at minimum, depending on the verification option selected by the project developer.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register a livestock project:

- Project Submittal form
- Project diagram from Monitoring Plan – see Appendix F (not public)
- Completed Reserve Livestock Calculation Tool, if used (not public)
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form[37]
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each verification period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Project diagram from Monitoring Plan – see Appendix F (not public)
- Completed Reserve Livestock Calculation Tool, if used (not public)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form (second crediting period only)

Unless otherwise specified, the above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project forms can be found athttp://www.climateactionreserve.org/how/program/documents/. .

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

[37] A project developer only needs to attest that the project passes the Legal Requirement Test during its first verification period of a crediting period. Meeting the Legal Requirement Test is not required for the remainder of the first crediting period after initial verification.

System Information:

- All data inputs for the calculation of the baseline emissions and project emission reductions
- CO_2e annual tonnage calculations (including copies of the Reserve Livestock Calculation Tool, if used)
- Relevant sections of the BCS operating permits
- Executed Attestation of Title forms, Attestation of Regulatory Compliance forms, and Attestation of Voluntary Implementation form
- BCS information (installation dates, equipment list, etc.)
- Biogas flow meter information (model number, serial number, manufacturer's calibration procedures)
- Cleaning and inspection records for all biogas meters
- Field check results for all biogas meters
- Calibration results for all biogas meters
- Methane monitor information (model number, serial number, calibration procedures)
- Biogas flow data (for each flow meter)
- Biogas temperature and pressure readings (only if flow meter does not correct for temperature and pressure automatically)
- Methane concentration monitoring data
- Destruction device monitoring data (for each destruction device)
- Destruction device, methane monitor and biogas flow monitor information (model numbers, serial numbers, calibration procedures)
- Initial and annual verification records and results
- All maintenance records relevant to the BCS, monitoring equipment, and destruction devices

If using a calibrated portable gas analyzer for CH_4 content measurement:

- Date, time, and location of methane measurement
- Methane content of biogas (% by volume) for each measurement
- Methane measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.3 Reporting and Verification Cycle

To provide flexibility and help manage verification costs associated with livestock projects, there are three verification options to choose from after a project's initial verification and registration. Regardless of the option selected, project developers must report GHG reductions resulting from project activities during each reporting period. A "reporting period" is a period of time over which a project developer quantifies and reports GHG reductions to the Reserve. Under this protocol, the reporting period cannot exceed 12 months. A "verification period" is the period of time over which GHG reductions are verified. Under this protocol, a verification period may cover multiple reporting periods (see Section 7.3.4). The end date of any verification period must correspond to the end date of a reporting period.

A project developer may choose to utilize one option for the duration of a project's crediting period, or may choose different options at different points during a single crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.

7.3.1 Initial Reporting and Verification Period

While a reporting period cannot exceed 12 months, a project developer may register multiple reporting periods (i.e. more than 12 months of data) during a project's initial verification period. A project developer may also register a project's initial verification period as a zero-credit reporting period (see the Reserve Program Manual for more information on zero-credit reporting periods).

Once a project is registered and has had at least 3 months of emission reductions verified, the project developer may choose one of the verification options below.

7.3.2 Option 1: Twelve-Month Maximum Verification Period

Under this option, the verification period may not exceed 12 months. Verification with a site visit is required for CRT issuance. The project developer may choose to have a sub-annual verification period (e.g. quarterly or semi-annually).

7.3.3 Option 2: Twelve-Month Verification Period with Desktop Verification

Under this option, the verification period cannot exceed 12 months. However, CRTs may be issued upon successful completion of a desktop verification as long as: (1) site-visit verifications occur at two-year intervals; and (2) the verifier has confirmed that there have been no significant changes in data management systems, equipment, or personnel since the previous site visit. Desktop verifications must cover all other required verification activities.

In order to utilize this option, there are two additional requirements that must be satisfied:

1. Prior to a desktop verification commencing, the project developer must attest to the verifier that there have been no significant changes to the project's data management systems, project set up/equipment, or site personnel involved with the project since the last site-visit verification. For each verification period, the project developer must provide the following documentation for review by the verifier prior to the desktop verification commencing:
    a. A schematic of system equipment and configuration, detailing any changes since the previous site visit, and any other supporting documentation for system or operation changes
    b. A list of personnel performing key functions related to project activities (personnel who manage and perform monitoring, measurement, and instrument QA/QC activities for the project), and documentation of any personnel or roles or changes since the pervious site visit; this shall include documented handover of personnel changes, including personnel change dates
    c. The sections from the Monitoring Plan that summarize the data management systems and processes in place and a summary of any changes to the systems or processes since the previous site visit

2. Desktop verifications must be conducted by the same verification body that conducted the most recent site-visit verification.

For projects using this option, the initial verification in this cycle shall be a full verification, including a site visit, and shall cover a minimum of 3 months and maximum 12 months of project data. All subsequent verification periods under this option shall be 12-month verification periods. Projects that wish to upgrade to the latest protocol version from a previous version whilst simultaneously taking advantage of the desktop verification option shall be allowed to do so, provided:

i. The verification of the previous verification period (e.g. under Version 2.1, 2.2 or 3.0) was a full verification, including site visit, and covered a minimum of 3 months of project data, and
ii. The two additional requirements specified in Section 7.3.3 are satisfied.

Taking into consideration the Reserve's policy that a verification body may provide verification services to a project for a maximum of six consecutive years (see the Verification Program Manual, Section 2.6 for more information), Table 7.1 below details what the verification cycle might look under Option 2.

Table 7.1. Sample Verification Cycle under Option 2

Reporting Period	Verification Activity	Verification Body (VB)
Year 1 *(initial verification)*	Site-visit verification	VB A
Year 2	Desktop verification	VB A
Year 3	Site-visit verification	VB A
Year 4	Desktop verification	VB A
Year 5	Site-visit verification	VB A
Year 6	Desktop verification	VB A
Year 7	Site-visit verification	VB B *(new verification body)*
Year 8	Desktop verification	VB B

7.3.4 Option 3: Twenty-Four Month Maximum Verification Period

Under this option, the verification period cannot exceed 24 months and the project's monitoring report must be submitted to the Reserve for the interim 12 month reporting period. The project monitoring report must be submitted for projects that choose Option 3 to meet the annual documentation requirement of the Reserve program. It is meant to provide the Reserve with information and documentation on a project's operations and performance, and adherence to the project's monitoring plan. It is submitted via the Reserve's online registry, but is not a publicly available document. A monitoring report template for livestock projects is available at http://www.climateactionreserve.org/how/program/documents/. The monitoring report shall be submitted within 30 days of the end of the interim reporting period. The only exception to this requirement is for projects that verify under Option 3 as part of a protocol upgrade, and fall within the specific timeline outlined below.

Project developers that wish to upgrade to Version 4.0 of this protocol and immediately utilize the 24-month verification period shall be allowed to do so, provided that the verification of the previous verification period (e.g. under Version 2.0, 2.1, 2.2, or 3.0) was a full verification, including a site visit, and covered a minimum of 3 months of project data.

All project developers utilizing the 24-month verification period must submit the monitoring report within 30 days of the end of the interim reporting period.

Under this option, CRTs may be issued upon successful completion of a site-visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of project monitoring plans/reports. Project developers may choose to have a verification period shorter than 24 months.

Taking into consideration the Reserve's policy that a verification body may provide verification services to a project for a maximum of six consecutive years (see the Verification Program Manual, Section 2.6 for more information), Table 7.2 below details what the verification cycle might look under Option 3.

Table 7.2. Sample Verification Cycle under Option 3

Reporting Period	Verification Activity	Verification Body (VB)
Year 1 *(initial verification)*	Site-visit verification	VB A
Year 2	Project monitoring plan and report submitted to Reserve	n/a
Year 3	Site-visit verification for years 2 & 3	VB A
Year 4	Project monitoring plan and report submitted to Reserve	n/a
Year 5	Site-visit verification for years 4 & 5	VB A
Year 6	Project monitoring plan and report submitted to Reserve	n/a
Year 7	Site-visit verification for years 6 & 7	VB B *(new verification body)*
Year 8	Project monitoring plan and report submitted to Reserve	n/a

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with installing a biogas control system for manure management on dairy cattle and swine farms. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to livestock manure management projects.

Verification bodies trained to verify livestock projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve U.S. Livestock Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only Reserve-approved verification bodies are eligible to verify livestock project reports. Verification bodies approved under other project protocol types are not permitted to verify livestock projects. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org.

8.1 Standard of Verification

The Reserve's standard of verification for livestock projects is the U.S. Livestock Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify a livestock project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Section 6 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm a livestock project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for livestock projects. This table does

not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for a Livestock Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing within 6 months of the project start date	Once during first verification
Location	United States, its territories, and U.S. tribal areas	Once during first verification
Performance Standard Test	Installation of a biogas control system that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities on livestock operations	Once during first verification
Anaerobic Baseline	Projects must demonstrate that the depth of the anaerobic lagoons or ponds prior to the project's implementation were sufficient to prevent algal oxygen production and create an oxygen-free bottom layer; which means at least 1 meter in liquid depth	Once during first verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and additional documentation demonstrating that the project passes the Legal Requirement Test	Once during first verification for first crediting period; every verification for second crediting period
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier, and monitoring; project must be in material compliance with all applicable laws	Every verification

8.4 Core Verification Activities

The U.S. Livestock Project Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with installing a BCS to capture and destroy methane gas from livestock operations. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a livestock project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the SSRs identified for a project, such as energy use waste collection and transport, treatment and storage, and uncombusted methane from the biogas control system.

Reviewing GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the methodologies and management systems that the livestock project operator uses to gather data and calculate baseline and project emissions. This includes the examination of assertions or assumptions regarding MS, the percentage of manure going to anaerobic treatment systems in the baseline, and the baseline lagoon cleaning frequency.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.5 Verification Period

Per Section 7.3, this protocol provides project developers three verification options for a project after its initial verification and registration in order to provide flexibility and help manage verification costs associated with livestock projects. The different options require verification bodies to confirm additional requirements specific to this protocol, and in some instances, to utilize professional judgment on the appropriateness of the option selected.

8.5.1 Option 1: Twelve-Month Maximum Verification Period

Option 1 does not require verification bodies to confirm any additional requirements beyond what is specified in the protocol.

8.5.2 Option 2: Twelve-Month Verification Period with Desktop Verification

Option 2 requires verification bodies to review the documentation specified in Section 7.3.3 in order to determine if a desktop verification is appropriate. The verifier shall use his/her professional judgment to assess any changes that have occurred related to a project's data management systems, equipment, or personnel and determine whether a site visit should be required as part of verification activities in order to provide a reasonable level of assurance on the project's verification. The documentation shall be reviewed prior to the COI/NOVA renewal being submitted to the Reserve, and the verification body shall provide a summary of its assessment and decision on the appropriateness of a desktop verification when submitting the COI/NOVA renewal. The Reserve reserves the right to review the documentation provided by the project developer and the decision made by the verification body on whether a desktop verification is appropriate.

8.5.3 Option 3: Twenty-Four Month Maximum Verification Period

Under Option 3 (see Section 7.3.4), verification bodies shall look to the project monitoring report submitted by the project developer to the Reserve for the interim 12 month reporting period as a resource to inform its planned verification activities. While verification bodies are not expected to provide a reasonable level of assurance on the accuracy of the monitoring report as part of verification, the verification body shall list a summary of discrepancies between the monitoring report and what was ultimately verified in the List of Findings.

8.6 Livestock Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a livestock project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to livestock projects that must be addressed during verification.

8.6.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for livestock projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.1	Verify that the project meets the definition of a livestock project	No
2.2	Verify ownership of the reductions by reviewing Attestation of Title and other relevant contracts, documentation	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that project is within its 10-year crediting period	No
3.4	Verify that all pre-project manure treatment lagoons/ponds/tanks were of sufficient depth to ensure an oxygen free bottom layer (> 1m)	Yes
3.4	Verify that the pre-project manure management system met the requirements of this section for the relevant period of time	Yes
3.4	If the project is a greenfield project, verify that the project site meets the definition of a greenfield	Yes
3.5.1	Verify that the project meets the Performance Standard Test	No
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test (initial verification only)	No
3.6	Verify that the project activities comply with applicable laws by reviewing instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that variance has been approved for monitoring variations	No
6	Verify that all gas flow meters and continuous methane analyzers adhered to the inspection, cleaning, and calibration schedule specified in the protocol. If they do not, verify that a variance has been approved for	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
	monitoring variations or that adjustments have been made to data per the protocol requirements	
6	Verify that adjustments for failed calibrations were properly applied	No
6, Appendix D	If used, verify that data substitution methodology was properly applied	No

8.6.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
5	Verify that the modeled baseline is compared with the total amount of methane metered and destroyed by the project, and the lesser of the two values is used as the baseline for the GHG reduction calculation	No
5.1	Verify that the livestock categories (L) are correctly differentiated	Yes
5.1	Verify that the project developer applied the correct VS and B_0 values for each livestock category	No
5.1, 6.1	If site-specific B_0 values were developed, verify that the sampling and analysis procedures were correctly followed	Yes
5.1	Verify that the fraction of manure (MS) handled by the different manure management system components (i.e. GHG source) is satisfactorily represented	Yes
5.1	Verify that the baseline lagoon cleaning frequency is satisfactorily represented	Yes
5.1	Verify that the project developer used methane conversion factors (MCF) differentiated by temperature	No
5.1	Verify that the methane baseline emissions calculations for each livestock category were calculated according to the protocol with the appropriate data	No
5.1	Verify that the project developer correctly aggregated methane emissions from sources within each livestock category	Yes
5.4	Verify that the project developer correctly monitored, quantified and aggregated electricity use	Yes
5.2, 5.4	Verify that the project developer correctly monitored, quantified and aggregated fossil fuel use	Yes
5.2, 5.4	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5.2	Verify that the project developer applied the correct methane destruction efficiencies	No
5.2	Verify that the project developer applied the correct B_0 value for Modeled Project Methane Emissions from Anaerobic Treatment of BCS Effluent	No
5.2	Verify that the project developer correctly quantified the amount of uncombusted methane	No

Protocol Section	Quantification Item	Apply Professional Judgment?
5.2	Verify that methane emissions resulting from any venting event are estimated correctly	Yes
5.2, 5.4	Verify that the project emissions calculations were calculated according to the protocol with the appropriate data	No
5.2, 5.1	Verify that the project developer assessed baseline and project emissions on a month-to-month basis	No
5.2	Verify that the project developer correctly monitored and quantified the amount of methane destroyed by the project	No
5.3	Verify that the modeled methane emission reductions are compared with the *ex-post* methane metered and destroyed by the project, and the lesser of the two values is used to quantify project emission reductions	No

8.6.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that the BCS was operated and maintained according to manufacturer specifications	No
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
7.2	Verify that all required records have been retained by the project developer	No

8.7 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Reserve to provide verification services for project developers.
Additionality	Manure management practices that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel combustion, deforestation etc.).
Biogas	The mixture of gas (largely methane) produced as a result of the anaerobic decomposition of livestock manure.
Biogas control system (BCS)	A system designed to capture and destroy the biogas that is produced by the anaerobic treatment and/or storage of livestock manure and/or other organic material. Commonly referred to as a "digester."
Biogenic CO_2 emissions	CO_2 emissions resulting from the combustion and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the carbon cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Emission factor	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Flare	A destruction device that uses an open flame to burn combustible gases with combustion air provided by uncontrolled ambient air around the flame.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenfield	For the purposes of this protocol, a livestock facility that has been in operation for less than two years at a site that had no prior manure management infrastructure.
Greenhouse gas	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O),

(GHG)	sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs).
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Emissions that are a consequence of the actions of a reporting entity, but are produced by sources owned or controlled by another entity.
Livestock project	Installation of a biogas control system that, in operation, causes a decrease in GHG emissions from the baseline scenario through destruction of the methane component of biogas.
Metric ton (tonne, MT, t)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
Nitrous oxide (N_2O)	A GHG consisting of two nitrogen atoms and a single oxygen atom.
Project baseline	A business-as-usual GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a project activity, as identified in the Livestock Project Protocol. A project developer may be an independent third party or the dairy/swine operating entity.
Reporting period	The period of time over which a project developer quantifies and reports GHG reductions to the Reserve. Under this protocol, the reporting period cannot exceed 12 months.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
van't Hoff-Arrhenius factor (*f*)	The proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system.[38]

[38] Mangino, et al.

Verification	The process used to ensure that a given participant's greenhouse gas emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	An accredited firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Verification period	The period of time over which GHG reductions are verified. Under this protocol, a verification period may cover multiple reporting periods (see Section 7.3.4). The end date of any verification period must correspond to the end date of a reporting period.

10 References

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Appendix A Associated Environmental Impacts

Manure management projects have many documented environmental benefits, including air emission reductions, water quality protection, and electricity generation. These benefits are the result of practices and technologies that are well managed, well implemented, and well designed. However, in cases where practices or technologies are poorly or improperly designed, implemented, and/or managed, local air and water quality could be compromised.

With regard to air quality, there are a number of factors that must be considered and addressed to realize the environmental benefits of a biogas project and reduce or avoid potential negative impacts. Uncontrolled emissions from combustion of biogas may contain between 200 to 300 ppm NOx. The anaerobic treatment process creates intermediates such as ammonia, hydrogen sulfide, orthophosphates, and various salts, all of which must be properly controlled or captured. In addition, atmospheric releases at locations off-site where bio-gas is shipped may negate or decrease the benefit of emissions controls on-site. Thus, while devices such as Selective Catalyst Reduction (SCR) units can reduce NOx emissions and proper treatment system operation can control intermediates, improper design or operation may lead to violations of federal, state, and local air quality regulations as well as release of toxic air contaminants.

With regard to water quality, it is critical that project developers and managers ensure digester integrity and fully consider and address post-digestion management of the effluent in order to avoid contamination of local waterways and groundwater resources. Catastrophic digester failures; leakage from pipework and tanks; and lack of containment in waste storage areas are all examples of potential problems. Further, application of improperly treated digestate and/or improper application timing or rates of digestate to agricultural land may lead to increased nitrogen oxide emissions, soil contamination, and/or nutrient leaching, thus negating or reducing benefits of the project overall.

Project developers must not only follow the protocol to register GHG reductions with the Reserve, they must also comply with all local, state, and national air and water quality regulations. Projects must be designed and implemented to mitigate potential releases of pollutants such as those described, and project managers must acquire the appropriate local permits prior to installation to prevent violation of the law.

The Reserve agrees that GHG emission reduction projects should not undermine air and water quality efforts and will work with stakeholders to establish initiatives to meet both climate-related and localized environmental objectives.

Appendix B Emission Factor Tables

Table B.1. Manure Management System Components

System	Definition
Pasture/Range/ Paddock	The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.
Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year. Per IPCC Guidelines, if manure contains less than 20% dry matter it can be considered liquid.
Uncovered anaerobic lagoon	A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.
Pit storage below animal confinements	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.
Anaerobic digester	Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO2 and CH4, which is captured and flared or used as a fuel.
Burned for fuel	The dung and urine are excreted on fields. The sun dried dung cakes are burned for fuel.
Cattle and Swine deep bedding	As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture.
Composting – In-vessel*	Composting, typically in an enclosed channel, with forced aeration and continuous mixing.
Composting – Static pile*	Composting in piles with forced aeration but no mixing.
Composting – Intensive windrow*	Composting in windrows with regular (at least daily) turning for mixing and aeration.
Composting – Passive windrow*	Composting in windrows with infrequent turning for mixing and aeration.
Aerobic treatment	The biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.

*Composting is the biological oxidation of a solid waste including manure usually with bedding or another organic carbon source typically at thermophilic temperatures produced by microbial heat production.
Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management, Table 10.18: Definitions of Manure Management Systems, p. 10.49.

Table B.2. Livestock Categories and Typical Animal Mass

Livestock Category (L)	Livestock Typical Animal Mass (TAM) in kg	
	2006 - 2008	2009 - 2010
Dairy cows (on feed)	604[b]	680[c]
Non-milking dairy cows (on feed)	684[a]	684[a]
Heifers (on feed)	476[b]	407[c]
Bulls (grazing)	750[b]	750[c]
Calves (grazing)	118[b]	118[c]
Heifers (grazing)	420[b]	351[c]
Cows (grazing)	533[b]	582.5[c]
Nursery swine	12.5[a]	12.5[a]
Grow/finish swine	70[a]	70[a]
Breeding swine	198[b]	198[c]

Sources for TAM:
[a.] American Society of Agricultural Engineers (ASAE) Standards 2005, ASAE D384.2.
[b.] Environmental Protection Agency (EPA), Inventory of US GHG Emissions and Sinks 1990-2006 (2007), Annex 3, Table A-161, pg. A-195.
[c.] Environmental Protection Agency (EPA), Inventory of US GHG Emissions and Sinks 1990-2010 (2012), Annex 3, Table A-191, pg. A-246.

Table B.3. Volatile Solids and Maximum Methane Potential by Livestock Category

Livestock category (L)	VS_L (kg/day/1000 kg mass)	$B_{0,L}$ [b] (m^3 CH_4/kg VS added)
Dairy cows	See Appendix B, Tables 5a-e	0.24
Non-milking dairy cows	5.56	0.24
Heifers	See Appendix B, Tables 5a-e	0.17
Bulls (grazing)	6.04[b]	0.17
Calves (grazing)	6.41[b]	0.17
Heifers (grazing)	See Appendix B, Tables 5a-e	0.17
Cows (grazing)	See Appendix B, Tables 5a-e	0.17
Nursery swine	8.89[b]	0.48
Grow/finish swine	5.36[b]	0.48
Breeding swine	2.71[b]	0.35

[a.] American Society of Agricultural Engineers (ASAE) Standards 2005, ASAE D384.2, VS_L(kg/day per animal) from table 1.b (p.2) converted to (kg/day/1000 kg mass) using average Live Weight (kg)values from table 5c (p.7).
[b.] Environmental Protection Agency (EPA) – Climate Leaders Draft Manure Offset Protocol, October 2006, Table IIa: Animal Waste Characteristics (VS, B_0, and N_{ex} rates), p. 18.

Table B.4. Biogas Collection Efficiency by Digester Type

Digester Type	Cover Type	Biogas Collection Efficiency (BCE) as a Decimal
Covered Anaerobic Lagoon	Bank-to-Bank, impermeable	0.95
	Partial area (modular), impermeable	(0.95) x (% area covered)
Complete mix, plug flow, or fixed film digester	Enclosed vessel	0.98
Two stages of differing types	With flow metered for each stage	$\frac{(BCE1) \times (Gasflow1) + (BCE2) \times (Gasflow2)}{Total\ biogas\ flow}$
	No separate flow metering	$(BCE1) \times 0.7 + (BCE2) \times 0.3$

Adapted from: U.S. EPA Climate Leaders, Offset Project Methodology for Managing Manure and Biogas Recovery Systems, 2008. Table IIf (original table has been expanded upon).

Table B.5a. 2010 Volatile Solid Default Values for Dairy Cows, Heifers, Heifers-Grazing and Cows-Grazing by State (kg/day/1000 kg mass)

State	VS Dairy Cow	VS Heifer	VS Heifer-Grazing	VS Cows-Grazing
Alabama	8.99	8.43	8.53	7.82
Alaska	7.98	8.43	9.98	8.89
Arizona	11.47	8.43	9.77	8.89
Arkansas	8.30	8.43	8.48	7.82
California	11.27	8.43	9.48	8.89
Colorado	11.54	8.43	9.27	8.89
Connecticut	10.22	8.43	8.62	7.87
Delaware	9.53	8.43	8.53	7.87
Florida	10.26	8.43	8.63	7.82
Georgia	10.03	8.43	8.49	7.82
Hawaii	8.43	8.43	9.77	8.89
Idaho	11.24	8.43	9.41	8.89
Illinois	10.19	8.43	7.78	7.47
Indiana	10.54	8.43	7.91	7.47
Iowa	10.67	8.43	7.64	7.47
Kansas	10.74	8.43	7.61	7.47
Kentucky	9.11	8.43	8.40	7.82
Louisiana	7.98	8.43	8.63	7.82
Maine	9.94	8.43	8.51	7.87
Maryland	10.00	8.43	8.51	7.87
Massachusetts	9.67	8.43	8.53	7.87
Michigan	11.42	8.43	7.83	7.47
Minnesota	10.25	8.43	7.83	7.47
Mississippi	8.59	8.43	8.53	7.82
Missouri	8.81	8.43	7.97	7.47
Montana	10.63	8.43	8.42	7.82
Nebraska	10.38	8.43	9.25	8.89
Nevada	11.08	8.43	8.01	7.47
New Hampshire	10.40	8.43	9.62	8.89
New Jersey	9.69	8.43	8.45	7.87
New Mexico	11.81	8.43	8.43	7.87
New York	10.69	8.43	9.50	8.89
North Carolina	10.54	8.43	8.61	7.87
North Dakota	9.92	8.43	8.31	7.82
Ohio	10.27	8.43	7.95	7.47
Oklahoma	9.59	8.43	7.90	7.47
Oregon	10.54	8.43	8.33	7.82
Pennsylvania	10.39	8.43	9.56	8.89
Rhode Island	9.76	8.43	8.66	7.87
South Carolina	10.02	8.43	8.61	7.87
South Dakota	10.59	8.43	8.19	7.82
Tennessee	9.56	8.43	8.12	7.47
Texas	10.87	8.43	8.21	7.82
Utah	10.86	8.43	8.42	7.82
Vermont	10.00	8.43	9.56	8.89
Virginia	10.09	8.43	8.52	7.87
Washington	11.50	8.43	8.25	7.82
West Virginia	9.15	8.43	9.73	8.89
Wisconsin	10.63	8.43	7.96	7.47
Wyoming	10.46	8.43	9.62	8.89

Source: Environmental Protection Agency (EPA). U.S. Inventory of GHG Sources and Sinks 1990-2010 (2012), Annex 3, Table A-192, page A-237.

Table B.5b. 2009 Volatile Solid Default Values for Dairy Cows, Heifers, Heifers-Grazing and Cows-Grazing by State (kg/day/1000 kg mass)

State	VS Dairy Cow	VS Heifer	VS Heifer-Grazing	VS Cows-Grazing
Alabama	9.13	8.42	8.61	7.90
Alaska	7.43	8.42	11.51	10.15
Arizona	11.35	8.42	11.23	10.15
Arkansas	8.24	8.42	8.53	7.87
California	10.97	8.42	8.13	7.70
Colorado	11.37	8.42	7.42	7.27
Connecticut	10.05	8.42	8.53	7.77
Delaware	9.54	8.42	8.29	7.77
Florida	10.08	8.42	8.71	7.90
Georgia	10.24	8.42	8.61	7.90
Hawaii	8.70	8.42	11.32	10.15
Idaho	11.07	8.42	10.86	10.15
Illinois	10.10	8.42	8.10	7.77
Indiana	10.48	8.42	8.20	7.77
Iowa	10.55	8.42	7.98	7.77
Kansas	10.77	8.42	7.38	7.27
Kentucky	8.91	8.42	8.52	7.90
Louisiana	8.01	8.42	8.68	7.87
Maine	9.86	8.42	8.43	7.77
Maryland	9.92	8.42	8.32	7.77
Massachusetts	9.71	8.42	8.43	7.77
Michigan	11.18	8.42	8.15	7.77
Minnesota	10.21	8.42	8.17	7.77
Mississippi	8.82	8.42	8.60	7.90
Missouri	8.83	8.42	8.33	7.77
Montana	10.42	8.42	7.83	7.27
Nebraska	10.36	8.42	7.42	7.27
Nevada	10.99	8.42	11.14	10.15
New Hampshire	10.30	8.42	8.37	7.77
New Jersey	9.81	8.42	8.34	7.77
New Mexico	11.74	8.42	11.06	10.15
New York	10.46	8.42	8.20	7.77
North Carolina	10.55	8.42	8.60	7.90
North Dakota	9.46	8.42	7.68	7.27
Ohio	10.06	8.42	8.28	7.77
Oklahoma	9.55	8.42	8.32	7.87
Oregon	10.36	8.42	11.03	10.15
Pennsylvania	10.25	8.42	8.20	7.77
Rhode Island	9.78	8.42	8.55	7.77
South Carolina	10.29	8.42	8.64	7.90
South Dakota	10.48	8.42	7.57	7.27
Tennessee	9.53	8.42	8.58	7.90
Texas	10.73	8.42	8.26	7.87
Utah	10.74	8.42	11.11	10.15
Vermont	9.93	8.42	8.23	7.77
Virginia	10.08	8.42	8.56	7.90
Washington	11.39	8.42	10.93	10.15
West Virginia	8.85	8.42	8.35	7.77
Wisconsin	10.46	8.42	8.33	7.77
Wyoming	10.08	8.42	7.72	7.27

Source: Environmental Protection Agency (EPA). U.S. Inventory of GHG Sources and Sinks 1990-2009 (2011), Annex 3, Table A-186, page A-225.

Table B.5c. 2008 Volatile Solid Default Values for Dairy Cows, Heifers, Heifers-Grazing and Cows-Grazing by State (kg/day/1000 kg mass)

State	VS Dairy Cow	VS Heifer	VS Heifer-Grazing	VS Cows-Grazing
Alabama	8.40	8.35	7.81	7.02
Alaska	7.30	8.35	10.05	9.02
Arizona	10.37	8.35	10.34	9.02
Arkansas	7.59	8.35	7.86	7.00
California	10.02	8.35	7.95	6.85
Colorado	10.25	8.35	7.69	6.46
Connecticut	9.22	8.35	7.67	6.90
Delaware	8.63	8.35	7.72	6.90
Florida	8.90	8.35	7.75	7.02
Georgia	9.07	8.35	7.85	7.02
Hawaii	7.00	8.35	10.26	9.02
Idaho	10.11	8.35	10.82	9.02
Illinois	9.07	8.35	8.07	6.91
Indiana	9.38	8.35	7.98	6.91
Iowa	9.46	8.35	8.27	6.91
Kansas	9.63	8.35	7.75	6.46
Kentucky	7.89	8.35	7.91	7.02
Louisiana	7.39	8.35	7.73	7.00
Maine	8.99	8.35	7.76	6.90
Maryland	9.02	8.35	7.76	6.90
Massachusetts	8.63	8.35	7.74	6.90
Michigan	10.05	8.35	7.99	6.91
Minnesota	9.17	8.35	8.04	6.91
Mississippi	8.19	8.35	7.82	7.02
Missouri	8.02	8.35	7.85	6.91
Montana	9.03	8.35	7.17	6.46
Nebraska	9.09	8.35	7.71	6.46
Nevada	9.65	8.35	10.49	9.02
New Hampshire	9.44	8.35	7.74	6.90
New Jersey	8.51	8.35	7.89	6.90
New Mexico	10.34	8.35	10.56	9.02
New York	9.42	8.35	8.02	6.90
North Carolina	9.38	8.35	7.83	7.02
North Dakota	8.40	8.35	7.43	6.46
Ohio	9.01	8.35	7.93	6.91
Oklahoma	8.58	8.35	8.08	7.00
Oregon	9.40	8.35	10.54	9.02
Pennsylvania	9.26	8.35	8.00	6.90
Rhode Island	8.94	8.35	7.60	6.90
South Carolina	9.05	8.35	7.81	7.02
South Dakota	9.45	8.35	7.50	6.46
Tennessee	8.60	8.35	7.86	7.02
Texas	9.51	8.35	8.21	7.00
Utah	9.70	8.35	10.51	9.02
Vermont	9.03	8.35	7.89	6.90
Virginia	9.02	8.35	7.87	7.02
Washington	10.36	8.35	10.77	9.02
West Virginia	8.13	8.35	7.74	6.90
Wisconsin	9.34	8.35	7.87	6.91
Wyoming	9.29	8.35	7.30	6.46

Source: Environmental Protection Agency (EPA). U.S. Inventory of GHG Sources and Sinks 1990-2008 (2010), Annex 3, Table A-181, page A-213.

For VS values for reporting years prior to 2008, please refer to the Livestock Project Protocol V3.0, Appendix B.

Table B.6. IPCC 2006 Methane Conversion Factors by Manure Management System Component/Methane Source 'S' [39]

MCF Values by Temperature for Manure Management Systems																				
	Average annual temperature (°C)																			
	Cool					Temperate											Warm			
System[a]	<10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	>28	Source and comments
Pasture/Range/Paddock	0.010					0.015											0.020			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Daily spread	0.001					0.005											0.010			Hashimoto and Steed (1993).
Solid storage	0.02					0.04											0.05			Judgment of IPCC Expert Group in combination with Amon et al. (2001), which shows emissions of approximately 2% in winter and 4% in summer. Warm climate is based on judgment of IPCC Expert Group and Amon et al. (1998).
Dry lot	0.010					0.015											0.020			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Liquid/slurry w/natural crust cover[40]	0.10	0.11	0.13	0.14	0.15	0.17	0.18	0.20	0.22	0.24	0.26	0.29	0.31	0.34	0.37	0.41	0.44	0.48	0.50	Judgment of IPCC Expert Group in combination with Mangino et al. (2001) and Sommer (2000). The estimated reduction due to the crust cover (40%) is an annual average value based on a limited data set and can be highly variable dependent on temperature, rainfall, and composition.
Liquid/slurry uncovered	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).
Uncovered anaerobic lagoon	0.66	0.68	0.70	0.71	0.73	0.74	0.75	0.76	0.77	0.77	0.78	0.78	0.78	0.79	0.79	0.79	0.79	0.80	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Uncovered lagoon MCFs vary based on several factors, including temperature, retention time, and loss of volatile solids from the system (through removal of lagoon effluent and/or solids).
Pit storage below animal confinements (<1 month)	0.03					0.03											0.03			Judgment of IPCC Expert Group in combination with Moller et al. (2004) and Zeeman (1994). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions.
Pit storage below animal confinements (>1 month)	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions.

[39] Adapted from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management, Table 10.17. MCF values shall be chosen based on the average temperature at the site for an entire calendar year, even if the reporting period does not exactly cover a calendar year.

[40] A "natural crust cover" is a naturally-forming layer that covers the majority of the liquid surface at a thickness sufficient to support communities of oxidizing bacteria, and which persists throughout the year. Evidence of such a cover (including the area covered, thickness, and persistence) must be provided by the project developer during verification in order to justify the use of this MCF value.

Anaerobic digester	0 - 1					0 - 1											0 - 1			Should be subdivided in different categories, considering amount of recovery of the biogas, flaring of the biogas and storage after digestion. Calculation with Formula 1.
Burned for fuel	0.10					0.10											0.10			Judgment of IPCC Expert Group in combination with Safley et al. (1992).
Cattle and swine deep bedding (<1 month)	0.03					0.03											0.30			Judgment of IPCC Expert Group in combination with Moller et al. (2004). Expect emissions to be similar, and possibly greater, than pit storage, depending on organic content and moisture content.
Cattle and swine deep bedding (>1 month)	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.90	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).
Composting - in-vessel or aerated static pile[b]	0.005					0.005											0.005			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are less than half of solid storage. Not temperature dependant.
Composting - passive or intensive windrow[b]	0.005					0.010											0.015			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are slightly less than solid storage. Less temperature dependant.
Aerobic treatment	0.00					0.00											0.00			MCFs are near zero. Aerobic treatment can result in the accumulation of sludge which may be treated in other systems. Sludge requires removal and has large VS values. It is important to identify the next management process for the sludge and estimate the emissions from that management process if significant.

[a] Definitions for manure management systems are provided in Table B.1.
[b] Composting is the biological oxidation of a solid waste, including manure, usually with bedding or another organic carbon source, typically at thermophilic temperatures produced by microbial heat production.

Table B.7. Biogas Destruction Efficiency Default Values by Destruction Device

If available, the official source tested methane destruction efficiency shall be used in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies, for each of the combustion devices used in the project case performed on an annual basis. Site-specific values must be provided by an independent air emissions testing body that is accredited by a state or local regulatory agency, or the Stack Testing Accreditation Council. Where a state/region does not have an appropriate accreditation system or accredited service providers, the project developer may look to another state/region to find suitably qualified service providers.

Biogas Destruction Device	Biogas Destruction Efficiency (BDE)*
Open Flare	0.96[2]
Enclosed Flare	0.995[2]
Lean-burn Internal Combustion Engine	0.936[2]
Rich-burn Internal Combustion Engine	0.995[2]
Boiler	0.98[2]
Microturbine or large gas turbine	0.995[2]
Upgrade and use of gas as CNG/LNG fuel	0.95[2]
Upgrade and injection into natural gas transmission and distribution pipeline	0.98[3]
Direct pipeline to an end-user	Per corresponding destruction device

Source:
[1] Seebold, J.G., et al., Reaction Efficiency of Industrial Flares, 2003
[2] The default destruction efficiencies for this source are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data are made available to the Reserve.
[3] The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH4/PJ, which is 0.8%. These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations.[41]

[41] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

Table B.8. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBTU / Short ton**	**kg C / MMBTU**		**kg CO_2 / MMBTU**	**kg CO_2 / Short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**BTU / Standard ft^3**	**kg C / MMBTU**		**kg CO_2 / MMBTU**	**kg CO_2 / Standard ft^3**
975 to 1,000 Btu / Standard ft^3	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Standard ft^3	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Standard ft^3	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Standard ft^3	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Standard ft^3	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Standard ft^3	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBTU / Barrel**	**kg C / MMBTU**		**kg CO_2 / MMBTU**	**kg CO_2 / gallon**
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2, and 4) (diesel)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 and 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401°F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401°F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable). Heat content factors are based on higher heating values (HHV).

Table B.9. Volatile Solids Removed Through Solids Separation[42]

Type of Solids Separation	Volatile Solids Removed (fraction)
Gravity	0.45
Mechanical:	
Stationary screen	0.17
Vibrating screen	0.15
Screw press	0.25
Centrifuge	0.50
Roller drum	0.25
Belt press/screen	0.50

Table B.10. Baseline Assumptions for Greenfield Projects[43]

Baseline Assumption	Dairy Cattle Operations		Swine Operations
	>200 Mature Dairy Cows	<200 Mature Dairy Cows	
Anaerobic manure storage system	Flush system into an anaerobic lagoon with >30 day retention time	Flush system into an anaerobic lagoon with >30 day retention time	Flush system into an anaerobic lagoon with >30 day retention time
Non-anaerobic manure storage system(s)	Solids storage	Solids Storage	Solids Storage
MS_L	90% lagoon 10% solids storage	50% lagoon 50% solids storage	95% lagoon 5% solids storage
Lagoon cleaning schedule	Annually, in September	Annually, in September	Annually, in September

[42] U.S.EPA National Pollutant Discharge Elimination System (NPDES) Development Document, Chapter 5, "Industry Subcategorization for Effluent Limitations Guidelines and Standards". Adapted from Moser et al. (1999).
[43] The simplified assumptions contained within this table are based on the waste management system data compiled by the U.S. Environmental Protection Agency for the development of Table A-194 in Annex 3 of the U.S. Inventory of GHG Sources and Sinks 1990-2010 (2012).

Appendix C Summary of Performance Standard Development

The analysis to establish a performance standard for the U.S. Livestock Project Protocol was undertaken by Science Applications International Corporation (SAIC) and independent consultant Kathryn Bickel Goldman. It took place at the end of 2006. The analysis culminated in a paper that provided a performance standard recommendation to support the Reserve's protocol development process, which the Reserve has incorporated into the protocol's eligibility rules (see Section 33). This analysis was re-visited during the development of Version 4.0 of the protocol and, although there was no recommended change to the performance standard, this appendix has been updated to reflect more recent data and analysis.

The purpose of a performance standard is to establish a threshold that is significantly better than average GHG production for a specified service, which, if met or exceeded by a project developer, satisfies the criterion of "additionality." This protocol focuses on the following direct emission reduction activity: avoiding methane emissions from the anaerobic storage and treatment of livestock manure. Therefore, in this case the methane emissions correspond to GHG production, and manure treatment/storage correspond to the specified service.

The analysis to establish the performance standard evaluated U.S.- and California-specific data on dairy and swine manure management systems. Ultimately, it recommended a practice-based/technology-specific GHG emissions performance standard – i.e. the installation of a manure digester (or Biogas Control System (BCS), more generally). The paper was composed of the following sections:

- The livestock industry in the U.S. and California
- Livestock manure management practices
- GHG emissions from livestock manure management
- Data on livestock manure management practices in the U.S. and California
- Current and anticipated regulations in California impacting manure management practices
- Recommendation for a performance threshold for livestock operations
- Considerations for baseline determinations

The initial analysis from that paper can be found in earlier versions of the U.S. Livestock Project Protocol Performance Standard Appendix.[44] In this updated Performance Standard Appendix, The additional, California-specific analysis showed adoption rates similar to the rest of the country, and thus has been removed from this document to reflect the Reserve's decision to apply the same performance standard to all operations across the United States. Beef facility and animal information has also been removed as beef operations are not currently eligible under the Protocol.

[44] Climate Action Reserve U.S. Livestock Project Protocol V1.0-3.0, Appendix C, http://www.climateactionreserve.org/how/protocols/us-livestock/

C.1 Analysis of Common Practice

C.1.1 U.S. Data on Manure Management Practices

For the initial performance standard analysis, data from the Draft EPA Climate Leaders Offset Protocol for Managing Manure with Biogas Recovery Systems (2006) were used to assess national-level manure management practices. That protocol relied on data describing farm distribution and manure management systems from the Manure Management portion of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2004 and used data on the number of farms by farm size and geographic location from the 2002 Census of Agriculture.[45]

Information compiled for the EPA's U.S. GHG Inventory also provided a breakdown of the assumed predominant manure management systems in use for dairy and swine operations. Table C.1 and Table C.3 show data compiled for the systems in place in 2006. Table C.2 and Table C.4 show the Reserve's approximate recreation of the same analysis using the most recently published numbers.[46]

Table C.1. Dairy and Swine Operations in the U.S. by Manure Management System (2006)

Animal	Number of Operations by Manure Management System						
	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	72,487	62	4,453	4,345	9,494	1,147	91,989
Swine	53,230	18	6,571	6,303	1,129	11,643	78,894

Source: U.S. EPA Climate Leaders Offset Protocol for Managing Manure with Biogas Recovery Systems (2008), Table I.A.

Table C.2. Dairy and Swine Operations in the U.S. by Manure Management System (2012)

Animal	Number of Operations by Manure Management System						
	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	56,075	185*	3,332	3,261	6,263	775	69,890
Swine	55,110	30	5,740	4,641	892	9,029	75,442

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture

* There are three systems in operation that digest both swine and dairy manure. For the purpose of this analysis they are considered as dairy.

[45] EPA GHG Inventory Reports in subsequent years (including 2010) still rely on the results of the 2002 Census for this data.

[46] The equivalent analysis based on the 2007 census is unavailable in the same format from the EPA Climate Leaders program. The Reserve performed a similar analysis using data for manure management from the Inventory of U.S. Greenhouse Gas Emissions and Sinks (2012), data on the prevalence of anaerobic digesters from the U.S. EPA's AgSTAR database (Sept. 2012), and data on the number of farms by farms size and geographic location from the 2007 Census of Agriculture, the results of which are Table C.2 and Table C.4. This analysis may not have been performed in precisely the same way as the EPA Climate Leaders Program analysis; however it serves the purpose of evaluating the current state of the dairy and swine manure management practices. The following classification assumptions were made: 1. digester projects associated with farms of size are classified by based on other information in the AgSTAR database, if available, or assumed to be in the medium size class; 2. farms employing anaerobic digesters are subtracted from the USDA counts based on "Baseline System" or other information in the AgSTAR database, if available. Where the "Baseline System" is categorized as "Storage Tank or Pond or Pit," the farm is assumed to belong in the "Liquid/Slurry" category for Dairy and the "Deep Pit" category for Swine.

The distribution of livestock across different sized operations can be an important criterion when developing a livestock manure management performance standard. There is a general relationship between manure management practices and operation size, where larger operations (in terms of livestock numbers) tend to use manure management systems that treat and store waste in liquid form (i.e. flush or scrape/slurry systems), particularly in dairy and swine operations.[47]

Table C.3. Dairy and Swine Operations by Size and Manure Management System (2006)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	320	48	1,614	675	245	-	2,902
	200-499	3,213	9	617	652	54	-	4,546
	1-199	6,8954	5	2,223	3,017	9,195	1,147	84,541
Swine	≥2000 head	-	14	2,581	1,084	297	2,774	6,749
	200-2000	-	3	3,990	5,219	832	8,869	18,913
	1-199	53,230	1	-	-	-	-	53,231

Source: U.S. 2002 Census of Agriculture.

Table C.4. Dairy and Swine Operations by Size and Manure Management System (2012)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	312	154	1,824	710	284	-	3,284
	200-499	3205	25	502	531	44	-	4,307
	1-199	52559	6	1,006	2,020	5,934	775	62,299
Swine	≥2000 head	-	26	3,182	1,295	358	3,345	8,206
	200-2000	-	3	2,557	3,347	534	5,685	12,125
	1-199	55,110	1	-	-	-	-	55,111

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture.

According to the Interim Draft Winter 2006 AgSTAR Digest used for the initial analysis, of 91,988 dairy and 78,894 swine farm operations in the United States, a total of 80 anaerobic digesters were in operation: 62 (0.07%) for dairy manure and 18 (0.02%) for swine manure.

Data were also disaggregated in the Climate Leaders protocol to determine whether digester installation was a common practice in any animal production operation size range. As was shown in Table C.3, even at large animal production operations, very few digester systems were in place. At dairy farms with ≥500 head, only 1.7% of manure management systems included digesters, and of swine farms with >2000 head, only 0.2% had digesters.

[47] U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2004 (and earlier editions), US Environmental Protection Agency, Report # 430-R-06-002, April 2006.

The most current information from the AgSTAR database (September 2012) shows that the number of anaerobic digesters in operation or under construction has nearly tripled at dairy farms and increased by more than 50% at swine farms. In terms of prevalence as a manure management practice across farms however, the practice remains the exception, rather than the rule. Currently there are 185 digesters at dairy farms (0.14%), and 30 at swine farms (0.03%). The number of digesters at the largest farms increased the most significantly, with 154 digesters at dairy farms with ≥500 head (4.69%), and 26 at swine operations with ≥2000 head (0.32%). Of the 185 dairy farms with anaerobic digesters in operation, 84 have participated in GHG offset programs; eight of the 30 swine farms with anaerobic digester have participated in GHG offset programs. Table C.5 shows the distribution and percentages of digesters in operation or under construction by size farm, compared to farms with other manure management practices; Table C.6 shows the same distribution, but does not include the digesters at farms participating in GHG offset programs.

The "natural" market penetration of anaerobic digesters on livestock facilities can be considered as the percentage of farms that choose this management option without the incentive provided by GHG offset programs. Table C.6 shows that the natural market penetration of anaerobic digesters on dairy and swine facilities in the U.S. remains very low. The highest rate of adoption is among dairy farms with ≥500 head, at 2.31%. However, this number conservatively includes anaerobic digestion facilities that are currently under construction. As many if not all of these facilities may actually be installed in response to GHG offset programs (which is often not known until they are operational and become publicly listed in one of these programs), even this small rate of adoption is likely to be overestimated by this analysis. If the anaerobic digesters that are under construction are all assumed to be GHG offset projects, then the natural market penetration of anaerobic digesters on dairy facilities of ≥ 500 head drops to 1.71%.

Table C.5. Dairy and Swine Operations by Size and Manure Management System (2012)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	312 9.49%	154 4.69%	1,824 55.53%	710 21.63%	284 8.66%	- -	3,284
	200-499	3,205 74.41%	25 0.58%	502 11.66%	531 12.32%	44 1.03%	- -	4,307
	1-199	52,559 84.37%	6 0.01%	1,006 1.61%	2,020 3.24%	5,934 9.52%	775 1.24%	62,299
	Total	56,075 80.23%	185 0.26%	3,332 4.77%	3,261 4.67%	6,263 8.96%	775 1.11%	69,890
Swine	≥2000 head	- -	26 0.32%	3,182 38.78%	1,295 15.78%	358 4.37%	3,345 40.76%	8,206
	200-1999	- -	3 0.02%	2,557 21.09%	3,347 27.60%	534 4.40%	5,685 46.88%	12,125
	1-199	55,110 99.998%	1 0.002%	- -	- -	- -	- -	55,111
	Total	55,110 73.05%	30 0.04%	5,740 7.61%	4,641 6.15%	892 1.18%	9,029 11.97%	75,442

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture.

Table C.6. Dairy and Swine Operations by Size and Manure Management System (2012)
Not including those participating in a GHG offset program.

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	**P/R/P**	**Anaerobic Digester**	**Lagoon**	**Liquid/ Slurry**	**Solid Storage**	**Deep Pit**	**Total**
Dairy	≥500 head	312 *9.73%*	74 *2.31%*	1,824 *56.91%*	710 *22.17%*	284 *8.88%*	- -	3,204
	200-499	3,205 *74.47%*	21 *0.49%*	502 *11.67%*	531 *12.33%*	44 *1.03%*	- -	4,303
	1-199	52,559 *84.37%*	6 *0.01%*	1,006 *1.61%*	2,020 *3.24%*	5,934 *9.52%*	775 *1.24%*	62,299
	Total	56,075 *80.33%*	101 *0.14%*	3,332 *4.77%*	3,261 *4.67%*	6,263 *8.97%*	775 *1.11%*	69,806
Swine	≥2000 head	- -	19 *0.23%*	3,182 *38.81%*	1,295 *15.79%*	358 *4.37%*	3,345 *40.80%*	8,199
	200-1999	- -	2 *0.02%*	2,557 *21.09%*	3,347 *27.60%*	534 *4.40%*	5,685 *46.89%*	12,124
	1-199	55,110 *99.998%*	1 *0.002%*	- -	- -	- -	- -	55,111
	Total	55,110 *73.06%*	22 *0.03%*	5,740 *7.61%*	4,641 *6.15%*	892 *1.18%*	9,029 *11.97%*	75,434

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture, open GHG offset program registries.

Finally, as anaerobic digesters are most likely to be installed on livestock facilities that already utilize liquid-based manure management systems, it is useful to examine the market penetration among only these facilities. Table C.7 shows that, among the total facilities utilizing liquid manure management systems, the natural market penetration of anaerobic digesters is 1.35% for dairy farms and 0.11% for swine farms.[48] The highest rate, seen among dairy farms of ≥500 head, is 2.84%. This continues to be an extremely low rate of adoption for anaerobic digestion technology.

[48] There is seemingly 100% market penetration on swine farms with <200 animals, due to the fact that there was only one farm in the dataset utilizing liquid manure management, and it also had an anaerobic digester. A greater trend of adoption of anaerobic digestion cannot be drawn from this single farm.

Table C.7. Dairy and Swine Operations Utilizing Liquid Manure Management, by Size and Manure Management System (2012)

Not including those participating in a GHG offset program.

Animal	Number of Operations by Farm Size Using Anaerobic Manure Management (Excluding GHG Offsets)			
	Farm Size	Anaerobic Digester	Liquid Manure Management	Total
Dairy	≥500 head	74 *2.84%*	2,534 *97.16%*	2,608
	200-499	21 *1.99%*	1,033 *98.01%*	1,054
	1-199	6 *0.16%*	3,800 *99.84%*	3,806
	Total	101 *1.35%*	7,367 *98.65%*	7,468
Swine	≥2000 head	19 *0.24%*	7,822 *99.76%*	7,841
	200-1999	2 *0.02%*	11,589 *99.98%*	11,591
	1-199	1 *100.00%*	- -	1
	Total	22 *0.11%*	19,410 *99.89%*	19,432

C.1.2 U.S. and State Manure Management Regulations

As a part of the Reserve's protocol management, regulatory developments are tracked through, among other outreach and research activities, reporting on regulatory requirements by project developers and verification bodies in the verification process. Of the farms with an anaerobic digester that have participated in GHG offset projects documented in EPA's AgSTAR program, 65 have listed their projects under the Reserve's U.S. Livestock Project Protocol. Twenty-seven projects have been registered with the Reserve, i.e., successfully undergone the verification process. This includes projects in four of the five top dairy producing states, namely, California, Wisconsin, Texas and Idaho. In states where registered Reserve projects are located, no state or federal regulations have been found that would require the use of a BCS.

C.2 Performance Standard Recommendation

The original SAIC report recommended that a performance standard apply to the control of methane emissions from dairy and swine livestock operations in the U.S. and California. In particular, the performance standard should be a technology-specific threshold that dairy or swine operators would meet. The recommended threshold would be the installation of a BCS (e.g. an anaerobic digester).

The report found that even under favorable conditions digesters were found on less than 1% of the dairies in California, which was found to be representative of the U.S. market; and that if a dairy operator chose to install a digester then the farmer would be managing waste in the 99th percentile. This constitutes above and beyond common practice. The report also found that the main barrier inhibiting the installation and use of digesters was cost. Cost studies performed by EPA's AgSTAR program and the California Electricity Commission indicated that significant subsidies and/or incentives were needed to encourage additional digester installations.

The Reserve adopted this performance standard recommendation based on the data available at the time of the SAIC report. While the number of anaerobic digesters has increased significantly, the market penetration of BCS technology remains quite low, especially among those farms which are not receiving revenues from GHG offset markets. Today a dairy operator who chooses to install a digester would be managing waste in the 98th percentile—a modest increase since the original analysis, but hardly a significant shift in common practice. Furthermore, cost continues to inhibit wider adoption of BCS technologies according to a recent EPA report on the status of anaerobic digester adoption.[49] In light of these facts, the Reserve will not alter the current performance standard, but will continue to monitor market developments in the future.

C.3 Renewable Energy Credits and Other Revenue Opportunities for Biogas-to-Energy Projects

Along with carbon credits, there are opportunities for farms installing digesters to earn additional revenues from a variety of sources that support renewable energy generation. These include loans and grants for developing biogas-to-energy projects and the sale of Renewable Energy Certificates (RECs) for use in a renewable portfolio standard (RPS) or a renewable portfolio goal (RPG)[50].

When considering additionality and the ability to generate RECs and CRTs from a livestock project, it is important to remember that the REC and CRT are created by two different but related activities. The REC is awarded for generating renewable electricity from the biogas collected by the BCS, whereas the CRT is awarded for the climate benefit created by the conversion of CH_4 in the biogas into CO_2 through combustion of the biogas. Under this protocol, projects are not required to generate electricity with collected biogas or send it to a natural gas pipeline. Rather, they are only required to destroy the biogas. So while a project may generate renewable electricity with its biogas, renewable energy generation is not an activity required or credited under this protocol.

As there are a number of active RPS, RPG and voluntary REC programs nationwide, the availability of revenue from the sales of RECs is inherently represented in the data analyzed to set the performance standard. Since this analysis shows that the installation of a digester is not common practice at dairy and swine farms, the Reserve does not limit a project's ability to generate or sell RECs. Due to the numerous barriers to implementation of an anaerobic digester project, their success typically relies on a complex array of factors, including multiple incentive program. Renewable energy incentives alone have not significantly increased the natural market penetration of these projects.

When considering additionality and the availability of public dollars to support the development of biogas-to-energy projects, the Reserve has identified numerous state and local programs to support such projects through grants, loans and payments. Although the Reserve's performance standard tests do not require individual project assessments of financial viability or returns, they are designed to reflect these factors in determining which projects are additional. Even with the funds available, the installation of anaerobic digesters according to this protocol is still very rare. Thus, even if a project does receive a grant or loan to support the generation of renewable

[49] U.S. Anaerobic Digester Status Report, October 2010, http://www.epa.gov/agstar/documents/digester_status_report2010.pdf

[50] Whereas compliance with an RPS is mandatory, RPGs set voluntary compliance targets.

energy from a biogas project, the performance standard and rules set forth in this protocol should ensure the additionality of the CRTs generated.

Beyond grants and loans for biogas-to-energy projects, there are two nationwide payment programs administered by USDA Natural Resource Conservation Service (NRCS) that support the installation of anaerobic digesters. Authorized by the 2008 Farm Bill, the Environmental Quality Incentives Program (EQIP), and the Chesapeake Bay Watershed Initiative (CBWI) are programs that provide payments to support the installation of a BCS and are implemented at the state- and county-level. NRCS expressly allows the sale of environmental credits from enrolled lands,[51] but does not provide any additional guidance on ensuring the environmental benefit of any mitigation payment stacked with an NRCS payment.

All NRCS programs share a common set of conservation practice standards that contain information on why and where the practice is to be applied, and set forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s).

NRCS Conservation Practice Standard 366 – *Anaerobic Digester* (CPS 366) provides assistance to farmers for the treatment of manure and other byproducts of animal agricultural operations for one or more of the following reasons: to capture biogas for energy production, to manage odors, to reduce the net effect of greenhouse gas emissions, or to reduce pathogens.[52]

Data obtained from NRCS show that less than 0.3% of farms eligible for funding under CPS 366 (i.e., farms with anaerobic operations) have received NRCS funds to install a BCS.[53] In practice, only 9% of the farms that installed BCS since 2004 have received NRCS funds. Because the installation of anaerobic digesters is expensive, uncommon and generally not already funded by NRCS programs, the use of NRCS payments to help finance project activity is allowed under this protocol.

[51] EQIP, 7 CFR §1466.36; CSP, 7 CFR §1470.37.
[52] Natural Resources Conservation Service. (September 2009). Conservation Practice Standard, Anaerobic Digester, Code 366. State-specific conservation practice standards can be downloaded from http://efotg.sc.egov.usda.gov//efotg_locator.aspx.
[53] Based on 2004-2011 data obtained from NRCS Resource Economics, Analysis and Policy Division through personal communication.

Appendix D Data Substitution

This appendix provides guidance on calculating emission reductions when data integrity has been compromised either due to missing data points or a failed calibration. No data substitution is permissible for the operational status of destruction devices. Rather, the methodologies presented below are to be used only for the methane concentration and flow metering parameters. If operational data are missing for a destruction device, then the device shall be assumed to have been inoperable, and will be assigned a destruction efficiency of zero for that period.

D.1 Missing Data

The Reserve expects that projects will have continuous, uninterrupted data for the entire verification period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously. If data are missing for both parameters, no reductions can be credited.

Further, substitution may only occur when the following is true:

1. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
2. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology maybe applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours immediately before and following the outage
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness
Greater than one week	No data may be substituted and no credits may be generated

Note: It is conservative to use the upper confidence limit when calculating emissions from the BCS (Equation 5.6); however it is conservative to use the lower confidence limit when calculating the total amount of methane that is destroyed in the BCS Equation 5.10.

For periods when it is not possible to use data substitution to fill data gaps, no emission reductions may be claimed. The methane flow volume for these days shall be zero, and the number of reporting days for that month shall be reduced to exclude the days of missing data. This guidance is not to be used for venting events.

Appendix E Development of the B_0 Sampling and Analysis Methodology

With the release of Livestock Protocol Version 4.0, the Reserve has adopted a novel methodology for the sampling and analysis of livestock manure to determine maximum methane potential. In all previous versions of the protocol, the value of this term was defined by the default options provided in Table B.3, which were themselves sourced from the EPA Climate Leaders Draft Manure Offset Protocol. Other than a change in the value of the default for Dairy Cows with Version 2.1 from a "low roughage" value to a "high roughage" value, these default values have not changed since the first version of the protocol was adopted. Reserve staff have received feedback from stakeholders that in many cases, the default value for a particular animal category, especially Dairy Cows, is excessively conservative. Based on this feedback, the Reserve initiated a process to explore the options for updating the default values for maximum methane potential (B_0). After review of existing methodologies and literature related to manure methane potential, the Reserve determined that there is currently not a clear basis for establishing different default values. However, direct sampling and analysis were identified as an option that could be immediately provided as an alternative to the existing default values.

In 2009 the Reserve adopted the Organic Waste Digestion project protocol (updated to Version 2.0 in 2011). This protocol introduced a procedure for the determination of site-specific B_0 value for organic wastewater streams (OWD V2.0, Section 6.1.3.2). These requirements formed the basis for the development of a sampling and analysis procedure for livestock projects.

In early September, 2012, the Reserve solicited stakeholder interest for participation in the development process for this new methodology. A diverse group of 36 stakeholders representing carbon project developers, academia, government, livestock industry, GHG verification bodies, and others, responded to this request. These stakeholders then received a memorandum detailing the proposed methodology and were invited to a webinar on September 19, 2012 to provide feedback and engage in discussion. 22 individuals participated in the webinar discussion, providing a great deal of feedback and suggestions for improvement.

In addition to the public stakeholder consultation, Reserve staff worked directly with experts in industry and academia to further refine the methodology. The goal was to identify a sampling and testing regime that could consistently provide accurate estimates of the B_0 value of different manure streams, and that would be reasonably practical for implementation. The major considerations and decisions are addressed below.

Sampling Schedule

The sampling procedure requires that six samples be taken at regular intervals throughout the day. These individual samples are then combined into one composite sample to represent that event. The sampling procedure in the OWD protocol calls for 10 samples spaced out over at least one week. In consultation with expert stakeholders, it was determined that livestock manure will be less variable over such short timescales, and that the collection of multiple samples in a single day would be sufficient to control for sample variability and error. A more onerous sampling requirement would introduce additional resourcing requirements and costs disproportionate to any reduction in uncertainty/error.

The procedure also requires that the sampling event take place between the months of August through November (inclusive). The Reserve has limited the applicability of this procedure to dairy facilities, and expects that it will mainly be used for the determination of a site-specific B_0

for dairy cows. Thus, the timing of the sampling procedure is designed to avoid overestimating the B_0 value for this particular livestock category. Academic experts advised the Reserve that the methane generating potential of dairy cow manure tends to be positively correlated with milk production.[54] To ensure that the average B_0 value for the year is not overestimated, it is appropriate to avoid sampling the manure during periods of above-average milk production. Reserve staff used data from the National Agricultural Statistics Service[55] to examine monthly milk production trends. For the years 1998-2011, the milk production for each month (in lb/head) was compared to the average monthly milk production for that year. This process highlighted the months with above or below-average milk production, while controlling for the overall trend of increasing milk production year-over-year. Figure E.1 shows the results of this analysis and the consistent pattern of milk production during this 14 year period.

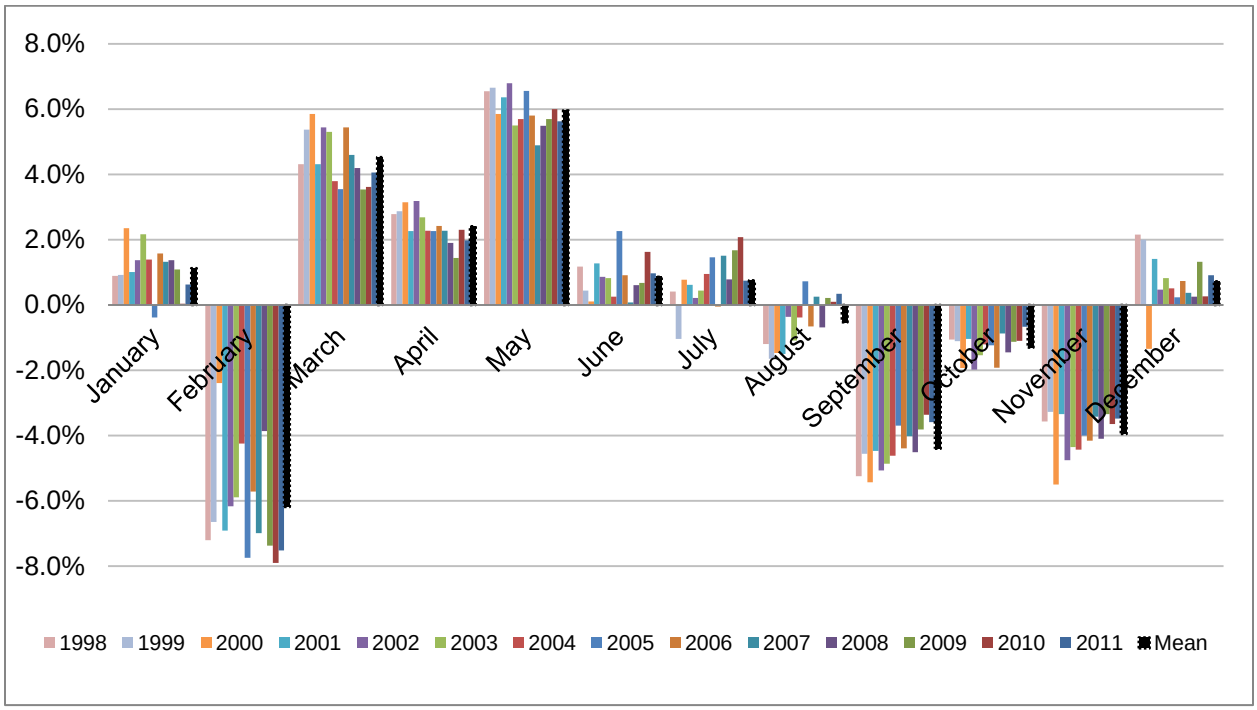


Figure E.1. Monthly Milk Production Trends as a Percent Change Over Annual Average Monthly Milk Production (1998-2011)

Based on this analysis the Reserve has limited the sampling period to August through November. These months consistently exhibit average- to below-average milk production, which should result in a conservative estimate of the annual average B_0 value.

Sample Source

The procedure instructs the user to obtain a manure sample that represents only a single animal category, prior to mixing with other residues (except for flush water in the case of flush systems). While certain stakeholders indicated through public comment that they would prefer to sample the entire waste stream as it enters the digester, there are two main reasons why this requirement was not amended:

[54] In the future, it may be possible to develop a default methane potential that is based directly on monthly milk production, though additional research is needed.
[55] Accessed from the USDA website at http://quickstats.nass.usda.gov/.

1. The waste stream entering the digester may contain ineligible materials which, while permitted to be processed by the project BCS, should not be represented in the quantification of baseline emissions.
2. The baseline quantification model is run on a monthly basis, using the actual animal population figures for that month. The relative populations of different animal categories may change during the year, resulting in an overall B_0 value for the manure from that facility that is variable through time. To use a composite B_0 value, representative of multiple animal categories, would create quantification inaccuracies if relative populations change from one month to the next (see Table E.1).

Table E.1. Effects of Relative Population Size on Composite B_0 Value

Animal Category	B_0 Value	Population in Month 1	Population in Month 2	Population in Month 3
Dairy Cows	0.24	2,000	800	3,000
Heifers	0.17	500	2,000	200
Calves	0.17	500	1,200	0
	Composite B_0 Value	***0.22***	***0.18***	***0.24***

There is an additional step for dairies that utilize a flush system for manure management, as the flush water is typically composed of some type of wastewater, which could have a significant methane potential. For these systems it is necessary to also sample the flush water inlet point prior to mixing with the manure, so that the methane potential of the flush water can then be subtracted from the methane potential of the sample.

Laboratory Analysis

The Reserve undertook research to determine whether standard procedures/processes existed for the professional analysis of B_0 potential. This research revealed that while there is currently no standard laboratory certification scheme within the US pertaining to this type of analysis, there are commonly-accepted methods for undertaking the relevant biochemical methane potential (BMP) analysis itself. The requirements to document a laboratory's experience and standard operating procedures were introduced to ensure rigor and consistency among testing bodies.

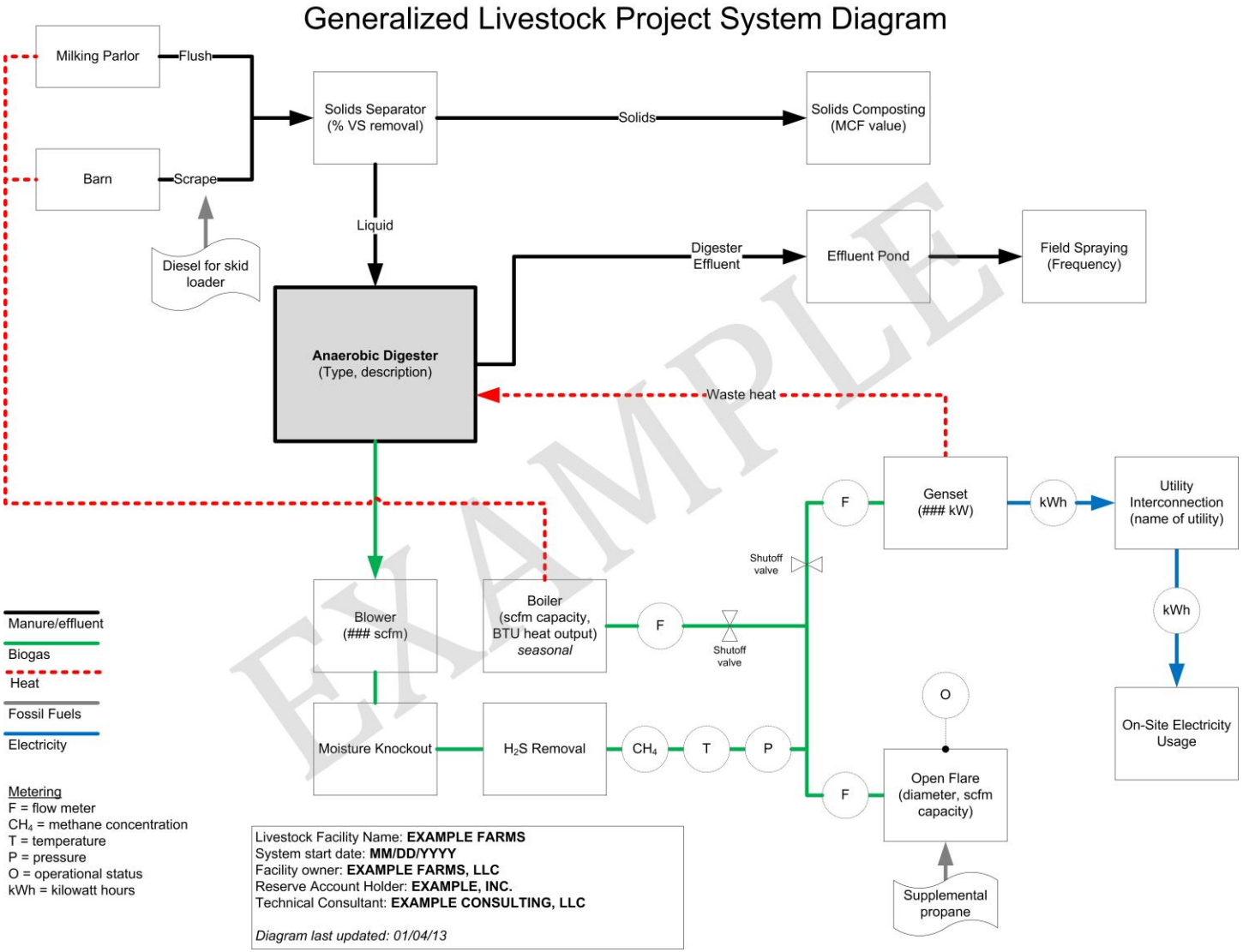
The Reserve consulted with commercial and university testing laboratories regarding the requirements for the biochemical methane potential (BMP) assay. The resulting requirements closely resemble the standard procedures of existing laboratories. It is necessary for the protocol to prescribe at least basic parameters for the BMP assay in order to ensure consistency among projects that hire different laboratories. The inclusion of a control assay was suggested by multiple laboratories as an important quality check on the viability of the seed inoculum that is used for the BMP assay.

Stakeholder Participation

The Reserve would like to thank the following stakeholders, in addition to others not listed here, for their participation in the research and development of this methodology.

David Belcher	Camco
Michael Carim	First Environment, Inc.
Dr. Craig Frear	Washington State University
Noel Gurwick	Smithsonian Environmental Research Center
Karen Haugen-Kozyra	The Prasino Group
Cortney Itle	Eastern Research Group, Inc.
Dr. Xiaomei Li	XY Green Carbon
Dr. John H. Martin, Jr.	Hall Associates
Carl Morris	Joseph Gallo Farms
Dr. Scott Subler	Environmental Credit Corp.
Peter Weisberg	The Climate Trust

Appendix F Sample Livestock Project Diagram



U.S. Livestock Project Protocol
Version 4.0
ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its U.S. Livestock Project Protocol Version 4.0 (LSPP V4.0) in January 2013. While the Reserve intends for the LSPP V4.0 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the LSPP V4.0.[1]

Per the Reserve's Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered livestock projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the protocol.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact Policy at policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Climate Action Reserve Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications are contained in this single document.

Errata and Clarifications (arranged by protocol section)

Section 3

1. Regulatory Compliance at Centralized Digesters (CLARIFICATION – July 21, 2016) 3

Section 5

2. Accounting for Methane Emissions during Temporary Project Shutdown (CLARIFICATION – October 29, 2013) 3
3. Service Providers for Site-Specific Destruction Efficiency Testing (CLARIFICATION – January 21, 2014) 4

Section 6

4. Monitoring Operational Status (CLARIFICATION – October 29, 2013) 5
5. Meter Field Check Procedures (CLARIFICATION – October 29, 2013) 5
6. Methane Analyzer Factory Calibrations (CLARIFICATION – November 16, 2017)..... 6

Appendix D

7. Data Substitution when Operational Data are Missing (ERRATUM – October 29, 2013).. 6
8. Data Substitution for Continuous Methane Data (CLARIFICATION – October 29, 2013) . 7

Section 3

1. Regulatory Compliance at Centralized Digesters (CLARIFICATION – July 21, 2016)

Section: 3.6 (Regulatory Compliance)

Context: This section states that, where a verifier determines that project activities have caused a material violation, no CRTs will be issued during the period(s) when the violation occurred. The guidance in this section does not specify how to address regulatory compliance for projects where manure is received from multiple farms and managed in a centralized BCS.

It is unclear whether a violation with respect to one manure source facility would jeopardize the ability of the project to receive credit from emission reductions related to manure from other source facilities. It may be possible for an offset project at a centralized digester to have CRTs issued to it for manure from compliant manure source facilities during a period of time when one or more manure source facilities are materially noncompliant with a regulation.

Clarification: The following text shall be inserted on page 7, at the end of Section 3.6:

"With respect to projects that accept and manage manure from multiple, discrete source facilities (separate from the project BCS in both physical location and management), it may be possible for a project developer to demonstrate that a regulatory violation at one source facility does not affect the eligibility of the entire project under this section. Project developers should contact the Reserve to discuss potential regulatory non-compliance issues."

Section 5

2. Accounting for Methane Emissions during Temporary Project Shutdown (CLARIFICATION – October 29, 2013)

Section: 5.3 (Calculating Project Methane Emissions)

Context: The last full paragraph on page 24 reads: "Although not common under normal digester operation, it is possible that a venting event may occur due to catastrophic failure of digester cover materials, the digester vessel, or the gas collection system. In the event that a catastrophic system failure results in the venting of biogas, the quantity of methane released to the atmosphere shall be estimated according to Equation 5.7 below."

Equation 5.7 on page 26 provides guidance for calculating the quantity of methane released during a venting event, which is added to the total Project Methane Emissions from the BCS, as calculated in Equation 5.6. Equation 5.7 accounts for two releases of biogas: the initial release of biogas being stored in the digester, and then the daily release of additional gas that is generated in the digester until the gas collection system is functional.

The intent of the current guidance is to account for situations where the project digester continues to receive and treat manure, but the gas collection system is discovered to be compromised. In situations where the project digester has been shut down for longer periods of

time, biogas is typically released from the digester and then project manure directed to an anaerobic system (e.g. either the covers are taken off the digester or manure is diverted to open lagoons) that would meet the definition in Section 3.4. During such longer shutdowns, it has not been clear whether this entire period of time should be considered a venting event and, if so, how quantification of emissions should proceed.

Clarification: The following text shall be inserted between Equation 5.7 and Equation 5.8 on page 26:

"A venting event occurs when the project digester continues to process manure, but biogas is vented directly to the atmosphere (e.g. through a rip in a lagoon cover or a broken pipe). Projects that experience a venting event shall continue to use Equation 5.7 to calculate the resulting project methane emissions.

A project shutdown occurs when the project digester is no longer functional. This occurs when the project reverts to an open, uncontrolled, anaerobic manure treatment system (e.g. the manure is redirected to open, anaerobic lagoons, or the cover is completely removed from a covered lagoon digester and no heating or mixing occurs). A project shutdown is defined as a venting event on the day of the shutdown, and then a cessation of project operations until the BCS is once again operable.

In the case where the project BCS is shut down and the manure is treated in an open, uncontrolled, anaerobic system (meeting the definition in Section 3.4), the project scenario shall be assumed to be equal to the baseline scenario. In this case the project must quantify the release of stored biogas (MS_{BCS} in Equation 5.7) at the time that the system is shut down, but not the subsequent daily release of biogas from the open lagoons. In these situations the project will cease quantification of emission reductions until the BCS is once again operational."

3. Service Providers for Site-Specific Destruction Efficiency Testing (CLARIFICATION – January 21, 2014)

Section: 5.3 (Calculating Project Methane Emissions)

Context: Footnote 19 on page 25 provides guidelines for service provider accreditation. It is not clear what specific options are available and permissible for projects located in a state or locality which does not have an accreditation program for source test service providers. Footnote 26 on page 29 and the first full paragraph on page 69 in Appendix B contain similar language.

Clarification: The intent of this requirement is to ensure that any source testing conducted for the determination of a site-specific value for methane destruction efficiency is of a quality that would be acceptable for compliance by a regulatory body. The following text shall replace the last sentence of footnote 19 on page 25, of footnote 26 on page 29, and of the first full paragraph on page 69 of Appendix B:

> "If neither the state nor locality relevant to the project site offer accreditation for source testing service providers, projects may use an accredited service provider from another U.S. state or domestic locality. Alternatively, projects may choose a non-accredited service provider, under the following conditions: 1) the service provider must provide verifiable evidence of prior testing which was accepted for compliance by a domestic regulatory agency, and 2) the prior testing procedures must be substantially similar to

the procedures used for determining methane destruction efficiency for the project destruction device(s)."

Section 6

4. Monitoring Operational Status (CLARIFICATION – October 29, 2013)

Section: 6.2 (Biogas Control System Monitoring Requirements)

Context: The first and second paragraphs of page 35 in Section 6.2 states that "[o]perational activity of the destruction devices shall be monitored and documented at least hourly to ensure actual methane destruction. … If for any reason the destruction device or the operational monitoring equipment…is inoperable, then all metered biogas going to the particular device shall be assumed to be released to atmosphere…[and] the destruction efficiency of the device must be assumed to be zero."

Certain types of destruction devices, such as internal combustion engines and most large boiler systems, are designed in such a way that gas may not flow through the device if it is not operational. It has not been clear how the requirements of Section 6.2 apply to these devices.

Clarification: The first sentence of the first paragraph on page 35 shall be read to apply to all destruction devices in use during the reporting period. The paragraph on page 34 of Section 6.2 starting, "[a] single flow meter may be used…," shall not be construed to relax the requirement for hourly operational data for all destruction devices. Rather, that paragraph is allowing a specific metering arrangement during periods when one or more devices are known to be not operating. All destruction devices must have their operational status monitored and recorded at least hourly. If these data are missing or never recorded for a particular device, that device will be assumed to be not operating and will be assigned a destruction efficiency of zero for all flow data that are assigned to that device.

5. Meter Field Check Procedures (CLARIFICATION – October 29, 2013)

Section: 6.3 (Biogas Measurement Instrument QA/QC)

Context: The second paragraph below the first bulleted list of page 36 in Section 6.3 states that "[i]f the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment…"

Certain types of biogas flow meters and methane analyzers are susceptible to measurement drift due to buildup of moisture or contaminants on the metering sensor, even if the equipment itself is not out of calibration. If the as-found condition of the meter is outside of the accuracy threshold, but the as-left condition (after cleaning) is within the accuracy threshold, it is not clear whether a full calibration is still required for this piece of equipment. In some cases the manufacturer provides specific guidance to this effect.

Clarification: The following text shall be inserted after the second paragraph following the bulleted list on page 36:

"The as-found condition (percent drift) of a field check must always be recorded. If the meter is found to be measuring outside of the +/- 5% threshold for accuracy, the data must be adjusted for the period beginning with the last successful field check or calibration event up until the meter is confirmed to be in calibration. If, at the time of the failed field check, the meter is cleaned and checked again, with the as-left condition found to be within the accuracy threshold, a full calibration is not required for that piece of equipment. This shall be considered a failed field check, followed by a successful field check. The data adjustment shall be based on the percent drift recorded at the time of the failed field check. However, if the as-left condition remains outside of the +/- 5% accuracy threshold, calibration is required by the manufacturer or a certified service provider for that piece of equipment."

6. Methane Analyzer Factory Calibrations (CLARIFICATION – November 16, 2017)

Section: 6.3 (Biogas Measurement Instrument QA/QC)

Context: The fourth bullet in the list at the beginning of this section (page 36) states that "[all gas flow meters and continuous methane analyzers must be] calibrated by the manufacturer or a certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent."

The principle underlying this requirement is the need to ensure data integrity. More specifically, the intent of this requirement is that meters meet such requirement every time they are used to gather data that is used in project emission reduction quantification. If a meter was out of conformance with this calibration requirement during a portion of the reporting period when it is not in use, but is brought back into conformance with this requirement before again being used to gather data which is used for project emission reduction calculations, then the underlying intent of this requirement is met.

Clarification: The following text shall be inserted after the fourth bulleted point at the beginning of Section 6.3:

"Conformance with this requirement is only required during periods of time where data gathered by the meter are used for emission reduction quantification. Periods where the meter did not meet this requirement will not cause the project to fail this requirement, provided the meter was not being used for project emission reduction quantification during such periods, and provided the meter was brought back into conformance before being employed to gather data which is used for project emission reduction quantification."

Appendix D

7. Data Substitution when Operational Data are Missing (ERRATUM – October 29, 2013)

Section: Appendix D (Data Substitution)

Context: There are three parameters necessary for the quantification of biogas destruction: biogas flow volume, methane concentration, and operational status of the destruction device. Section D.1 on page 80 provides a methodology for the substitution of missing biogas flow or methane concentration data. Data on the operational status of a destruction device are not eligible for substitution. Substitution of one parameter (i.e. flow or concentration) is only allowed if both other parameters are successfully recorded during the data gap. Thus, to employ the data substitution methodology, it is required that the record of operational status be intact during the gap.

This data substitution methodology was originally developed to resolve incidents of missing methane destruction data in landfill gas projects. Under that project type, excluding the data gap entirely is equivalent to the use of a destruction efficiency (DE) value of zero, whereas the same is not true for a livestock project. In the case of the Livestock Project Protocol, there is additional guidance on page 35 of Section 6.2 that requires the use of a DE value of zero for periods where the destruction device is inoperable, or the operational data are missing. This procedure effectively provides substitution of missing operational data with the assumption that the device was inoperable during the data gap. The effect of this substitution is an increase in project emissions, resulting in a more conservative estimate of emission reductions, regardless of whether the ultimate estimate of emission reductions is based on the modeled baseline or the metered methane destruction.

Because of the nature of the quantification methodology for livestock projects, and the ways that it differs from that of landfill projects, it is appropriate and conservative to carry out flow or methane data substitution, even if the destruction device is inoperable. Under this protocol, the quantification of emission reductions will be more conservative than if the data substitution were not employed.

Correction: The guidance on page 35 of Section 6.2 shall supersede the guidance in Appendix D. The following text shall be inserted after the second paragraph of Section D.1 in Appendix D:

"If the destruction device is inoperable, or its operational data are missing, the destruction efficiency for the device shall be zero during that period of time. Data substitution may be employed for missing biogas flow or methane concentration data during periods of missing operational data, provided the dataset is able to fulfill all other requirements of this data substitution methodology. The data substitution methodology shall be employed in the manner resulting in the greatest level of conservativeness for the quantification of emission reductions."

8. Data Substitution for Continuous Methane Data (CLARIFICATION – October 29, 2013)

Section: Appendix D (Data Substitution)

Context: The data substitution methodology in Appendix D may not be used for data gaps that are greater than seven days. However, the minimum measurement frequency for methane concentration data is once per quarter (three months). For projects that measure methane concentration at a frequency that is greater than quarterly, it is not clear how methane values should be applied during gaps of more than one week but less than an entire quarter.

Clarification: As long as a livestock project has at least one methane concentration reading per quarter, the project may satisfy the monitoring requirements in Section 6.2. A livestock project may have gaps between methane concentration readings that are greater than one week

without this being considered “missing data” as it is conceived in Appendix D. Thus, project developers may devise a reasonable approach by which to assign a value to periods of time between recorded methane concentration values. The verifier shall confirm that the value(s) applied by the project is reasonable and conservative. No data substitution may be applied if there are no methane concentration readings during an entire quarter.

CLIMATE FORWARD

PROGRAM MANUAL

March 2, 2020

A program of the

CLIMATE ACTION RESERVE

NOTE TO USERS:

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Climate Forward, a program of the Climate Action Reserve
www.climateforward.org

Released March 2, 2020

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
1.1 Climate Forward 2
1.2 Program Objectives 4
1.3 Use of Forecasted Mitigation Units 5
1.3.1 For Voluntary Use 6
1.3.2 Under the California Environmental Quality Act (CEQA) 6
1.3.3 Recommended Best Practices for the Use of FMUs 6
1.4 Programmatic Concepts and Issuance Options 7
1.4.1 Project Confirmation 8
1.4.2 Crediting Options 8
1.4.2.1 Initial Crediting Period 8
1.4.2.2 Crediting Period Renewal 9
1.5 Program Manual 10
1.5.1 Revisions to the Program Manual 10
1.6 Pilot Phase 10
2 Program Principles and Criteria 11
3 Forecast Methodologies 13
3.1 Criteria for Forecast Methodologies 13
3.1.1 Definition of Mitigation Project 13
3.1.2 Start Date 14
3.1.3 Demonstration of Additionality 14
3.1.3.1 Legal Requirement Test 15
3.1.3.2 Performance Standard Test 15
3.1.4 Market Expansion Objective 17
3.1.5 Discussion of Environmental and Social Safeguards 18
3.1.5.1 Criteria Applied for Environmental and Social Safeguards 18
3.1.6 Demonstration of *Ex Ante* Suitability 19
3.1.7 Crediting Period and Rationale 19
3.1.8 Bundling/Aggregation of Projects 20
3.1.9 GHG Assessment Boundary 20
3.1.9.1 Physical Project Boundary 21
3.1.10 Leakage Accounting 21
3.1.11 Description and Justification of Chosen Baseline Scenario 21
3.1.12 Conservative Estimation of GHG Reductions 22
3.1.12.1 Estimating Performance Decline 23
3.1.12.2 Estimating Abandonment Rates 23
3.1.13 *Ex Ante* Program Risk Deductions 23
3.1.14 Ensuring Permanence 24
3.1.15 Project Implementation and Confirmation 24
3.1.16 Voluntary Ongoing Monitoring Incentive 24
3.1.17 Confirmation Activities 25
3.2 Criteria for Mitigation Projects 25
3.2.1 Additionality 26
3.2.1.1 Project Submission Deadline 26
3.2.2 Double Counting 26
3.2.3 Conservative Quantification 26
3.2.4 Market Expansion Objective 27

3.2.5 Regulatory Compliance and Environmental and Social Safeguards 27
3.3 Methodology Approval 27
3.3.1 Methodology Approval Costs 28
3.3.2 Reserve Review 28
4 Project Cycle 30
4.1 Account Registration 32
4.1.1 Types of Accounts 33
4.2 Project Submittal 33
4.3 Project Listing 33
4.4 Project Confirmation 33
4.4.1 Attestation of Title 34
4.4.2 Attestation of Legal Additionality 34
4.4.3 Attestation of Regulatory Compliance 35
4.4.4 Project Verification 35
4.5 Stakeholder Input for Individual Projects 35
4.5.1 Local Stakeholder Consultations 35
4.5.2 Feedback and Grievance Process 36
4.6 Registration 36
4.7 Credit Issuance 36
4.8 Credit Transfers 37
4.9 Credit Retirement 37
4.10 Transferring Projects from Climate Forward 37
4.11 Record Keeping and Retention 37
4.12 Publicly Available Information 38
5 Glossary 39

List of Figures

Figure 1.1. Upfront Crediting Upon Successful Confirmation..... 8
Figure 1.2. Voluntary Opt-In to Ongoing Monitoring and Reporting 9
Figure 1.3. Transition to *Ex Post* Monitoring, Reporting, and Verification After Opt-In to Voluntary Ongoing Monitoring Incentive.....10
Figure 3.1. Summary Overview of the Forecast Methodology Approval Process.....28
Figure 4.1. Program Flowchart and Relevant Parties 31

List of Boxes

Box 3.1. Determining Acceptable Performance Standard Thresholds 17
Box 3.2. Example of Market Expansion Objective 17
Box 3.3. Acceptable Parameters for Default Values.....23
Box 3.4. Rationale and Example of Ongoing Monitoring Incentive 25

Abbreviations and Acronyms

C	Carbon
CEQA	California Environmental Quality Act
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CRT	Climate Reserve Tonne
FMU	Forecasted Mitigation Unit
GHG	Greenhouse gas
lb	Pound
N_2O	Nitrous oxide
Reserve	Climate Action Reserve

1 Introduction

The Climate Action Reserve (Reserve) is an environmental nonprofit organization that promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. Based in Los Angeles, the Reserve is the foremost carbon offset registry in North America with internationally recognized expertise in project-level GHG accounting.

The Reserve establishes regulatory-quality standards for the development and quantification of GHG emission reduction projects; issues GHG emission reduction credits for use in compliance and voluntary carbon programs; and tracks the transaction of credits over time in transparent, publicly accessible systems. Adherence to the Reserve's standards ensures that emission reductions associated with projects are real, permanent, and additional, thereby instilling confidence in the environmental benefit, credibility, and efficiency of carbon markets.

1.1 Climate Forward

Climate Forward, a greenhouse gas mitigation program of the Reserve, provides a practical solution to companies and organizations seeking cost-effective mitigation of anticipated (i.e., future) operational and/or project related GHG emissions. Climate Forward facilitates investments in GHG reduction[1] activities that are practical, scientifically-sound, transparent, and aligned with forward-looking mitigation needs such as the California Environmental Quality Act (CEQA). Climate Forward will drive forward-looking investment into actions expected to result in GHG reductions, with a goal of expanding the scope and scale of feasible emission reduction project types.

Climate Forward enables companies and organizations to invest proactively in projects that reduce GHG emissions in order to mitigate forecasted GHG emissions from "business as usual" operations. Climate Forward provides a transparent and trusted resource for users to reduce their GHG footprints in a manner that is responsible, administered in a consistent manner, and ensures accountability. By following standardized and conservative quantification methodologies approved by the Reserve, project proponents are issued high quality credits to reward the mitigation measures identified. The intent of this program is to recognize investments now that will reduce greenhouse gas emissions in order to mitigate emissions that will occur in the future from new types of economic activity (e.g., a new manufacturing facility, distribution center, housing development, construction project, etc.).

One potential use case of Climate Forward is for GHG mitigation requirements under CEQA. The CEQA use case of Climate Forward is intended to provide entities subject to CEQA GHG mitigation requirements with a cost effective and environmentally rigorous option for GHG mitigation. The CEQA use case is intended to be consistent with established CEQA mitigation requirements for any new project that will produce greenhouse gases, as approved by relevant lead agencies.

This manual describes the framework, criteria, and process for:

1. GHG reduction methodology submission and review,

[1] Throughout this document, the term 'reduction' is intended to address both GHG emission reductions that are the result of activities designed to reduce emissions, and GHG removals, which are those activities aimed at removing atmospheric CO_2 at rates that exceed "business as usual" sequestration.

2. Project submission and implementation,
3. Issuance of Forecasted Mitigation Units (FMUs), and
4. Retirement of FMUs against anticipated future streams of GHG emissions including, but not limited to, those subject to CEQA GHG mitigation obligations.

Offsets vs. FMUs. *Climate Forward issues Forecasted Mitigation Units (FMUs) on an* ex ante *basis. It is not to be confused with carbon offsets, which are credits that are established after rigorous,* ex post *monitoring and verification of project activities. Offsets can be used for compliance and voluntary purposes and are typically applied against past emission-producing activities (e.g., a company's carbon footprint in the previous year). Climate Forward targets mitigation actions now that will produce a future stream of emission reductions, which can be applied against new investments that will create a future stream of greenhouse gas emissions. Climate Forward projects are eligible to transition into the Climate Action Reserve voluntary offset program if there exists an applicable offset protocol, as long as the project meets protocol-specified transition rules at the time of transition (See Section 1.4.2.2 and Section 4.10).*

Ex ante *vs.* ex post *crediting*. *FMUs are issued on an* ex ante *basis, meaning units are issued prior to the realization of the expected GHG reductions. This is by far the most fundamental difference between FMUs and CRTs. It is important for the user to recognize that each FMU represents an expectation of a future outcome, rather than an assurance of a past result. Correspondingly, FMUs are intended to apply to a future stream of emissions from a future investment activity. Thus, there is inherent risk that the GHG reduction will never be realized. Climate Forward, as well as each individual methodology, employs mechanisms at several levels to mitigate this risk, however. These include avoiding project types with unacceptably high risk, requiring implementation of "resilience measures" to mitigate risks of project failure or under-performance, conservative GHG accounting approaches, and the use of a risk pool.*

Confirmation vs. verification. *Climate Forward projects undergo a detailed audit process known as confirmation, which is functionally similar to the process of verification for Reserve offset projects but occurs at a different time in a project's life cycle. Due to the* ex ante *nature of FMUs, confirmation only occurs once, at the outset of the crediting period, rather than periodically. Confirmation typically occurs a certain period of time following the initial project implementation, so there is adequate time for the confirmation body (the auditor) to see that the project has been implemented according to the requirements of the methodology. FMUs are issued for the entire crediting period following the successful confirmation.*

Additionality. *Both FMUs and CRTs are only issued for GHG reductions that are additional, meaning they go above and beyond "business as usual". Offset protocols and Climate Forward forecast methodologies will lay out several tests for the determination of additionality. However, in cases where FMUs are to be used for CEQA compliance or any similar regulatory purpose, the agency may include the specific mitigation projects as a condition of approval. This does not affect the additionality of the project's activities. In this case, the permit applicant is required to mitigate GHG emissions somewhere, and it is choosing to do so through mitigation activities that would not otherwise occur. Prior to the CEQA approval, the project activity itself was not mandated. Had the applicant not selected this mitigation activity for CEQA compliance, it would not have otherwise occurred.*

GHG Reductions in Capped Sectors. *The Reserve does not issue CRTs for GHG reductions in sectors that are currently or are expected to be covered by a binding cap on GHG emissions. In capped sectors, although the project activity itself may not be required, the GHG emission reductions will be claimed for compliance with the program. Common practice for a capped sector is not to allow offsets because the capped sector's emissions are represented by emission allowances, not offsets. Climate Forward allows GHG reductions in a capped sector because the intent is to apply any GHG reductions to the increase in GHG emissions that will occur as a result of a new, future project. The project proponent essentially takes responsibility for its future emissions and has agreed to mitigate those emissions with FMUs. The net result is to avoid changing the overall emission reduction*

requirements of the capped sector, thereby avoiding a potential additional cost to consumers from future increases in emissions. A key takeaway from the creation of FMUs is that while the Climate Forward mitigation investment will reduce emissions in the future, the future investment against which FMUs are being applied will be creating additional GHG emissions from its investment that cannot be mitigation on-site. The net effect for any future investment that mitigates all of its GHG emissions through FMUs is that the capped sector will not need to address any change in total GHG emissions that need to be mitigated, i.e., the net long-term effect is zero impact on the capped sector's GHG emission reduction requirements.

Guidance in this manual is limited to Climate Forward and does not apply to any other Reserve program.

1.2 Program Objectives

Climate Forward is designed to provide companies, organizations, developers, and other entities with a conservative, robust, and methodologically rigorous option to mitigate an estimate of expected GHG emissions, on a voluntary or compliance basis, using FMUs generated from mitigation projects under Climate Forward. This program fundamentally differs from existing carbon credit programs through its focus on projecting and crediting estimated emission reductions on an *ex ante* basis. Climate Forward was developed to meet the following standards and objectives:

Program Standards

- **Real:** Estimated GHG reductions must be real and not be an artifact of incomplete or inaccurate emissions accounting. Methods for quantifying emission reductions must be conservative to avoid overstating a project's effects. The effects of a project on GHG emissions must be comprehensively accounted for, including unintended effects (often referred to as "leakage"). It is acceptable to use methodologies that are based on predictive *ex ante* approaches so long as probabilities of non-achievement are included in the estimated credit yield.

- **Additional:** GHG-reducing actions must be additional to any that would have been taken in the absence of Climate Forward, or in the absence of a market for GHG reductions generally.

- **Permanent:** In the context of project activities that protect existing carbon reservoirs or sequester new carbon, in order to function as mitigation units, GHG reductions must effectively be "permanent." Permanence under Climate Forward means that the carbon remains out of the atmosphere for at least 100 years. Methodologies that cannot reasonably assure the carbon remains out of the atmosphere for the entire 100-year standard may only receive a proportional quantity of mitigation credits relative to the amount of time that storage is likely to be achieved. Appropriate discounts must be built into any methodology to account for the risk that a given GHG reduction will not remain out of the atmosphere for the 100-year permanence period.

  For project activities that achieve mitigation through avoided emissions, permanence is enforced through conservative crediting periods and quantification that account for project degradation and anticipated changes to markets and technologies.

- **Confirmable:** *Ex ante* methodologies provide credits based on a conservative estimation of expected emission reductions. Activities must be confirmed by a Climate

Action Reserve approved third-party confirmation body to ensure that they have been properly implemented per the terms of the forecast methodology and this Program Manual. That is, credits will only be recognized once the funds for any proposed mitigation activity have already been committed and the mitigation activity is operating as proposed. *Ex post* credits may also be issued based on verification of GHG reductions achieved that are in addition to any credits issued on an *ex ante* basis.

- **Enforceable (where applicable):** If an entity's GHG mitigation efforts are legally mandated, enforcement is handled by the lead approving agency. Once a project has been agreed upon by an agency as adequately mitigating an impact and implemented by the relevant entity, the agency may require that the entity seeking mitigation has retired an appropriate quantity of credits on the registry. Each methodology accepted under Climate Forward will incorporate clear and enforceable safeguards to ensure project activities are carried out as described in the methodology, and that ownership rights to resulting emission reductions are unambiguous and enforceable in these circumstances.

Program Objectives

- **Integrity:** GHG emission reduction accounting must be based on credible evidence and sound science, and credits must not have been issued for the same GHG emission reductions in any other program, whether voluntary or mandatory.

- **Transparency:** Mitigation activities conducted under Climate Forward will be documented on a public registry, available to responsible agencies and stakeholders.

- **Open and scalable:** Climate Forward is open to all stakeholders to allow for voluntary mitigation measures to be taken. Methodologies developed under this program ideally have broad geographic flexibility and demonstrable cost effectiveness to incentivize investment in and development of projects.

- **Expand GHG mitigation market:** There are many creative, innovative mitigation activities that could be considered under Climate Forward. Climate Forward is designed to expand the scope of feasible GHG mitigation project types by encouraging third parties to submit their own methodologies for mitigation activities. Methodologies and projects under the program are encouraged (but not required) to demonstrate that they expand the scope of GHG mitigation options currently available under existing incentive programs (such as existing offset protocols).

- **Consistency with Requisite Regulatory Frameworks:** The use of FMUs must be compatible with existing regulatory frameworks, such as for CEQA mitigation obligations. For end users subject to CEQA mitigation requirements, Climate Forward is designed to be consistent with established CEQA mitigation requirements for a project, as approved by the relevant lead agency.

1.3 Use of Forecasted Mitigation Units

Under Climate Forward, estimated GHG reductions from the mitigation project are recognized as Forecasted Mitigation Units (FMUs), which are each equal to one metric ton of carbon dioxide equivalent (CO_2e) expected to be reduced or sequestered. FMUs can be retired for multiple purposes, including for CEQA mitigation or for other voluntary mitigation purposes, as

described in Sections 1.3.1 and 1.3.2 below. The Reserve's recommended best practices for the appropriate use of FMUs and CRTs are described in Section 1.3.3.

1.3.1 For Voluntary Use

Companies, entities, or individuals seeking to address anticipated emissions from future activities may retire FMUs to proactively mitigate those anticipated emissions. The reason for FMU retirement is publicly disclosed by the retiring entity upon retirement in the registry. The Reserve encourages the use of FMUs for accounting for anticipated or projected emissions. Companies, entities, and individuals should use Climate Reserve Tonnes (CRTs) issued under the Reserve's voluntary offset program to offset past emissions. As Forecasted Mitigation Units, FMUs are intended to mitigate forecasted emissions from new economic activity.

1.3.2 Under the California Environmental Quality Act (CEQA)

One potential use of Climate Forward is for activities requiring approval by the State of California under CEQA (California Environmental Quality Act). The use of FMUs for CEQA is intended to provide entities subject to CEQA GHG mitigation requirements with a cost effective and environmentally rigorous option for GHG mitigation, along with the flexibility to select new, creative mitigation actions of local interest to the community's stakeholders, including environmental justice advocates, among others. Climate Forward is intended to be consistent with established CEQA mitigation requirements for any new project that will produce greenhouse gases, as approved by relevant lead agencies.

The California Environmental Quality Act (CEQA) requires companies and other entities to identify the environmental impacts of their actions, and California agencies and municipalities may require that those impacts be mitigated. Both FMUs generated through Climate Forward as well as CRTs generated through the voluntary offset program can be used for CEQA GHG mitigation obligations.

The Reserve does not guarantee the use of FMUs or CRTs will be accepted as a means to meet CEQA GHG mitigation obligations where required by an approving agency(ies). It is the responsibility of developers to ensure the lead approving agency(ies) will accept the use of FMUs and/or CRTs to meet relevant CEQA GHG mitigation obligations, and it would be in the developers' best interests to do so prior to securing procurement of FMUs or CRTs.

1.3.3 Recommended Best Practices for the Use of FMUs

1. **Use of FMUs to mitigate future emissions**

   FMUs represent a future stream of emission reductions. FMUs may allow a company to take responsibility for the emissions from a future activity and make investments in GHG mitigation.

   For entities subject to GHG mitigation requirements under the CEQA approval process, FMUs allow these entities to utilize new, innovative mitigation options to meet their compliance obligation (pending approval from the agency).

2. **Difference between FMUs and Offsets**

   FMUs are different from and are not offsets (e.g., ARBOCs or CRTs). ARBOCs are Air Resources Board Offset Credits, which are compliance instruments issued by the California Air Resources Board that may be surrendered by a compliance entity to comply with the

California Cap-and-Trade program. CRTs are Climate Reserve Tonnes issued by the Climate Action Reserve and represent the past reduction or sequestration of one metric ton of carbon dioxide equivalent as quantified and verified in accordance with Climate Action Reserve protocols. Like CRTs, FMUs are also issued by the Climate Action Reserve. Unlike CRTs that represent the past reduction or sequestration of GHG emissions, however, FMUs represent the forecasted, risk-adjusted reduction or sequestration of GHG emissions, in the future, in accordance with Climate Forward program rules. Based on the foregoing, FMUs, CRTs, and ARBOCs are different and not fungible.

Additionally, if an entity would like to use FMUs to satisfy voluntary GHG mitigation commitments, it is important to remember that FMUs represent an expected future stream of emission reductions and not reductions that have already taken place. FMUs do provide a high level of certainty around the implementation of the GHG-reducing activities, as well as methods used to estimate the future benefits of the activities, but are not quantified reductions that have, in fact, already occurred. Companies that intend to use FMUs as part of their efforts to meet GHG mitigation goals should be aware of this fact and reflect this accordingly in any GHG mitigation claims made.

3. Understand the Timing of Both Emission Reductions and Emissions

Before participating in Climate Forward and/or before acquiring FMUs, project proponents and market participants should carefully review the rules of Climate Forward, especially as those rules govern the timing of the reduction or sequestration of GHG emissions. Importantly, market participants should understand and appreciate the risk that there could be a time period, or a temporal disconnect, between the occurrence of the emissions and the occurrence of reduction or sequestration represented by FMUs. When making claims in connection with GHG emissions mitigation or reductions achieved in support of FMUs, the Reserve strongly recommends that market participants clearly disclose any temporal issue that may arise or exist with respect to the emission reduction or sequestration of GHGs.

For example, if a company wishes to mitigate the GHG emissions associated with a new initiative that will last 10 years with FMUs from a project with a crediting period of 50 years, the FMUs generated (and thus the anticipated emission reductions they represent) may not align with activity timeline. That is, the emission reductions expected to be generated might occur after the actual emissions from the new initiative. Conversely, it may also be the case that sufficient FMUs can be gained from a Climate Forward project with a short lifetime such that the expected reductions occur before the expected emissions of a company's investment). Companies are encouraged to understand how their mitigation activities align with their emissions when making any claims regarding GHG mitigation.

1.4 Programmatic Concepts and Issuance Options

Under this program, FMUs are issued up front after a project's initial implementation confirmation ("confirmation") for the project's entire crediting period, with certain deductions applied based on estimated project performance and estimated project abandonment (see Section 3.1.12). Confirmation refers to an independent third party ("confirmation body") conducting a site visit and desk audit to confirm the mitigation project has been implemented as described in the relevant approved forecast methodology, this Program Manual, and the Confirmation Manual.

1.4.1 Project Confirmation

The *ex ante* nature of this program necessitates the introduction of different terminology to clearly describe how this program differs from existing *ex post* emissions reporting and carbon crediting programs. Those who are familiar with carbon markets and emissions reporting should note the introduction of the concept of "project confirmation," which is different from "project verification." The term "verification" has an existing and widely understood definition, suggesting *ex post* substantiation of claims made by the project undergoing verification, while "confirmation" refers to the confirmation by an accredited, independent third party that a project has been implemented in accordance with the requirements established by this Program Manual and the relevant approved forecast methodology. A "confirmation" is designed to demonstrate that a proposed mitigation project has been implemented according to an approved methodology and will generate FMUs to mitigate future greenhouse emissions from new economic activity. Further details regarding project confirmation can be found in the Confirmation Manual.

1.4.2 Crediting Options

If a project proponent believes that their project will generate more GHG emission reductions than credited up front, they may opt to submit periodic monitoring and reporting data to Climate Forward in accordance with frequencies described in the relevant forecast methodology. This data will be subject to an *ex post* verification (see Glossary) upon the completion of the crediting period and the project may be issued additional FMUs based on the results of that verification, in accordance with Section 3.1.16. This voluntary option provides the program with greater assurance of the environmental integrity of underlying projects by creating an incentive for ongoing monitoring, reporting, and verification, while also allowing project proponents the opportunity to generate additional downstream credits from their projects.

1.4.2.1 Initial Crediting Period

Within the initial crediting period, a project has two options for FMU issuance. A project may either: (1) receive upfront crediting upon successful project implementation and confirmation, or (2) opt into the optional voluntary monitoring incentive program. For further explanation, see Figure 1.1 and Figure 1.2 below, as well as Section 3.1.16.

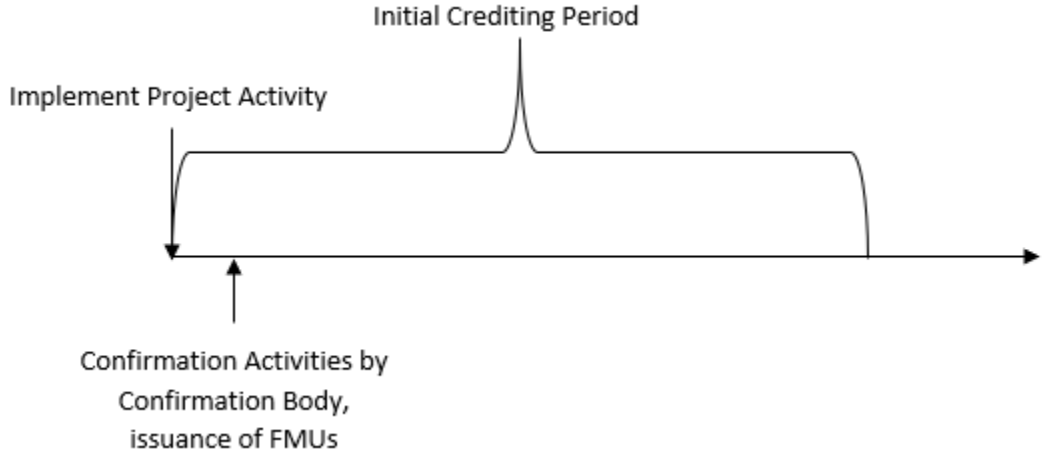

Figure 1.1. Upfront Crediting Upon Successful Confirmation

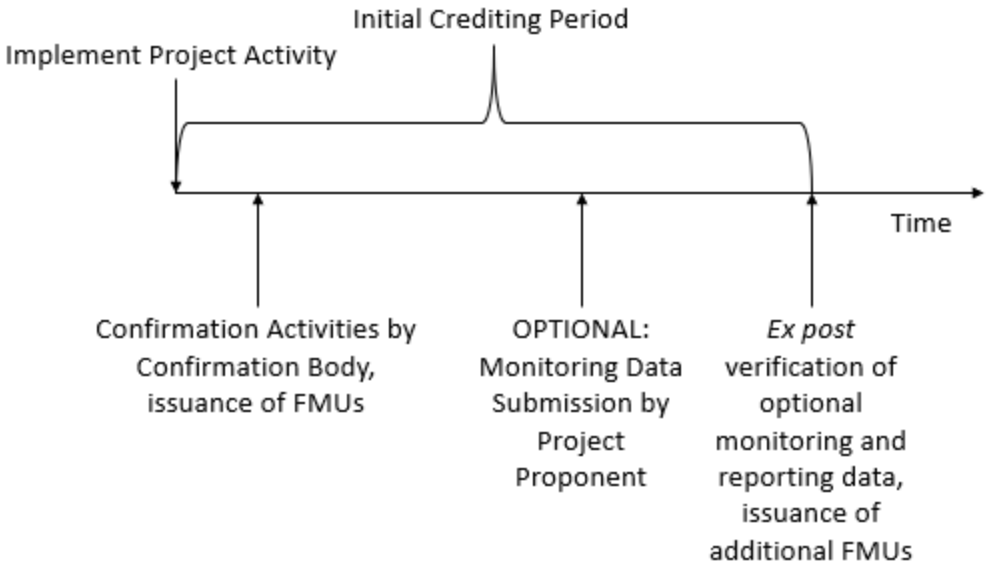

Figure 1.2. Voluntary Opt-In to Ongoing Monitoring and Reporting
(See Section 3.1.16)

1.4.2.2 Crediting Period Renewal

Upon completion of the initial crediting period, a project may cease further crediting, or it may transition the project to periodic *ex post* monitoring, reporting, and verification as established in the relevant forecast methodology. Transitioning to *ex post* monitoring, reporting, and verification may occur under the Climate Forward program for issuance of FMUs (see Figure 1.3), or the project may apply to transition into the voluntary offset program for issuance of CRTs under an applicable offset protocol.

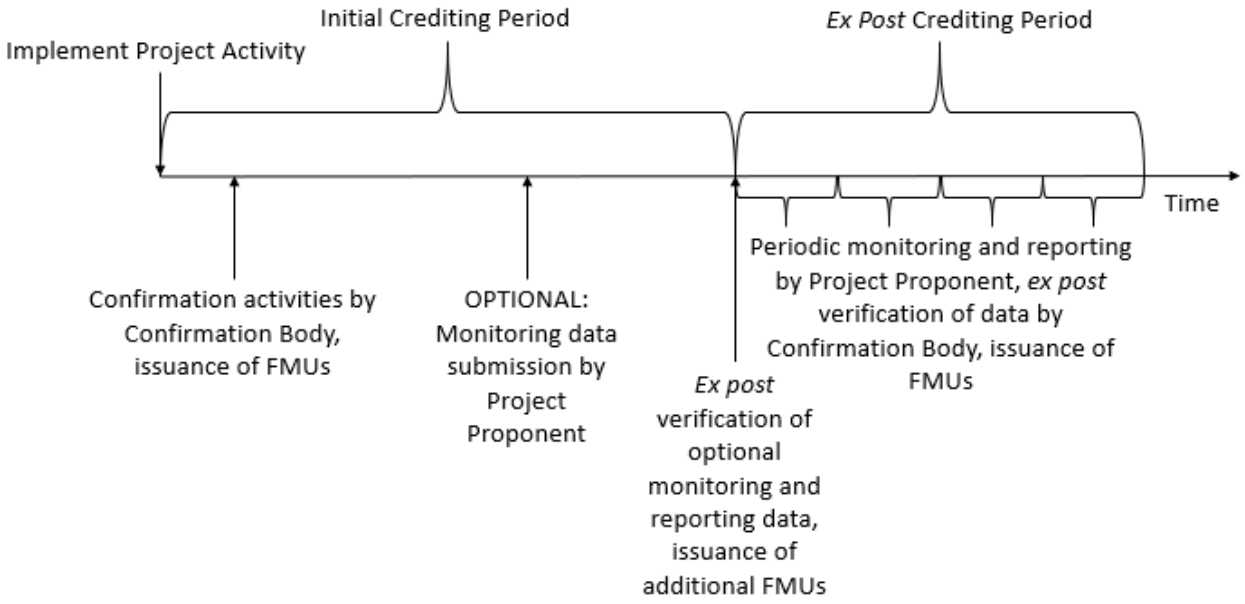

Figure 1.3. Transition to *Ex Post* Monitoring, Reporting, and Verification After Opt-In to Voluntary Ongoing Monitoring Incentive

1.5 Program Manual

This manual contains details on the Climate Forward program, policies, and requirements. Users of this program, including confirmation bodies, are subject to the requirements and guidance specified in the most recent version of this document. This manual is considered effective as of the date it is posted on the Climate Forward website. All account holders and confirmation bodies are notified when an update to the manual is released, and the manual is available on the Climate Forward website at www.climateforward.org.

1.5.1 Revisions to the Program Manual

Between updates, the Reserve may release memos that update or replace guidance in this manual or approved forecast methodologies. These memos are considered effective on the date they are posted on the Climate Forward website; users of the Climate Forward program and confirmation bodies must follow the guidance specified in the memo from that date forward. All account holders and confirmation bodies are notified when a policy memo is released, and memos are posted on the Climate Forward website at www.climateforward.org. In most cases, the contents of the memos are incorporated into the next update of the Program Manual.

1.6 Pilot Phase

Climate Forward engaged in a “pilot” phase. The purpose of this pilot phase was to allow the program rules, criteria, and procedures to be developed within a pre-defined “sandbox” to allow for sufficient testing of program procedures before the program is launched more broadly. A preliminary set of methodologies and associated projects was identified for inclusion within the pilot phase.

The methodologies approved as part of the pilot phase were only allowed for use with specific, pre-identified projects. Methodologies that were approved as part of the pilot phase were not guaranteed approval when the program exited the pilot phase. All pilot methodologies were re-assessed for adherence to Climate Forward standards and criteria at the time the program exited the pilot phase.

2 Program Principles and Criteria

This section describes the general criteria and requirements against which mitigation projects and forecast methodologies will be assessed. This includes criteria to assess eligibility, additionality, and the accuracy and conservativeness of the quantification approach.

There is strong international consensus around a core standard set of overarching principles to guide decisions about the accounting, quantification, and reporting of project-based GHG reductions. These consensus principles are listed and defined in both the International Organization for Standardization (ISO) 14064-2: 2006 and The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) Greenhouse Gas Protocol for Project Accounting[2]. Definitions of these principles differ slightly between the two standards; for this program, the Reserve interprets the principles as follows:

- **Relevance:** Data, methods, criteria, assumptions, and accounting boundaries should be chosen based on their "intended use." For this program, this means forecast methodologies are designed around practical, conservative approaches that adhere to core accounting principles and support environmental integrity.

- **Completeness:** All relevant GHG emissions and removals should be accounted for and all relevant information should be considered. Forecast methodologies shall use all relevant information to comprehensively identify the GHG sources, sinks, and reservoirs affected by mitigation projects and account for all significant changes in GHG emissions or removals that may result from a mitigation project.

- **Consistency:** Data, methods, criteria, and assumptions should allow meaningful and valid comparisons of the GHG reductions achieved by different mitigation projects, forecast methodologies, and different activity types.

- **Transparency:** Sufficient information should be disclosed to allow reviewers and stakeholders to make decisions about the credibility and reliability of GHG reduction claims with reasonable confidence. Access to sufficient and appropriate GHG-related information is critical for assuring that a mitigation project's GHG reduction claims are credible.

- **Accuracy:** Uncertainties and bias should be reduced as far as is practical. Greater accuracy in estimating GHG emissions and reductions will help ensure credibility of GHG reduction claims. Where accuracy is sacrificed, data and assumptions used to estimate GHG reductions should be conservative. Sampled data used to establish forecast methodology parameters or project inputs must achieve a minimum statistical confidence of +/- 5 percent at 1 Standard Error.

- **Conservativeness:** Conservative assumptions, values, and procedures should be used to ensure that GHG reductions are not over-estimated. Because the GHG reductions

[2] International Organization for Standardization, 2005. ISO 14064, Part 2: "Specification with guidance at the project level for quantification, monitoring, and reporting of greenhouse gas emission reductions or removal enhancements." International Organization for Standardization, Geneva, Switzerland; World Resources Institute and World Business Council for Sustainable Development, 2005. The GHG Protocol for Project Accounting, World Resources Institute, Washington, DC.

under this program will be estimated and credited at the point of activity implementation, approved forecast methodologies must employ conservative estimation methods. Where project benefits are based on projections of project activities, the projections of project benefits must be justified through scientific literature or defensible direct analysis.

Forecast methodologies must establish an empirical approach to demonstrating conservative forecasting or apply a methodology specified discount to the total projected quantity of GHG emission reductions. This is required to account for potential performance uncertainties as well as the likelihood of project non-performance and project abandonment. Each proposed forecast methodology must provide summary statistics around each default value or quantitative assumption that goes into the overall FMU issuance estimation.

These principles underpin all aspects of Climate Forward and will guide decisions where the program affords flexibility or discretion, or where the requirements or guidance are ambiguous. These principles should guide the development of the forecast methodologies and will guide the Reserve's review and approval of such methodologies.

3 Forecast Methodologies

Forecast methodologies contain the eligibility rules, quantification methods, documentation requirements, and confirmation requirements that ensure the consistency and rigor of GHG reduction accounting for a specific mitigation project. When the Reserve has not already approved a forecast methodology applicable to a mitigation project a project proponent wants to undertake, the project proponent will need to develop a forecast methodology and submit it to Climate Forward for approval. The Reserve will only issue FMUs for forecasted GHG reductions estimated and confirmed, as well as *ex post* reductions that are quantified and verified under an approved forecast methodology.

This section details the specific eligibility criteria, including but not limited to a rigorous additionality evaluation that each proposed forecast methodology will be evaluated against, as well as the principles that a proposed forecast methodology will be required to meet. It is expected that the forecast methodology will be developed at the project level and will consider existing methodologies for that activity type.

3.1 Criteria for Forecast Methodologies

Forecast methodologies shall contain the following sections, each of which are described in more detail below:

1. Definition of the mitigation project
2. Start date
3. Demonstration of additionality
    a. Meeting the legal requirement test
    b. Description and discussion of the performance standard test(s)
4. Description of market expansion focus
5. Discussion of environmental and social safeguards (if applicable)
6. Demonstration of *ex ante* suitability
7. Crediting period and rationale
8. Bundling and aggregation of Projects
9. GHG Assessment Boundary
10. Leakage accounting
11. Description and justification of chosen baseline scenario
12. Estimation of GHG reductions, including assumptions to ensure conservativeness
13. *Ex ante* program risk deduction
14. Ensuring permanence (if applicable)
15. Project implementation and confirmation
16. Voluntary ongoing monitoring incentive
17. Confirmation activities

3.1.1 Definition of Mitigation Project

A GHG mitigation project is a specific activity or set of activities intended to reduce GHG emissions or increase the storage of carbon or enhance GHG removals from the atmosphere.[3] Under this program, a mitigation project is the undertaking or funding of activities that directly

[3] World Resources Institute (WRI), World Business Council for Sustainable Development (WBCSD), 2005. *The GHG Protocol for Project Accounting*. World Resources Institute, Washington, D.C.

reduce or sequester GHG emissions (mitigation projects) at a location other than the site of a project with anticipated GHG emissions.

Every forecast methodology shall clearly define the type of activity (or activities) that constitutes the proposed mitigation project type. Methodologies shall be designed to be as widely applicable as possible within the target sector, rather than being limited to the specific characteristics of an individual project. A clear definition ensures that GHG quantification methods prescribed by the forecast methodology are applied only where they are relevant and appropriate (e.g., location, required pre-existing conditions, etc.).

The definition section should also include any specific relevant exclusions where required conditions could not be met, or the forecast methodology would not be applicable. It is also possible for a "project" to be defined in a way that allows for the implementation of the same activity at multiple sites over a finite period of time. Such "batch" projects shall be clearly defined within the applicable forecast methodology.

3.1.2 Start Date

Start dates are often defined by reference to a discrete action undertaken by the project to create reductions. Each methodology must outline what action, or set of actions, defines the start date. Some methodologies will include some flexibility, in the form of a staged and finite start-up period, allowing projects to test out equipment and processes, intermittently or at a small scale, before being considered operational. For other project types, the start of a project may be defined by the entering into force of a particular legal agreement, such as a contract to initiate project activities or the recordation of an easement.

Projects are only eligible if the project is submitted to Climate Forward no more than one year after the mitigation project start date.[4] Projects may always be submitted prior to the start date. Each Reserve-approved forecast methodology provides specific requirements for what denotes a project start date

3.1.3 Demonstration of Additionality

The Reserve requires a standardized approach to determining additionality for this program, where methodology developers will propose in the forecast methodology a set of criteria designed to exclude non-additional mitigation projects and include additional ones on a sector-wide basis.[5]

All forecast methodologies shall incorporate standardized additionality tests, rather than providing rationale for additionality based only on project-specific implementation barriers and/or expected benefits. Two elements must be included in the forecast methodology: demonstration that the mitigation project is not mandated by law (the legal requirement test) and the development of an appropriate performance standard test(s) that demonstrates the mitigation

[4] A mitigation project is considered "submitted" when all appropriate forms have been completed, and all applicable fees have been paid to the Reserve.

[5] Within existing carbon offset programs, there are two basic approaches to determining "additionality": project-specific and standardized. The Reserve has built its reputation and gained prominence by pioneering standardized approaches to crediting GHG reductions. For example, standardized tests could involve determinations that a project: (1) is not mandated by law; (2) exceeds common practice; (3) involves a particular type of high-performing technology relative to the common practice; and/or (4) has an emission rate lower than most others in its class (e.g., relative to a performance standard).

project would not have been implemented under a conservative "business as usual" baseline scenario. These are described in more detail below, in Section 3.1.3.

Two elements must be included in the forecast methodology: demonstration that the mitigation project is not mandated by law (the legal requirement test) and the development of an appropriate performance standard test(s) that demonstrates the mitigation project would not have been implemented under a conservative "business as usual" baseline scenario.

3.1.3.1 Legal Requirement Test

Mitigation projects are very likely to be considered non-additional if their implementation is required by law. The legal requirement test ensures that eligible mitigation projects would not have occurred anyway in order to comply with national, regional, state, local, or other relevant regulations, or other legally binding mandates. For the purposes of the program, a mitigation project passes the legal requirement test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring its implementation.

Under this program, the specific provisions of the legal requirement test may differ depending on the mitigation project. The Reserve expects the project proponent to perform a review of existing and pending regulations to identify any specific regulatory requirements that would mandate the implementation of mitigation projects covered by the methodology, including local agency ordinances or rulings. In evaluating a proposed forecast methodology, the Reserve will consider any adopted, but not yet effective, law, regulation, order, or other legal requirements legally mandating implementation of the proposed mitigation activity.

Depending on the location of the mitigation project, there may be insufficient compliance and/or enforcement of national, regional, state, local, or other regulations. The level of compliance and enforcement of relevant regulations is something that can be explored and assessed within each proposed forecast methodology. It may be possible for a mitigation project to pass the legal requirement test even if there is a law that requires its implementation in circumstances where there is a lack of compliance and enforcement on the ground. Forecast methodologies must describe how the proposed project type meets the legal requirement test.

In cases where FMUs are to be used for CEQA compliance or any similar regulatory purpose, the lead agency may include the specific mitigation projects as a condition of approval. This does not affect the additionality of the project's activities. In this case, the project applicant is required to mitigate GHG emissions somewhere, and it is choosing to do so through mitigation activities that would not otherwise occur. Prior to the CEQA approval, the project activity itself was not mandated. Had the permittee not selected this mitigation activity for CEQA compliance, it would not have otherwise occurred.

3.1.3.2 Performance Standard Test

Mitigation projects that are not legally required may still be non-additional if they would have been implemented for other reasons, including, for example, because they are economically-attractive investments irrespective of the value of their GHG reductions (and do not face other significant barriers). Performance standard tests are intended to screen out this type of mitigation project. In developing performance standards, project proponents must consider financial, economic, social, technical, and technological drivers and barriers that may affect decisions to undertake a mitigation project. Standards are specified such that, to the maximum extent feasible, mitigation projects that meet the standard would not have been implemented

due to these other drivers. In other words, incentives created by the GHG mitigation market are highly likely to have played a critical role in decisions to implement mitigation projects that meet the performance standard.

Although performance standard tests do not require individual assessments of financial returns and implementation barriers, they are designed to reflect these factors in determining which mitigation projects are additional. Mitigation projects that pass a performance standard test should be those that – in the absence of their GHG reduction value – would have insufficient financial returns or would face other types of insurmountable implementation barriers.

Performance standard tests are developed through analysis of standard practices and technology deployment in industry sectors related to a specific mitigation project. They may also be based on an assessment of "typical" financial, implementation, and operating conditions facing a certain type of mitigation project.

Under this program, performance standards may be specified in several ways – for example:

- **Emission rate thresholds.** For some mitigation projects, a performance standard may be specified in terms of a rate of GHG emissions (usually per unit of production of some product or service, e.g., metric tons of CO_2 per megawatt-hour). Generally, the threshold rate would be based on a level of performance that is significantly better than average for the industry or sector. Mitigation projects that have lower emission rates than the threshold, for example, would be considered additional.

- **Practice- or technology-based thresholds.** Performance standards may also be specified in terms of a specific practice or technology that is rarely or never implemented in the absence of a carbon market. Such standards are generally based on surveys of the market penetration rates of candidate practices or technologies. Mitigation projects employing a qualifying technology or practice are typically considered additional.

- **Other qualifying conditions or criteria.** Performance standards may also incorporate, or be based on, other specific qualifying conditions that a mitigation project must meet in order to be considered eligible. Conditions may include characteristics related to the mitigation project site, specifications for a particular eligible technology or practice, or other contextual factors. Mitigation projects meeting the conditions would be considered additional.

Several specifications may be combined in a single performance standard test. For example, a forecast methodology may define a performance standard in terms of a specific type of technology that has an emission rate below a certain threshold and is implemented at an eligible location.

This program has no predefined threshold for determining an acceptable performance standard. Rather, establishing performance standards involves balancing the need to prohibit eligibility for non-additional mitigation projects with the goal of allowing additional (and otherwise eligible) mitigation projects to participate. Setting a threshold always involves making tradeoffs between these two goals and may also involve considerations about the size of the market for mitigation credits and the potential supply of reductions available from certain mitigation project types. See Box 3.1 for further discussion and a hypothetical example.

Box 3.1. Determining Acceptable Performance Standard Thresholds

A common rule of thumb for establishing performance standards is that they should make eligible only technologies or practices that are not common practice. However, "common practice" is often difficult to define. Instead of adopting a simple rule for defining common practice (for example, a threshold market penetration rate) the Reserve requires setting performance standards based on an overall assessment of the market for GHG reductions and the risk of crediting non-additional reductions.

For example, suppose a particular emission-reducing technology has a market penetration rate of five percent, and there is no indication that it is increasing in any appreciable way. In most instances, such a technology would not be considered common practice. However, if a threshold were established allowing all instances of this technology to be eligible for crediting, we could expect existing users of the technology to apply for credit even though they were employing it already, without any incentives from the value of the GHG reduction. This will have adverse consequences for the integrity of the Climate Forward program. Whether such consequences are serious depends on the potential supply of reductions from this technology compared to overall demand for reductions. If five percent of the market would result in hundreds of millions of metric tons of GHG reductions, for example, then a simple technology-based threshold would be too lenient, and the Reserve would explore using additional criteria that could further exclude "business as usual" instances of the technology despite its relative rarity. If five percent of the market would result in only a few thousand metric tons of GHG reductions, then the Reserve may consider a simple technology-based threshold acceptable. In addition, the performance standard works in concert with other additionality criteria, such as the acceptability of certain project start dates.

3.1.4 Market Expansion Objective

All submitted projects under an approved forecast methodology are required to describe how the project encourages actions leading to GHG reductions that are generally not feasible under existing GHG crediting or incentive programs (See Section 3.2.4). Forecast methodologies may provide a general overview of project characteristics that would make projects under the proposed forecast methodology meet this concept, as well as guidance for how projects can demonstrate that they have those characteristics. See Box 3.2 for an illustrative example.

Box 3.2. Example of Market Expansion Objective

Mitigation projects under Climate Forward are developed with the intent of expanding the scope of GHG mitigation project types through innovative methodologies that expand the breadth of activities occurring under current programs, such as the offset market. To that end, forecast methodologies for project types that have been adopted on a wide scale in existing offset programs should provide a general description of characteristics that outline how the activities expand opportunities for GHG mitigation.

For example, livestock dairy digester projects have been adopted on a large scale in existing offset programs. However, there may be practical size limitations that prevent all dairies from participating in these programs. The forecast methodology should provide a brief description of the general size that a dairy farm must exceed before a dairy digester project would be feasible under an offset program, such that specific projects that are submitted to Climate Forward can demonstrate that they are smaller than the described size threshold. Forecast methodologies should endeavor to describe a comprehensive set of criteria that a given individual project can use to demonstrate market expansion beyond existing programs.

3.1.5 Discussion of Environmental and Social Safeguards

The Reserve requires project proponents to demonstrate that their GHG projects will not undermine progress on other environmental issues such as air and water quality, endangered species and natural resource protection, and environmental justice. When registering a project, the project proponent must attest that the project is and will be in material compliance with all applicable laws, including environmental regulations, during the crediting period. Methodologies and/or projects that can demonstrate quantifiable, direct social and environmental co-benefits resulting from project implementation may be granted discounted fees on a case by case basis.

The project proponent must advise their confirmation body and the Reserve of any regulatory violations incurred at the project since the project start date. The project proponent should also provide copies of all relevant permits and permissions, demonstrating that the project is in compliance with all key regulatory requirements (as appropriate). Confirmation bodies will be required to review all such documentation, review any regulatory databases that are available, and proactively liaise with key regulatory agencies that regulate the project facility and/or activities to confirm no regulatory violations have occurred since the project start date. The project proponent should also provide the confirmation body with a narrative of measures enacted to ensure the project remains in compliance with all regulatory requirements for the duration of the crediting period. Implementation of these measures are subject to confirmation by the confirmation body. Determination of whether the measures are sufficient to reasonably mitigate the risk of regulatory non-compliance is at the sole and final discretion of the Reserve. Individual forecast methodologies may be required to include measures for projects designed to ensure specific environmental and social safeguards are in place.

All forecast methodologies that involve local communities and indigenous peoples must ensure their values and rights are recognized and respected throughout the project life, and that project design, implementation, and any ensuing confirmation or verification is established and executed in accordance to the spirit of Free, Prior and Informed Consent, in an inclusive and transparent manner sensitive to all concerned stakeholders, and in particular all marginalized and vulnerable groups.

3.1.5.1 Criteria Applied for Environmental and Social Safeguards

In determining whether environmental and social harms are likely to occur, the Reserve will use the following criteria:

Legal Obligation

The Reserve will rely first and foremost on legal requirements within the jurisdiction(s) where the project is implemented.

"Do No Harm" Beyond Legal Requirements

In some cases, the Reserve may determine that existing legal requirements are insufficient to guarantee protection against important environmental and social harms. In these cases, the Reserve may require additional criteria in forecast methodologies to ensure that projects will not give rise to these harms or may screen out certain project types or activities from eligibility altogether.

The forecast methodology shall contain a narrative describing an evaluation of any potential adverse environmental, social, or economic impacts that may be caused by the mitigation project, and actions that must or should be taken to avoid adverse impacts.

In some cases, the Reserve may determine, in consultation with experts, that additional safeguards are needed to protect against important environmental and social harms. In these cases, the project proponent may be required to include additional criteria in the forecast methodology to ensure that mitigation projects will not give rise to these harms or may screen out certain activity types from eligibility under a forecast methodology altogether.

3.1.6 Demonstration of *Ex Ante* Suitability

To ensure that any issued FMUs have a reasonable expectation of being realized over time, methodologies must demonstrate that the type of project activity described in the methodology is suited for *ex ante* crediting. To do this, the methodology must provide guidance for establishing cost estimates for the initial implementation of the mitigation project, and cost estimates for ongoing maintenance, upkeep, and operation to maximize the likelihood that the mitigation project is operational for the lifetime of its crediting period. Further, all submitted forecast methodologies must provide justification showing that the proposed project type, once implemented, is likely to continue, and continue at the levels forecast. Project types that are unlikely to continue without sufficient ongoing incentives to the project proponents are not suitable for an *ex ante* crediting framework. As a general principle, project types that have relatively high initial implementation costs and relatively low ongoing maintenance, upkeep, and operation costs are better suited for *ex ante* crediting. Mitigation activities that provide additional co-benefits beyond greenhouse gas emission reductions may provide increased incentive for continued implementation through the entire crediting period.

3.1.7 Crediting Period and Rationale

The mitigation project "crediting period" defines the period of time over which GHG reductions from a mitigation project are estimated and eligible to be confirmed as mitigation credits. Because of the *ex ante* nature of crediting under this program, the forecast methodology must set criteria for project proponents to define and justify the proposed crediting period. Reference to any analysis and supporting datasets shall be included in this section of the forecast methodology, and such analysis will generally be included as an appendix. The default crediting period for sequestration-based project types is set at 25 years with the option to renew the crediting period up to 100 years in cases where sequestration can be demonstrated to be sufficiently secured to the Reserve's discretion. Under no circumstances will the combined total of crediting periods for sequestration-based project types exceed 100 years. Mitigation projects that are implemented in batches may quantify crediting periods on a batch-specific basis, such that the overarching mitigation project generates credits for a period of time greater than 25 years, but no single project installation is credited with *ex ante* crediting for greater than 25 years.

Forecast methodologies must establish the rules and requirements for *ex ante* crediting period renewal. If desired, the methodology must also establish rules and requirements for *ex post* monitoring, reporting, and verification if it can be determined that the project type is suitable for transitioning to *ex post* monitoring, reporting, and verification upon the conclusion of the initial *ex ante* crediting period. If a project pursues further crediting beyond the crediting period through *ex post* monitoring, reporting, and verification, verification must be conducted in accordance with the procedures and frequencies established by the forecast methodology. If a given forecast methodology is silent on verification procedures for *ex post* crediting, the Reserve shall work with the interested project proponent to develop appropriate verification guidelines.

3.1.8 Bundling/Aggregation of Projects

Aggregation of multiple projects of the same type together for reporting purposes is allowed for only certain project types, with bundling and aggregation rules described within specific methodologies. Generally, each mitigation project, as defined by the project definition and/or project boundary (described in each forecast methodology), must register separately in Climate Forward. However, forecast methodologies for certain project types may allow project boundaries to span multiple activities or locations. A single mitigation project may be defined as a pre-determined batch of discrete installations (e.g., a batch of solar PV panel installations may constitute one mitigation project).

Proponents of mitigation projects should check specific forecast methodologies and associated guidance documents for direction on whether and how aggregation is allowed.

3.1.9 GHG Assessment Boundary

The GHG Assessment Boundary[6] delineates the GHG sources, sinks, and reservoirs (SSRs)[7] that must be quantified by the methodology to determine the total net change in GHG emissions caused by a mitigation project.

The GHG Assessment Boundary is not necessarily a boundary related to a mitigation project's physical location. Instead, it encompasses all SSRs that could be significantly affected by a mitigation project, regardless of where such SSRs are located or who owns or controls them. A comprehensive and clearly-defined GHG Assessment Boundary is required to provide a complete accounting of the net GHG reductions achieved by a mitigation project.

SSRs are only included in the GHG Assessment Boundary if a mitigation project will have a *significant* effect on their associated GHG emissions or removals. The project proponent shall propose significance based on an assessment of the range of possible outcomes for a relevant SSR. Inclusion or exclusion of SSRs is determined for each forecast methodology based on the principles of completeness, accuracy, and conservativeness, and the need for practicality (e.g., related to measurement costs). In general, relevant SSRs should only be excluded from the GHG Assessment Boundary if:

1. Mitigation projects are likely to reduce GHG emissions (or increase removals) at an SSR, so that excluding the SSR would be conservative (i.e., doing so would result in an underestimation of total net GHG reductions for the mitigation project); or
2. The total increase in GHG emissions from *all* excluded SSRs is likely to be less than five percent of the total GHG reductions achieved by a mitigation project.

All SSRs determined to be within the GHG Assessment Boundary shall be identified in the calculation of GHG reductions.

The forecast methodology shall:

- List all SSRs potentially affected by a mitigation project

[6] See World Resources Institute and World Business Council for Sustainable Development, 2005. *The GHG Protocol for Project Accounting*, World Resources Institute, Washington, DC.
[7] Terminology is from International Organization for Standardization, 2019. ISO 14064, Part 2: "Specification with guidance at the project level for quantification, monitoring, and reporting of greenhouse gas emission reductions or removal enhancements." International Organization for Standardization, Geneva, Switzerland.

- Explain or describe the SSR
- Identify whether the SSR is present in the baseline, project case, or both
- Indicate whether each SSR is included in the GHG Assessment Boundary
- Justify instances where an SSR is excluded from the GHG Assessment Boundary
- Identify whether and how GHG emissions, removals, or storage from the SSR will be estimated
- If GHG emissions, removals or storage will be estimated, justify why values will be estimated rather than measured (or calculated from other measurements) and how measures will be taken to ensure estimates are conservative

Climate Forward does not restrict the GHGs that may be considered within the GHG Assessment Boundary. Any gas that has been determined by the IPCC to have a radiative forcing effect on the atmosphere may be considered for inclusion in a protocol. Forecast methodologies may address gases other than the six GHGs regulated under the Kyoto Protocol (i.e., CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs). All non-CO_2 GHGs will be normalized into tonnes of CO_2e through the use of 100-year global warming potential (GWP) values published by the IPCC. Projects shall apply the same GWP values as specified for the Reserve's offset program (the IPCC 4th Assessment Report, as of this writing), unless otherwise specified in the forecast methodology or public communications from the Reserve.

3.1.9.1 Physical Project Boundary

For some types of mitigation projects, it is necessary to define a physical boundary for the mitigation project in addition to a GHG Assessment Boundary. Physical boundaries are defined in terms of the physical area affected by a mitigation project and possibly specific equipment or facilities involved. Forecast methodologies will only require identification of a physical boundary where a physical boundary is necessary to estimate the magnitude of GHG emissions, removals, or storage associated with one or more SSRs included in the GHG Assessment Boundary. An example of this would be a land-use-based carbon sequestration project, where the amount of carbon stored depends on the area of land on which the mitigation project takes place.

3.1.10 Leakage Accounting

The term "leakage" is often used to refer to unintended increases in GHG emissions that may result from a mitigation project. Generally, leakage occurs at SSRs that are physically distant from the mitigation project itself or otherwise outside the mitigation project's physical boundaries. Each methodology must address whether leakage is a risk for the particular sector and project activity. To the extent that any proposed methodology may introduce leakage of claimed environmental benefits, i.e., directly result in emissions sources increasing outside of the project boundary, proper accounting of any leakage impacts shall be included in the methodology.

3.1.11 Description and Justification of Chosen Baseline Scenario

Baseline emissions are always subject to uncertainty because they are counterfactual, i.e., they are an estimate of GHG emissions or removals that would have occurred in the absence of the mitigation project. This notion is especially true in the context of *ex ante* mitigation. Depending on the mitigation project type and SSRs involved, many methods can be used to try to estimate baseline emissions. The Reserve requests that project proponents use standardized baselines in forecast methodologies to the extent possible, meaning that the same conservative assumptions, emission factors, and calculation methods would be applied to all registered projects within a mitigation project type. Standardized baseline approaches seek to avoid case-

by-case analysis of individual mitigation projects while maintaining overall levels of estimation accuracy and environmental integrity. Project-specific calculations and emission factors may be used wherever necessary to ensure accuracy, or where standardized methods would result in estimates that are overly conservative in many cases. It is common for methodologies to utilize both standardized assumptions and project specific calculations and factors.

Standardized baselines are developed by considering broad trends (economic, technological, regulatory, and policy) in the industry or sector relevant to a mitigation project type and determining what future "business as usual" alternative activities are likely to be. To develop standardized baselines, the methodology developer should determine the most likely alternative technologies or practices. In many cases, a single practice, activity, or technology is assumed to be the common baseline alternative for a class of mitigation projects. In some cases, the performance threshold developed for additionality may also be used as an emissions baseline.

The narrative describing and defending the chosen baseline scenario should address if the baseline represents a fixed baseline over the duration of the crediting period, or if it considers projected changes in baseline conditions over time. A dynamic baseline may be necessary to ensure conservativeness of the baseline over time. For example, if a project type is related to the implementation of an energy efficiency measure, baseline quantification should account for anticipated changes to the underlying marginal grid emission factors.

3.1.12 Conservative Estimation of GHG Reductions

GHG reductions are calculated by comparing the forecasted baseline to the forecasted mitigation project performance over a certain time period. GHG reductions are achieved when the mitigation project results in lower GHG emissions to the atmosphere over a certain time period compared to what would have happened absent the mitigation project. The general formula for calculating GHG reductions is:

GHG Reductions = (Forecasted Baseline Emissions – Forecasted Mitigation Project Emissions)

For biological carbon sequestration mitigation projects, GHG removals are achieved when the forecasted mitigation project performance results in more carbon sequestered in biological carbon stocks over a certain time period than would have been in the absence of the mitigation project. The general formula for calculating GHG removals is:

GHG Removals = [(Incremental Forecasted Mitigation Project Sequestration – Incremental Forecasted Baseline Sequestration) + (Forecasted Baseline Emissions – Forecasted Mitigation Project Emissions)]

The forecast methodology shall contain a detailed quantification methodology for both baseline and project emissions in order to calculate the estimated emission reductions associated with all SSRs for the mitigation project. The forecast methodology must account for the risk that the emission reductions might not be achieved as forecasted. As a result, the methodology will be conservative in terms of estimating total GHG reductions achieved.

Where default values are proposed, the source/reference for the default value must be included. Examples of evidence that may satisfy this requirement include independent studies conducted in the past 10 years, literature reviews, independent expert testimony, or values utilized in active projects issuing carbon credits under reputable carbon crediting programs such as the Clean Development Mechanism (CDM) or similar programs in the region or country concerned. All

assumptions should be clearly described and defended, and references provided for any relevant datasets, studies, or methodologies to be used.

If any proposed default values are independently developed and do not meet the standards as described above, the following general principles apply. If the proposed default value is independently developed and has a positive correlation with FMU issuance, that value should be no greater than the 25th percentile of the sampled data points. If the default value is independently developed and has a negative correlation with FMU issuance, that value should be no less than the 75th percentile of the sampled data points. These guidelines are to be followed unless statistical justification is provided that there is sufficient certainty regarding variable estimation. To demonstrate that a default value should be greater than the 25th percentile or less than the 75th percentile, respectively, analysis must be provided showing that variance does not exceed 10 percent of the proposed value. See Box 3.3 for further discussion and a hypothetical example.

Box 3.3. Acceptable Parameters for Default Values

Where default value inputs to the overall GHG Estimation quantification for a mitigation project are required, and no reputable values are available for use in developing the relevant forecast methodology, the methodology developer may propose their own default values for GHG reduction estimation. To do this, the methodology developer must engage with an independent third party to conduct an independent study to propose an evidence-based default value for use in the methodology. For example, if the forecast methodology in development is for methane destruction at a dairy farm, and the methodology does not have a reputable source for modeling the methane generated by the average population of livestock at the dairy, the methodology developer must engage with a third party to conduct an independent survey that establishes a formula for estimating methane generated per head of livestock. This formula must be calibrated to the 25th percentile, as an increase in the assumed methane generated per head of livestock would also lead to an increase in estimated FMU generation (positive correlation with FMU issuance).

3.1.12.1 Estimating Performance Decline

The quantification approach must explicitly describe how mitigation project efficiency is expected to change over the crediting period, and what assumptions are built into the calculations to account for any decreasing performance over time (e.g., declining conversion efficiency of PV panels over time). Performance decline assumptions built into the forecast methodology must be supported by current peer reviewed academic literature or other similar sources.

3.1.12.2 Estimating Abandonment Rates

The quantification approach must explicitly describe and account for any expected mitigation project abandonment over the crediting period (e.g., rate of abandonment of energy efficient lighting over time). Project abandonment rates built into the forecast methodology must be supported by current peer reviewed academic literature or other similar sources.

3.1.13 *Ex Ante* Program Risk Deductions

All projects make deductions of FMUs to account for programmatic *ex ante* risk. This deduction is comprised of the quantitative discounts applied to account for performance decline and abandonment rates. These deductions, applied to all projects, will ensure that the Climate Forward program issues FMUs that are conservative beyond the estimation calculations as described in Section 3.1.12, mostly to address potential concerns over project performance

falling below the levels assumed using conservative assumptions (e.g., catastrophic project failure such as a forest fire or complete shutdown of a project). The Climate Action Reserve reserves the right to apply a further percentage deduction at the program level in addition to the discounts applied to account for performance decline and abandonment rates, if warranted. The Reserve will conduct periodic, random audits of a subset of projects within Climate Forward to evaluate program-wide performance and adjust the percent deduction at the program level in accordance with the results of these audits.

3.1.14 Ensuring Permanence

Because CO_2 and other GHG emissions remain in the atmosphere for long periods of time, reductions in GHG emissions must effectively be permanent. However, some types of mitigation projects cause GHG reductions by removing CO_2 from the atmosphere and storing it in a reservoir (e.g., in trees or other organic materials, or in geologic formations). In these cases, there is a risk that CO_2 may be re-emitted to the atmosphere, leading to a "reversal" of GHG removals. A reversal occurs when the total amount of CO_2 stored by a mitigation project becomes less than the total number of mitigation credits issued to the mitigation project. This can happen, for example, if some or all the trees associated with a forest mitigation project are destroyed by fire, disease, or intentional harvesting in excess of growth.

If a mitigation project type has a risk for reversal, it must be described and addressed in the forecast methodology. This will most likely be in the form of a discount on mitigation credits issued depending on the assumed risk of reversal for a given mitigation project or mitigation project type. Discounts due to the risk of reversal are not eligible to be issued through the Voluntary Ongoing Monitoring Incentive described in Section 3.1.16.

3.1.15 Project Implementation and Confirmation

Summary project information, input data, estimation summaries, and continued implementation measures should be submitted in the form of a Project Implementation Report prepared by the project proponent. The forecast methodology must detail what information should be included in such a Project Implementation Report.

Beyond criteria for the confirmation of initial implementation, the forecast methodology shall describe and address any Project Resilience Measures that will be undertaken to continue the implementation of the mitigation project for the duration of its crediting period. All proposed methodologies must thoroughly identify risk factors that negatively affect project performance or cause project abandonment and describe Project Resilience Measures. Such measures will need to be methodology-specific for a proposed project type. For example, a forecast methodology might include a funding mechanism to ensure the mitigation project is managed appropriately into the future or require a conservation easement to ensure land conservation in perpetuity.

3.1.16 Voluntary Ongoing Monitoring Incentive

As described in Section 3.1.13, all projects are required to contribute a methodology-specific percentage of anticipated GHG reductions to the *ex ante* risk pool. The Reserve recognizes that project proponents may believe that submitted projects can exceed the FMU issuance granted upon initial registration due to this contribution. To the extent that projects can demonstrate that actual GHG reductions have exceeded the original quantity of FMUs recognized by the project, this program is structured to allow project proponents to receive credit for additional reductions beyond the initial *ex ante* crediting by submitting documentation verifying the additional quantity of GHG reductions produced.

Forecast methodologies must specify the monitoring information and data required for submittal to Climate Forward on an ongoing basis to be eligible for crediting from the project's contribution to the risk pool. All submitted monitoring information and data must be verifiable and will require periodic third-party verification to confirm the veracity of reported data and continued operation of the project, the frequency of which is set by the relevant methodology. The project proponent must also provide a final data report, subject to verification, describing how the monitoring information demonstrates that project performance exceeded anticipated GHG reductions to justify issuance of some portion of a project's contribution to the risk pool.

All monitoring and reporting, inclusive of the final data report, are subject to verification. As this ongoing monitoring is voluntary in nature, the project proponent may decide to cease ongoing monitoring and reporting to Climate Forward at any point in time prior to the conclusion of the crediting period without penalty but would then forfeit the right to be issued any credits from the risk pool.

Projects may be issued the full quantity of FMUs warranted upon successfully completing an *ex post* verification. The verification must be conducted in accordance with verification rules established within the relevant methodology.

See Box 3.4 for further discussion and a hypothetical example.

Box 3.4. Rationale and Example of Ongoing Monitoring Incentive

Recognizing that mitigation projects under Climate Forward are developed with the intent of generating credits on an *ex ante* basis, the inclusion of a voluntary incentive for ongoing monitoring of project data creates greater assurance of environmental integrity of underlying GHG reduction claims.

For example, suppose a forecast methodology is related to reforestation projects with a 25-year crediting period. In year 1, after confirmation, the project is issued 80,000 FMUs. In year 25, the project proponent hires a third-party verifier to conduct a full site inventory using inventory methods from the approved methodology, and the verifier concludes that the project area has sequestered 120,000 MT CO_2e (after accounting for permanence). The project proponent could then consider applying for an additional issuance of 40,000 FMUs.

3.1.17 Confirmation Activities

There is no requirement for ongoing verification of the mitigation project under this program. This program requires a one-time implementation confirmation by an independent third party to confirm the mitigation project has been implemented as described in the forecast methodology. The confirmation incorporates both a desktop documentation review and a site visit assessment of the mitigation project. The forecast methodology shall describe what type of documentation and data the independent third party should expect to review as part of the confirmation activities, and what criteria/activities the independent third party shall confirm when on site after mitigation project implementation. Confirmation bodies should also consult the Climate Forward Confirmation Manual for further requirements related to project confirmation and confirmation body rules and requirements.

3.2 Criteria for Mitigation Projects

Eligibility criteria specify essential characteristics that a GHG mitigation project must have to register under this program. These criteria must be detailed in each forecast methodology and

any subsequent project submittal. To be eligible, the project proponent must demonstrate that the mitigation project will:

1. Be additional, i.e., it would not have happened in a conservative "business as usual" scenario.
2. Be unique, i.e., not be listed, registered, or credited through another GHG reduction scheme.
3. Be conservatively estimated.
4. Have characteristics that expand the accessibility of actions available under existing GHG reduction incentive programs (such as existing offset protocols).
5. Not cause adverse environmental, social, or economic impacts.

Each of these criteria is discussed further below.

3.2.1 Additionality

It is important to credit only GHG reductions from mitigation projects that are additional to their "business as usual" baseline scenarios. Baselines represent counterfactual scenarios in which the Climate Forward program does not exist to provide incentives to implement the mitigation project. Ensuring that the activity would not have taken place in the absence of the program ensures that FMUs issued for the mitigation activities are additional. Additionality is critical to the success and integrity of programs that recognize project-based GHG reductions. The Reserve requires a standardized approach to determining additionality under this program, where performance standards and other conditions or criteria that mitigation projects must meet will be assessed by a confirmation body and ultimately approved by the Reserve.

3.2.1.1 Project Submission Deadline

To be eligible as a mitigation project, the project must be submitted to Climate Forward no more than one year after the mitigation project start date, as defined in the relevant approved forecast methodology. Projects may always be submitted prior to the mitigation project start date.

3.2.2 Double Counting

To ensure the integrity of the mitigation credits issued and avoid any issues of double counting, the mitigation project must not be concurrently listed, registered, or earning credits under any other GHG reduction scheme. It may be possible for a mitigation project that has previously been credited under another scheme to transfer into this program, but no previously credited reductions will be recognized by this program.

3.2.3 Conservative Quantification

Climate Forward is premised on the idea that mitigation activities, including CEQA mitigation, often allow for the forecast of GHG emissions from certain development projects and activities and allows emitters to quantify and address the impact of those emissions on an *ex ante* basis. The program is designed to mirror this forward-looking approach. The program aims to provide documentation that will demonstrate to a high degree of transparency that a quantity of forecasted emission reductions from a mitigation project (i.e., FMUs) have been issued and retired which the project proponent can then balance against the mitigation of forecasted emissions associated with a specific project approval. To that end, forecast methodologies used to quantify forecasted emission reductions must contain robust and conservative assumptions to account for uncertainty and ensure environmental integrity.

3.2.4 Market Expansion Objective

Mitigation projects submitted to Climate Forward are required to describe, in accordance with the guidance set forth in the relevant forecast methodology, how the project supports the program's objective of market expansion. This description may be qualitative in nature.

3.2.5 Regulatory Compliance and Environmental and Social Safeguards

The Reserve requires project proponents to demonstrate that their GHG projects will not undermine progress on other environmental issues such as air and water quality, endangered species and natural resource protection, and environmental justice. When registering a project, the project proponent must attest that the project was in material compliance with all applicable laws, including environmental regulations, during the period of confirmation, as well as that the project is designed to continue to be in material compliance with all applicable laws for the duration of the crediting period. Moreover, preference will be given to methodologies and/or projects that deliver other direct social and environmental benefits.

The project proponent must implement measures that reasonably ensure that the project will remain in material compliance with all applicable laws for the duration of the crediting period. Implementation of these measures are subject to confirmation by the confirmation body. Determination of whether the measures are sufficient to reasonably mitigate the risk of regulatory non-compliance is at the sole and final discretion of the Reserve. Individual forecast methodologies may be required to include measures for projects designed specifically to ensure environmental and social safeguards.

3.3 Methodology Approval

When the Reserve has not already approved a forecast methodology applicable to a mitigation project, the project proponent will need to propose a forecast methodology for approval. The Reserve will only issue FMUs for forecasted GHG reductions estimated and confirmed under an approved forecast methodology. The Reserve reserves the right to reject any submitted methodology that does not meet the standards for high environmental integrity described in this manual. The decision to approve or reject a methodology is solely at the discretion of the Reserve.

Proposed forecast methodologies are reviewed by the Reserve and by third-party technical experts (peer reviewers), if necessary, and will also undergo a public review and comment process (see Figure 3.1). The process for third-party technical expert review is to be initiated as soon as the Reserve determines that third-party technical expert review is warranted. The Reserve will work with the project proponent to revise the forecast methodology to meet the principles of the Climate Forward program (see Section 1.6). Once a forecast methodology has been approved by the Reserve, mitigation projects may be submitted and issued FMUs using that approved methodology. See below for an overview of the forecast methodology approval process. For a more detailed description of the forecast methodology approval process, please see the Forecast Methodology Approval Manual.

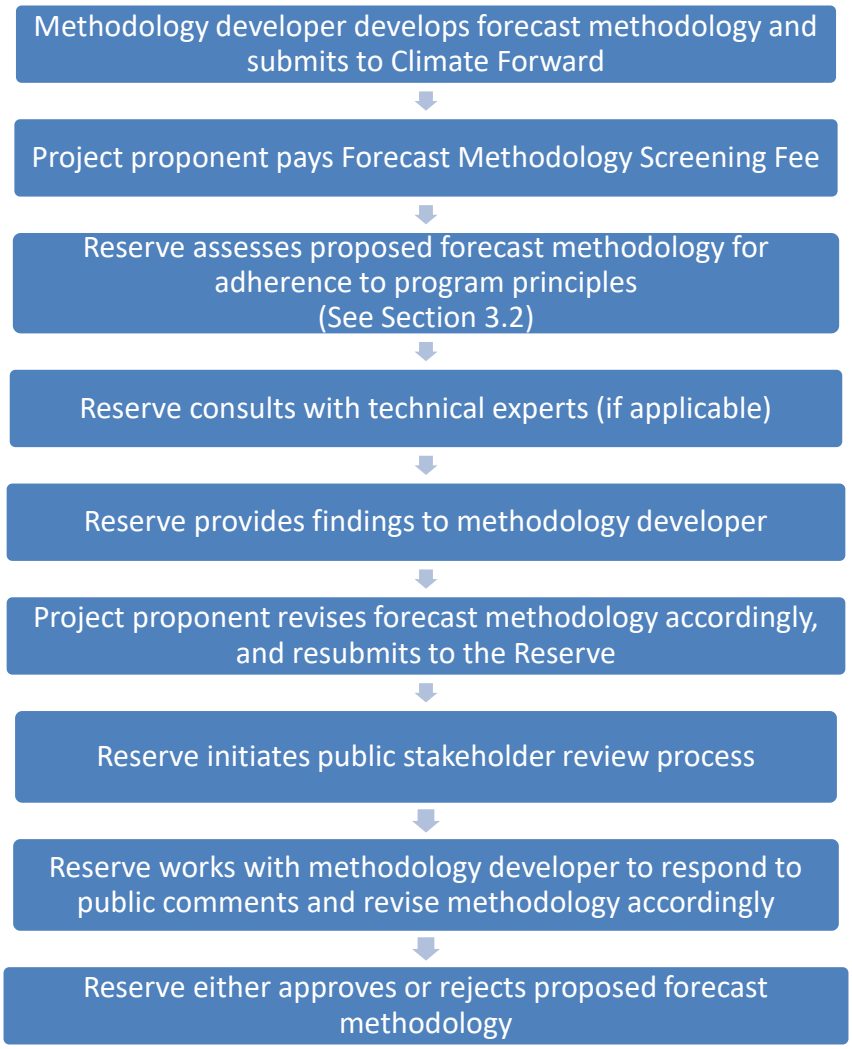

Figure 3.1. Summary Overview of the Forecast Methodology Approval Process
For more details regarding the process, please see the Forecast Methodology Approval Manual.

3.3.1 Methodology Approval Costs

The cost of the methodology approval process consists of a screening fee and a variable peer review fee for the technical expert review of the forecast methodology. The forecast methodology developer is responsible for all fees associated with methodology review, and all fees must be paid before the review process begins. Payment of all fees is final and is not contingent on whether or not the methodology is ultimately accepted by the Reserve. Please refer to the Climate Forward Fee Schedule for specific fees.

3.3.2 Reserve Review

Once a forecast methodology has been submitted to Climate Forward and the appropriate fees have been paid, the Reserve will conduct a review of the forecast methodology for adherence to methodology requirements detailed in the Section 3.1.

The Reserve will provide its findings to the project proponent. The project proponent must respond to all findings, which may require amendment of the forecast methodology.

In recognition that the Reserve may not have sufficient experience or expertise regarding the submitted forecast methodology, the Reserve may engage with one (or more) third-party technical expert(s) to assist in assessing forecast methodologies for their adherence to Climate Forward requirements. Technical experts will document their assessment of the proposed forecast methodology to the Reserve. This assessment will address each of the sections listed above and the technical expert's opinion on whether the forecast methodology presents an approach to estimating emission reductions from the mitigation projects that is in line with this program's principles and reflects the latest scientific understanding and sector-based best practices.

4 Project Cycle

This section summarizes the administrative steps a project proponent must follow to register a mitigation project under Climate Forward. Each phase of the cycle denotes a milestone that the mitigation project has reached on the pathway to mitigation credit issuance. The project cycle can be summarized into the following steps:

- **Account registration:** Entities or individuals that wish to undertake a mitigation project (a project proponent) request an account in the Climate Forward registry.

- **Submittal:** The project proponent submits the mitigation project to Climate Forward, using a previously approved forecast methodology (see Section 3.3).

- **Listing:** The mitigation project is publicly posted in the Climate Forward registry. This means that the project has passed an initial review for completeness and consistency with the program and the forecast methodology requirements.

- **Project implementation:** The project proponent implements the mitigation project and estimates the forecasted emission reductions according to the requirements of the approved forecast methodology.

- **Implementation confirmation:** Subject to approval by the Reserve, the project proponent retains an accredited independent third party to confirm that the mitigation project has been implemented, the forecasted emission reductions have been estimated appropriately, and that the project has met all requirements of the applicable forecast methodology. Confirmation activities shall not commence prior to the project start date. The timing of confirmation should allow for full implementation of the project activities, and will be specified by each forecast methodology. Specific project circumstances presented to the Reserve may serve to justify approval of an alternative schedule.

- **Project verification (optional):** For projects seeking additional crediting beyond the initial FMU issuance, project verification is required. Subject to approval by the Reserve, the project proponent retains an accredited independent third party to review documentation, monitoring data, and procedures used to estimate GHG emission reductions. The verification body submits a Verification Statement and Verification Report that provide the basis for determining the quantity of FMUs that can be issued to the project in addition to the FMUs issued after implementation confirmation.

- **Registration:** The Reserve reviews the third-party evaluation and, if appropriate, approves the project for registration and issuance of a specific quantity of forward-looking mitigation credits.

- **FMU issuance:** The Reserve issues the forward-looking mitigation credits into the account of the project proponent.

- **Mitigation credit transfer (optional):** The project proponent may sell or purchase mitigation credits after issuance; the Reserve records transfers of mitigation credits in the Climate Forward registry.

- **Mitigation credit retirement:** The credit holder requests the permanent retirement of mitigation credits to mitigate specific development activities.

Project proponents, accredited independent third parties, and the Reserve each have varying roles and degrees of responsibility throughout the project cycle. See Figure 4.1 for a representation of the project cycle steps and relevant parties. See the sections below for more detail on each step of the project cycle.

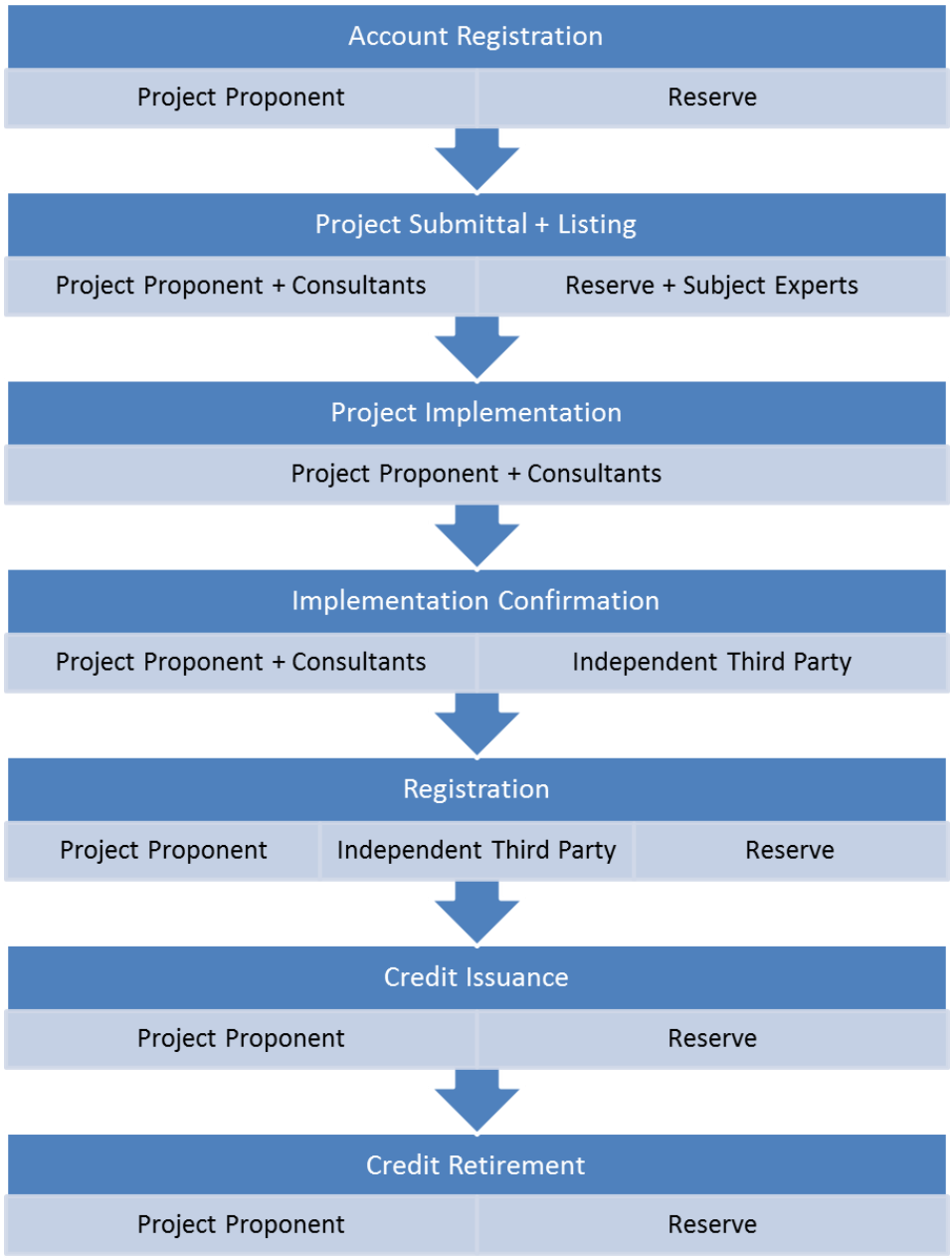

Figure 4.1. Program Flowchart and Relevant Parties

4.1 Account Registration

As a first step, an individual or entity wishing to pursue issuance of mitigation credits for a mitigation project must set up an account in Climate Forward. Account registration occurs once; any number of mitigation projects can be registered under the same account.

The Reserve conducts due diligence on all individuals or entities that wish to hold an account in the Climate Forward registry through a rigorous "know your client" (KYC) process to ensure that entities with accounts are legitimate organizations This will safeguard against fraud. The Reserve KYC process requires the submittal of the following documentation and information:

1. Copy of account manager's (individual managing the account) government issued identification (e.g., driver's license, passport, etc.), as well as a copy of the government issued identification of the individual authorized to sign the Terms of Use (TOU), if that individual is not the account manager.
2. A copy of a bank statement of the account holder (organization).
3. A copy of one of the following:
    a. The account holder's certificate of incorporation, certificate of formation, certificate of partnership or equivalent formation document, certified by an official of the account holder's jurisdiction of formation;
    b. A certificate of good standing issued by the account holder's jurisdiction of formation; or
    c. With respect to a partnership for which no certificate as described above is available, a copy of the executed partnership agreement.
4. A copy of the organization's Articles of Incorporation and any amendments or corrections hereto.
5. Documentation (Board resolution or similar evidence) showing that the account holder has been authorized to become an account holder in the Climate Forward registry.
6. Documentation (Board resolution or similar evidence) showing that the account manager has been authorized to act on behalf of the account holder in connection with the application to become an account holder in the Climate Forward registry.
7. A copy of the organization's corporate structure or organization chart, which includes the names of the account manager's immediate supervisors, if applicable.
8. A brief summary of experience and the mitigation project types that are intended to be developed.

Along with reviewing this documentation, the Reserve also performs the following checks:

1. Verification of entity's legal existence by conducting business search in relevant Secretary of State website;
2. Internet search to confirm accuracy of management team, personnel, contact information represented in application; and
3. Internet search to confirm entity is not a bad actor or a fraudulent account.

In addition to completing the application and undergoing the Reserve's KYC process, each applicant must agree to the Terms of Use for Climate Forward. It sets out the terms by which the Reserve has agreed to provide account holders with access to use Climate Forward and participate in the program.

Once the KYC process has been satisfactorily completed and the Terms of Use has been signed, the Reserve will approve and open the account.

4.1.1 Types of Accounts

There are three types of accounts in Climate Forward:

1. **Project proponent**. An account type for organizations that wish to register mitigation projects that generate GHG reductions. This account type can also be used to transfer and manage FMUs.
2. **Confirmation body**. An account type for accredited confirmation bodies that have been trained and authorized by the Reserve to confirm the proper implementation of mitigation projects. There is no annual account fee for confirmation bodies.
3. **Trader/Broker/Retailer**. An account type for users to receive, manage, and transfer offset credits, but cannot develop or register projects.

The public also can view information on the Climate Forward registry, but an account is not needed to view publicly available information.

4.2 Project Submittal

Project proponents must submit to Climate Forward the appropriate submittal documentation for the mitigation project type and pay a mitigation project submittal fee to the Reserve (see Section 3.3.1). Submittal documentation is specified in each approved forecast methodology and includes mitigation project descriptions and preliminary information used to assess the project's eligibility. A mitigation project is considered "submitted" when all appropriate documentation has been completed and submitted to Climate Forward and the submittal fee has been paid.

4.3 Project Listing

Once the mitigation project is submitted, the Reserve reviews the documentation to determine whether it is complete and conducts a preliminary assessment of the project's eligibility according to the eligibility criteria set forth within the relevant approved forecast methodology. Once this review is satisfactorily completed, the mitigation project is "listed" and made publicly available on the Climate Forward registry. Confirmation activities cannot begin until a mitigation project is listed.

Listing a mitigation project does not constitute a validation or confirmation of the mitigation project; it is a preliminary review of information provided to the Reserve by the project proponent. It is not a final determination of the eligibility of the mitigation project, nor does it guarantee mitigation credit issuance or mitigation credit ownership.

4.4 Project Confirmation

There is a requirement for an accredited confirmation body to perform a one-time confirmation that the mitigation project has been implemented as described in the forecast methodology, and that the estimated emission reductions have been calculated accurately. The confirmation incorporates both a desktop documentation review and a site visit assessment of the mitigation project. Confirmation activities shall generally not commence prior to one year following the project start date in order to establish an observable level of project performance, unless otherwise specified by the forecast methodology and/or project circumstances approved by the Reserve in advance of any confirmation. The confirmation body submits a Confirmation Statement and Confirmation Report that provide the basis for determining the quantity of FMUs

that can be issued to the project. The Reserve makes these documents publicly available. Project Experts (someone who has completed the confirmation body's internal training processes and procedures to achieve this designation and passed the Reserve training course(s) on program implementation confirmation) conducting confirmation activities for projects listed or registered with Climate Forward must be trained by the Reserve.

Confirmation bodies follow guidelines set forth in the Climate Forward Program Manual and Climate Forward Confirmation Manual, as well as rules and procedures described in the specific confirmation guidance that is included in each approved forecast methodology.

Beyond criteria for the confirmation of mitigation project implementation, the confirmation body also confirms Project Resilience Measures as specified in the forecast methodology that are to be undertaken to ensure the continued implementation of the mitigation project for the duration of its crediting period. The confirmation body assesses whether such measures have been appropriately implemented during the site visit.

Registration and mitigation credit issuance are contingent upon successful confirmation by an accredited confirmation body and the submission and approval of all required forms and documents, including, but not limited to:

- Attestation of Title
- Attestation of Legal Additionality
- Attestation of Regulatory Compliance
- Project Implementation Report
- Confirmation Report, Confirmation Statement, and List of Findings (see Climate Forward Confirmation Manual)

4.4.1 Attestation of Title

All project proponents must submit a signed Attestation of Title form indicating that they have exclusive ownership rights to the emission reductions resulting from the mitigation project.

This form shall be signed and submitted prior to confirmation activities. Note that the entity/individual signing the Attestation of Title must be the account holder who submitted the mitigation project. Mitigation projects will not be registered unless the account holder and signatory to the attestation forms match.

4.4.2 Attestation of Legal Additionality

All project proponents must submit a signed Attestation of Legal Additionality form that confirms the mitigation project activity was not required by any law, statute, rule, regulation or other legally binding mandate by any national, regional, state, local or other governmental or regulatory agency having jurisdiction over the project. The project proponent also attests that the mitigation project activity was not established or implemented, and was not at any time prior to the project's start date operated, in anticipation of or to avoid the anticipated requirements of any law, statute, rule, regulation or other legally binding mandate by any national, regional, state, local or other governmental or regulatory agency having jurisdiction over the project.

This form is signed and submitted prior to confirmation activities. The Attestation of Legal Additionality is one of the primary mechanisms by which the mitigation project passes the legal requirement test, as specified in each forecast methodology.

4.4.3 Attestation of Regulatory Compliance

All project proponents must sign and submit an Attestation of Regulatory Compliance form that confirms the mitigation project has implemented measures to address the risks of regulatory non-compliance identified in the forecast methodology associated with initial and ongoing project implementation. In addition, the form is used to attest that the project is in material compliance with all applicable laws, including environmental regulations, during the confirmation period, and has been designed and is expected to remain in material compliance with all applicable laws for the duration of the crediting period. The Attestation of Regulatory Compliance form is signed and submitted prior to confirmation activities.

4.4.4 Project Verification

If a project opts to seek additional FMU issuance through either the Voluntary Ongoing Monitoring Incentive or by seeking an *ex post* crediting period renewal, the Reserve requires periodic third-party verification, as specified in each approved forecast methodology. This provides an independent review of data and information used to register additional FMUs beyond the initial issuance. For every project, a third-party verification body reviews documentation, monitoring data, and procedures used to estimate GHG reductions or removals. The verification body submits a Verification Statement and Verification Report that provide the basis for determining the quantity of FMUs that can be issued to the project. The Reserve makes these documents publicly available. Verifiers conducting verification activities for projects listed or registered with Climate Forward must be trained by the Reserve. Any entity accredited as a confirmation body by the Reserve is also accredited as a verification body for Climate Forward for the purpose of conducting *ex post* verifications in support of the Voluntary Ongoing Monitoring Incentive. If a confirmation body wishes to conduct verifications under the Reserve's voluntary offset program, it must adhere to all verification accreditation requirements of the Reserve voluntary offset program. Any individual accredited to perform confirmations by the Reserve is also accredited as a verifier for the purpose of performing *ex post* verifications under Climate Forward.

4.5 Stakeholder Input for Individual Projects

Direct and indirect stakeholder interaction is an integral part of the process for developing forecast methodologies under Climate Forward. This includes comment periods that are open to the general public. At the project level, interactions generally involve those stakeholders with a commercial interest in the projects (e.g., facility owners, project proponents, confirmation bodies, consultants, FMU end users, regulators, etc.). This section details avenues for non-commercial stakeholders to interact with the Reserve in relation to individual projects (rather than forecast methodologies).

4.5.1 Local Stakeholder Consultations

Every Climate Forward methodology includes requirements to ensure that credits are only issued for emission reductions at projects that are in compliance with applicable regulations, and which do no net environmental harm. In some cases, Climate Forward projects may have the potential to create social impacts on the local community, either positive or negative, which may not be appropriately handled by other, existing government structures. In those cases, the individual forecast methodology may include additional requirements for local stakeholder consultations. In addition, every forecast methodology development process involves at least one public comment period, with a public webinar. Local stakeholders are welcome to participate in any of these public events.

4.5.2 Feedback and Grievance Process

For any project type, it is possible that a stakeholder may want to contact the Reserve to provide feedback, either positive or negative. For general feedback or inquiries, stakeholders may contact info@climateforward.org, or call the Reserve office at (213) 891-1444.

The Reserve strives to avoid adopting forecast methodologies for activities that present a risk of negative environmental or social impacts. However, if a stakeholder has a grievance about a specific project, the initial point of contact would be the same as described above. The Reserve staff member receiving this initial contact will collect as much information as possible from the stakeholder about the specific project and grievance. This will then be communicated to the senior management at the Reserve, including the President. The specific action taken will depend on the nature of the grievance.

- For cases of a potential over-issuance, Reserve staff will conduct a thorough review and analysis, then ensure that the program is "made whole."
- For disputes related to ownership of the FMUs, the Reserve senior management and legal counsel will review the positions and documentation of the parties involved and determine the appropriate owner (based on existing Reserve guidance related to ownership of FMUs), as well as whether any additional action against the project or the project proponent is warranted. The Reserve will not be party to any disputes where the involved parties pursue actions beyond the Reserve issuing a determination as previously described.
- For grievances related to potential negative social or environmental impacts related to a Climate Forward project, which are not in violation of existing regulations (and thus handled by the relevant government agency), the Reserve senior management will conduct a finding of facts and consider the stakeholder's position. Such instances may be referred to the Board of Directors for a decision on project eligibility.

4.6 Registration

Once the confirmation body completes the Confirmation Statement, Confirmation Report, and List of Findings, the project proponent reviews the confirmation body's documents and then submits them to Climate Forward to seek project registration. The Reserve reviews the documents and either registers the project or requests a resubmittal of one or more components. It is possible that a project could be rejected if insufficient and/or unsatisfactory information is submitted to the Reserve. Upon registration, the status of the mitigation project changes from listed to registered in the Climate Forward registry.

Registration of projects using forecast methodologies developed for Climate Forward is limited to the Climate Forward program and other carbon offset programs that have pre-existing agreements in place with the Reserve. If a project proponent is seeking crediting under a forecast methodology developed for Climate Forward under a different program, it is the project proponent's responsibility to notify the Reserve and to ensure that there is such a pre-existing agreement in place.

4.7 Credit Issuance

Once a mitigation project is registered by the Reserve, FMUs are issued as "pending" into the project proponent's account. The project proponent then receives an invoice for the issuance of FMUs generated by the mitigation project. Once the invoice is paid, the FMUs are activated and can be transferred to another account holder or retired. An account holder can only hold or retire

FMUs in its account for which it is the sole holder of legal title, except as permitted under Section 9 of the Climate Forward Terms of Use.

To ensure proper tracking and accounting, each FMU has a unique serial number with embedded information that discloses various project specific details. The unique serial number persists indefinitely. Information on the number of FMUs that have been issued to each registered mitigation project is publicly available information.

4.8 Credit Transfers

In order to transfer FMUs to another party, that party must have an approved account in Climate Forward. There is a transfer fee per FMU charged to the transferor. Once the credit transfer invoice has been paid, the FMUs are transferred from one account to the other.

Note that Climate Forward does not function as a trading system or commodity exchange. The sale or purchase of FMUs takes place outside of the Climate Forward registry. Account holders may record sales by using the Climate Forward registry to move FMUs from one account to another. However, the Reserve makes no warranties concerning, and has no control over, the legal ownership of FMUs that may be held in individual accounts.

4.9 Credit Retirement

FMUs may be retired to indicate that the forecasted GHG emission reductions they represent have been used to satisfy a mitigation claim. To support such a claim, FMUs are taken out of circulation so that they cannot be used to support any further claims. The Reserve retires FMUs by transferring them to a locked retirement account where they remain in perpetuity, precluding further use or transfer to other parties. Information about retired FMUs is publicly available and includes details regarding the underlying mitigation project as well as the reason for retirement.

In order to retire FMUs, an account holder must request the retirement of a specific quantity of FMUs in writing and the Reserve confirms the account has sufficient FMUs to support the retirement request. There is no retirement fee per FMU charged to the account holder. Once the retirement transaction has been approved, the Reserve transfers the requested quantity of FMUs to the locked retirement account and issues a certificate to the account holder detailing the quantity and serial numbers of FMUs that have been retired. The account holder can present this retirement certificate to any entity, including the regulating body with its permit application, as evidence of approved GHG mitigation activity.

4.10 Transferring Projects from Climate Forward

Projects may be transferred from Climate Forward to other GHG registries and offset programs. To transfer a project, the project proponent shall provide a signed Project Transfer Letter to the Reserve specifying the effective date of transfer and confirming that no further reporting will be done under Climate Forward.

Once a project is transferred, no future reductions or removals from that project will be registered as FMUs. Project information and previously issued FMUs will remain in the Climate Forward registry under their given serial numbers.

4.11 Record Keeping and Retention

According to the Terms of Use, the Reserve has the right to examine, audit, and obtain copies of users' records relevant to their most recent project registration under Climate Forward. The

Reserve does not anticipate this being a routine need, but rather a rare event to verify the accuracy of any attestation, transfer or statement, or to review account holders' performance of obligations under the forecast methodologies, this Program Manual, or the Terms of Use.

Project proponent account holders in the Climate Forward registry must also maintain copies of all relevant records related to their projects and associated account usage for the time period specified in each methodology. If the methodology is silent, documentation must be retained for a minimum of seven years after the most recent year of credit issuance. If a project proponent intends to participate in the Voluntary Monitoring Incentive program, documentation must be retained to support such participation.

4.12 Publicly Available Information

Climate Forward is intended to serve both project proponents and the interested public. To this end, information about each mitigation project and account holder is accessible to the public. This openness and transparency provides interested parties with valuable information and enhances the credibility of the issued FMUs. The public and all account holders can access the following information online:

- **Participating entities.** Organizations/individuals that have an active account (address or contact information is not disclosed).

- **Mitigation projects.** Mitigation projects that are listed or registered with Climate Forward. Rejected mitigation project submittals and mitigation projects that are de-listed prior to registration and/or FMU issuance are not displayed; however, information will be made publicly available indefinitely for any mitigation project to which FMUs have been issued.

- **Approved forecast methodologies.** All approved forecast methodologies are available for download on the Climate Forward website.

- **FMUs issued.** The quantity of FMUs issued to each mitigation project will be publicly accessible, and each FMU will be serialized. FMU balances in individual accounts are not disclosed.

- **Retired FMUs.** Displays the FMUs that have been retired by account holders for use against anticipated emissions.

Information that is never shared with the public includes:

- Company street addresses
- Company phone, fax, or email addresses
- Internal company information, like billing addresses
- Any person's contact information

5 Glossary

Business day	Any day except Saturday, Sunday, or an observed Federal Reserve Bank holiday. A business day shall open at 8:00 a.m. and close at 5:00 p.m. Pacific Prevailing Time.
Confirmation	The process used to ensure that a given project proponent's projected GHG emission reductions have met a minimum quality standard and complied with Climate Forward's procedures and approved forecast methodologies
Confirmation body	An organization or company that has been ISO-accredited and approved by the Reserve to perform GHG confirmation activities for specific forecast methodologies.
Confirmed	A mitigation project is considered "confirmed" when the mitigation project confirmation body has submitted the mitigation project's Confirmation Statement and the Confirmation Report in the Climate Forward registry and it has been accepted by the Reserve.
Mitigation project	A mitigation project is the undertaking or funding of activities that directly reduce or sequester GHG emissions at a location other than the site of a project with anticipated GHG emissions.
Forecast methodology	A document that contains the eligibility rules, GHG assessment boundary, quantification methodologies, monitoring and reporting parameters, confirmation requirements, etc. for a specific mitigation project type.
Forecasted Mitigation Unit (FMU)	The unit of mitigation credits used by Climate Forward. One FMU represents one metric ton of carbon dioxide equivalent (CO_2e) expected to be reduced or sequestered.
GHG emission reduction (Reduction)	A reduction of GHG emissions to the atmosphere or removal of carbon dioxide from the atmosphere that is used to compensate for an equivalent amount of emissions from another GHG emitting activity occurring elsewhere as the result of a mitigation project. For the purposes of Climate Forward, an FMU becomes a mitigation credit when it is retired.
Listed	A mitigation project is considered "listed" once the Reserve has satisfactorily reviewed all mitigation project submittal forms. The mitigation project will then appear in the public interface of the Climate Forward registry.
Project proponent	An organization or individual that registers mitigation projects for generating emission reductions or removals. In the Climate Forward registry, project proponents may be issued FMUs for the confirmed emission reductions or removals that their mitigation projects achieve. They can also transfer and manage FMUs.

Project Implementation Report	A report provided by the project proponent detailing all data sources, estimations, and implementation of Project Resilience Measures.
Project Resilience Measure	A measure required to be implemented by the project to address the risks of project abandonment, underperformance, or failure.
Registered	A mitigation project is considered “registered” when the mitigation project has been confirmed by an approved third-party confirmation body, submitted by the project proponent to Climate Forward for approval, and accepted by the Reserve.
Retired	When FMUs are transferred to a retirement account in the Climate Forward registry, they are considered retired. Retirement accounts are permanent and locked, so that a retired FMU cannot be transferred again. FMUs are retired when they have been used to mitigate an equivalent tonne of emissions or have been removed from further transactions on behalf of the environment.
Submitted	A mitigation project is considered “submitted” when all the appropriate forms have been completed, uploaded, and submitted to Climate Forward.
Verification	The process used to ensure that a given project proponent’s historic, reported GHG emission reductions have met a minimum quality standard and complied with Climate Forward’s procedures and forecast methodologies.

CLIMATE FORWARD

Dairy Digester Project Forecast Methodology

Version 1.0 | September 25, 2019

A program of the CLIMATE ACTION RESERVE

Climate Action Reserve
www.climateactionreserve.org

Released September 25, 2019

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
2 The GHG Reduction Project 4
2.1 Project Definition 4
2.2 The Project Proponent 4
3 Eligibility Rules 6
3.1 Location 6
3.2 Project Start Date and Crediting Period 6
3.3 Additionality 7
3.3.1 The Performance Standard Test 7
3.3.2 The Legal Requirement Test 8
3.3.3 Uncontrolled Anaerobic Baseline 9
3.4 Environmental and Social Safeguards 10
3.5 Regulatory Compliance 11
3.6 Ownership and Double Counting 11
3.7 Project Resilience Measures 11
3.8 Demonstration of *Ex Ante* Suitability 13
4 The GHG Assessment Boundary 14
5 Quantifying GHG Emission Reductions 19
5.1 Required Parameters for Modeling Baseline and Project Emissions 19
5.2 Estimating Baseline GHG Emissions 22
5.2.1 Baseline Methane Emissions 22
5.2.2 Retention of Volatile Solids 24
5.2.3 Baseline CO_2 Emissions 28
5.3 Estimating Project GHG Emissions 29
5.3.1 Estimating Project Methane Emissions 29
5.3.2 Project CO_2 Emissions 35
5.3.3 Estimating Abandonment Rates and Performance Decline 36
5.4 Leakage Accounting 36
6 Project Implementation and Documentation 37
6.1 Quantification Parameters 37
6.2 Voluntary Ongoing Monitoring Incentive 40
7 Reporting and Record Keeping 41
7.1 Project Submittal and Confirmation Documentation 41
7.2 Record Keeping 41
7.3 Reporting and Confirmation Period 42
7.3.1 Expansion Project Confirmations 42
7.4 *Ex Post* Verification 42
8 Confirmation Guidance 44

8.1 Standard of Confirmation 44
8.2 Project Implementation Report 44
8.3 Core Confirmation Activities 45
8.3.1 Reviewing GHG Management Systems and Estimation Methodologies 45
8.3.2 Confirming Emission Reduction Estimates 45
8.3.3 Undertaking Site Visits 45
8.3.4 Confirming Implementation of Project Resilience Measures 46
8.4 Confirmation Items 46
8.4.1 Project Eligibility and Credit Issuance 46
8.4.2 Quantification 47
8.4.3 Risk Assessment 48
8.5 Completing Confirmation 49
9 Glossary of Terms 50
10 References 52
Appendix A Associated Environmental Impacts 53
Appendix B Emission Factor Tables 54
Appendix C Summary of Performance Standard Development 63
C.1 Analysis of Common Practice 63
C.1.1 U.S. Data on Manure Management Practices 63
C.1.2 U.S. and State Manure Management Regulations 68
C.2 Performance Standard Recommendation 68
C.3 Renewable Energy Certificates and Other Revenue Opportunities for Biogas-to-Energy Projects 69
Appendix D Risk Assessment 71
D.1 Variability in emission reductions from dairy digester projects 71
D.1.1 Offset Registry Data 71
D.1.2 Data Management 71
D.1.2 Emission Reductions 72
D.2 Longevity of Dairy Digester Projects 76
D.2.1 AgStar Database 76
D.2.2 Data Management 76
D.2.3 Results 77
D.2.3 Causes of Project Termination 78
Appendix E Sample Dairy Project Diagram 80

List of Tables

Table 3.1. Mitigation Measures Implemented to Reduce Risk of Project Underperformance.....12
Table 4.1. Description of GHG Sources, Sinks, and Reservoirs 15
Table 6.1. Project Monitoring Parameters 37
Table 8.1. Eligibility Confirmation Items 46
Table 8.2. Quantification Confirmation Items.....47
Table 8.3. Risk Assessment Confirmation Items 48
Table B.1. Manure Management System Components…….54
Table B.2. Livestock Categories and Typical Animal Mass 56
Table B.3. Volatile Solids and Maximum Methane Potential by Livestock Category 56
Table B.4. Biogas Collection Efficiency by Digester Type 56
Table B.5. 2010 Volatile Solid Default Values for Livestock Category Types (kg/Mg animal mass day).....57
Table B.6. IPCC 2006 Methane Conversion Factors by Manure Management System Component / Methane Source 58
Table B.7. Biogas Destruction Efficiency Default Values by Destruction Device.....60
Table B.8. CO_2 Emission Factors for Fossil Fuel Use 61
Table B.9. Volatile Solids Removed Through Solids Separation 62
Table B.10. Baseline Assumptions for Greenfield Projects.....62
Table C.1. Dairy and Swine Operations in the U.S. by Manure Management System (2006)…….....64
Table C.2. Dairy and Swine Operations in the U.S. by Manure Management System (2012)....64
Table C.3. Dairy and Swine Operations by Size and Manure Management System (2006) 65
Table C.4. Dairy and Swine Operations by Size and Manure Management System (2012) 65
Table C.5. Dairy and Swine Operations by Size and Manure Management System (2012) 66
Table C.6. Dairy and Swine Operations by Size and Manure Management System (2012) – Not Including Participants in a GHG Offset Program 67
Table C.7. Dairy and Swine Operations Utilizing Liquid Manure Management System, by Size and Manure Management System (2012) – Not Including Participants in a GHG Offset Program 68
Table D.1. Reasons for Termination of 21 Dairy Digester Projects Included in the AgStar Database……78
Table D.2. Project Longevity Adjustment Factor: Mitigation Measures that must be Implemented to Reduce the Risk of Project Underperformance 79

List of Figures

Figure 4.1. General illustration of the GHG Assessment Boundary 14
Figure 5.1. Calculation of Baseline and Project Methane Emissions Based on Livestock Manure Volatile Solids Production 23
Figure D.1. Emission Reductions as a Function of Time (Project Years) for 56 Individual Projects (P3 – P79)……..73
Figure D.2. Emission Reductions as a Function of Time (Project Years) for 56 Dairy Digester Projects.....74
Figure D.3. Deviation of Project Emission Reductions from the Associated Project's Initial Value as a Function of Time (Years after the Initial Observation) for 55 Dairy Digester Projects.....76
Figure D.4. Frequency Distribution and Cumulative Frequency Distribution for Dairy Digester Project Duration 77

List of Equations

Equation 5.1. Forecasted GHG Emission Reductions for a Project that Installs a Biogas Control System....19
Equation 5.2. Modeled Baseline Emissions....22
Equation 5.3. Modeled Annual Baseline Methane Emissions....24
Equation 5.4. Modeled Annual Baseline Methane Emissions from Anaerobic Storage/Treatment Systems....25
Equation 5.5. Calculation of Volatile Solids Degraded Monthly in Baseline Anaerobic Storage/Treatment Systems....25
Equation 5.6. Calculation of Volatile Solids Available Monthly for Degradation in Baseline Anaerobic Storage/Treatment Systems....26
Equation 5.7. Calculation of van 't Hoff-Arrhenius Factor....27
Equation 5.8. Calculation of Livestock Volatile Solids Excretion....27
Equation 5.9. Modeled Baseline Methane Emissions for Non-Anaerobic Storage/Treatment Systems....28
Equation 5.10. Modeled Annual Baseline CO_2 Emissions....29
Equation 5.11. Forecast Annual Project Emissions....29
Equation 5.12. Forecast Annual Project Methane Emissions....30
Equation 5.13. Forecast Monthly Methane Production by the Project BCS....31
Equation 5.14. Forecast Annual Project Methane Emissions from the BCS....31
Equation 5.15. Forecast Overall Monthly Methane Destruction Efficiency of the Project BCS....32
Equation 5.16. Forecast Annual Quantity of Methane Vented by the Project....32
Equation 5.17. Forecast Annual Project Methane Emissions from Anaerobic Storage/Treatment Systems Receiving BCS Effluent....33
Equation 5.18. Forecast Quantity of Volatile Solids Input Daily to Effluent Treatment Systems in the Project Scenario....33
Equation 5.19. Forecast Annual Project Methane Emissions from Non-Anaerobic Storage/Treatment Systems Receiving BCS Effluent....34
Equation 5.20. Forecast Annual Project Methane Emissions from Non-BCS-Related Sources....35
Equation 5.21. Annual Project CO_2 Emissions from Electricity and Fossil Fuel Use....36
Equation 5.22. Forecast Annual Project CO_2 Emissions....36

Abbreviations and Acronyms

BCS	Biogas control system
CEQA	California Environmental Quality Act
CO_2	Carbon dioxide
CH_4	Methane
EF	Emission factor
FMU	Forecasted Mitigation Unit
GHG	Greenhouse gas
t	Metric ton (or tonne)
N_2O	Nitrous oxide
Reserve	Climate Action Reserve
SSR	Source, sink, and reservoir

1 Introduction

The Climate Action Reserve (Reserve) is an environmental nonprofit organization that promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. Based in Los Angeles, the Reserve is the foremost carbon offset registry in North America with internationally recognized expertise in project-level GHG accounting. The Reserve establishes regulatory-quality standards for the development and quantification of GHG emission reduction projects; issues GHG emission reduction credits for use in compliance and voluntary carbon programs; and tracks the transaction of credits over time in transparent, publicly-accessible systems. Adherence to the Reserve's standards ensures that emission reductions associated with projects are real, permanent, and additional, thereby instilling confidence in the environmental benefit, credibility, and efficiency of carbon markets.

Climate Forward, a greenhouse gas mitigation program of the Climate Action Reserve, provides a practical solution to companies and organizations seeking cost-effective mitigation of anticipated (i.e., future) operational and/or project-related GHG emissions. Climate Forward facilitates investments in GHG reduction[1] activities that are practical, scientifically-sound, transparent, and aligned with forward-looking mitigation needs such as the California Environmental Quality Act (CEQA). Climate Forward will drive forward-looking investment into actions expected to result in GHG reductions, with a goal of expanding the scope and scale of feasible emission reduction project types.

Climate Forward is designed to provide companies, organizations, developers, and other entities with a conservative, robust, and methodologically rigorous option to mitigate an estimate of expected GHG emissions, on a voluntary or compliance basis, using Forecasted Mitigation Units (FMUs) generated from mitigation projects under this program. Climate Forward fundamentally differs from existing carbon credit programs through its focus on projecting and crediting estimated emission reductions on an *ex ante* basis. Under Climate Forward, estimated GHG reductions from the mitigation project are recognized as FMUs, which are each equal to one metric ton of carbon dioxide equivalent (CO_2e) expected to be reduced or sequestered. FMUs can be retired for multiple purposes, including for CEQA mitigation or for other voluntary mitigation purposes.

The Dairy Digester Project Forecast Methodology provides guidance to forecast and report GHG emission reductions associated with the installation or expansion of a biogas control system (BCS) for manure management on dairy cattle farms.[2] This methodology focuses on quantifying the change in methane emissions, but also accounts for potential increases in carbon dioxide emissions. Project proponents that install manure biogas capture and destruction technologies use this document to register forecasted GHG reductions with Climate Forward. The methodology provides eligibility rules, methods to forecast and calculate reductions, and procedures for reporting project information to Climate Forward. Additionally, a Project Implementation Report will receive independent confirmation by a Reserve-approved confirmation body selected by the project proponent. Guidance for confirmation bodies to

[1] Throughout this document, the term "reduction" is intended to address both GHG emission reductions that are the result of activities designed to reduce or avoid emissions, and GHG removals, which are those activities aimed at removing atmospheric CO_2 at rates that exceed "business as usual" sequestration.

[2] The Dairy Digester Project Forecast Methodology is largely adapted from the Climate Action Reserve's U.S. Livestock Project Protocol Version 4.0 and includes much of the original language, pertinent appendices, and background material.

confirm reductions is provided in the Climate Forward Confirmation Manual and Section 8 of this methodology.

This methodology facilitates the creation of GHG emission reductions determined in a complete, consistent, transparent, accurate, and conservative manner while incorporating relevant sources.[3]

[3] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG accounting principles.

2 The GHG Reduction Project

Manure treated and stored under anaerobic conditions decomposes to produce methane, which, if uncontrolled, is emitted to the atmosphere. This predominantly occurs when dairy operations manage waste with anaerobic, liquid-based systems (e.g., in lagoons, ponds, tanks, or pits). Within the livestock sector, the primary drivers of methane generation include the amount of manure produced and the fraction of volatile solids (VS) that decompose anaerobically. Temperature and the retention time of manure during treatment and storage also affect methane production.

2.1 Project Definition

For the purpose of this methodology, the GHG reduction project is defined as the installation, or expansion, and operation of a BCS[4] that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities at dairy operations. The BCS must destroy methane gas that would otherwise have been emitted to the atmosphere in the absence of the project from uncontrolled anaerobic treatment and/or storage of manure.

Captured biogas must then be destroyed onsite (whether by flare or combustion for electricity generation), or transported for offsite use (e.g., through gas distribution or transmission pipeline), or used to power vehicles. Regardless of how project proponents utilize the captured biogas, the ultimate fate of the methane must be destruction.

"Centralized digesters" that integrate waste from more than one dairy operation do not meet the definition of a project under this methodology; however, a dairy operation that maintains offsite housing for support animal stock and transports manure regularly to the project BCS meets the project definition under this methodology, provided the housing is permitted and operated by the dairy operation comprising the BCS. Third-party facilities contracted to maintain support animal stock or facilities contracted to contribute manure to the project BCS do not meet this definition, although this methodology does not prohibit project proponents from co-digesting these manure waste sources.

Note that this methodology does not preclude project proponents from co-digesting organic matter in the BCS. However, the additional organics could impact the nutrient properties of digester effluent and project proponents should consider this when assessing the project's associated water quality impacts.

2.2 The Project Proponent

The "project proponent" is an entity that has an active account on the Climate Forward registry, submits a project for listing and registration with Climate Forward, and is ultimately responsible for all project reporting and confirmation activities. In all cases, the project proponent must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from the project. At the time a project is confirmed, the project proponent must attest that no other entities are reporting or claiming (e.g., for voluntary reporting or regulatory compliance purposes) the GHG reductions caused by the project (see Section 3.6).[5] The Reserve will not issue credits for GHG

[4] Biogas control systems encompass anaerobic digester systems – which may be designed and operated in a variety of ways (ambient temperature covered lagoons, heated lagoons, mesophilic plug flow or complete mix tank digesters) – as well as methane destruction systems, such as flares or engines.

[5] A standard form for this attestation is available on the Climate Forward website at https://climateforward.org/program/program-and-project-forms/.

reductions that are reported or claimed by entities other than the project proponent (e.g., implementation agents or others not designated as the project proponent). Under this methodology, the project proponent is the only required party to be involved with project implementation.

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to register with Climate Forward. The criteria only apply to projects that meet the definition of a GHG reduction project (Section 2.1).

Eligibility Rule I:	Location	→	United States, its territories and tribal lands
Eligibility Rule II:	Start Date	→	Start date is no more than one year prior to project submission
	Crediting Period	→	Crediting period may be up to 15 years
Eligibility Rule III:	Additionality	→	Meet performance standard: Installation of a BCS that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities on dairy operations
		→	Demonstrate that project passes the legal requirement test
		→	Demonstrate anaerobic baseline conditions at existing dairy operations or common practice for greenfield projects
		→	Exceed regulatory requirements
Eligibility Rule IV:	Environmental and Social Safeguards	→	No negative environmental and social impacts
Eligibility Rule V:	Regulatory Compliance	→	Comply with all applicable laws
Eligibility Rule VI:	Ownership and Double Counting	→	Must not receive credits from more than one program, where GHG boundaries overlap
Eligibility Rule VII:	Project Resilience Measures	→	Project must address risks of failure to reach expectations

3.1 Location

Only projects located in the United States and its territories, or on U.S. tribal lands, are eligible to register FMUs with Climate Forward under this methodology.

3.2 Project Start Date and Crediting Period

The start date for a dairy digester project is defined as the date on which the project's BCS becomes operational. For the purpose of this methodology, a BCS is considered operational on the date that the system begins producing and destroying methane gas after completion of an initial start-up period. An initial start-up period must not exceed a nine-month period following the date on which the BCS first began producing and destroying methane gas.

Projects must be submitted to Climate Forward no more than one year after the project start date, and the project confirmation must be completed no later than two years after the project

start date. Projects may always be submitted prior to the project start date, and a project proponent may change the proposed start date prior to completion of registration of the project with the Climate Forward registry.

Project proponents are eligible to register FMUs with Climate Forward according to this methodology for a period of fifteen (15) years following the project's start date. All projects that initially pass the eligibility requirements set forth in this methodology are eligible to register FMUs through the Climate Forward registry for the duration of the project's crediting period. Project crediting periods are proposed upon project submittal and established upon successful completion of the project confirmation.

A 15-year project crediting period conforms to industry-standard minimum operational life expectancies of major BCS components. Project proponents are required to demonstrate that the life expectancy of the BCS meets or exceeds the crediting period as outlined in Sections 7 and 8. Project proponents that cannot reasonably demonstrate a 15-year life expectancy may apply for a reduced crediting period that conforms to the expected BCS lifespan specific to the project.

For projects seeking FMUs for expansion projects (Section 3.3.3.3), credits will be issued from the date the expansion was completed until the end of previously confirmed crediting period. For the purpose of this methodology, an expansion is considered complete on the date that the expanded BCS system begins producing and destroying methane gas from the additional, stabilized dairy population.

3.3 Additionality

Climate Forward registers only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of the project.

Projects must satisfy the following to be considered additional:

1. The performance standard test
2. The legal requirement test
3. Uncontrolled anaerobic baseline requirement

3.3.1 The Performance Standard Test

GHG reduction activities that are not legally required may still be non-additional if they would have been implemented for other reasons, including, for example, because they are attractive investments irrespective of the value of their GHG reductions. Performance standard tests are intended to screen out this potential set of GHG reduction activities. Standards are specified such that the large majority of projects that meet the standard are unlikely to have been implemented due to financial, economic, social, and technical or technological drivers. In other words, incentives created by the carbon market are likely to have played a critical role in decisions to implement GHG reduction activities that meet the performance standard test.

Mitigation projects pass the performance standard test by meeting a program-wide performance threshold (i.e., a standard of performance applicable to all manure management projects) established on an *ex ante* basis. The performance threshold represents "better than business as usual" manure management. If the project meets the threshold, then it exceeds what would happen under the "business as usual" scenario and generates surplus/additional GHG reductions.

This methodology uses a technology-specific threshold; sometimes also referred to as a practice-based threshold, where it serves as a "best-practice standard" for managing livestock manure. By installing a BCS, or expanding one installed for an earlier project under Section 3.3.3.3, a project proponent passes the performance standard test. This installation standard is adopted from the Reserve's U.S. Livestock Project Protocol, which defined it by evaluating manure management practices in California and the United States (see Appendix C). This installation standard is also the current criterion for the California Air Resources Board (ARB) Compliance Offset Protocol for Livestock Projects.

The performance standard test is applied at the time of the project's start date, even if a project proponent develops an expansion project under Section 3.3.3.3. All projects that pass this test at the project's start date are eligible to register GHG reductions with Climate Forward for the corresponding project crediting period, even if the performance standard test is revised in subsequent versions of this methodology during that period.

3.3.2 The Legal Requirement Test

Mitigation projects are very likely to be non-additional if their implementation is required by law. The legal requirement test ensures that eligible projects and the GHG reductions they achieve would not have occurred anyway in order to comply with federal, state or local regulations, or other legally binding mandates issued by a governmental authority. A mitigation project passes the legal requirement test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, or other legally binding mandates issued by a governmental authority directly applicable to the mitigation project and requiring its implementation, or requiring the implementation of similar measures specifically at the project site that would achieve equivalent levels of GHG emission reductions.

A mitigation project passes the legal requirement test when there are no legally binding mandates issued by a governmental authority requiring the installation of a BCS or otherwise requiring the reduction or removal of methane emissions at a dairy facility ("methane reduction requirement"). If a methane reduction requirement applies, only the reductions in excess of methane reduction requirement are eligible under this methodology.

Projects submitted to Climate Forward with a project start date (or expansion completion date under Section 3.3.3.3) prior to the date that a methane reduction requirement is adopted and/or promulgated through regulations meet the legal requirement test and remain eligible for crediting for the full project crediting period. Similarly, projects registered or listed with Climate Forward prior to the date that the methane reduction requirement is adopted and/or promulgated pass the legal requirement test and remain eligible for crediting for the full project crediting period, provided the project start date is before the date on which the methane reduction requirement is implemented or becomes effective.

To satisfy the legal requirement test, project proponents must submit a signed Attestation of Legal Additionality form[6] prior to the commencement of confirmation activities.

The Reserve's analysis of manure management practices in the U.S. for the development of the U.S. Livestock Project Protocol identified no regulations that obligate livestock owners to invest in a manure BCS. The analysis looked most closely at stringent California air quality regulations (e.g., San Joaquin Valley APCD Rule 4570 and Sacramento Metropolitan AQMD Rule 496) and

[6] Attestation forms available at https://climateforward.org/program/program-and-project-forms/.

found that installing an anaerobic digester is one of several compliance options, although high capital costs appear to prevent the use of anaerobic digesters as a practical compliance mechanism for these air quality regulations.

The California Air Resources Board is pursuing anaerobic digester requirements and other air quality regulations under a Short-Lived Climate Pollution reduction strategy under California Senate Bills 605 (2014) and 1383 (2016); however, official implementation has been hampered by significant infrastructure, procurement, funding, and environmental barriers. Senate Bill 1383 set January 1, 2024 as the earliest date regulations can be implemented at livestock and dairy operations, provided the regulations are determined to be feasible, economical, cost effective, and minimize leakage. These barriers to successful implementation previously barred the Short-Lived Climate Pollution reduction strategy drafted under Senate Bill 605 from early adoption and execution in 2018 to meet aggressive targets at livestock and dairy operations beginning in 2020. While the use of anaerobic digesters is one of several compliance options, high capital costs and the likelihood of leakage appear to bar anaerobic digesters as a practical compliance mechanism under California's reduction strategy given the current policy timetable.

3.3.3 Uncontrolled Anaerobic Baseline

The installation of a BCS at a dairy operation where the primary manure management system is aerobic (produces little to no methane) may result in an increase of the amount of methane emitted to the atmosphere. Thus, the BCS must digest manure that would primarily be treated in an anaerobic system in the absence of the project for the project to be eligible to register FMUs. Sections 3.3.3.1, 3.3.3.2, and 3.3.3.3 explain the specific baseline scenario options. Under any one of these scenarios, the uncontrolled anaerobic baseline requirement may be temporarily disrupted for the purposes of construction of the project digester. In these cases, the confirmation body may use professional judgment to confirm that the requirements of this section have been met.

3.3.3.1 Existing Dairy Facilities

For dairy facilities that have been in operation prior to the project start date, the project proponent must demonstrate that an uncontrolled anaerobic manure management system was in place prior to the date that manure was first loaded into the project digester. That anaerobic system may include a lagoon, pond, or other treatment system if the design and depth of the system was sufficient to prevent algal oxygen production and create an oxygen-free bottom layer (i.e., greater than 1 meter in liquid depth).[7]

Under this baseline evaluation, if an anaerobic digester or lagoon cover was ever present and processed manure from the dairy facility, the baseline would be the digester.

3.3.3.2 New Dairy Facilities (Greenfield Projects)

Greenfield dairy projects (i.e., digester projects that are implemented concurrently with the development of a dairy facility at a site that had no prior manure management infrastructure) are eligible only if the project proponent can demonstrate that there are no restrictions to the

[7] This is consistent with the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) methodology ACM00010 (available at: http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html). For additional information on the design and maintenance of anaerobic wastewater treatment systems, see U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Storage Facility, No. 313; and U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Treatment Lagoon, No. 359.

construction and operation of an open, uncontrolled, anaerobic manure storage system at the dairy facility. Additionally, proponents must demonstrate that uncontrolled anaerobic storage of manure is common practice in the industry and geographic region of the digester project.

Since a greenfield project will not have an existing manure management system that can be used to model the baseline methane emissions, all greenfield projects shall utilize a set of standardized baseline management assumptions (Table B.10).

3.3.3.3 Expansion of Existing Mitigation Projects (Expansion Projects)

For project proponents that increase the BCS capacity for newly-expanded herds at projects successfully registered under this methodology, the new BCS capacity is eligible for crediting under the most current version of this methodology as a new, expanded digester project. New projects initiated under this section are eligible for FMU issuance for the increased herd count over the initial, confirmed herd numbers for the remaining years of the original project's crediting period, provided the project proponent complies with all methodology requirements in the expansion project and meets the additionality requirements specific to expansion projects.

An expansion is a continuation of the uncontrolled anaerobic baseline determined during the project confirmation (e.g., an initial greenfield project established under Section 3.3.3.2 will continue to utilize the standardized baseline management assumptions under the new, expansion project). Expansion projects must be submitted to Climate Forward during the crediting period registered in the initial project.

Expansions are confirmed separately from the initial project after the new GHG reduction activities have commenced, although the BCS construction and/or expansion can take place as a part of initial development or as a later event. Project proponents must demonstrate at the time of confirmation that the additional BCS storage capacity exceeds the capacity required for the dairy herd confirmed in the initial, registered project, and has sufficient capacity for the expanded herd size. To be eligible under this section, dairy expansions must meet or exceed fifteen percent (15%) of the baseline herd capacity confirmed in the initial mitigation project and have stabilized (monthly variance no greater than 15% from the 12-month running mean) for at least 12-months prior to commencement of confirmation activities.[8]

3.4 Environmental and Social Safeguards

It is anticipated that the implementation of projects pursuant to this methodology will only result in positive environmental and social impacts. For each project that is implemented, the project proponent shall confirm that no negative environmental and social impacts are expected, and describe any measures taken to avoid any such potential negative impacts. Furthermore, project proponents are encouraged to include information in the Project Implementation Report regarding any non-GHG benefits of the project activities to the environment or society. This may include discussion of how the project aligns with the United Nations' Sustainable Development Goals,[9] as well as additional quantification of any non-GHG benefits (such quantification is not specified by this methodology).

[8] The threshold was selected for congruity with dairy permitting requirements, which often require a permit amendment for herd increases that will exceed 15% of existing permitted levels.

[9] Additional information regarding the Sustainable Development Goals may be found online at: https://sustainabledevelopment.un.org/.

3.5 Regulatory Compliance

The project proponent must attest that no laws have been broken in carrying out project activities since the project start date, and provide an assessment of any aspects of the project which may present a risk of future regulatory violations. Where such risks are identified, the project proponent shall describe measures undertaken to reduce and/or mitigate these risks. The confirmation body shall endeavor to confirm that the project implementation did not result in any regulatory noncompliance, and also that the measures implemented to ensure no future violations occur, are appropriate in the circumstances of that particular project.

3.6 Ownership and Double Counting

The project proponent must attest that the project is not being submitted for emission reductions credit under any other carbon crediting program, world-wide. By signing the Attestation of Title, the project proponent attests that the FMUs have not and will not be registered with, reported in, held, transferred or retired via any emissions registry or inventory other than the Climate Forward registry, or registered with Climate Forward under a different project title or location. Evidence of transfer of rights of all emission reductions to the project proponent is required and must be confirmed by the confirmation body. The project proponent must provide a signed Attestation of Title document for each project, attesting to their ownership of all emission reductions generated by the project. This signed attestation, and any necessary supporting evidence, must be provided to the confirmation body. In addition to the Attestation of Title, confirmation bodies may wish to review relevant contracts, agreements, and/or supporting documentation between project proponents, end users, utilities, and other parties that may have a claim to the mitigation credits generated by the project.

3.7 Project Resilience Measures

It is assumed that without specific mitigation measures or conditions employed prior to project confirmation, there would be significant risk that a project would fail to produce, for the entire crediting period, the quantity of emission reductions estimated using this methodology. Therefore, specific mitigation measures (Project Resilience Measures) must be implemented at the time of project commencement to reduce this risk. Project proponents must provide adequate demonstration that all of the risk mitigation measures provided in Table 3.1 have been appropriately implemented. Appendix D provides expanded discussion for project longevity analyses and considerations for inclusion in this methodology.

Table 3.1. Mitigation Measures Implemented to Reduce Risk of Project Underperformance

Category	Mitigation Measures
Financial	1. Commercial contracts for long-term supply of digester products (e.g., electricity, biogas), including delivery incentives/penalties based on assumptions of stable or increasing herd size, for the duration of the crediting period.
	2. Proforma demonstration of sufficient cash flows to sustain project viability during the crediting period. Operating expenses should fall within the typical range for projects of similar type and size, and sources of working capital and project revenues must be identified.
	3. Demonstrated long-term financial stability of the BCS Owner. The BCS Owner is defined as the legal entity or entities responsible for the long-term maintenance and performance of the anaerobic digester project, including biogas utilization systems or offtake contracts for biogas supply. Long-term financial stability may be demonstrated by providing a list and discussion of historical financial records or other indications of adequate project capitalization, potentially including bank records, loans, letters of credit or other financial commitments.
Design	4. Demonstration that the primary digester and biogas utilization technologies are commercially available, proven, and appropriate for the specific project design. A Project Description must be provided that includes a list and discussion of primary anaerobic digester, biogas utilization, and emissions control technologies employed, with reference to their historical use, performance, and suitability to the project.
	5. Basis of Design documentation for the digester system including a manure volatile solids mass flow diagram and estimated annual biogas production.
Operating	6. Operations and Monitoring Plan that ensures long-term maintenance and operation of related project equipment within stated performance standards, in addition to risk mitigation measures employed and asserted for confirmation activities. At a minimum, the Operations and Monitoring Plan should meet the requirements of Section 8.2 of this methodology.
	7. Long-term service warranties or contracts that include guarantees of rapid response for project-related equipment repairs.
Dairy Closure	8. Demonstration that the project is not located within a probable range of accelerated commercial/residential development. This may include a review and discussion of historical and recent trends in land development near the project locale.
	9. Demonstrated long-term financial stability of the livestock operation. This must include a list and discussion of historical herd size, financial records or other indications of adequate livestock operation capitalization, potentially including bank records, loans, letters of credit or other financial commitments.
	10. Long-term commercial milk or animal supply contracts with delivery penalties impacted by reduced herd size, or, commercial contracts that include penalties for reducing animal numbers or manure collection/delivery quantities during the project crediting period.

3.8 Demonstration of *Ex Ante* Suitability

This methodology is suitable for *ex ante* crediting, as it provides for the complete, consistent, transparent, accurate, and conservative estimation of emission reductions from the project activities, while providing sufficient safeguards to ensure the activities continue for the duration of the crediting period. Specific safeguards to ensure projected emission reductions are realized throughout the crediting period included in Section 3.7, Project Resilience Measures, and the guidance in Section 5.3.3, Estimating Abandonment Rates and Performance Decline.

In addition, the majority of the lifetime costs of installation and operation of a BCS at a dairy operation occur up front, as capital costs of implementation. Once the BCS is operational and integrated into standard practices at the dairy, the main financial barrier has been overcome. In this context, *ex ante* crediting for the future GHG benefits is an appropriate mechanism to drive increased adoption of this type of manure management system and, thus, enhanced GHG emission reductions. The timing of the incentive corresponds to the relevant financial barrier.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project proponents in order to determine the net change in emissions caused by a project.[10]

Figure 4.1 illustrates the GHG assessment boundary for dairy projects, indicating which SSRs are included or excluded from the project boundary. Descriptions of SSRs for dairy projects, indicating which gases are included or excluded within the assessment boundary, are listed in Table 4.1.

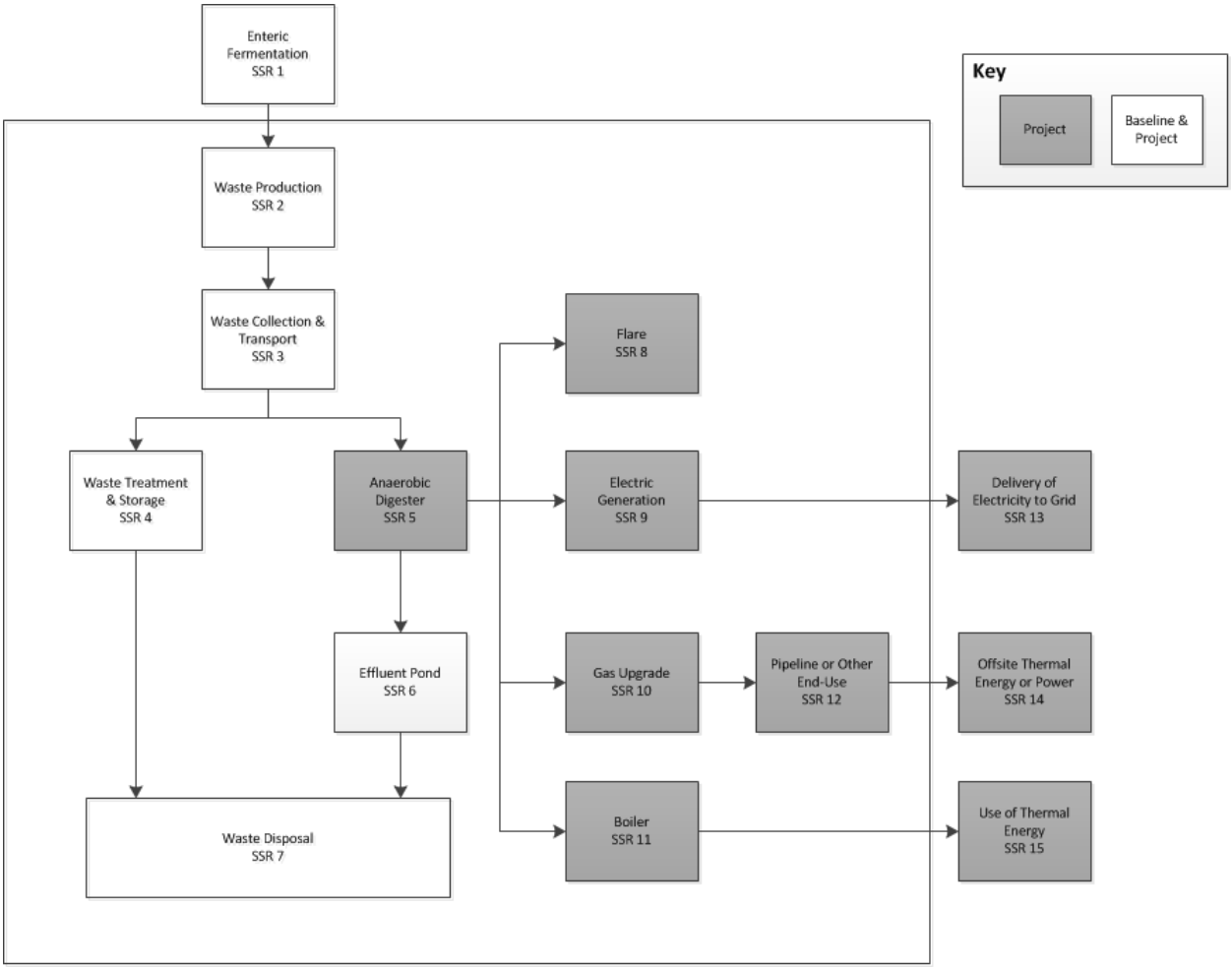


Figure 4.1. General illustration of the GHG Assessment Boundary

All SSRs within the large rectangle are included within the Assessment Boundary and must be accounted for under this methodology. Unshaded boxes represent SSRs included in the baseline and project scenarios; shaded boxes represent SSRs relevant only to project emissions. (Diagram from ARB Compliance Offset Protocol for Livestock Projects, Nov 2014).

[10] The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.

Table 4.1. Description of GHG Sources, Sinks, and Reservoirs
(Adapted from ARB Compliance Offset Protocol for Livestock Projects, November 2014.)

SSR	GHG Source	GHG	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Explanation
1	Emissions from enteric fermentation	CH_4	B, P	Excluded	It is very unlikely that a livestock operation would change its feeding strategy to maximize biogas production from a digester; thus impacting enteric fermentation emissions from ruminant animals.
2	Emissions from waste deposits in barn, milking parlor, or pasture/corral	N_2O	B, P	Excluded	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the project scenario.
	Emissions from mobile and stationary support equipment	CO_2	B, P	Included	If any additional vehicles or equipment are required by the project beyond what is required in the baseline, emissions from such sources shall be accounted for.
		CH_4		Excluded	Emission source is assumed to be very small.
		N_2O		Excluded	Emission source is assumed to be very small.
3	Emissions from mechanical systems used to collect and transport waste (e.g., engines and pumps for flush systems; vacuums and tractors for scrape systems)	CO_2	B, P	Included	If any additional vehicles or equipment use is required by the project beyond what is required in the baseline, emissions from such sources shall be accounted for.
		CH_4		Excluded	Emission source is assumed to be very small.
		N_2O		Excluded	Emission source is assumed to be very small.
	Vehicle emissions (e.g., for manure transport from remote	CO_2		Included	If any additional vehicles or fuel use

SSR	GHG Source	GHG	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Explanation
	or temporary holding)				is required by the project beyond what is required in the baseline, emissions from such equipment shall be accounted for.
		CH_4		Excluded	Emission source is assumed to be very small.
		N_2O		Excluded	Emission source is assumed to be very small.
4	Emissions from waste treatment and storage including: anaerobic lagoons, dry lot deposits, compost piles, solid storage piles, manure settling basins, aerobic treatment, storage ponds, etc.	CO_2	B, P	Excluded	Biogenic emissions are excluded.
		CH_4		Included	Primary source of emissions in the baseline.
		N_2O		Excluded	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the project scenario.
	Emissions from support equipment	CO_2		Included	If any additional equipment is required by the project beyond what is required in the baseline, emissions from such equipment shall be accounted for.
		CH_4		Excluded	Emission source is assumed to be very small.
		N_2O		Excluded	Emission source is assumed to be very small.
5	Emissions from the anaerobic digester due to biogas collection inefficiencies and venting events	CH_4	P	Included	Project may result in leaked emissions from anaerobic digester.
6	Emissions from the effluent pond	CH_4	B, P	Included	Primary source of emissions from project activities.
		N_2O		Excluded	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the

SSR	GHG Source	GHG	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Explanation
					project scenario.
7	Emissions from land application	N_2O	B, P	Excluded	Project activity is unlikely to increase emissions relative to baseline activity.
	Vehicle emissions for land application and/or offsite transport	CO_2	B, P	Included	If any additional vehicle use is required by the project beyond what is required in the baseline, associated additional emissions shall be accounted for.
		CH_4		Excluded	Emission source is assumed to be very small.
		N_2O		Excluded	Emission source is assumed to be very small.
8	Emissions from combustion during flaring, including emissions from incomplete combustion of biogas	CO_2	P	Excluded	Biogenic emissions are excluded.
		CH_4		Included	Primary source of emissions from project activities.
		N_2O		Excluded	Emission source is assumed to be very small.
9	Emissions from combustion during electric generation, including incomplete combustion of biogas	CO_2	P	Excluded	Biogenic emissions are excluded.
		CH_4		Included	Primary source of emissions from project activities.
		N_2O		Excluded	Emission source is assumed to be very small.
10	Emissions from equipment upgrading biogas for pipeline injection or use as CNG/LNG fuel	CO_2	P	Included	Emissions resulting from onsite fossil fuel use and/or grid electricity may be significant.
		CH_4		Excluded	Emission source is assumed to be very small.
		N_2O		Excluded	Emission source is assumed to be very small.
11	Emissions from combustion at boiler including emissions from incomplete combustion of biogas	CO_2	P	Excluded	Emission source is assumed to be very small.
		CH_4		Included	Emissions resulting from onsite fossil

SSR	GHG Source	GHG	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Explanation
					fuel use and/or grid electricity may be significant.
		N_2O		Excluded	Emission source is assumed to be very small.
12	Emissions from combustion of biogas by end user of pipeline or CNG/LNG, including incomplete combustion	CO_2	P	Excluded	Biogenic emissions are excluded.
		CH_4		Included	Primary source of emissions from project activities.
		N_2O		Excluded	Emission source is assumed to be very small.
13	Delivery and use of project electricity to grid	CO_2	P	Excluded	This methodology does not cover displacement of GHG emissions from the use of biogas-generated electricity.
		CH_4			
		N_2O			
14	Offsite thermal energy or power	CO_2	P	Excluded	This methodology does not cover displacement of GHG emissions from the use of biogas offsite.
		CH_4			
		N_2O			
15	Use of project-generated thermal energy	CO_2	P	Excluded	This methodology does not cover displacement of GHG emissions from the use of biogas offsite.
		CH_4			
		N_2O			
16	Project construction and decommissioning emissions	CO_2	P	Excluded	Emissions source assumed to be very small.
		CH_4			
		N_2O			

5 Quantifying GHG Emission Reductions

GHG emission reductions from a dairy project are quantified by comparing forecast project emissions to baseline emissions within the project boundary. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the dairy project. Project emissions are forecasted GHG emissions that are expected to occur from sources within the GHG Assessment Boundary during the crediting period. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

GHG emission reductions for Climate Forward are quantified and confirmed at the time of project implementation. The length of time over which GHG emission reductions are quantified and forecast is called the "confirmation period." For the purposes of calculation, both baseline emissions and project emissions are quantified using annual models. The period for which GHG baseline emissions are modeled is called the "baseline calculation period"; quantification is based largely on actual and historical data. The period for which project GHG emissions are forecast is called the "project forecast period"; quantification is based on both historical data and conservative *ex ante* projections.

Some equations to calculate baseline and project emissions utilize monthly data or projections. As applicable, monthly emissions data (for baseline and project) are summed to forecast emission reductions over an annual period, which is then multiplied by the number of years in the crediting period to give total forecast emission reductions. The calculations provided in this methodology are derived from internationally accepted methodologies.[11] Project proponents shall use the calculation methods provided in this methodology to determine baseline and project GHG emissions to forecast GHG emission reductions.

Equation 5.1. Forecasted GHG Emission Reductions for a Project that Installs a Biogas Control System

$$\boldsymbol{ER = (BE - PE) \times Y_{cp} \times U_{pl}}$$

Where,			Units
ER	=	Forecasted GHG emission reductions	tCO_2e
BE	=	Modeled annual baseline methane emissions	tCO_2e
PE	=	Forecast annual project emissions	tCO_2e
Y_{cp}	=	Number of years in the crediting period	years
U_{pl}	=	Project Longevity Adjustment Factor = 0.95 (Section 5.3.3 and Appendix D)	fraction

5.1 Required Parameters for Modeling Baseline and Project Emissions

The following parameters must be determined for the modeling of baseline and project emissions:

[11] The methodology's GHG reduction calculation method is derived from the Kyoto Protocol's Clean Development Mechanism (ACM0010 V.5), the EPA's Climate Leaders Program (Manure Offset Protocol, August 2008), the RGGI Model Rule (January 5, 2007), and the Climate Action Reserve's U.S. Livestock Project Protocol.

Livestock Population – P_L

The methodology requires project proponents to differentiate between livestock categories (L) (e.g., lactating dairy cows, non-milking dairy cows, heifers, etc.). This accounts for differences in methane generation across livestock categories. See Appendix B, Table B.2 for methane generation factors. For both baseline and project calculations, recent actual population data, spanning twelve consecutive months, is required for each livestock category. Population data must include monthly animal counts for each livestock category (herd inventory).

Baseline and project scenario calculations utilize actual population data from the twelve-month period prior to confirmation, provided the population numbers were stable (defined as a monthly variance no greater than 15% from the 12-month running mean) or increasing throughout the period (defined as a monthly variance no greater that 15% *below* the 12-month running mean). If monthly variance does not meet this requirement in the twelve-month period, calculations will utilize the actual population data from the thirty six-month period prior to confirmation. The monthly average population for each livestock category (L) will be used if the twelve-month lookback is deemed the acceptable approach for calculations; for thirty six-month lookbacks, project proponents must use the lowest average monthly population for each livestock category (L).

Volatile solids – VS_L

This value represents the daily organic material in the manure for each livestock category and consists of both biodegradable and non-biodegradable fractions. The VS content of manure is a combination of excreted fecal material (the fraction of a livestock category's diet consumed and not digested) and urine, expressed on a dry matter weight basis (kg/animal)[12]. Default VS factors for each livestock category are provided in Appendix B, Table B.2 and Table B.4.

Animal mass – $Mass_L$

This value is the annual average live weight of the animals, per livestock category. These data are necessary because default VS values are supplied in units of kg/day/1000kg mass, therefore the average mass of the corresponding livestock category is required to convert the units of VS into kg/day/animal. Site specific livestock mass is preferred for all livestock categories. If site-specific data are unavailable, Typical Animal Mass (TAM) values may be used (see Table B.2).

Maximum methane production – $B_{0,L}$

This value represents the maximum methane-producing capacity of the manure, differentiated by livestock category (L) and diet. Project proponents shall use the default B_0 factors from Table B.3.

Management system manure fraction – MS_S

The MS value apportions manure from each livestock category to appropriate manure management system component (S) and is a critical factor in determining a project baseline, as well as project emissions from effluent treatment. It reflects the reality that waste from the operation's livestock categories are not managed uniformly. The MS value accounts for the operation's multiple types of manure management systems. It is expressed as a percent (%), relative to the total amount of VS produced by the livestock category. As waste production is normalized for each livestock category, the percentage shall be calculated as percent of population for each livestock category. For example, a dairy operation might send 85% of its

[12] *IPCC 2006 Guidelines* volume 4, chapter 10, p. 10.42.

milking cows' waste to an anaerobic lagoon and 15% could be deposited in a corral. In this situation, an MS value of 85% would be assigned to Equation 5.6 and 15% to Equation 5.9.

Importantly, the MS value indicates where the waste would have been managed in the baseline scenario. If a portion of the VS was removed from the waste stream through a separation procedure, the MS value shall be adjusted to accurately reflect the baseline treatment of the VS. To account for VS removal from solids separation equipment, project proponents may use a default value for the type of separation mechanisms employed (Table B.9), or a site-specific value based on the removal efficiency of the baseline system.

MS_{BCS}, which represents the fraction of manure that is sent to the BCS in the project scenario, follows the same logic as above, but is used to accurately quantify the project methane emissions from effluent treatment (see Equation 5.13).

Methane conversion factor – MCF[13]

This factor reflects the site-specific annual or monthly biological conversion of manure volatile solids to methane for each of the dairy operation's manure storage and treatment systems, as predicted using the van't Hoff-Arrhenius equation or default regional values, and the most recent ten-year historical monthly average of ambient temperatures specific to the project location from the nearest official weather monitoring station.[14]

Each manure management system component has a volatile solids-to-methane conversion efficiency that represents the degree to which maximum methane production (B_0) is achieved. Methane production is a function of the extent of anaerobic conditions present in the system, the temperature of the system, and the retention time of organic material in the system.[15]

Default MCF values for non-anaerobic baseline manure management system components (as well as certain project BCS effluent treatment and Non-BCS sources) are available in Appendix B. These are used in and Equation 5.9.

In contrast, site-specific calculations of volatile solids-to-methane conversion efficiency are required for anaerobic baseline manure management system components and for the anaerobic treatment of project BCS effluent. For anaerobic lagoons, storage ponds, liquid slurry tanks, and other anaerobic storage solutions, project proponents perform a site-specific calculation of the mass of volatile solids degraded by the anaerobic storage/treatment system. This is expressed as "degraded volatile solids" or VS_{deg} in Equation 5.4, which equals the system's monthly available volatile solids multiplied by 'f', the van't Hoff-Arrhenius factor. The 'f' factor effectively converts total available volatile solids in the anaerobic manure storage/treatment system to methane-convertible volatile solids, based on the monthly temperature of the system. The

[13] Anaerobic digesters commonly used at livestock operations in the United States are typically designed with hydraulic retention times and process controls to convert about eighty percent (80%) of the input manure volatile solids to methane. However, depending largely on management effort, digesters occasionally suffer equipment or process disruptions that result in reduced methane conversion. Consistent with current Reserve and ARB livestock project emission reduction quantification methodologies, a conservative default methane conversion factor (MCF_{BCS}) of seventy percent (70%) will be used in the calculation of methane production by the BCS to address the risk of digester underperformance. Risk assessment as outlined in Section 6 will not be required for this factor; however, the project proponent must demonstrate during confirmation that the anaerobic digestion system is designed with adequate capacity (hydraulic retention time relative to process type) to digest manure VS input from the modeled livestock population at rates at or above this factor threshold.

[14] The method is derived from Mangino et al., "Development of a Methane Conversion Factor to Estimate Emissions from Animal Waste Lagoons" (2001).

[15] *IPCC 2006 Guidelines* volume 4, chapter 10, p. 10.42.

multiplication of VS_{deg} by B_0 quantifies the maximum potential methane emissions that would have been produced for each livestock category's contribution of manure to that system.

5.2 Estimating Baseline GHG Emissions

Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that would have occurred if not for the installation of the BCS. For the purposes of this methodology, project proponents calculate their baseline emissions according to the manure management system in place prior to installing the BCS. For Greenfield projects, as defined in Section 3.3.3.2, the baseline manure management practices shall be modeled according to the assumptions provided in Table B.10.

Equation 5.2. Modeled Baseline Emissions

$$\boldsymbol{BE = BE_{CH_4} + BE_{CO_2}}$$

Where,			Units
BE	=	Modeled annual baseline methane emissions	tCO_2e
BE_{CH4}	=	Modeled annual baseline CH_4 emissions	tCO_2e
BE_{CO2}	=	Modeled annual baseline CO_2 emissions	years

5.2.1 Baseline Methane Emissions

The procedure to determine the modeled baseline methane emissions follows, which incorporates Equation 5.4 through Equation 5.9. The calculation procedures use a combination of site-specific values and default factors. Calculations of methane emissions for both baseline and project scenarios are based on common volatile solids production values (Figure 5.1).

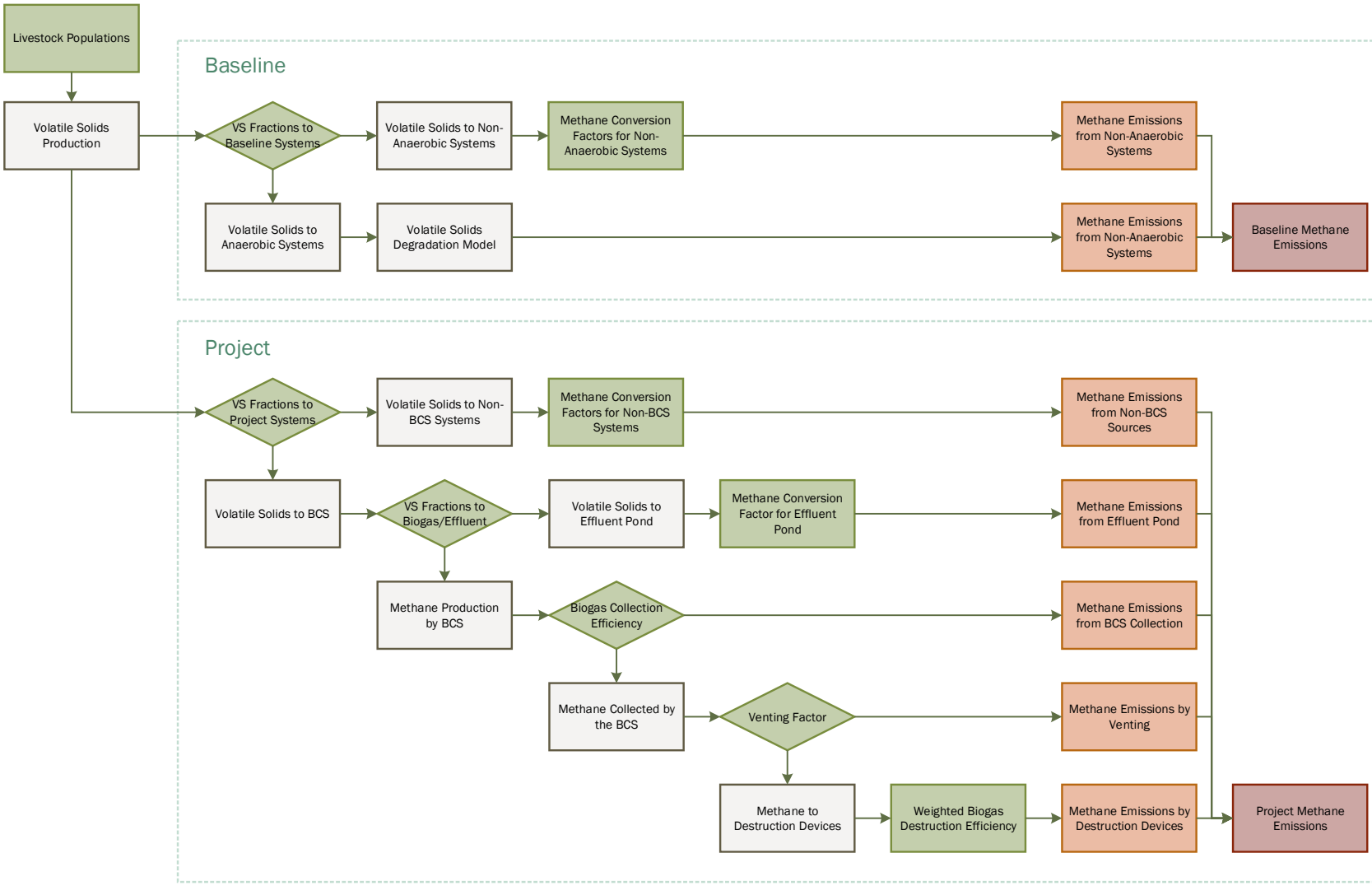


Figure 5.1. Calculation of Baseline and Project Methane Emissions Based on Livestock Manure Volatile Solids Production

Equation 5.3. Modeled Annual Baseline Methane Emissions

$$BE_{CH_4} = \sum_{AS} BE_{CH_4,AS} + \sum_{nAS} BE_{CH_4,nAS}$$

Where,			Units
BE_{CH4}	=	Annual project baseline methane emissions	tCO_2e
$BE_{CH4,AS}$	=	Annual baseline methane emissions for each baseline anaerobic storage/treatment system	tCO_2e
$BE_{CH4,nAS}$	=	Annual baseline methane emissions for each baseline non-anaerobic storage/treatment system	tCO_2e
AS	=	Anaerobic storage/treatment systems	
nAS	=	Non-anaerobic storage/treatment systems	

5.2.2 Retention of Volatile Solids

Equation 5.4 through Equation 5.6 calculate methane emissions from anaerobic manure storage/treatment systems based on site-specific information on the mass of volatile solids degraded by the anaerobic storage/treatment system and available for methane conversion. Calculations incorporate the effects of temperature through the van't Hoff-Arrhenius (f) factor (see Equation 5.7) and account for the retention of volatile solids using monthly assumptions of baseline conditions. Equation 5.8 describes the calculation of VS production by livestock. Each month, a certain quantity of VS is converted into methane (VS_{deg}). The VS that is available for conversion each month (VS_{avail}) is the sum of VS that enters the manure management system, as well as VS that remains in the system from the previous month ($VS_{avail,m-1} – VS_{deg,m-1}$). Volatile solids carryover in the first month of the both the baseline calculation period and the project forecast period models should reflect carryover from the last month of the period models, at equilibrium (i.e., adjusted iteratively so that the volatile solids carryover to the first month is equal to the volatile solids remaining at the end of the last month).

Project proponents shall not carry over volatile solids from one month to the next when modeling baseline anaerobic treatment systems where the retention time was 30 days or less. For these systems ($VS_{avail,m-1} – VS_{deg,m-1}$) = 0 in Equation 5.6 for every month.

Depending on the accumulation of sludge in the baseline manure storage system, it may have been necessary to drain and clean the system on a periodic basis. This cleaning removes the non-degraded VS that has accumulated in the system. For anaerobic lagoons with a retention time greater than 30 days, project developers shall zero out the VS retained in the system following the month when the system would have been completely drained and sludge removed under baseline operating conditions. For the month following the sludge removal, ($VS_{avail,m-1} – VS_{deg,m-1}$) = 0 in Equation 5.6. For projects where a BCS is being retrofit into existing operations, baseline anaerobic system management practices should reflect actual pre-project manure management practices on that farm.

If the farm utilized solids separation in the baseline (thus preventing or delaying sludge accumulation), this removal and alternative treatment of VS should be reflected in the MS values, as explained earlier in this section.

The removal of supernatant liquids for spraying on fields at agronomic rates does not affect the monthly carryover of VS provided the system maintains at least one meter of liquid depth.

Projects therefore do not need to account for regular field spraying activities that meet this description.

Equation 5.9 applies to non-anaerobic storage/treatment systems. Both Equation 5.3 and Equation 5.4 reflect basic biological principles of methane production from available volatile solids, determine methane generation for each livestock category, and account for the extent to which the waste management system handles each category's manure.

Equation 5.4. Modeled Annual Baseline Methane Emissions from Anaerobic Storage/Treatment Systems

$$\boldsymbol{BE_{CH_4,AS} = \sum_{L,m} \left(VS_{deg,AS,L,m} \times B_{0,L}\right) \times D_{CH_4} \times C_{Mg/kg} \times GWP_{CH_4}}$$

Where,			Units
$BE_{CH4,AS}$	=	Annual baseline methane emissions from baseline anaerobic storage/treatment system *AS*	tCO_2e
$VS_{deg,AS,L,m}$	=	Monthly volatile solids degraded in anaerobic storage/treatment system *AS* for each livestock category and month	kg dry matter
$B_{0,L}$	=	Maximum methane producing potential of manure for each livestock category	m^3CH_4/kg VS
D_{CH4}	=	Density of methane (1 atm, 60°F) = 0.68	kg/m^3
$C_{Mg/kg}$	=	Conversion factor, kg to Mg = 1×10^{-3}	Mg/kg
GWP_{CH4}	=	Global warming potential of methane	tCO_2e/tCH_4
AS	=	Anaerobic storage/treatment system	
L	=	Livestock category	
m	=	Month in the baseline calculation period	month

Equation 5.5. Calculation of Volatile Solids Degraded Monthly in Baseline Anaerobic Storage/Treatment Systems

$$\boldsymbol{VS_{deg,AS,L,m} = VS_{avail,AS,L,m} \times f}$$

Where,			Units
$VS_{deg,AS,L,m}$	=	Monthly volatile solids degraded available for degradation in anaerobic storage/treatment system *AS* for each livestock category and month	kg dry matter
$VS_{avail,AS,L,m}$	=	Monthly volatile solids available for degradation in the previous month in anaerobic storage/treatment system *AS* for each livestock category and month	kg dry matter
f	=	van 't Hoff-Arrhenius factor[16] Monthly volatile solids degraded in the previous month in anaerobic storage/treatment system *AS* for each livestock category	
AS	=	Anaerobic storage/treatment system	
L	=	Livestock category	
m	=	Month in the baseline calculation period	month

[16] Mangino, et al.

Equation 5.6. Calculation of Volatile Solids Available Monthly for Degradation in Baseline Anaerobic Storage/Treatment Systems

$$VS_{avail,AS,L,m} = \left(VS_L \times P_{L,m} \times MS_{AS,L} \times d_m \times MDP\right) + \left(VS_{avail,AS,L,m-1} - VS_{deg,AS,L,m-1}\right)$$

Where,			Units
$VS_{avail,AS,L,m}$	=	Monthly volatile solids available for degradation in anaerobic storage/treatment system *AS* for each livestock category and month	kg dry matter
VS_L	=	Volatile solids excreted by livestock category *L*	kg dry matter/ animal·day
$P_{L,m}$	=	Monthly average population of livestock category *L*	animals
$MS_{AS,L}$	=	Fraction of volatile solids sent to (managed in) anaerobic manure storage/treatment system *AS* from each livestock category[17]	fraction (0–1)
d_m	=	Number of days in each month	days
MDP	=	Model calibration factor for management and design practices = 0.8[18]	
$VS_{avail,AS,L,m-1}$	=	Monthly volatile solids available for degradation in the previous month in anaerobic storage/treatment system *AS* for each livestock category[19]	kg dry matter
$VS_{deg,AS,L,m-1}$	=	Monthly volatile solids degraded in the previous month in anaerobic storage/treatment system *AS* for each livestock category	kg dry matter
AS	=	Anaerobic storage/treatment system	
L	=	Livestock category	
m	=	Month in the baseline calculation period	month

[17] The MS value represents the percent of manure that would be sent to (managed by) the anaerobic manure storage/treatment systems in the baseline case – as if the biogas control system was never installed.
[18] Mangino, et al. This factor was derived to "account for management and design practices that result in the loss of volatile solids from the management system." This reflects the difference between the theoretical modeled biological activity and empirical measurement of biological activity due to removal of liquid or other management practices that result in loss of VS from the treatment system. This does not account for removal of solids prior to the treatment system.
[19] *IPCC 2006 Guidelines* (Volume 4, Chapter 10, p. 42); ACM0010 (V2, p.8); and EPA Climate Leaders Manure Offset Protocol (August 2008).

Equation 5.7. Calculation of van 't Hoff-Arrhenius Factor

$$f = \begin{cases} min\left(exp\left[\frac{E(T_{amb} - T_{max})}{R \times T_{max} \times T_{amb}}\right], f_{max}\right), if\ T_{amb} \geq 278 \\ 0.104, \quad if\ T_{amb} < 278 \end{cases}$$

Where,			Units
f	=	van 't Hoff-Arrhenius factor	fraction
E	=	Activation energy constant = 15,175	cal/mol
T_{max}	=	Temperature of maximum reaction rate constant = 303.16	Kelvin
T_{amb}	=	Monthly average ambient temperature	Kelvin
R	=	Ideal gas constant = 1,987	cal/Kelvin·mol
f_{max}	=	Maximum f factor = 0.95	fraction

The equation can be read as*: if the ambient temperature is greater than or equal to 278 K, then f is equal to the minimum of the van 't Hoff-Arrhenius function or the maximum f factor; otherwise, f is equal to 0.104. The calculated f value is constrained to the range 0.104 – 0.950.*

Equation 5.8. Calculation of Livestock Volatile Solids Excretion

$$VS_L = VSR_L \times Mass_L \times C_{Mg/kg}$$

Where,			Units
VS_L	=	Volatile solids excreted by livestock category *L*	kg dry matter/ animal·day
VSR_L	=	Default volatile solids excretion rate for livestock category *L* (Table B.2 or Table B.4)	kg dry matter/Mg animal mass·day
$Mass_L$	=	Average live weight for livestock category *L*; if site specific data is unavailable, use default values from Table B.2	kg animal mass/animal
$C_{Mg/kg}$	=	Conversion factor, kg animal mass to Mg animal mass = 1×10^{-3}	Mg/kg

Equation 5.9. Modeled Baseline Methane Emissions for Non-Anaerobic Storage/Treatment Systems

$$BE_{CH_4,nAS} = \sum_{L,m} \left(P_{L,m} \times MS_{nAS,L} \times VS_L \times d_m \times MCF_{nAS} \times B_{0,L}\right) \times D_{CH_4} \times C_{Mg/kg} \times GWP_{CH_4}$$

Where,			Units
$BE_{CH4,nAS}$	=	Annual baseline methane emissions from baseline non-anaerobic storage/treatment system *nAS*	tCO_2e
$P_{L,m}$	=	Average population size of livestock category *L* for each month	animals
$MS_{nAS,L}$	=	Fraction of volatile solids sent to (managed in) non-anaerobic manure storage/treatment system *nAS* from each livestock category	fraction (0–1)
VS_L	=	Volatile solids excreted by livestock category *L*	kg dry matter/ animal·day
d_m	=	Number of days in each month	days
MCF_{nAS}	=	Methane conversion factor for non-anaerobic treatment system *nAS*	fraction (0–1)
$B_{0,L}$	=	Maximum methane producing potential of manure volatile solids for each livestock category	m^3CH_4/kg VS
D_{CH4}	=	Density of methane (1 atm, 60°F) = 0.68	kg/m^3
$C_{Mg/kg}$	=	Conversion factor, kg to Mg = 1×10^{-3}	Mg/kg
GWP_{CH4}	=	Global warming potential of methane	tCO_2e/tCH_4
nAS	=	Non-anaerobic storage/treatment system	
L	=	Livestock category	
m	=	Month in the baseline calculation period	month

5.2.3 Baseline CO_2 Emissions

Sources of carbon dioxide emissions associated with a dairy operation within the GHG Assessment Boundary (Figure 4.1) may include grid electricity use by pumps and equipment, fossil fuel generators used to power pumping systems or milking parlor equipment, tractors that operate in barns or free-stalls, onsite manure hauling trucks, or vehicles that transport manure offsite.

Project proponents shall use Equation 5.10 to calculate baseline project emissions using fuel and electricity invoices or other documentation for the baseline calculation period, or, if they can demonstrate during project confirmation that project carbon dioxide emissions are estimated to be equal to or less than 5% of the total baseline emissions, then the project proponent may estimate baseline and project carbon dioxide emissions. If an estimation method is used, the confirmation body shall confirm based on professional judgment that project carbon dioxide emissions are equal to or less than 5% of the total baseline emissions based on documentation and the estimation methodology provided by the project proponent. Regardless of the method used, all estimates or calculations of anthropogenic carbon dioxide emissions within the GHG Assessment Boundary must be confirmed and included in emission reduction calculations.

Equation 5.10. Modeled Annual Baseline CO_2 Emissions

$$BE_{CO_2} = \left(\sum_{E} Q_{E,grid} \times EF_{grid}\right) + \left(\sum_{F} Q_{F,fuel} \times EF_{fuel} \times C_{Mg/kg}\right)$$

Where,			Units
BE_{CO2}	=	Modeled annual baseline CO_2 emissions	tCO_2
$Q_{E,grid}$	=	Quantity of grid-connected electricity consumed for each emissions source *E* during the baseline calculation period	MWh
EF_{grid}	=	eGrid emission factor for grid electricity consumed	tCO_2/MWh
$Q_{F,fuel}$	=	Quantity of fossil fuel consumed for each mobile and stationary combustion source *F* during the baseline calculation period	MMBtu or gal
EF_{fuel}	=	Fuel-specific emission factor, from Table B.8	$kgCO_2$/ MMBtu or gal
$C_{Mg/kg}$	=	Conversion factor, kg to Mg = 1×10^{-3}	Mg/kg

5.3 Estimating Project GHG Emissions

Project emissions are forecasted GHG emissions that are expected to occur within the GHG assessment boundary after the installation of the BCS. Project emissions calculated *ex ante* for a twelve-month "project forecast period" assumed to be representative of the entire crediting period.

Equation 5.11 describes the calculation of annual project emissions. Equation 5.12 through Equation 5.20 describe calculations for project methane emissions. Equation 5.21 describes calculation of project CO_2 emissions.

Equation 5.11. Forecast Annual Project Emissions

$$PE = PE_{CH_4} + PE_{CO_2}$$

Where,			Units
PE	=	Forecast annual project methane emissions	tCO_2e
PE_{CH4}	=	Forecast annual project CH_4 emissions	tCO_2e
PE_{CO2}	=	Modeled annual project CO_2 emissions	tCO_2e

5.3.1 Estimating Project Methane Emissions

Consistent with the methodology's baseline methane calculation approach, the formula to account for project methane emissions incorporates all potential sources within the waste treatment and storage category. As shown in Equation 5.12, project methane emissions include:

- Methane created by the BCS that is not captured and destroyed by the control system
- Methane from the digester effluent treatment systems, both anaerobic and non-anaerobic (where applicable)
- Methane from sources in the manure storage and treatment systems other than the BCS and associated effluent treatment systems. This includes all other manure treatment systems such as compost piles, solids storage, etc.

Equation 5.12. Forecast Annual Project Methane Emissions

$$PE_{CH_4} = \left(PE_{CH_4,BCS} + PE_{CH_4,ET_{AS}} + PE_{CH_4,ET_{nAS}} + PE_{CH_4,nBCS}\right) \times GWP_{CH_4}$$

Where,			Units
PE_{CH4}	=	Forecast annual project methane emissions	tCO_2e
$PE_{CH4,BCS}$	=	Forecast annual methane emissions from the biogas control system	tCH_4
$PE_{CH4,ETAS}$	=	Forecast annual methane emissions from anaerobic storage/treatment systems receiving BCS effluent, as quantified in Equation 5.17	tCH_4
$PE_{CH4,ETnAS}$	=	Forecast annual methane emissions from non-anaerobic storage/treatment systems receiving BCS effluent	tCH_4
$PE_{CH4,nBCS}$	=	Forecast annual methane emissions from manure storage/treatment systems other than the BCS and associated effluent treatment systems	tCH_4
GWP_{CH4}	=	Global warming potential of methane	tCO_2e/tCH_4

5.3.1.1 Methane Emissions from the Biogas Control System

Annual methane production by the project BCS is forecast based on the quantity of volatile solids degraded in the anaerobic digester(s) during the project forecast period, and a conservative default methane conversion factor (Equation 5.13). Calculations assume the same monthly livestock populations and average ambient temperatures as used in baseline calculations.

Methane emissions from the BCS are calculated using Equation 5.14 and Equation 5.15. Calculations utilize a default BCS biogas collection efficiency, based on digester type, and a forecast overall biogas destruction efficiency, weighted by proportional biogas flow through each destruction device.

Although not common under normal digester operations, it is possible that planned venting events may occur during the crediting period. Sources of methane venting are various and may be due to maintenance on digester cover materials, the digester vessel, or the gas collection system during the crediting period. Additionally, project proponents should account for vented emissions due to partial system collection and destruction design (i.e., surplus biogas is vented instead of combusted by an auxiliary system). To account for the probability of planned events, methane emissions due to venting are estimated by the project proponent for the project forecast period and included in Equation 5.16.

Equation 5.13. Forecast Monthly Methane Production by the Project BCS

$$BCS_{CH_4,prod,m} = \sum_{L} \left(P_{L,m} \times VS_L \times MS_{BCS,L} \times d_m \times MCF_{BCS} \times B_{0,L}\right) \times D_{CH_4} \times C_{Mg/kg}$$

Where,			Units
$BCS_{CH4,prod,m}$	=	Forecast annual methane production by the BCS	tCH_4
$P_{L,m}$	=	Average population size of livestock category *L* for each month	animals
VS_L	=	Volatile solids excreted by livestock category *L*	kg dry matter/ animal·day
$MS_{BCS,L}$	=	Fraction of volatile solids sent to (managed in) the BCS from each livestock category in the project scenario	fraction (0–1)
d_m	=	Number of days in month	days
MCF_{BCS}		Methane Conversion Factor for the BCS = 0.70	fraction (0–1)
$B_{0,L}$	=	Maximum methane producing potential of manure volatile solids for each livestock category	m^3CH_4/kg VS
D_{CH4}	=	Density of methane (1 atm, 60°F) = 0.68	kg/m^3
$C_{Mg/kg}$	=	Conversion factor, kg to Mg = 1×10^{-3}	Mg/kg
L	=	Livestock category	
m	=	Month in the project forecast period	month

Equation 5.14. Forecast Annual Project Methane Emissions from the BCS

$$PE_{CH_4,BCS} = \sum_{m} \left[BCS_{CH_4,prod,m} \times \left(1 - \left(BCE \times BDE_{BCS,m}\right)\right)\right] + BCS_{CH_4,vent,m}$$

Where,			Units
$PE_{CH4,BCS}$	=	Forecast annual methane emissions from the biogas control system	tCH_4
$BCS_{CH4,prod,m}$	=	Forecast monthly methane production by the BCS, as quantified in Equation 5.13	tCH_4
BCE	=	Biogas collection efficiency of the BCS, from Appendix B	fraction (0–1)
$BDE_{BCS,m}$	=	Forecast overall monthly methane destruction efficiency of the BCS, as quantified in Equation 5.15	fraction (0–1)
$BCS_{CH4,vent,m}$	=	Forecast annual quantity of methane vented to the atmosphere due to venting events, as quantified in Equation 5.16	tCH_4

Equation 5.15. Forecast Overall Monthly Methane Destruction Efficiency of the Project BCS

$$\boldsymbol{BDE_{BCS,m} = \sum_{DD,m} \left(BDE_{DD} \times FP_{DD,m}\right)}$$

Where,			Units
$BDE_{BCS,m}$	=	Forecast overall monthly methane destruction efficiency of the BCS	fraction (0–1)
BDE_{DD}	=	Default device biogas destruction efficiency for destruction device *DD*, from Appendix B	fraction (0–1)
$FP_{DD,m}$	=	Forecast monthly percentage of total biogas flow to destruction device *DD*	fraction (0–1)
DD	=	Destruction device	
m	=	Month in the project forecast period	month

Equation 5.16. Forecast Annual Quantity of Methane Vented by the Project

$$\boldsymbol{BCS_{CH_4,vent,m} = \left(BCS_{CH_4,prod,m}\right) \times \left(V_f\right)}$$

Where,			Units
$BCS_{CH4,vent,m}$	=	Forecast monthly quantity of methane vented to the atmosphere due to venting events	tCH_4
$BCS_{CH4,prod,m}$	=	Forecast monthly methane production by the BCS	tCH_4
V_f	=	Methane venting factor (site-specific, see Table 6.1)	fraction (0–1)

5.3.1.2 Methane Emissions from the BCS Effluent Treatment Systems

Methane emissions from all storage/treatment systems associated with the management of BCS effluent are calculated as in Equation 5.17 through Equation 5.19. Anaerobic effluent treatment systems are those which store liquid effluent in a lagoon, pond, or tank. This includes liquid storage systems that employ non-airtight covers (i.e., biogas is freely vented to the atmosphere) as long as the entire system is managed as a passive storage system, rather than an actively-managed treatment system (e.g., no heating, mixing, etc.).

If the project includes the installation of an impermeable cover on an effluent pond (potentially creating an additional anaerobic digester) and the biogas generated in this covered pond is collected and destroyed by the project BCS, then this covered pond shall be considered part of the project digester system. If the biogas generated by this covered pond is not destroyed, it must be quantified as project methane emissions using Equation 5.17.

The factor ETF_{ET} shall be estimated by the project proponent as the fraction of effluent VS exiting the digester is input to each effluent treatment system 'ET', and is used to calculate the quantity of effluent VS entering the effluent treatment systems (Equation 5.18). In other respects, the calculation approach for quantifying methane emissions from anaerobic storage/treatment systems receiving BCS effluent is similar to that used for baseline anaerobic manure storage/treatment systems.

Equation 5.17. Forecast Annual Project Methane Emissions from Anaerobic Storage/Treatment Systems Receiving BCS Effluent

$$PE_{CH_4,ET_{AS}} = \sum_{ET_{AS},L,m} \left(VS_{ET_{AS},L,m} \times B_{0,L} \times d_m \times MDP \times f_m \times D_{CH_4} \times C_{Mg/kg}\right)$$

Where,			Units
$PE_{CH4,ETAS}$	=	Forecast annual methane emissions from anaerobic storage/treatment systems receiving BCS effluent	tCH_4
$VS_{ETAS,L,m}$	=	Forecast volatile solids input to anaerobic effluent treatment system *ET* for month *m*	kg dry matter/ day
$B_{0,L}$	=	Maximum methane producing potential of manure volatile solids for livestock category *L*	m^3CH_4/kg VS
d_m	=	Number of days in each month	days
MDP	=	Model calibration factor for management and design practices = 0.8	
f_m	=	van 't Hoff-Arrhenius factor for each month in the project forecast period, using historical 10-year average monthly temperatures; calculation as in Equation 5.7	fraction
D_{CH4}	=	Density of methane (1 atm, 60°F) = 0.68	kg/m^3
$C_{Mg/kg}$	=	Conversion factor, kg to Mg = 1×10^{-3}	Mg/kg
ET_{AS}	=	Anaerobic effluent treatment system	
L	=	Livestock category	
m	=	Month in the project forecast period	month

Equation 5.18. Forecast Quantity of Volatile Solids Input Daily to Effluent Treatment Systems in the Project Scenario

$$VS_{ET,L,m} = \left(P_{L,m} \times VS_L \times MS_{BCS,L,m}\right) \times \left(1 - MCF_{BCS}\right) \times ETF_{ET}$$

Where,			Units
$VS_{ET,L,m}$	=	Forecast quantity of volatile solids input daily to effluent treatment system *ET* in month *m*	kg dry matter/ day
$P_{L,m}$	=	Average population size of livestock category *L* for the project forecast period in month *m*	animals
VS_L	=	Volatile solids excreted by livestock category *L*	kg dry matter/ animal·day
$MS_{BCS,L,m}$	=	Fraction of volatile solids sent to (managed in) the BCS from each livestock category in the project forecast period in month *m*	fraction (0–1)
MCF_{BCS}		Methane conversion factor for the BCS = 0.70	fraction (0–1)
ETF_{ET}	=	Fraction of effluent that exits the digester and is input directly to the effluent treatment system *ET*	fraction (0–1)
ET	=	Effluent treatment system	

Equation 5.19. Forecast Annual Project Methane Emissions from Non-Anaerobic Storage/Treatment Systems Receiving BCS Effluent[20]

$$PE_{CH_4,ET_{nAS}} = \sum_{ET_{nAS}} \left(VS_{ET_{nAS}} \times B_{0,ET_{nAS}} \times d_p \times MCF_{ET_{nAS}} \times D_{CH_4} \times C_{Mg/kg}\right)$$

Where,			Units
$PE_{CH4,ETnAS}$	=	Forecast annual methane emissions from non-anaerobic storage/treatment systems receiving BCS effluent	tCH_4
VS_{ETnAS}	=	Forecast volatile solids input to non-anaerobic effluent treatment system *ET*	kg dry matter/ day
$B_{0,ETnAS}$	=	Maximum methane producing potential of manure volatile solids for non-anaerobic effluent treatment system *ET*[21]	m^3CH_4/kg VS
d_p	=	Number of days in the project forecast period	days
MCF_{ETnAS}	=	Methane conversion factor for the non-anaerobic effluent treatment system	
D_{CH4}	=	Density of methane (1 atm, 60°F) = 0.68	kg/m^3
$C_{Mg/kg}$	=	Conversion factor, kg to Mg = 1×10^{-3}	Mg/kg
ET_{nAS}	=	Non-anaerobic effluent treatment system	

5.3.1.3 Methane Emissions from Non-BCS Sources

Calculation of methane emissions from non-BCS-related sources[22] follows the approach provided in the baseline methane equations. Several activity data for the variables in Equation 5.12 to Equation 5.20 will be the same as those in Equation 5.9.

[20] Non-anaerobic effluent treatment systems are those which manage effluent in solid form, or those which manage liquid effluent in a way that would be considered aerobic (e.g., a pond with effective aeration equipment).
[21] The B_0 value for the project effluent pond is not differentiated by livestock category. Project proponents shall use the B_0 value that corresponds with a weighted average of the operation's livestock categories that contribute manure to the BCS (weighted by the kg of VS contributed by each livestock category). Supporting laboratory data and documentation need to be supplied to the confirmation body to justify an alternative value.
[22] According to this methodology, non-BCS-related sources means manure management system components (system component 'S') other than the biogas control system and the BCS effluent treatment systems (if used).

Equation 5.20. Forecast Annual Project Methane Emissions from Non-BCS-Related Sources

$$PE_{CH_4,nBCS} = \sum_{nBCS,L} \left(P_L \times VS_L \times MS_{nBCS,L} \times B_{0,L} \times MCF_{nBCS}\right) \times d_p \times D_{CH_4} \times C_{Mg/kg}$$

Where,			Units
$PE_{CH4,nBCS}$	=	Forecast annual project methane emissions from non-BCS-related sources	tCH_4
P_L	=	Average population size of livestock category *L* for the project forecast period	animals
VS_L	=	Forecast volatile solids input to non-BCS-related source *nBCS*	kg dry matter/ day
$MS_{nBCS,L}$	=	Fraction of volatile solids sent to (managed in) non-BCS-related sources from each livestock category in the project forecast period	fraction (0–1)
$B_{0,L}$	=	Maximum methane producing potential of manure volatile solids for non-anaerobic effluent treatment system *ET*	m^3CH_4/kg VS
MCF_{nBCS}	=	Methane conversion factor for the non-BCS related source *nBCS*	
d_p	=	Number of days in the project forecast period	days
D_{CH4}	=	Density of methane (1 atm, 60°F) = 0.68	kg/m^3
$C_{Mg/kg}$	=	Conversion factor, kg to Mg = 1×10^{-3}	Mg/kg

5.3.2 Project CO_2 Emissions

Per Table 4.1, the carbon dioxide emissions from any additional equipment, vehicles, or fuel use that is required by the project beyond what is required in the baseline shall be accounted for. In practice, project developers shall forecast the emissions from any new electric- or fuel-powered equipment or vehicles purchased and installed/operated specifically for the purpose of implementing the project, as well as any additional fuel used by old or new vehicles to collect or transport waste (Equation 5.21).

Equation 5.21. Annual Project CO_2 Emissions from Electricity and Fossil Fuel Use

$$EFF_{CO_2} = \left(\sum_{E} Q_{E,grid} \times EF_{grid}\right) + \left(\sum_{F} Q_{F,fuel} \times EF_{fuel} \times C_{Mg/kg}\right)$$

Where,			Units
EFF_{CO2}	=	Annual project CO_2 emissions from electricity and fossil fuel use	tCO_2
$Q_{E,grid}$	=	Quantity of grid-connected electricity consumed for each emissions source *E* during the project forecast period	MWh
EF_{grid}	=	eGrid emission factor for grid electricity consumed[23]	tCO_2/MWh
$Q_{F,fuel}$	=	Quantity of fossil fuel consumed for each mobile and stationary combustion source *F* during the project forecast period	MMBtu or gal
EF_{fuel}	=	Fuel-specific emission factor, from Appendix B	$kgCO_2$/ MMBtu or gal
$C_{Mg/kg}$	=	Conversion factor, kg to Mg = 1×10^{-3}	Mg/kg

Equation 5.22. Forecast Annual Project CO_2 Emissions

$$PE_{CO_2} = BE_{CO_2} + \left(EFF_{CO_2} - BE_{CO_2}\right)$$

Where,			Units
PE_{CO2}	=	Forecast annual project CO_2 emissions	tCO_2
EFF_{CO2}	=	Forecast annual project CO_2 emissions from electricity and fossil fuel use	tCO_2
BE_{CO2}	=	Modeled annual baseline CO_2 emissions	tCO_2

5.3.3 Estimating Abandonment Rates and Performance Decline

For this Dairy Digester Project Forecast Methodology, uncertainty related to project longevity (representing both abandonment rates and performance decline) during the full crediting period will be accounted for using a Project Longevity Adjustment Factor (U_{pl}), applied as a fraction of 0.95 to discount the calculation of forecast emission reductions (Equation 5.1). In addition to taking this discount, project proponents must provide adequate demonstration that all of the risk mitigation measures provided in Table 3.1 have been appropriately implemented, in order for the project to be eligible to generate FMUs. Appendix D provides expanded discussion for project longevity analyses and considerations for inclusion in this methodology.

5.4 Leakage Accounting

This methodology is not expected to cause the movement of dairy related emissions outside of the project area (termed 'leakage') as a result of project activities. Instead, the implementation of this activity in intended to provide sufficient financial incentive to achieve emission reduction goals, without causing dairies to move to parts of the country without such environmental regulations.

[23] Refer to the version of the United States EPA eGRID most closely corresponding to the time period of confirmation. Projects shall use the annual total output emission rates for the subregion where the project is located, not the annual non-baseload output emission rates. The eGRID tables are available from the EPA website: www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

6 Project Implementation and Documentation

Climate Forward requires a Project Implementation Report to be established for all monitoring and reporting activities associated with the project. The Project Implementation Report will serve as the basis for the confirmation body to confirm that the monitoring and reporting requirements in this methodology have been met. The Project Implementation Report must cover all aspects of monitoring and reporting contained in this methodology and must specify how data for all relevant parameters will be collected and recorded.

At a minimum, the Project Implementation Report shall include the frequency of data acquisition, parameter values, a record keeping plan, and the role of individuals performing each specific monitoring activity. The Project Implementation Report must also include procedures that the project proponent has followed to ascertain and demonstrate that the project passes the legal requirement test and is in regulatory compliance.

Project proponents are responsible for ensuring that all monitoring and reporting requirements of this methodology have been met.

6.1 Quantification Parameters

Each project must include the prescribed monitoring parameters necessary to calculate baseline and project emissions. These must be shown in a table such as below in Table 6.1. The project proponent must provide the Reserve robust evidence demonstrating to the Reserve's satisfaction that proposed parameter values are reasonable and conservative. Confirmation bodies will confirm Reserve-approved parameter values are used in each project.

Table 6.1. Project Monitoring Parameters

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Comment
ER	Forecasted GHG emission reductions	tCO_2e	c	
BE	Modeled baseline GHG emissions	tCO_2e	c	
PE	Forecasted project GHG emissions	tCO_2e	c	
Regulations	Project proponent attestation to compliance with regulatory requirements relating to the dairy digester project	All applicable regulations	n/a	Information used to demonstrate compliance with associated regulations and rules, e.g., criteria pollutant and effluent discharge limits
L	Type of livestock categories on the farm	Livestock categories	o	Select from list provided in Table B.2 and Table B.3

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Comment
MS_S	Fraction of manure managed in the baseline waste handling system *S*	Percent (%)	o	Reflects the percent of waste handled by the system components *S* pre-project. Each system component must have an MS value per livestock category Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 100%. Select from list provided in Table B.1
P_L	Average number of animals for each livestock category *L*	Population (# head)	o	
$Mass_L$	Average live weight by livestock category *L*	kg	o, r	From operating records, or if onsite data are unavailable, from lookup table (Table B.2 and Table B.4) *Confirmation body:* Confirm correct value from table used
T_{mo}	Average monthly temperature at location of the operation	°C	m/o	Used for van't Hoff calculation and for choosing appropriate MCF value. *Confirmation body:* Review temperature records obtained from weather service
$B_{0,L}$	Maximum methane producing capacity for manure by livestock category	(m^3 CH_4/kgVS)	r	From Table B.3 *Confirmation body:* Confirm correct value from table used
MCF	Methane conversion factor	Percent (%)	r	From Appendix B Differentiate by livestock category. *Confirmation body:* Confirm correct value from table used
VS_L	Daily volatile solid production for each livestock category *L*	(kg/animal/day)	r, c	Table B.2 and Table B.4 *Confirmation body:* Confirm correct value from table used
f	van't Hoff-Arrhenius factor	n/a	c	The proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system
Y_{cp}	Number of years in crediting period	years	r	
U_{pl}	Project Longevity Adjustment Factor	fraction	r	Use value of 0.95
D_{CH4}	Density of methane	kg/m^3	r	Use value of 0.68
$C_{Mg/kg}$	Conversion factor, kg to Mg	Mg/kg	r	Use value of 1×10^{-3}
GWP_{CH4}	Global warming potential of methane	tCO_2e/tCH_4	r	As of this writing, the value shall be 25 (in accordance with the IPCC 4th Assessment Report, 2007), until updated guidance is issued by Climate Forward
AS	Anaerobic storage / treatment system	n/a	r	Select from list provided in Table B.1
m	Month in baseline calculation period	month	o	

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Comment
VS_{avail}	Monthly volatile solids available for degradation in each anaerobic storage system, for each livestock category	kg dry matter	c, o	
$VS_{deg\ AS,L}$	Monthly volatile solids degraded in each anaerobic storage system *AS*, for each livestock category *L*	kg dry matter	c, o	
d_m	Number of days in each month	days	r	
MDP	Model calibration factor for management and design practices	fraction	r	Use value of 0.8[24]
E	Activation energy constant	cal/mol	r	Use value of 15,175
T_{max}	Temperature of maximum reaction rate constant	Kelvin	r	Use value of 303.16
T_{amb}	Monthly ambient temperature	Kelvin	o	
R	Ideal gas constant	cal/Kelvin·mol	r	Use value of 1,987
f_{max}	Maximum *f* factor	fraction	r	Use value of 0.95
$Q_{E,grid}$	Quantity of grid-connected electricity consumed for each emission source 'E' during the baseline calculation period	MWh	o	
EF_{grid}	eGrid emission factor for grid electricity consumed	tCO_2/MWh	r	
$Q_{F,fuel}$	Quantity of fossil fuel consumed for each mobile and stationary combustion source 'F' during the baseline calculation period	MMBtu or gal	o	Make sure data units are consistent across parameters in Equation 5.10
EF_{fuel}	Fuel specific emission factor	$kgCO_2$/ MMBtu or gal	r	Use default values from Table B.8
BCE	Biogas capture efficiency of the anaerobic digester, accounts for gas leaks	Fraction	r	Use default value Appendix B
$BDE_{BCS,m}$	Forecast overall monthly methane destruction efficiency of the BCS	fraction	c	As quantified in Equation 5.15

[24] Mangino, et al. This factor was derived to "account for management and design practices that result in the loss of volatile solids from the management system." This reflects the difference between the theoretical modeled biological activity and empirical measurement of biological activity due to removal of liquid or other management practices that result in loss of VS from the treatment system. This does not account for removal of solids prior to the treatment system.

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Comment
$BCS_{CH4,vent,m}$	Forecast annual quantity of methane vented to the atmosphere due to venting events	tCH_4	c	As quantified in Equation 5.16
$FP_{DD,m}$	Forecast monthly percentage of total biogas flow to destruction device "DD"	fraction	o	
V_f	Methane Venting Factor	fraction		Site specific value must be set based on available historical data, manufacturer guidance, published literature, or similar source, and must be approved by Climate Forward prior to confirmation
$VS_{ETAS,L,m}$	Forecast volatile solid input to effluent treatment system 'ET' for livestock category 'L'	Kg dry matter/day	c	
ETF_{ET}	Fraction of effluent that exits the digester and is input directly to the effluent treatment system 'ET'	fraction	c	
d_p	Number of days in the forecast period	days	o	

6.2 Voluntary Ongoing Monitoring Incentive

Each Climate Forward methodology is designed to ensure the quantification of emission reductions over the crediting period is conservative. It may be possible to have additional FMUs issued following *ex post* verification, using data collected by the project through ongoing monitoring of parameters relevant to the quantification methodology. For this methodology, *ex ante* risk related to project abandonment and performance decline during the full crediting period is accounted for through the application of the Project Longevity Adjustment Factor (U_{pl}). This factor, valued at 0.95 for all projects, discounts the calculation of forecast emission reductions (Equation 5.1).

In order to conduct a successful *ex post* project verification, and generate additional FMUs from the dairy project, the project proponent shall conduct ongoing monitoring of all relevant project parameters. This methodology does not currently prescribe detailed monitoring and metering or QA/QC procedures, but it is strongly recommended that the project follow an approach as close as possible to that required by the most current version of the Reserve's U.S. Livestock Project Protocol.[25]

[25] Current and previous versions of the Reserve's U.S. Livestock Project Protocol, as well as supporting documents and information, are available online at: http://www.climateactionreserve.org/how/protocols/us-livestock/. As of this writing, the Reserve also makes available an Excel-based calculation tool for livestock projects.

7 Reporting and Record Keeping

This section provides requirements and guidance on reporting rules and procedures. A priority of Climate Forward is to facilitate consistent and transparent information disclosure among project proponents. Project proponents must submit an emission reduction report as part of the Project Implementation Report to Climate Forward.

7.1 Project Submittal and Confirmation Documentation

The following documents are required for project listing and confirmation with Climate Forward:

- Project Submission form
- Signed Attestation of Title form
- Signed Attestation of Legal Additionality form
- Signed Attestation of Regulatory Compliance form
- Project Implementation Report
- Confirmation Report
- Confirmation Statement

At a minimum, the above project documentation will be available to the public via the Climate Forward online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Climate Forward registry. [26]

7.2 Record Keeping

For purposes of independent confirmation and historical documentation, project proponents are required to keep all information outlined in this methodology for a period equal to either the project crediting period or seven years after the information is generated, whichever is greater. This information will not be publicly available, but may be requested by the confirmation body or the Reserve. Records must be kept in both hard copy and digital format, where possible.

Examples of information the project proponent must retain includes:

- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Copies of all permits, formal notices of regulatory violations, and any relevant administrative or legal consent orders dating back at least 3 years prior to the implementation of the first project device
- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Legal Additionality forms
- Results of emission reduction calculations
- Confirmation records and results
- All evidence relating to Continued Implementation

Climate Forward also requires that the following project-related records be retained by the confirmation body for a period equal to either the project crediting period or seven years after the completion of confirmation activities, whichever is greater. It must be noted that some records may be subject to fiscal or other legal requirements that are longer than Climate Forward's mandated period.

[26] Climate Forward documents and forms are available at https://climateforward.org/program/program-and-project-forms/

Confirmation bodies shall retain electronic copies, as applicable, of:

- The project's Project Implementation Report
- The project proponent's SSR and/or project activity data as well as evidence cited
- The confirmation plan
- The sampling plan
- The Confirmation Report
- The List of Findings
- The Confirmation Statement

Each confirmation body must have an easily accessible record-keeping system, preferably electronic, that provides readily available access to project information. Copies of the original activity and source data records shall be maintained within said record-keeping system. Records must be kept in both hard copy and digital format, where possible. The Reserve may at any time request access to the record-keeping system or any supporting documentation for oversight or auditing purposes.

7.3 Reporting and Confirmation Period

Project proponents must report forecasted GHG reductions from the project for the entire crediting period. A confirmation period is the period of time over which forecasted GHG reductions are confirmed. The confirmation period is the period of time beginning with the project start date and ending with the submission of the final Confirmation Report to Climate Forward. The end date of any confirmation period may not extend past the project crediting end date.

Confirmation activities cannot commence until the project is submitted by the project proponent and approved by the Reserve, and at least three months following the project start date. Confirmation must conclude, and a Confirmation Statement must be issued, no later than two years after the project start date, except for in cases of greenfield projects, which require confirmation conclusion and Confirmation Statement issuance no later than three calendar years after the project start date. Successful confirmation fixes the start and ends dates of the project crediting period for the duration of the project.

7.3.1 Expansion Project Confirmations

Expansion project confirmation activities cannot commence until the expansion project is submitted and approved by the Reserve. Confirmation must conclude, and a Confirmation Statement must be issued, no later than two years after expansion completion, as defined in Section 3. The confirmation period for a project expansion starts when the expansion is completed; the confirmation period end date is not permitted to extend past the project crediting end date confirmed and fixed during project confirmation. There is no limit to the number of expansion confirmations that may be conducted throughout the established project crediting period. A site visit is required during any expansion confirmation, including confirmation of Project Resilience Measures.

7.4 *Ex Post* Verification

Ex post issuance may be possible for dairy projects if data from each year of the crediting period are submitted in a Project Monitoring Report and verified at the conclusion of the crediting period. A site visit is required during an *ex post* verification. This methodology does not currently prescribe detailed *ex post* verification procedures, but it is strongly recommended that

the verifier follow an approach as close as possible to that required by the most current version of the Reserve's U.S. Livestock Project Protocol.[27]

[27] Current and previous versions of the Reserve's Livestock Project Protocol, as well as supporting documents and information, are available online at: http://www.climateactionreserve.org/how/protocols/us-livestock/.

8 Confirmation Guidance

This section provides confirmation bodies with guidance on confirming GHG emission reductions associated with the project activity. This confirmation guidance supplements the Climate Forward Confirmation Manual and describes confirmation activities specifically related to this methodology.

Confirmation bodies trained to confirm a given methodology type must be familiar with the following documents:

- Climate Forward Program Manual
- Climate Forward Confirmation Manual
- Dairy Digester Project Forecast Methodology (this document)

The Climate Forward Program Manual, Climate Forward Confirmation Manual, and Climate Forward methodologies are designed to be compatible with each other and are posted on the Climate Forward website at http://www.climateforward.org.

Only confirmation bodies trained and accredited by the Reserve are eligible to confirm project reports. Information about confirmation body accreditation and Climate Forward project confirmation training can be found on the Climate Forward website at http://www.climateforward.org/program/confirmation/.

8.1 Standard of Confirmation

While there is no requirement for *ex post* verification of this project under Climate Forward, there is a requirement for an accredited confirmation body to confirm the project has been implemented as described in the forecast methodology and that the estimated emission reductions or removals have been calculated accurately. The confirmation incorporates both a desktop documentation review and a site visit assessment of the mitigation project.

Beyond criteria for the confirmation of mitigation project implementation, the confirmation body also confirms any provisions specified in the forecast methodology that are to be undertaken to ensure the continued implementation of the mitigation project for the duration of its crediting period. The confirmation body assesses whether such measures have been appropriately implemented.

8.2 Project Implementation Report

The Project Implementation Report serves as the basis for confirmation bodies to confirm that the monitoring and reporting requirements have been met. Confirmation bodies shall confirm that the Project Implementation Report covers all aspects of monitoring and reporting contained in this methodology and specifies how data for all relevant parameters were collected and recorded.

When assessing the Project Implementation Report, the confirmation body shall:

(a) Assess the compliance of the Project Implementation Report with the requirements of the methodology, Climate Forward Program Manual, and Climate Forward Confirmation Manual;

(b) Identify the list of parameters required by the methodology and confirm that the Project Implementation Report accounted for all necessary parameters;

(c) Assess the means of implementation of the project data capture, including data management and quality assurance and quality control procedures, and determine whether these are sufficient to ensure the accuracy of forecasted GHG emission reductions to be achieved by the project.

Where the project proponent has applied a sampling approach to determine data and parameters, the confirmation body shall assess the proposed sampling plan in accordance with sampling requirements in section 4.3.3 of ISO 14064-3.

8.3 Core Confirmation Activities

The Climate Forward Confirmation Manual describes the core confirmation activities that shall be performed by confirmation bodies for all project confirmations.

Confirmation is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The core confirmation activities are:

1. Reviewing GHG management systems and estimation methodologies
2. Confirming emission reduction estimates
3. Undertaking site visits
4. Confirming implementation of project resilience measures

8.3.1 Reviewing GHG Management Systems and Estimation Methodologies

The confirmation body reviews and assesses the appropriateness of the methodologies and management systems that the project proponent uses to gather data and calculate baseline and project emissions.

8.3.2 Confirming Emission Reduction Estimates

The confirmation body further investigates areas that have the greatest potential for material misstatements and then confirms whether material misstatements have occurred. Include confirmation activities required to confirm emission reduction estimates such as independent recalculation.

8.3.3 Undertaking Site Visits

In addition to undertaking a desk review, confirmation bodies shall conduct one or more site visits. The specific itinerary for a site visit and the activities to be confirmed will be determined by the confirmation body, following an assessment of project risk. A site visit shall be used to confirm the GHG Assessment Boundary, examine project equipment, identify any associated SSRs resulting from the project, and assess the implementation and operation of the project activity. Furthermore, confirmation bodies must confirm the project crediting period adequately represents project life expectancy as outlined in Section 3. At a minimum, the implementation of Project Resilience Measures must be confirmed during site visits (where practical). Site visits are also required for *ex post* verification (see Section 6.2), and the confirmation of expansion activities (see Section 7.3.1).

8.3.4 Confirming Implementation of Project Resilience Measures

The confirmation body reviews and assesses evidence provided to demonstrate each of the project resilience measures outlined in Section 3.7 and Table 3.1 have been appropriately implemented.

8.4 Confirmation Items

The confirmation body needs to address a set of items for each methodology type. This can be displayed in a table that lists the item, references the section in the methodology where requirements are specified, and identifies if professional judgment needs to be applied during the confirmation activity.

Confirmation bodies are expected to use their professional judgment to confirm that methodology requirements have been met in instances where the methodology does not provide sufficiently prescriptive guidance. For more information on Climate Forward's confirmation process and professional judgment, please see the Climate Forward Confirmation Manual.

Note: The tables below shall not be viewed as a comprehensive list or plan for confirmation activities, but rather guidance on areas specific to livestock projects that must be addressed during confirmation.

8.4.1 Project Eligibility and Credit Issuance

Table 8.1 lists the criteria for reasonable assurance with respect to eligibility and credit issuance for dairy manure digestion projects. These requirements determine if a project is eligible to register with Climate Forward and/or have credits issued. If any requirement is not met, the project may be determined ineligible.

Table 8.1. Eligibility Confirmation Items

Methodology Section	Eligibility Qualification Item	Apply Professional Judgment?
3.1	Location – confirm projects are located in the United States and its territories, or on U.S. tribal lands	No
3.2	Project start date – confirm the start date is appropriately chosen and that the project was submitted to Climate Forward within two calendar years of the project start date	Yes
3.2	Crediting period – confirm the crediting period is appropriate vis-à-vis the chosen digester technology	No
3.3.1	Additionality – performance standard test – confirm the project installed a biogas destruction system	No
3.3.2	Additionality – legal requirement test – confirm the project was not mandated by any laws – confirm the project was submitted to the Program with a start date prior to any relevant laws being adopted – confirm the project was registered / listed prior to the date any relevant law was adopted and that the start date is before the date on which such laws become effective	No
3.3.3	Additionality – uncontrolled anaerobic baseline – confirm manure was treated anaerobically before the project. Confirm baseline manure management system had sufficient depth to be considered anaerobic. For pre-existing dairies, confirm anaerobic manure treatment system	Yes

Methodology Section	Eligibility Qualification Item	Apply Professional Judgment?
	was in place prior to start date. For new dairy facilities, confirm there are no restrictions on the construction of uncontrolled anaerobic manure treatment systems in the industry and geographic region of the mitigation project. For expansions of existing projects, confirm that additional BCS storage capacity exceeds requisite capacity for the expanded herd size, and that the expansion in capacity meets or exceeds 15% of the baseline herd capacity, and herd capacity has stabilized for at least 12 months prior to commencement of confirmation activities	
3.4	Environmental and social safeguards – confirm the project is not expected to cause adverse environmental, social or economic impacts. Confirm appropriate mitigation measures are in place to guard against such risks	Yes
3.5	Confirm no laws have been broken in the implementation of the project	No
3.6	Confirm no other GHG mitigation credits have been issued for the project, during the crediting period	No
3.7	Confirm Project Resilience Measures have been implemented as described, including during site visit	Yes

8.4.2 Quantification

Table 8.2 lists the items that confirmation bodies shall include in their risk assessment and recalculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before FMUs are issued.

Table 8.2. Quantification Confirmation Items

Methodology Section	Quantification Item	Apply Professional Judgment?
4	Confirm that all SSRs in the GHG Assessment Boundary are accounted for	No
5.1	Confirm project longevity adjustment factor applied correctly	No
5.2	Confirm the livestock categories are correct differentiated	Yes
5.2	Confirm the project proponent applied the correct VS and B_0 values for each livestock category	No
5.2	Confirm the fraction of manure handled in different manure management system components is satisfactorily represented	*Yes*
5.2	Confirm the project proponent used methane conversion factors differentiated by temperature	No
5.2	Confirm the methane baseline emissions calculations for each livestock category were calculated according to the methodology with appropriate data	No
5.2	Confirm the project proponent correctly aggregated methane emissions from sources within each livestock category	No
5.2.3 5.3.2	Confirm that the project proponent correctly monitored, quantified and aggregated electricity use	No
5.2.3 5.3.2	Confirm that the project proponent correctly monitored, quantified and aggregated fossil fuel use	No

Methodology Section	Quantification Item	Apply Professional Judgment?
5.2.3 5.3.2	Confirm that the project proponent applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5.3	Confirm that the project emissions calculations were calculated according to the methodology with the appropriate data	No
5.3.1.1	Confirm that the project proponent applied the correct methane destruction efficiencies	No
5.3.1.1	Confirm that the project proponent correctly quantified the amount of uncombusted methane	No
5.3.1.1	Confirm that methane emissions resulting from venting are estimated correctly	Yes
5.3.1.2	Confirm that the project proponent applied the correct B_0 value for Modeled Project Methane Emissions from Anaerobic Treatment of BCS Effluent	No

In assessing the appropriateness of parameter values, the confirmation body shall*:*

a) Confirm approval was given by the Reserve for use of such values.

b) Determine whether all *ex ante* data sources and assumptions are appropriate and calculations are correct as applicable under the methodology and results in an accurate and conservative estimate of the forecasted emission reductions.

c) Determine whether all *ex post* data sources and assumptions are appropriate and calculations are correct. Whether these data, with respect to specific parameters defined, are replicable to a reasonable and logical extent.

8.4.3 Risk Assessment

Confirmation bodies will review the following items in Table 8.3 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.3. Risk Assessment Confirmation Items

Methodology Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Confirm that the project Monitoring Plan is sufficiently rigorous to support the requirements of the methodology and proper operation of the project	Yes
6	Confirm that the BCS was operated and maintained according to manufacturer specifications	No
6	Confirm that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Confirm that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Confirm that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Confirm that there is internal oversight to assure the quality of the contractor's work	Yes
7.2	Confirm that all required records have been retained by the project proponent	No

8.5 Completing Confirmation

The Climate Forward Confirmation Manual provides detailed information and instructions for confirmation bodies to finalize the confirmation process. It describes completing a Confirmation Report, preparing a Confirmation Statement, submitting the necessary documents to Climate Forward, and notifying the Reserve of the project's confirmed status.

9 Glossary of Terms

Accredited confirmation body	A confirmation firm approved by the Reserve to provide confirmation services for project proponents.
Additionality	Project activities that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e., fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Confirmation	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with Climate Forward's procedures and methodologies for calculating and reporting GHG emissions and emission reductions.
Confirmation body	An organization or company that has been ISO-accredited and approved by the Reserve to perform GHG confirmation activities for specific forecast methodologies.
Direct emissions	GHG emissions from sources that are owned or controlled by the reporting entity.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.

Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Metric ton (t, tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Project baseline	A "business as usual" GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project Implementation Report	A report prepared by the project proponent containing all data, calculations, and information necessary for the confirmation of the ICS project and the issuance of *ex ante* FMUs.
Project Monitoring Report	A report prepared by the project proponent containing all monitoring data, calculations, and information necessary for the *ex post* verification of the ICS project and the issuance of additional FMUs
Project proponent	An entity that undertakes a GHG project, as identified in Section 2.1 of this methodology.
Project Resilience Measures	Activities tailored to the specific project that are undertaken to ensure the continuing implementation of the project for the duration of the crediting period.

10 References

Climate Action Reserve's U.S. Livestock Project Protocol Version 4.0 (January 23, 2013)

Climate Forward Program Manual

Climate Forward Confirmation Manual

International Organization for Standardization, ISO 14064-2:2006 Greenhouse gases — Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements (2006).

Intergovernmental Panel on Climate Change, IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management (2006).

Mangino, J., Bartram, D. and Brazy, A. Development of a methane conversion factor to estimate emissions from animal waste lagoons. Presented at U.S. EPA's 17th Annual Emission Inventory Conference, Atlanta GA, April 16-18, 2001.

Regional Greenhouse Gas Initiative, Draft Model Rule (January 2007).

United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) methodology ACM00010 (available at: http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html).

U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Storage Facility, No. 313

U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Treatment Lagoon, No. 359.

U.S. Environmental Protection Agency – Climate Leaders Offset Methodology for Managing Manure with Biogas Recovery Systems V.1.3 (2008).

World Resource Institute and World Business Counsel for Sustainable Development, Greenhouse Gas Protocol for Project Accounting (November 2005).

Appendix A Associated Environmental Impacts

Manure management projects have many documented environmental benefits, including air emission reductions, water quality protection, and electricity generation. These benefits are the result of practices and technologies that are well managed, well implemented, and well designed. However, in cases where practices or technologies are poorly or improperly designed, implemented, and/or managed, local air and water quality could be compromised.

With regard to air quality, there are a number of factors that must be considered and addressed to realize the environmental benefits of a biogas project and reduce or avoid potential negative impacts. Uncontrolled emissions from combustion of biogas may contain between 200 to 300 ppm NO_X. The anaerobic treatment process creates intermediates such as ammonia, hydrogen sulfide, orthophosphates, and various salts, all of which must be properly controlled or captured. In addition, atmospheric releases at locations offsite where bio-gas is shipped may negate or decrease the benefit of emissions controls onsite. Thus, while devices such as Selective Catalyst Reduction (SCR) units can reduce NO_X emissions and proper treatment system operation can control intermediates, improper design or operation may lead to violations of federal, state, and local air quality regulations as well as release of toxic air contaminants.

With regard to water quality, it is critical that project developers and managers ensure digester integrity and fully consider and address post-digestion management of the effluent in order to avoid contamination of local waterways and groundwater resources. Catastrophic digester failures; leakage from pipework and tanks; and lack of containment in waste storage areas are all examples of potential problems. Further, application of improperly treated digestate and/or improper application timing or rates of digestate to agricultural land may lead to increased nitrogen oxide emissions, soil contamination, and/or nutrient leaching, thus negating or reducing benefits of the project overall.

Project proponents must not only follow the methodology to register GHG reductions with Climate Forward, they must also comply with all local, state, and national air and water quality regulations. Projects must be designed and implemented to mitigate potential releases of pollutants such as those described, and project managers must acquire the appropriate local permits prior to installation to prevent violation of the law.

The Reserve agrees that GHG emission reduction projects should not undermine air and water quality efforts and will work with stakeholders to establish initiatives to meet both climate-related and localized environmental objectives.

Appendix B Emission Factor Tables

Table B.1. Manure Management System Components

System	Definition
Pasture/Range/ Paddock	The manure from pasture and range grazing animals is allowed to lie as deposited and is not managed.
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.
Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year. Per IPCC Guidelines, if manure contains less than 20% dry matter it can be considered liquid.
Uncovered anaerobic lagoon	A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.
Pit storage below animal confinements	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.
Anaerobic digester	Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO_2 and CH_4, which is captured and flared or used as a fuel.
Burned for fuel	The dung and urine are excreted on fields. The sun-dried dung cakes are burned for fuel.
Cattle and Swine deep bedding	As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture.
Composting – In-vessel*	Composting, typically in an enclosed channel, with forced aeration and continuous mixing.
Composting – Static pile*	Composting in piles with forced aeration but no mixing.
Composting – Intensive windrow*	Composting in windrows with regular (at least daily) turning for mixing and aeration.
Composting – Passive windrow*	Composting in windrows with infrequent turning for mixing and aeration.

System	Definition
Aerobic treatment	The biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.

*Composting is the biological oxidation of a solid waste including manure usually with bedding or another organic carbon source typically at thermophilic temperatures produced by microbial heat production.
Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management, Table 10.18: Definitions of Manure Management Systems, p. 10.49.

Table B.2. Livestock Categories and Typical Animal Mass

Livestock Category (L)	Livestock Typical Animal Mass (TAM)
Dairy cows (on feed)	680[b]
Non-milking dairy cows (on feed)	684[a]
Heifers (on feed)	407[b]
Bulls (grazing)	750[b]
Calves (grazing)	118[b]
Heifers (grazing)	351[b]
Cows (grazing)	582.5[b]

Sources for TAM:
a. American Society of Agricultural Engineers (ASAE) Standards 2005, ASAE D384.2.
b. Environmental Protection Agency (EPA), Inventory of U.S. GHG Emissions and Sinks 1990-2010 (2012), Annex 3, Table A-191, pg. A-246.

Table B.3. Volatile Solids and Maximum Methane Potential by Livestock Category

Livestock Category (L)	VS_L (kg/Mg animal mass x·day)	$B_{0,L}$ [b] (m^3 CH_4/kg VS added)
Dairy cows	See Appendix B, Table B.5	0.24
Non-milking dairy cows	5.56	0.24
Heifers	See Appendix B, Table B.5	0.17
Bulls (grazing)	6.04[b]	0.17
Calves (grazing)	6.41[b]	0.17
Heifers (grazing)	See Appendix B, Table B.5	0.17
Cows (grazing)	See Appendix B, Table B.5	0.17

a. American Society of Agricultural Engineers (ASAE) Standards 2005, ASAE D384.2, VS_L(kg/day per animal) from table 1.b (p.2) converted to (kg/day/1000 kg mass) using average Live Weight (kg)values from table 5c (p.7).
b. Environmental Protection Agency (EPA) – Climate Leaders Draft Manure Offset Protocol, October 2006, Table IIa: Animal Waste Characteristics (VS, B_0, and N_{ex} rates), p. 18.

Table B.4. Biogas Collection Efficiency by Digester Type

Digester Type	Cover Type	Biogas Collection Efficiency
Covered Anaerobic Lagoon	Bank-to-Bank, impermeable	0.95
	Partial area (modular), impermeable	(0.95) × (% area covered)
Complete mix, plug flow, or fixed film digester	Enclosed vessel	0.98
Two stages of differing types	With flow metered for each stage	$\frac{(BCE_1 \times EstFlow_1) + (BCE_2 \times EstFlow_2)}{Total\ estimated\ biogas\ flow}$
	No separate flow metering	$(BCE_1 \times 0.7) + (BCE_2 \times 0.3)$

Adapted from: U.S. EPA Climate Leaders, Offset Project Methodology for Managing Manure and Biogas Recovery Systems, 2008. Table IIf (original table has been expanded upon).

Table B.5. 2010 Volatile Solid Default Values for Livestock Category Types (kg/Mg animal mass day)

State	VS Dairy Cow	VS Heifer	VS Heifer-Grazing	VS Cows- Grazing
Alabama	8.99	8.43	8.53	7.82
Alaska	7.98	8.43	9.98	8.89
Arizona	11.47	8.43	9.77	8.89
Arkansas	8.3	8.43	8.48	7.82
California	11.27	8.43	9.48	8.89
Colorado	11.54	8.43	9.27	8.89
Connecticut	10.22	8.43	8.62	7.87
Delaware	9.53	8.43	8.53	7.87
Florida	10.26	8.43	8.63	7.82
Georgia	10.03	8.43	8.49	7.82
Hawaii	8.43	8.43	9.77	8.89
Idaho	11.24	8.43	9.41	8.89
Illinois	10.19	8.43	7.78	7.47
Indiana	10.54	8.43	7.91	7.47
Iowa	10.67	8.43	7.64	7.47
Kansas	10.74	8.43	7.61	7.47
Kentucky	9.11	8.43	8.4	7.82
Louisiana	7.98	8.43	8.63	7.82
Maine	9.94	8.43	8.51	7.87
Maryland	10	8.43	8.51	7.87
Massachusetts	9.67	8.43	8.53	7.87
Michigan	11.42	8.43	7.83	7.47
Minnesota	10.25	8.43	7.83	7.47
Mississippi	8.59	8.43	8.53	7.82
Missouri	8.81	8.43	7.97	7.47
Montana	10.63	8.43	8.42	7.82
Nebraska	10.38	8.43	9.25	8.89
Nevada	11.08	8.43	8.01	7.47
New Hampshire	10.4	8.43	9.62	8.89
New Jersey	9.69	8.43	8.45	7.87
New Mexico	11.81	8.43	8.43	7.87
New York	10.69	8.43	9.5	8.89
North Carolina	10.54	8.43	8.61	7.87
North Dakota	9.92	8.43	8.31	7.82
Ohio	10.27	8.43	7.95	7.47
Oklahoma	9.59	8.43	7.9	7.47
Oregon	10.54	8.43	8.33	7.82
Pennsylvania	10.39	8.43	9.56	8.89
Rhode Island	9.76	8.43	8.66	7.87
South Carolina	10.02	8.43	8.61	7.87
South Dakota	10.59	8.43	8.19	7.82
Tennessee	9.56	8.43	8.12	7.47
Texas	10.87	8.43	8.21	7.82
Utah	10.86	8.43	8.42	7.82
Vermont	10	8.43	9.56	8.89
Virginia	10.09	8.43	8.52	7.87
Washington	11.5	8.43	8.25	7.82
West Virginia	9.15	8.43	9.73	8.89
Wisconsin	10.63	8.43	7.96	7.47
Wyoming	10.46	8.43	9.62	8.89

Source: Environmental Protection Agency (EPA). U.S. Inventory of GHG Sources and Sinks 1990-2010 (2012), Annex 3, Table A-192, page A-237.

Table B.6. IPCC 2006 Methane Conversion Factors by Manure Management System Component / Methane Source

MCF Values by Temperature for Manure Management Systems																				
	Average annual temperature (°C)																			
	Cool					Temperate											Warm			
System[a]	<10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	>28	Source and comments
Pasture/Range/Paddock	0.010					0.015											0.020			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Daily spread	0.00					0.005											0.010			Hashimoto and Steed (1993).
Solid storage	0.02					0.04											0.05			Judgment of IPCC Expert Group in combination with Amon et al. (2001), which shows emissions of approximately 2% in winter and 4% in summer. Warm climate is based on judgment of IPCC Expert Group and Amon et al. (1998).
Dry lot	0.010					0.015											0.020			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Liquid/slurry w/natural crust cover[40]	0.10	0.11	0.13	0.14	0.15	0.17	0.18	0.20	0.22	0.24	0.26	0.29	0.31	0.34	0.37	0.41	0.44	0.48	0.50	Judgment of IPCC Expert Group in combination with Mangino et al. (2001) and Sommer (2000). The estimated reduction due to the crust cover (40%) is an annual average value based on a limited data set and can be highly variable dependent on temperature, rainfall, and composition.
Liquid/slurry uncovered	0.17	0.19	0.20	0 22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).
Uncovered anaerobic lagoon	0.66	0 68	0.70	0.71	0.73	0.74	0.75	0.76	0.77	0.77	0.78	0.78	0.78	0.79	0.79	0.79	0.79	0.80	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Uncovered lagoon MCFs vary based on several factors, including temperature, retention time, and loss of volatile solids from the system (through removal of lagoon effluent and/or
Pit storage below animal confinements (<1 month)	0.03					0.03											0.03			Judgment of IPCC Expert Group in combination with Moller et al. (2004) and Zeeman (1994). Note that he ambient temperature, not the stable temperature is to be used for determining the climatic conditions.
Pit storage below animal confinements (>1 month)	0.17	0.19	0.20	0 22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions.
Anaerobic digester	0 - 1					0 - 1											0 - 1			Should be subdivided in different categories, considering amount of recovery of the biogas, flaring of the biogas and storage after digestion. Calculation
Burned for fuel	0.10					0.10											0.10			Judgment of IPCC Expert Group in combination with Safley et al. (1992).

MCF Values by Temperature for Manure Management Systems

System[a]	Average annual temperature (°C)																		Source and comments
	Cool					Temperate											Warm			
	<10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	>28	
Cattle and swine deep bedding (<1 month)	0.03					0.03											0.30			Judgment of IPCC Expert Group in combination with Moller et al. (2004). Expect emissions to be similar, and possibly greater, than pit storage, depending on organic content and moisture content.
Cattle and swine deep bedding (>1	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0 55	0.60	0.65	0.71	0.78	0.90	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).
Composting - in-vessel or aerated static pile[b]	0.005					0.005											0.005			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are less than half of solid storage. Not temperature dependant.
Composting - passive or intensive windrow[b]	0.005					0.010											0.015			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are slightly less than solid storage. Less temperature dependant.
Aerobic treatment	0 00					0.00											0.00			MCFs are near zero. Aerobic treatment can result in the accumulation of sludge which may be treated in other systems. Sludge requires removal and has large VS values. It is important to identify the next management process for the sludge and estimate the

[a] Definitions for manure management systems are provided in Table B.1.
[b] Composting is the biological oxidation of a solid waste, including manure, usually with bedding or another organic carbon source, typically at thermophilic temperatures produced by microbial heat production.

Adapted from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management, Table 10.17. MCF values shall be chosen based on the average temperature at the site for an entire calendar year, even if the reporting period does not exactly cover a calendar year.
A “natural crust cover” is a naturally-forming layer that covers the majority of the liquid surface at a thickness sufficient to support communities of oxidizing bacteria, and which persists throughout the year. Evidence of such a cover (including the area covered, thickness, and persistence) must be provided by the project developer during confirmation in order to justify the use of this MCF value.

Table B.7. Biogas Destruction Efficiency Default Values by Destruction Device

If available, the official source tested methane destruction efficiency shall be used in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site-specific methane destruction efficiencies, for each of the combustion devices used in the project case performed on an annual basis. Site-specific values must be provided by an independent air emissions testing body that is accredited by a state or local regulatory agency, or the Stack Testing Accreditation Council. Where a state/region does not have an appropriate accreditation system or accredited service providers, the project developer may look to another state/region to find suitably qualified service providers.

Biogas Destruction Device	Biogas Destruction Efficiency (BDE)[1]
Open Flare	0.96[2]
Enclosed Flare	0.995[2]
Lean-burn Internal Combustion Engine	0.936[2]
Rich-burn Internal Combustion Engine	0.995[2]
Boiler	0.98[2]
Microturbine or large gas turbine	0.995[2]
Upgrade and use of gas as CNG/LNG fuel	0.95[2]
Upgrade and injection into natural gas transmission and distribution pipeline	0.98[3]
Direct pipeline to an end-user	Per corresponding destruction device

Source:
1 Seebold, J.G., et al., Reaction Efficiency of Industrial Flares, 2003
2 The default destruction efficiencies for this source are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data are made available to the Reserve.
3 The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH_4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH_4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH_4/PJ, which is 0.8%. These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% x 99.4% x 99.6%) 98.5% for residential and commercial sector users, and (99.5% x 99.4% x 99.2%) 98.1% for industrial plants and power stations. [Source: GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007)]

Table B.8. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBTU / Short ton**	**kg C / MMBTU**		**kg CO_2 / MMBTU**	**kg CO_2 / Short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**BTU / Standard ft^3**	**kg C / MMBTU**		**kg CO_2 / MMBTU**	**kg CO_2 / S**
975 to 1,000 Btu / Standard ft^3	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Standard ft^3	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Standard ft^3	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Standard ft^3	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Standard ft^3	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Standard	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBTU / Barrel**	**kg C / MMBTU**		**kg CO_2 /**	**kg CO_2 / gallon**
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2, and 4)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 and 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401°F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401°F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable). Heat content factors are based on higher heating values (HHV).

Table B.9. Volatile Solids Removed Through Solids Separation

Type of Solids Separation	Volatile Solids Removed (fraction)
Gravity	0.45
Mechanical:	
Stationary screen	0.17
Vibrating screen	0.15
Screw press	0.25
Centrifuge	0.50
Roller drum	0.25
Belt press/screen	0.50

U.S.EPA National Pollutant Discharge Elimination System (NPDES) Development Document, Chapter 5, "Industry Subcategorization for Effluent Limitations Guidelines and Standards". Adapted from Moser et al. (1999).

Table B.10. Baseline Assumptions for Greenfield Projects

Baseline Assumption	>200 Mature Dairy Cows	<200 Mature Dairy Cows
Anaerobic manure storage system	Flush system into an anaerobic lagoon with >30-day retention	Flush system into an anaerobic lagoon with >30-day retention
Non-anaerobic manure storage system(s)	Solids storage	Solids storage
MS_L	90% lagoon; 10% solids storage	50% lagoon; 50% solids storage
Lagoon cleaning schedule	Annually, in September	Annually, in September

The simplified assumptions contained within this table are based on the waste management system data compiled by the U.S. Environmental Protection Agency for the development of Table A-194 in Annex 3 of the U.S. Inventory of GHG Sources and Sinks 1990-2010 (2012).

Appendix C Summary of Performance Standard Development

The analysis to establish a performance standard for the U.S. Livestock Project Protocol (LSPP) was undertaken by Science Applications International Corporation (SAIC) and independent consultant Kathryn Bickel Goldman. It took place at the end of 2006. The analysis culminated in a paper that provided a performance standard recommendation to support the Reserve's protocol development process, which the Reserve incorporated into the protocol's eligibility rules (see LSPP Section 3). This analysis was re-visited during the development of Version 4.0 of the protocol and, although there was no recommended change to the performance standard, this appendix has been updated to reflect more recent data and analysis.

The purpose of a performance standard is to establish a threshold that is significantly better than average GHG production for a specified service, which, if met or exceeded by a project developer, satisfies the criterion of "additionality." The LSPP focuses on the following direct emission reduction activity: avoiding methane emissions from the anaerobic storage and treatment of livestock manure. Therefore, in this case the methane emissions correspond to GHG production, and manure treatment/storage correspond to the specified service.

The analysis to establish the performance standard evaluated U.S.- and California-specific data on dairy and swine manure management systems. Ultimately, it recommended a practice-based/technology-specific GHG emissions performance standard – i.e., the installation of a manure digester (or Biogas Control System (BCS), more generally). The paper was composed of the following sections:

- The livestock industry in the United States and California
- Livestock manure management practices
- GHG emissions from livestock manure management
- Data on livestock manure management practices in the U.S. and California
- Current and anticipated regulations in California impacting manure management practices
- Recommendation for a performance threshold for livestock operations
- Considerations for baseline determinations

The initial analysis from that paper can be found in earlier versions of the U.S. Livestock Project Protocol Performance Standard, Appendix C. In this updated performance standard appendix, the additional and California-specific analysis showed adoption rates similar to the rest of the country, and thus has been removed from this document to reflect the Reserve's decision to apply the same performance standard to all operations across the United States. Beef facility and animal information has also been removed as beef operations are not currently eligible under the methodology.

C.1 Analysis of Common Practice

C.1.1 U.S. Data on Manure Management Practices

For the initial performance standard analysis, data from the Draft EPA Climate Leaders Offset Protocol for Managing Manure with Biogas Recovery Systems (2006) were used to assess national-level manure management practices. That protocol relied on data describing farm distribution and manure management systems from the Manure Management portion of the

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2004 and used data on the number of farms by farm size and geographic location from the 2002 Census of Agriculture.[28]

Information compiled for the EPA's U.S. GHG Inventory also provided a breakdown of the assumed predominant manure management systems in use for dairy and swine operations. Table C.1 and Table C.3 show data compiled for the systems in place in 2006. Table C.2 and Table C.4 show the Reserve's approximate recreation of the same analysis using the recently published numbers.[29]

Table C.1. Dairy and Swine Operations in the U.S. by Manure Management System (2006)

Animal	Number of Operations by Manure Management System						
	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	72,487	62	4,453	4,345	9,494	1,147	91,989
Swine	53,230	18	6,571	6,303	1,129	11,643	78,894

Source: U.S. EPA Climate Leaders Offset Protocol for Managing Manure with Biogas Recovery Systems (2008), Table I.A.

Table C.2. Dairy and Swine Operations in the U.S. by Manure Management System (2012)

Animal	Number of Operations by Manure Management System						
	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	56,075	185*	3,332	3,261	6,263	775	69,890
Swine	55,110	30	5,740	4,641	892	9,029	75,442

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture

* There are three systems in operation that digest both swine and dairy manure. For the purpose of this analysis they are considered as dairy.

The distribution of livestock across different sized operations can be an important criterion when developing a livestock manure management performance standard. There is a general relationship between manure management practices and operation size, where larger operations (in terms of livestock numbers) tend to use manure management systems that treat and store waste in liquid form (i.e., flush or scrape/slurry systems), particularly in dairy and swine operations.[30]

[28] EPA GHG Inventory Reports in subsequent years (including 2010) still rely on the results of the 2002 Census for this data.

[29] The equivalent analysis based on the 2007 census is unavailable in the same format from the EPA Climate Leaders program. The Reserve performed a similar analysis using data for manure management from the Inventory of U.S. Greenhouse Gas Emissions and Sinks (2012), data on the prevalence of anaerobic digesters from the U.S. EPA's AgSTAR database (Sept. 2012), and data on the number of farms by farms size and geographic location from the 2007 Census of Agriculture, the results of which are Table C.2 and Table C.4. This analysis may not have been performed in precisely the same way as the EPA Climate Leaders Program analysis; however, it serves the purpose of evaluating the current state of the dairy and swine manure management practices. The following classification assumptions were made: 1. digester projects associated with farms of size are classified by based on other information in the AgSTAR database, if available, or assumed to be in the medium size class; 2. farms employing anaerobic digesters are subtracted from the USDA counts based on "Baseline System" or other information in the AgSTAR database, if available. Where the "Baseline System" is categorized as "Storage Tank or Pond or Pit," the farm is assumed to belong in the "Liquid/Slurry" category for Dairy and the "Deep Pit" category for Swine.

[30] U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2004 (and earlier editions), U.S. Environmental Protection Agency, Report # 430-R-06-002, April 2006.

Table C.3. Dairy and Swine Operations by Size and Manure Management System (2006)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	320	48	1,614	675	245	-	2,902
	200-499	3,213	9	617	652	54	-	4,546
	1-199	6,8954	5	2,223	3,017	9,195	1,147	84,541
Swine	≥2000 head	-	14	2,581	1,084	297	2,774	6,749
	200-2000	-	3	3,990	5,219	832	8,869	18,913
	1-199	53,230	1	-	-	-	-	53,231

Source: U.S. 2002 Census of Agriculture.

Table C.4. Dairy and Swine Operations by Size and Manure Management System (2012)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	312	154	1,824	710	284	-	3,284
	200-499	3205	25	502	531	44	-	4,307
	1-199	52559	6	1,006	2,020	5,934	775	62,299
Swine	≥2000 head	-	26	3,182	1,295	358	3,345	8,206
	200-2000	-	3	2,557	3,347	534	5,685	12,125
	1-199	55,110	1	-	-	-	-	55,111

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture.

According to the Interim Draft Winter 2006 AgSTAR Digest used for the initial analysis, of 91,988 dairy and 78,894 swine farm operations in the United States, a total of 80 anaerobic digesters were in operation: 62 (0.07%) for dairy manure and 18 (0.02%) for swine manure.

Data were also disaggregated in the Climate Leaders protocol to determine whether digester installation was a common practice in any animal production operation size range. As was shown in Table C.3, even at large animal production operations, very few digester systems were in place. At dairy farms with ≥500 head, only 1.7% of manure management systems included digesters, and of swine farms with >2000 head, only 0.2% had digesters.

The most current information from the AgSTAR database (September 2012) shows that the number of anaerobic digesters in operation or under construction has nearly tripled at dairy farms and increased by more than 50% at swine farms. In terms of prevalence as a manure management practice across farms however, the practice remains the exception, rather than the rule. Currently there are 185 digesters at dairy farms (0.14%), and 30 at swine farms (0.03%).

The number of digesters at the largest farms increased the most significantly, with 154 digesters at dairy farms with ≥500 head (4.69%), and 26 at swine operations with ≥2000 head (0.32%). Of the 185 dairy farms with anaerobic digesters in operation, 84 have participated in GHG offset programs; eight of the 30 swine farms with anaerobic digester have participated in GHG offset programs. Table C.5 shows the distribution and percentages of digesters in operation or under construction by size farm, compared to farms with other manure management practices; Table

C.6 shows the same distribution, but does not include the digesters at farms participating in GHG offset programs.

The "natural" market penetration of anaerobic digesters on livestock facilities can be considered as the percentage of farms that choose this management option without the incentive provided by GHG offset programs. Table C.6 shows that the natural market penetration of anaerobic digesters on dairy and swine facilities in the U.S. remains very low. The highest rate of adoption is among dairy farms with ≥500 head, at 2.31%. However, this number conservatively includes anaerobic digestion facilities that are currently under construction. As many if not all of these facilities may actually be installed in response to GHG offset programs (which is often not known until they are operational and become publicly listed in one of these programs), even this small rate of adoption is likely to be overestimated by this analysis. If the anaerobic digesters that are under construction are all assumed to be GHG offset projects, then the natural market penetration of anaerobic digesters on dairy facilities of ≥ 500 head drops to 1.71%.

Table C.5. Dairy and Swine Operations by Size and Manure Management System (2012)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	312 9.49%	154 4.69%	1,824 55.53%	710 21.63%	284 8.66%	- -	3,284
	200-499	3,205 74.41%	25 0.58%	502 11.66%	531 12.32%	44 1.03%	- -	4,307
	1-199	52,559 84.37%	6 0.01%	1,006 1.61%	2,020 3.24%	5,934 9.52%	775 1.24%	62,299
	Total	56,075 80.23%	185 0.26%	3,332 4.77%	3,261 4.67%	6,263 8.96%	775 1.11%	69,890
Swine	≥2000 head	- -	26 0.32%	3,182 38.78%	1,295 15.78%	358 4.37%	3,345 40.76%	8,206
	200-1999	- -	3 0.02%	2,557 21.09%	3,347 27.60%	534 4.40%	5,685 46.88%	12,125
	1-199	55,110 99.998%	1 0.002%	- -	- -	- -	- -	55,111
	Total	55,110 73.05%	30 0.04%	5,740 7.61%	4,641 6.15%	892 1.18%	9,029 11.97%	75,442

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture.

Table C.6. Dairy and Swine Operations by Size and Manure Management System (2012) – Not Including Participants in a GHG Offset Program

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	**P/R/P**	**Anaerobic Digester**	**Lagoon**	**Liquid/ Slurry**	**Solid Storage**	**Deep Pit**	**Total**
Dairy	≥500 head	312 *9.73%*	74 *2.31%*	1,824 *56.91%*	710 *22.17%*	284 *8.88%*	- -	3,204
	200-499	3,205 *74.47%*	21 *0.49%*	502 *11.67%*	531 *12.33%*	44 *1.03%*	- -	4,303
	1-199	52,559 *84.37%*	6 *0.01%*	1,006 *1.61%*	2,020 *3.24%*	5,934 *9.52%*	775 *1.24%*	62,299
	Total	56,075 *80.33%*	101 *0.14%*	3,332 *4.77%*	3,261 *4.67%*	6,263 *8.97%*	775 *1.11%*	69,806
Swine	≥2000 head	- -	19 *0.23%*	3,182 *38.81%*	1,295 *15.79%*	358 *4.37%*	3,345 *40.80%*	8,199
	200-1999	- -	2 *0.02%*	2,557 *21.09%*	3,347 *27.60%*	534 *4.40%*	5,685 *46.89%*	12,124
	1-199	55,110 *99.998%*	1 *0.002%*	- -	- -	- -	- -	55,111
	Total	55,110 *73.06%*	22 *0.03%*	5,740 *7.61%*	4,641 *6.15%*	892 *1.18%*	9,029 *11.97%*	75,434

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture, open GHG offset program registries.

Finally, as anaerobic digesters are most likely to be installed on livestock facilities that already utilize liquid-based manure management systems, it is useful to examine the market penetration among only these facilities. Table C.7 shows that, among the total facilities utilizing liquid manure management systems, the natural market penetration of anaerobic digesters is 1.35% for dairy farms and 0.11% for swine farms.[31] The highest rate, seen among dairy farms of ≥500 head, is 2.84%. This continues to be an extremely low rate of adoption for anaerobic digestion technology.

[31] There is seemingly 100% market penetration on swine farms with <200 animals, due to the fact that there was only one farm in the dataset utilizing liquid manure management, and it also had an anaerobic digester. A greater trend of adoption of anaerobic digestion cannot be drawn from this single farm.

Table C.7. Dairy and Swine Operations Utilizing Liquid Manure Management System, by Size and Manure Management System (2012) – Not Including Participants in a GHG Offset Program

Animal	Number of Operations by Farm Size Using Anaerobic Manure Management (Excluding GHG Offsets)			
	Farm Size	Anaerobic Digester	Liquid Manure Management	Total
Dairy	≥500 head	74 *2.84%*	2,534 *97.16%*	2,608
	200-499	21 *1.99%*	1,033 *98.01%*	1,054
	1-199	6 *0.16%*	3,800 *99.84%*	3,806
	Total	101 *1.35%*	7,367 *98.65%*	7,468
Swine	≥2000 head	19 *0.24%*	7,822 *99.76%*	7,841
	200-1999	2 *0.02%*	11,589 *99.98%*	11,591
	1-199	1 *100.00%*	- -	1
	Total	22 *0.11%*	19,410 *99.89%*	19,432

C.1.2 U.S. and State Manure Management Regulations

As a part of the Reserve's protocol management, regulatory developments are tracked through, among other outreach and research activities, reporting on regulatory requirements by project developers and verification bodies in the verification process. Of the farms with an anaerobic digester that have participated in GHG offset projects documented in EPA's AgSTAR program, 65 have listed their projects under the Reserve's U.S. Livestock Project Protocol. Twenty-seven projects have been registered with the Reserve, i.e., successfully undergone the verification process. This includes projects in four of the five top dairy producing states, namely, California, Wisconsin, Texas and Idaho. In states where registered Reserve projects are located, no state or federal regulations have been found that would require the use of a BCS.

C.2 Performance Standard Recommendation

The original SAIC report recommended that a performance standard apply to the control of methane emissions from dairy and swine livestock operations in the U.S. and California. In particular, the performance standard should be a technology-specific threshold that dairy or swine operators would meet. The recommended threshold would be the installation of a BCS (e.g., an anaerobic digester).

The report found that even under favorable conditions digesters were found on less than 1% of the dairies in California, which was found to be representative of the U.S. market; and that if a dairy operator chose to install a digester then the farmer would be managing waste in the 99th percentile. This constitutes above and beyond common practice. The report also found that the main barrier inhibiting the installation and use of digesters was cost. Cost studies performed by EPA's AgSTAR program and the California Electricity Commission indicated that significant subsidies and/or incentives were needed to encourage additional digester installations.

The Reserve adopted this performance standard recommendation based on the data available at the time of the SAIC report. While the number of anaerobic digesters has increased significantly, the market penetration of BCS technology remains quite low, especially among those farms which are not receiving revenues from GHG offset markets. Today a dairy operator who chooses to install a digester would be managing waste in the 98th percentile—a modest increase since the original analysis, but hardly a significant shift in common practice. Furthermore, cost continues to inhibit wider adoption of BCS technologies according to a recent EPA report on the status of anaerobic digester adoption.[32] In light of these facts, the Reserve will not alter the current performance standard, but will continue to monitor market developments in the future.

C.3 Renewable Energy Certificates and Other Revenue Opportunities for Biogas-to-Energy Projects

Along with carbon credits, there are opportunities for farms installing digesters to earn additional revenues from a variety of sources that support renewable energy generation. These include loans and grants for developing biogas-to-energy projects and the sale of Renewable Energy Certificates (RECs) for use in a renewable portfolio standard (RPS) or a renewable portfolio goal (RPG).[33]

When considering additionality and the ability to generate RECs and CRTs from a livestock project, it is important to remember that the REC and CRT are created by two different but related activities. The REC is awarded for generating renewable electricity from the biogas collected by the BCS, whereas the CRT is awarded for the climate benefit created by the conversion of CH_4 in the biogas into CO_2 through combustion of the biogas. Under the LSPP, projects are not required to generate electricity with collected biogas or send it to a natural gas pipeline. Rather, they are only required to destroy the biogas. While a project may generate renewable electricity with its biogas, renewable energy generation is not an activity required or credited under the LSPP.

As there are a number of active RPS, RPG and voluntary REC programs nationwide, the availability of revenue from the sales of RECs is inherently represented in the data analyzed to set the performance standard. Since this analysis shows that the installation of a digester is not common practice at dairy and swine farms, the Reserve does not limit a project's ability to generate or sell RECs. Due to the numerous barriers to implementation of an anaerobic digester project, their success typically relies on a complex array of factors, including multiple incentive program. Renewable energy incentives alone have not significantly increased the natural market penetration of these projects.

When considering additionality and the availability of public dollars to support the development of biogas-to-energy projects, the Reserve has identified numerous state and local programs to support such projects through grants, loans and payments. Although the Reserve's performance standard tests do not require individual project assessments of financial viability or returns, they are designed to reflect these factors in determining which projects are additional. Even with the funds available, the installation of anaerobic digesters according to the LSPP is still very rare. Thus, even if a project does receive a grant or loan to support the generation of renewable

[32] U.S. Anaerobic Digester Status Report, October 2010, http://www.epa.gov/agstar/documents/digester_status_report2010.pdf

[33] Whereas compliance with an RPS is mandatory, RPGs set voluntary compliance targets.

energy from a biogas project, the performance standard and rules set forth in the LSPP should ensure the additionality of the CRTs generated.

Beyond grants and loans for biogas-to-energy projects, there are two nationwide payment programs administered by USDA Natural Resource Conservation Service (NRCS) that support the installation of anaerobic digesters. Authorized by the 2008 Farm Bill, the Environmental Quality Incentives Program (EQIP), and the Chesapeake Bay Watershed Initiative (CBWI) are programs that provide payments to support the installation of a BCS and are implemented at the state- and county-level. NRCS expressly allows the sale of environmental credits from enrolled lands, but does not provide additional guidance on ensuring the environmental benefit of any mitigation payment stacked with an NRCS payment.[34]

All NRCS programs share a common set of conservation practice standards that contain information on why and where the practice is to be applied, and set forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s).

NRCS Conservation Practice Standard 366 – Anaerobic Digester (CPS 366) provides assistance to farmers for the treatment of manure and other byproducts of animal agricultural operations for one or more of the following reasons: to capture biogas for energy production, to manage odors, to reduce the net effect of greenhouse gas emissions, or to reduce pathogens.[35]

Data obtained from NRCS show that less than 0.3% of farms eligible for funding under CPS 366 (i.e., farms with anaerobic operations) have received NRCS funds to install a BCS.[36] In practice, only 9% of the farms that installed BCS since 2004 have received NRCS funds. Because the installation of anaerobic digesters is expensive, uncommon and generally not already funded by NRCS programs, the use of NRCS payments to help finance project activity is allowed under the LSPP.

[34] EQIP, 7 CFR §1466.36; CSP, 7 CFR §1470.37.
[35] Natural Resources Conservation Service. (September 2009). Conservation Practice Standard, Anaerobic Digester, Code 366. State-specific conservation practice standards can be downloaded from http://efotg.sc.egov.usda.gov//efotg_locator.aspx.
[36] Based on 2004-2011 data obtained from NRCS Resource Economics, Analysis and Policy Division through personal communication.

Appendix D Risk Assessment[37]

This risk assessment presents a methodology for projecting project performance and project longevity on the basis of existing, publicly available data on existing dairy methane capture and destruction projects.

This risk assessment utilizes quantitative uncertainty analysis. Quantitative uncertainty analysis of emissions estimates is typically performed by estimating the 95 percent confidence interval of known emissions or removals for particular categories.[38] Details related to the quantification of specific project parameters for livestock offset projects, contained within monitoring and verification reports submitted to offset registries, are typically confidential and therefore not publicly available. However, aggregate estimates of baseline emissions, project emissions, and emission reductions are routinely included in public registry reports. Aggregate emissions scores incorporate the variability associated with individual monitored parameters in quantification models, and their use in uncertainty analysis and estimation may also avoid the potential for compounded error associated with the combined use of multiple specific parameters that may be correlated, leading to overestimation of the variability of the emissions score of primary interest—in this case, emission reductions over time for dairy manure anaerobic digestion projects in the U.S.

D.1 Variability in emission reductions from dairy digester projects

D.1.1 Offset Registry Data

Emissions data from U.S. dairy digester GHG offset projects were obtained from publicly-available online reports provided by two active GHG offset registries: The Climate Action Reserve[39] and American Carbon Registry[40] (ACR). Registry data for the livestock methane capture project type were presented by reporting period for each project, and included project name and registry ID, period start and end dates, quantification methodology (protocol and version) employed, baseline emissions, project emissions, metered emission reductions, modeled emission reductions, and total emission reductions issued as offset credits. Emissions data were presented as metric tons (Mg) CO_2e per reporting period.

D.1.2 Data Management

For the purposes of this analysis, the project start date was defined as the start date of the first reporting period for each project. For most projects, this represented the start of the initial offset program crediting period, rather than the actual commencement of project operations. The timing of emissions data for each project reporting period was expressed as the number of years from the project start date to the end of the reporting period (Project Years).

Project reporting periods varied in duration. Some offset program protocols required discrete reporting periods within a calendar year; others allowed reporting periods to extend across calendar years. The minimum reporting period duration in the collected registry data was nine days, and the maximum was two years. To reduce seasonal variability, emissions data from reporting periods using the same protocol version, and ending in the same calendar year, were combined (summed) for each project. After this adjustment, any reporting periods with a

[37] Appendix D is a modified version of a white paper prepared by ClimeCo Corporation.
[38] For example, see 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 3, Uncertainties.
[39] https://www.climateactionreserve.org/
[40] https://americancarbonregistry.org/

duration of less than 180 days were excluded from statistical analyses. To adjust for the differences in reporting period duration, emissions data were converted to Mg CO_2e per day.

For individual analyses of specific emissions scores (e.g., baseline emissions, project emissions, and emission reductions), records with missing or zero-values were also excluded (the latter since zero-credit reporting periods, in most cases, likely resulted from programmatic issues such as insufficient data or regulatory non-compliance, and therefore did not represent actual emissions). The first reporting period for each project was often of short duration, and for many projects, emissions scores for the first reporting period were considerably lower than for other reporting periods. This is likely a result of offset program-related start-up issues related to implementation of monitoring and documentation requirements. Therefore, the first reporting period for all projects was excluded from analyses. Finally, projects for which there were less than three reporting periods (in the combined and filtered data set, after excluding the first reporting period) were excluded from analyses, since data from at least three reporting periods were required to adequately assess within-project variability.

The resulting data set included 56 projects, representing 271 adjusted reporting periods. The number of reporting periods per project ranged from three to eight, with a median of five. The duration of each project ranged from 2.9 – 9.0 project years, with an average of 5.8 project years.

D.1.2 Emission Reductions

To evaluate the variability of emission reductions for dairy digester projects we used the statistical program R and the *lme4* and *nlme* packages to perform a linear mixed effects analysis of the relationship between emissions score and time, while accounting for repeated measurements within projects. Time (in project years) was the sole fixed effect in the model. As random effects, we included intercepts for projects, as well as by-project random slopes for the effect of time. Visual inspection of residual plots showed no obvious deviations from the standard assumptions of normality and homoscedasticity. P-values were obtained by a likelihood ratio test of the full model containing the time effect against the model without the time effect. For each project, emission reductions for each reporting period were plotted as a function of time (Figure D.1).

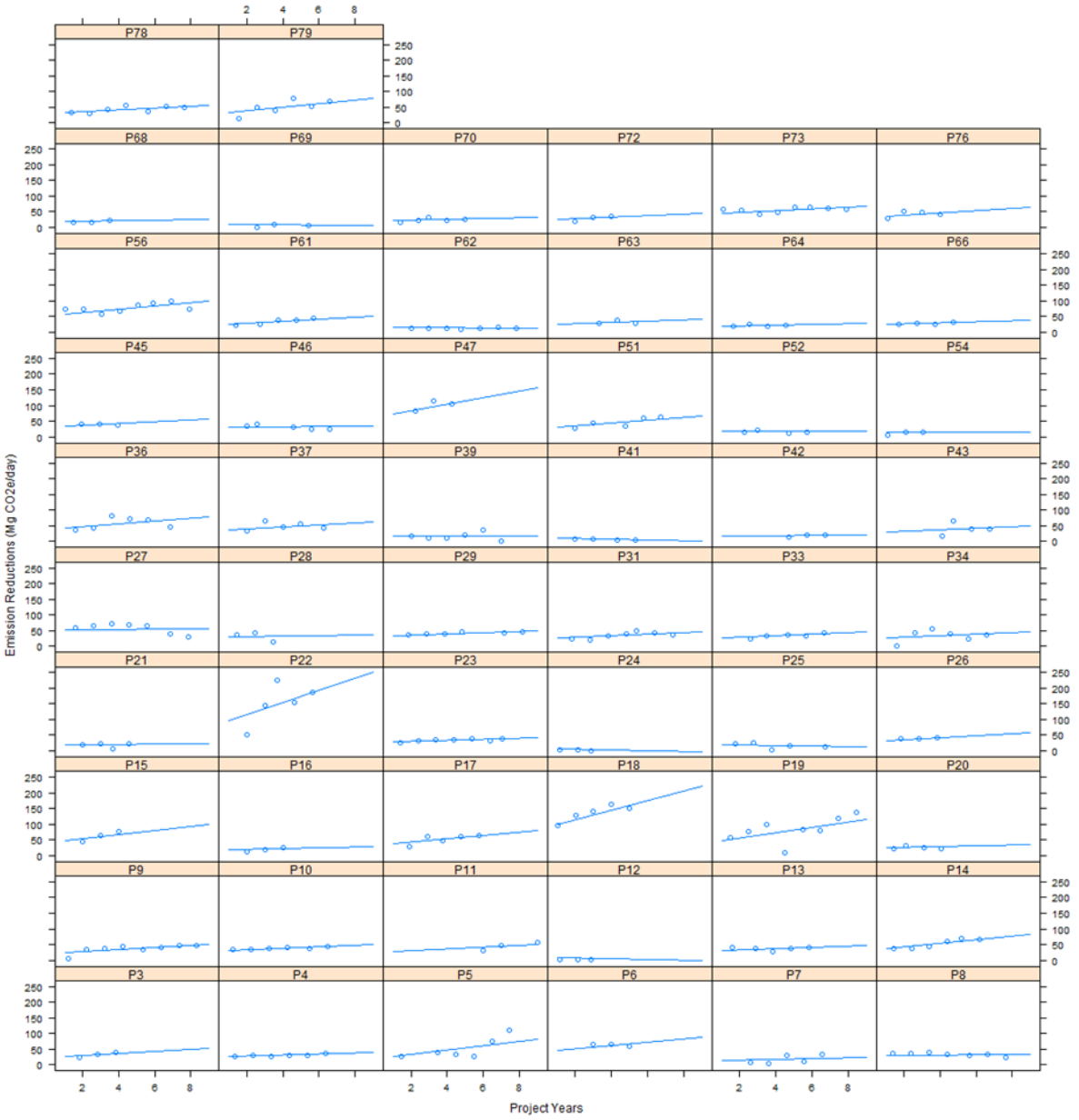


Figure D.1. Emission Reductions as a Function of Time (Project Years) for 56 Individual Projects (P3 – P79)

Independent intercepts and slopes (indicated by the solid lines) were modeled with linear mixed effects analysis with Project Years as the fixed effect and by-project intercepts and slopes as random effects.

Mean project emission reductions ranged from 0.9 – 226.0 Mg CO_2e/day. Linear mixed effects analysis indicated a significant overall increase in emission reductions with time ($p < 0.001$). The solid lines in Figure D.1 indicate the slopes modeled for each project. The effect of time varied among projects; however, positive slopes were observed for 49 of the 56 projects. Figure D.2 shows a plot of emission reductions as a function of time for all of the project reporting periods evaluated, including the modeled overall regression line and its 95% confidence bands. On average, emission reductions increased annually by about 2.86 Mg CO_2e/day (1,044 Mg CO_2e/year).

Similar analyses were conducted for baseline and project emissions for each project reporting period. As with emission reductions, baseline emissions showed a significant overall increase with time (4.3 Mg CO_2e/day each year; $p < 0.001$). Project emissions showed no significant effect with time.

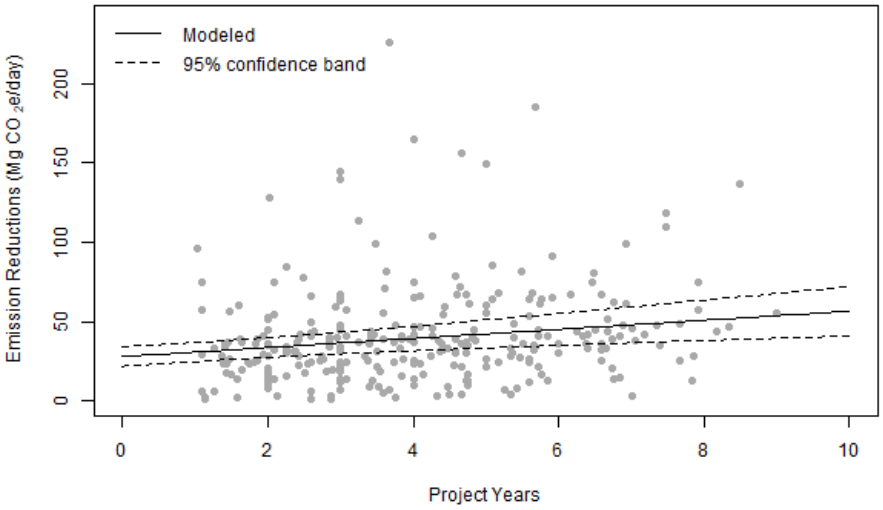


Figure D.2. Emission Reductions as a Function of Time (Project Years) for 56 Dairy Digester Projects
The regression line (solid line) and 95% confidence bands (dashed lines) were modeled with linear mixed effects analysis with time as the fixed effect and by-project intercepts and slopes as random effects.

The maximum potential emission reductions for an offset project is dependent on, and constrained by, the quantity of baseline emissions. For the sampled projects, baseline emissions and emission reductions are highly correlated ($p < 0.001$, $r^2 = 0.75$). Therefore, the observed increase in emission reductions with time appear to be related to corresponding increases in baseline emissions. Conventional offset methodologies for livestock projects employ a dynamic baseline, under the assumption that operational changes at dairy projects that impact baseline emissions would have happened with or without the project activity. The significant increase with time, observed for both baseline emissions and emission reductions, most likely results from increases in animal numbers and/or improvements in manure management at many of the project dairies.

To further evaluate the effect of time on project emission reductions, the data used in the previous analysis were transformed, by project, to represent the percentage deviation of the emissions score for each reporting period from the initial reporting period for that project:

$$\boldsymbol{TE_{p,rp} = \left(E_{p,rp} - E_{p,rp_0}\right)/E_{p,rp_0}}$$

Where,

$TE_{p,rp}$	=	Transformed emissions score for each project *p* and reporting period *rp*
$E_{p,rp}$	=	Emissions score for each project *p* and reporting period *rp*
$E_{p,rp0}$	=	Emissions score for the initial reporting period rp_0 within each project *p*

Observations for the initial reporting periods rp_0 were then dropped to avoid biasing the results (since information from the initial reporting periods was incorporated in the transformed scores for the subsequent reporting periods for each project). Also dropped was data from a single project (P34) that, upon transformation, represented an extreme outlier due to the very small emissions score for the initial reporting period relative to subsequent reporting periods.

Linear mixed effects analysis of the relationship between transformed project emission reductions and time, accounting for repeated measurements within projects, was performed as above. Time (as project years from the initial reporting period, by project) was the sole fixed effect in the model. As random effects, intercepts for projects were included, as well as by-project random slopes for the effect of time. As before, visual inspection of residual plots showed no obvious deviations from the standard assumptions of normality and homoscedasticity, and P-values were obtained by a likelihood ratio test of the full model containing the time effect against the model without the time effect.

Results of the analysis of the transformed emission reduction data are presented in Figure D.3. Overall, the deviation of emission reductions from the associated project's initial value increased significantly with time ($p < 0.001$)—about 8% per year on average. Notably, the lower 95% confidence band around the modeled regression line also increased with time and was greater than zero throughout. This indicates that, for a typical project, emission reductions in the years following the first reporting period have a greater than 95% probability of being greater than the emission reductions observed for the first reporting period.

Therefore, within a GHG mitigation program for dairy digester projects that employs a quantification methodology fundamentally similar to conventional livestock offset project methodologies, multiplying the quantity of annual emission reductions estimated at the commencement of project operations by the number of years in the project's crediting period represents a conservative approach for forecasting the total emission reductions achieved by a project during its crediting period (assuming project activities continue without disruption during the crediting period).

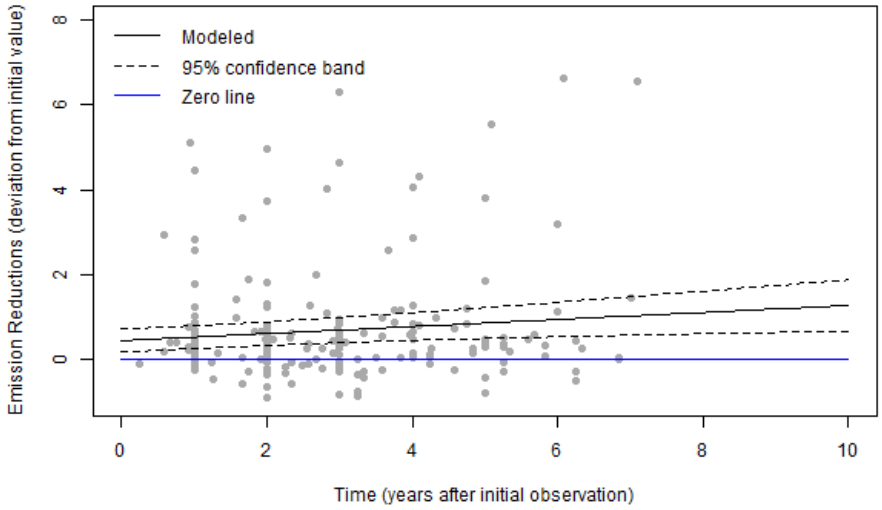


Figure D.3. Deviation of Project Emission Reductions from the Associated Project's Initial Value as a Function of Time (Years after the Initial Observation) for 55 Dairy Digester Projects

The regression line (solid line) and 95% confidence bands (dashed lines) were modeled with linear mixed effects analysis with time as the fixed effect and by-project intercepts and slopes as random effects.

D.2 Longevity of Dairy Digester Projects

The use of anaerobic digesters for manure treatment by U.S. dairies is a relatively recent development—the first dairy digester project in the U.S. began operations in 1979 (and is still operational 38 years later).[41] Significant changes in market penetration, technologies employed, business models, and financial and regulatory incentives for anaerobic digesters at dairy and other U.S. livestock operations have occurred in recent decades. Therefore, the relevance of historical data for developing meaningful probabilities for forecasting the longevity of future dairy digester projects is questionable. As technologies, operating experience, business models, and financial and regulatory incentives continue to evolve, information from historical data must be evaluated within the context of a rapidly changing, emerging industry.

D.2.1 AgStar Database

The U.S. Environmental Protection Agency (EPA), through its AgStar Program[42], tracks the historical development and status of anaerobic digesters on livestock farms in the U.S. The AgStar Livestock Anaerobic Digester Database[31] (AgStar database) is compiled from voluntary sources, so the completeness and accuracy of the information is not guaranteed; nevertheless, it represents the most complete publicly available history of U.S. dairy digester performance and longevity. The AgStar database also contains useful information regarding reasons for failure of individual projects that ceased operations. Information from the AgStar database pertaining to farm-scale dairy digester projects was analyzed to gain insight into the risk of failure for future dairy digester projects.

D.2.2 Data Management

The AgStar database was downloaded from the EPA website. The version used for analysis was last updated in November 2017. The database contained two tables: one listing projects

[41] U.S. EPA AgStar Livestock Anaerobic Digester Database (November 29, 2017)
[42] https://www.epa.gov/agstar/livestock-anaerobic-digester-database

that were under construction or operational, the other listing terminated ('shut down') projects. From both tables, we selected only those livestock operations that were classified (solely) as dairy and represented farm-scale projects (since community digester projects are much less common and have their own unique history of success or failure). Farm-scale projects that were not classified in the AgStar database by livestock operation type were reviewed and, based on professional experience and a web search, some of these projects were reclassified as dairies. Projects classified as 'in construction' were excluded, leaving only projects that were classified as either operational or shut down. The resulting dataset represented 210 farm-scale dairy digester projects; 171 were listed as operational, and 39 as shut down.

D.2.3 Results

Of the 210 farm-scale dairy digester projects selected from the AgStar database, about 80% operated for five or more years, 32% for ten or more years, and 10% for fifteen or more years. However, the inclusion of recently-started operational projects biases these results toward projects with shorter duration (e.g., for an operational project that started three years ago, it is not possible to know how long the project will continue until termination, but the project duration, to date, is only three years). If only operational projects that were started ten or more years ago (before the year of the database update: 2017) are included with all the terminated projects in the analysis, about 68% of the 99 projects operated for at least ten years, and about 18% operated for at least fifteen years; average project duration was 10.8 years. The frequency distribution and cumulative frequency distribution of project duration for these projects is plotted in Figure D.4. With time, the frequency distributions would be expected to shift to the right (increasing average project duration), unless many of the operational projects suddenly terminated.

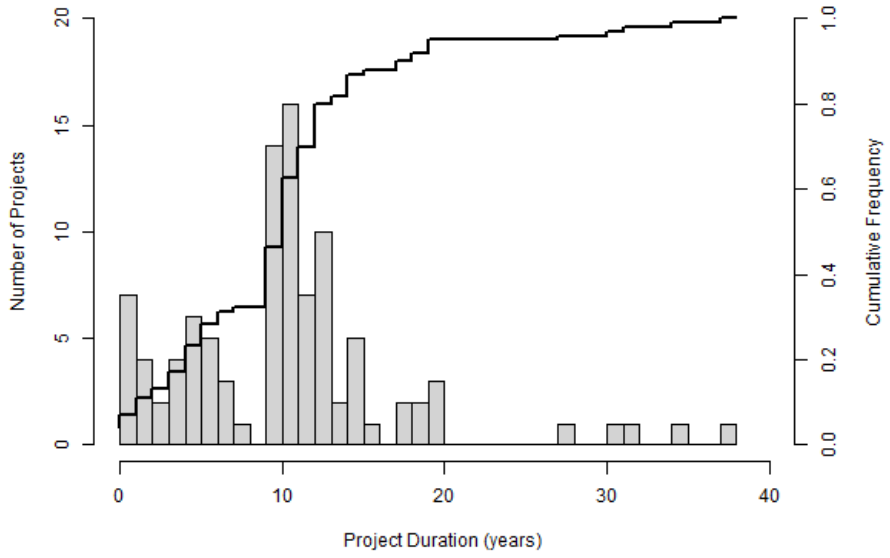


Figure D.4. Frequency Distribution and Cumulative Frequency Distribution for Dairy Digester Project Duration

Frequency distribution (bars) and cumulative frequency distribution (solid line). Data includes farm-scale dairy projects classified as 'shut down', and projects classified as 'operational' and started before 2008, in the AgStar database.

D.2.3 Causes of Project Termination

For the 39 farm-scale dairy digester projects classified as 'shut down', the average project duration was 7.0 years. About 44% of the projects operated less than five years before termination, 38% operated between five and nine years, and 18% operated for ten or more years (all of these had project durations of fifteen years or more). For 21 of these projects, brief explanations of the reasons for project termination were included in the AgStar database. The explanations largely fell within the general categories listed in Table D.1 (for some projects, more than one category).

Table D.1. Reasons for Termination of 21 Dairy Digester Projects Included in the AgStar Database (Some projects were scored in multiple categories)

Category	*Description*	*Projects*	*Percent of Total*	*Avg. Duration (yrs)*[1]
Financial	Lack of adequate finances or financial incentives, including developer bankruptcy	6	29%	2.3
Design	Inadequate digester system performance relative to initial design expectations	4	19%	5.5
Operating	Major or catastrophic equipment/system failures	8	38%	4.3
Regulatory	Changes in regulatory requirements requiring significant project modifications	1	5%	3.0
Dairy Closure	Cessation of dairy operations or change of control	5	24%	6.6
Other	Not specified, but described as unrelated to digester system performance	1	5%	1.0

[1] Differences in average project duration among categories were not significant, as determined by multi-factor ANOVA.

Although the AgStar database provides insight into historical performance of farm-scale dairy digester projects, regarding project longevity and reasons for termination, it does not provide sufficient information, by itself, to accurately forecast the longevity of future projects as the industry matures and technologies, performance, and financial incentives improve. Indeed, many recent dairy digester projects have been developed and financed with an expectation of project lifetimes exceeding fifteen to twenty years, and include design, operational, and financial features that mitigate the risk of failure.

Clearly, not all dairy digester projects are alike; each carries specific risks related to project longevity including local circumstances, dairy operation stability, and aspects of project finance, design, and operation. For a GHG mitigation project, individual projects can be assigned to risk levels (low, moderate, and high) based on the demonstration and confirmation of specific mitigation activities and measures undertaken by the project prior to commencement. Table D.2 lists mitigation requirements, corresponding to the general categories identified above as reasons for project termination[43], required for projects to demonstrate appropriate project longevity factors have been implemented. The implementation of all of these mitigation measures ensures projects will realize projected emission reductions without major disruption or termination during the project crediting period.

The mitigation requirements for a dairy digester project includes: i) adequate demonstration that the project's primary digester and biogas utilization technologies are commercially available, proven, and appropriate for the specific project design (innovative or unproven technologies carry significant uncertainty and are not considered to be appropriate for use within a mitigation

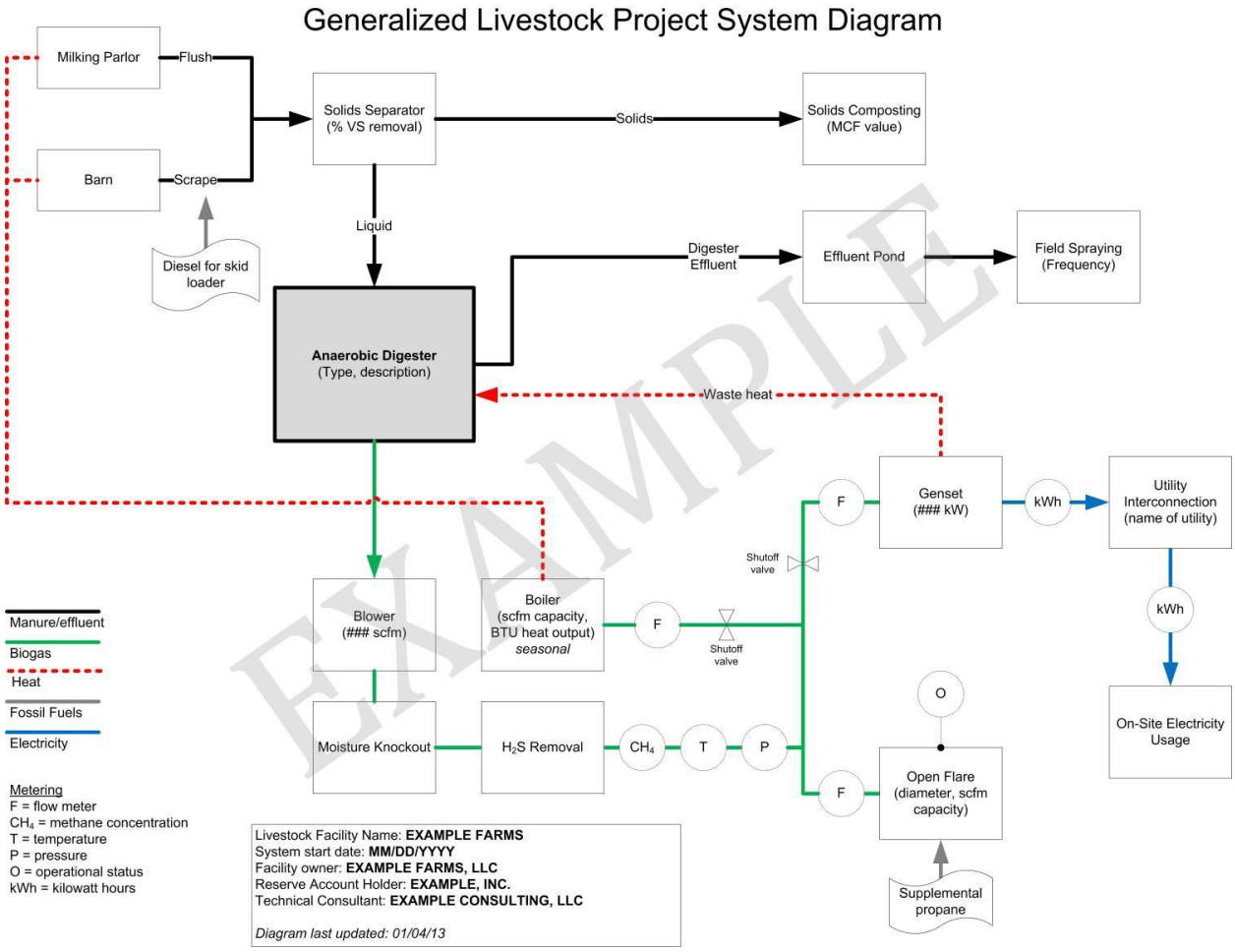
[43] Excluding less frequent regulatory issues (discussed in Section 3 of the methodology).

program); ii) an Operations Plan that adequately addresses long-term maintenance and operation of related project equipment within stated performance standards; and iii) adequate demonstration of the long-term financial stability of the livestock operation. Additional mitigation measures increase the probability of successful project completion for the entire crediting period.

Table D.2. Project Longevity Adjustment Factor: Mitigation Measures that must be Implemented to Reduce the Risk of Project Underperformance

Category	***Mitigation Measure***
Financial	Commercial contracts for long-term supply of digester products (e.g., electricity, biogas), including delivery incentives/penalties, for the duration of the crediting period.
	Proforma demonstration of sufficient cash flows to sustain project viability during the crediting period.
	Demonstrated long-term financial stability of the project operator.
Design	Demonstration that the primary digester and biogas utilization technologies are commercially available, proven, and appropriate for the specific project design.
	Basis of Design documentation for the digester system including a manure volatile solids mass flow diagram and estimated annual biogas production.
Operating	Operations Plan that ensures long-term maintenance and operation of related project equipment within stated performance standards.
	Long-term service warranties or contracts that include guarantees of rapid response for related equipment repairs.
Dairy Closure	Demonstration that the project is not located within a probable range of accelerated commercial/residential development.
	Demonstrated long-term financial stability of the livestock operation.
	Long-term commercial milk or animal supply contracts with delivery penalties impacted by reduced herd size, OR, contractual penalties for reducing animal numbers during the project crediting period.

Appendix E Sample Dairy Project Diagram



EXAMPLE

CLIMATE FORWARD

Mature Forest Management Forecast Methodology

Version 1.0 | March 24, 2020

A program of the CLIMATE ACTION RESERVE

Climate Forward, a program of the Climate Action Reserve
www.climateforward.org

Released March 24, 2020

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
2 The GHG Reduction Project 4
2.1 Project Definition 4
2.2 Forest Owners and Project Proponents 5
3 Eligibility Rules 6
3.1 Location 7
3.2 Project Start Date and Crediting Period 7
3.3 Additionality 7
3.3.1 The Performance Standard Test 8
3.3.2 The Legal Requirement Test 9
3.4 Environmental and Social Safeguards 10
3.5 Regulatory Compliance 11
3.6 Ownership and Double Counting 11
3.7 Project Resilience and Permanence Measures 12
3.8 Market Expansion Objective 12
3.9 Demonstration of *Ex Ante* Suitability 12
4 The Project Area 13
4.1 Project Configuration and Limitations 13
4.2 Project Area Acreage 14
5 The GHG Assessment Boundary 15
6 Quantifying GHG Emission Reductions 23
6.1 Estimating Baseline Carbon Stocks 27
6.1.1 Inventory Carbon Stocks within the Project Area 27
6.1.2 Model Growth and Harvesting Over 100 Years 28
6.1.3 Generate an Averaged Baseline 29
6.1.4 Apply Performance-Standard Criteria 30
6.1.5 Proportionally Adjust Other Reported Carbon Stocks 33
6.1.6 Final Adjusted Baseline Components 35
6.2 Estimating Project Carbon Stocks 35
6.2.1 Determining Forecasted Project Onsite Carbon Stocks 35
6.2.2 Determining Forecasted Project Carbon in Harvested Wood Products 36
6.3 Estimating Performance Decline 36
6.4 Abandonment Rates 36
6.5 Ensuring Conservativeness of Quantification 36
6.5.1 Modeling Parameters 36
6.5.2 Deduction to Allow for Resilience-Related Management 37
6.6 Quantifying Secondary Effects 37
7 Project Implementation and Monitoring 39

7.1 Quantification Parameters....39
7.2 Voluntary Ongoing Monitoring Incentive....40
8 Reporting and Record Keeping....41
8.1 Project Submittal and Confirmation Documentation....41
8.2 Record Keeping....42
8.3 Reporting and Confirmation Period....43
9 Confirmation Guidance....44
9.1 Standard of Confirmation....44
9.2 Confirming the Project Implementation Report....44
9.3 Core Confirmation Activities....45
9.4 Confirmation Items....45
9.4.1 Project Eligibility....45
9.4.2 Quantification....47
9.4.3 Confirming Carbon Inventories....49
9.4.4 Baseline and Forecasted Project Stock Estimation....56
9.4.5 Confirming Estimates of Carbon in Harvested Wood Products....58
9.5 Completing Confirmation....60
10 Glossary of Terms....61
Appendix A Quantification Guidance for MFM Projects....64
A.1 Reporting Requirements for Forest Carbon Pools....64
A.2 Guidance for Estimating Carbon in Forest Carbon Pools....64
A.2.1 Inventory Methodologies....65
A.2.2 Requirements for Estimating Carbon in Standing Live Trees....65
A.2.3 Use of Regression Equations....67
A.2.4 Forest Vegetation Stratification....67
A.2.5 Quantification of Carbon in Live Trees from Project Data....67
A.2.6 Adjustments to Standing Live Trees for Missing Volume....68
A.2.7 Total Onsite Carbon Stocks and Calculating the Confidence Deduction....69
A.2.8 Requirements for Calculating Carbon in Harvested Wood Products....70
A.2.9 Leakage....71
A.3 Modeling Carbon Stocks....71
A.3.1 Models and their Eligibility for Use with Forest Projects....71
A.3.2 Using Models to Forecast Carbon Stocks....72
A.3.3 Modeling Requirements....73

List of Tables

Table 5.1. Description of all Sources, Sinks, and Reservoirs....15
Table 6.1. Guidance for Adjusting Other Carbon Pools....34
Table 7.1. Project Quantification Parameters....39
Table 9.1.Eligibility Confirmation Items....46
Table 9.2. Quantification Confirmation Items....48
Table 9.3. Inventory Methodology Confirmation Items....52
Table 9.4. Number of Passing Plots in Sequence, as a Function of Project Size....54
Table 9.4. Modeled Baseline and Forecasted Project Stocks Confirmation Items....57
Table 9.5. Carbon in Harvested Wood Products Confirmation Items for Both Baseline and Forecasted Project Stocks. 59
Table A.1. Reserve Requirements for Carbon Pool Categories and Determination of Value for Pool 64
Table A.2. Requirements for Sampling Standing Live Trees 66
Table A.3. Assumed Percentages of Biomass in Each Aboveground Portion of the Tree....69
Table A.4. Example: Calculating Net Biomass in a Tree 69
Table A.5. Forest Carbon Inventory Confidence Deductions Based on Level of Confidence in the Estimate Derived from Field Sampling 70

List of Figures

Figure 6.1. Example of an *Unadjusted Averaged Baseline* Resulting from Equation 6.2 30
Figure 6.2. Determining a Project Area's High Stocking Reference....32

List of Equations

Equation 6.1. Net GHG Reductions and Removals 26
Equation 6.2. Formula for Averaging *Preliminary Unadjusted Baseline* Carbon Stocks....30
Equation 6.3. Determining the *Adjusted Averaged Baseline* for Aboveground Live Tree Carbon Stocks Where Initial Stocks Are at or Above Common Practice 31
Equation 6.4. Determining the *Adjusted Averaged Baseline* for Aboveground Live Tree Carbon Stocks Where Initial Stocks Are Below Common Practice....32
Equation 6.5. Secondary Effects Emissions....38
Equation A.1. Belowground biomass for trees in California, Oregon, Washington (Temperate Equation for 26-50° Latitude) 68
Equation A.2. Belowground biomass for trees in Alaska (Boreal Equation for ≥51° Latitude) 68
Equation A.3. Belowground biomass for trees in Hawaii (Tropical Equation for 0-25° Latitude).68

Abbreviations and Acronyms

AP	Assessor Parcel
C	Carbon
CARIT	Climate Action Reserve Inventory Tool
CO_2	Carbon dioxide
CH_4	Methane
EVT	Existing Vegetation Type
FIA	USFS Forest Inventory and Analysis[1]
FMU	Forecasted Mitigation Unit
FPP	Climate Action Reserve's Forest Project Protocol
FRAP	CAL FIRE Fire and Resource Assessment Program
GHG	Greenhouse gas
GIS	Geographic Information System
ISO	International Organization for Standardization
MFM	Mature Forest Management
N_2O	Nitrous oxide
PIR	Project Implementation Report
Reserve	Climate Action Reserve
SSR	Source, sink, and reservoir
SIM	Standardized Inventory Methodology
t	Metric ton (or tonne)
USFS	United States Forest Service

[1] http://fia.fs.fed.us/program-features/rpa/

1 Introduction

The Climate Action Reserve (Reserve) is an environmental nonprofit organization that promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. Based in Los Angeles, the Reserve is the foremost carbon offset registry in North America with internationally recognized expertise in project-level GHG accounting. The Reserve establishes regulatory-quality standards for the development and quantification of GHG emission reduction projects; issues GHG emission reduction credits for use in compliance and voluntary carbon programs; and tracks the transaction of credits over time in transparent, publicly-accessible systems. Adherence to the Reserve's standards ensures that emission reductions associated with projects are real, permanent, and additional, thereby instilling confidence in the environmental benefit, credibility, and efficiency of carbon markets.

Climate Forward, a greenhouse gas mitigation program of the Climate Action Reserve, provides a practical solution to companies and organizations seeking cost-effective mitigation of anticipated (i.e., future) operational and/or project-related GHG emissions. Climate Forward facilitates investments in GHG reduction[2] activities that are practical, scientifically-sound, transparent, and aligned with forward-looking mitigation needs such as the California Environmental Quality Act (CEQA). Climate Forward will drive forward-looking investment into actions expected to result in GHG reductions, with a goal of expanding the scope and scale of feasible emission reduction project types.

Climate Forward is designed to provide companies, organizations, developers, and other entities with a conservative, robust, and methodologically rigorous option to mitigate an estimate of expected GHG emissions, on a voluntary or compliance basis, using FMUs generated from mitigation projects under this program. Climate Forward fundamentally differs from existing carbon credit programs through its focus on projecting and crediting estimated emission reductions on an *ex ante* basis. Under Climate Forward, estimated GHG reductions from the mitigation project are recognized as Forecasted Mitigation Units (FMUs), which are each equal to one metric ton of carbon dioxide equivalent (CO_2e) expected to be reduced or sequestered. FMUs can be retired for multiple purposes, including for CEQA mitigation or for other voluntary mitigation purposes.

The Mature Forest Management (MFM) Forecast Methodology provides guidance to account for, report, and confirm forecasted (i.e., *ex ante*) greenhouse gas (GHG) emission reductions associated with sequestering carbon on forestland as described in this methodology. Project proponents that initiate MFM projects use this document to quantify and register forecasted GHG reductions with Climate Forward on an *ex ante* basis. The methodology provides eligibility rules and methods to calculate expected reductions, performance-monitoring instructions, and procedures for reporting project information to the Climate Forward. Supporting information related to the calculation of carbon stocks is provided in Appendix A. Additionally, a Project Implementation Report will receive independent confirmation by a Reserve-approved confirmation body selected by the project proponent. Guidance for confirmation bodies to confirm project implementation and FMU estimates is provided in the Climate Forward Program Manual, the Climate Forward Confirmation Manual, and Section 8 of this methodology.

[2] Throughout this document, the term "reduction" is intended to address both GHG emission reductions that are the result of activities designed to reduce or avoid emissions, and GHG removals, which are those activities aimed at removing atmospheric CO_2 at rates that exceed "business as usual" sequestration.

This methodology is designed to ensure the complete, consistent, transparent, accurate, and conservative *ex ante* quantification and confirmation of GHG emission reductions associated with MFM projects.[3]

[3] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Project Definition

An MFM project involves management activities that maintain and increase carbon stocks on forested land relative to baseline levels of carbon stocks through actions that focus on the development of stand structure characterized by an increased component of older and larger trees during harvest events, with increased basal area retention as is appropriate for the project area's growth capacity over time.

All MFM projects are required to be secured with a conservation easement granted to, and held by, an eligible land trust[4] that permanently dedicates the project area to forest use. The conservation easement must grant authority to the eligible land trust to monitor and enforce the restrictions contained within it. The terms of the conservation easement shall also do the following:

- Include a statement in the recitals indicating the easement is perpetual;
- Include a statement indicating that the easement is granted pursuant to the state enabling statute for conservation easements for the state in which the project is located (e.g., California Civil Code Section 815);
- Support the project activity, including but not limited to the following harvest-related activities on lands subject to timber harvest:
    - Requiring the submission of a timber harvest plan, developed by or under the supervision of a professional forester, to the easement holder for review prior to undertaking any timber harvest activities, with approval of such a plan based on whether the plan meets the goals and restrictions of the easement, including those required by this methodology;
    - Establishing a harvest retention level at the stand level that ensures quadratic mean diameter (QMD) increases compared to pre-harvest levels, based on trees of commercial species with a minimum diameter at breast height (DBH) as defined for each assessment area in the Assessment Area Data File;
    - Establishing any other restrictions deemed appropriate by the Eligible Land Trust to ensure an increase in timber volume across the project area while promoting mature forest conditions based on the forest type(s) comprising the property;
        - If restrictions are included that limit harvest based on timber inventory or growth, the easement must include a description of the minimum acceptable inventory confidence limits and age limits for inventory sample data.
    - Identifying conditions that would allow exceptions where harvest is required for safety and resilience to forest disturbances;
    - Identifying conditions that would allow salvage harvesting to be conducted after a natural disturbance.
- Include terms requiring reforestation of the site in the event of a loss of >50% live and dead tree canopy on >10% of the total project area as a result of harvest of any type or

[4] Land trust accredited by the Land Trust Alliance.

natural disturbance, whether through active planting, site preparation to promote natural regeneration, or passive management that otherwise allows the site to return to forest cover over time, provided passive management includes monitoring to ensure the disturbed site is recovering, with active management undertaken if monitoring indicates natural recovery is not occurring.

- Prohibit deep ripping on more than 1% of the project area in any year as determined by the area on which deep ripping is employed when using a multi-tine ripper or the area encompassed by the channels (as defined by the width of the ripper tine plus two feet on either side) produced by a single-tine ripper.
- Include as an option within the provisions for remedies in the event of violation(s) of the easement terms the restoration of the property to the condition prior to such violation(s).

2.2 Forest Owners and Project Proponents

A "forest owner" is an individual or a corporation or other legally constituted entity, or a combination thereof that has legal control of any amount of forest carbon[5] within the project area. Control of forest carbon means the forest owner has the legal authority to effect changes to forest carbon quantities, e.g., through timber rights or other forest management or land-use rights. Control of forest carbon occurs, for purposes of satisfying this methodology, through fee ownership and/or deeded encumbrances, such as conservation easements.

Multiple forest owners may exist with respect to a single MFM project, since control of forest carbon may be associated with fee ownership or through one or more deeded encumbrances that exist within a project area, any one of which may convey partial control of the project's forest carbon. Any unencumbered forest carbon is assumed to be controlled by the fee owner. Individuals or entities holding mineral, gas, oil, or similar *de minimis*[6] interests in the forest carbon without having an interest in the timber rights, are precluded from the definition of forest owner.

The "project proponent" is an entity that has an active account on the Climate Forward registry, submits a project for listing and registration with the Climate Forward, and is ultimately responsible for all project reporting and confirmation. A project proponent for an MFM project must be one of the forest owners. The term project proponent only applies to the forest owner from the project start date until completion of confirmation and FMU issuance by the Reserve, with the term not being applicable to any entity that acquires ownership of the project proponent's legal authority over the forest carbon on the project area. Nevertheless, the conservation easement placed on the project area would still restrict management of the forest under the new ownership.

In all cases, the project proponent must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from the project. At the time a project is confirmed , the project proponent must attest that no other entities are reporting or claiming (e.g., for voluntary reporting or regulatory compliance purposes) the GHG reductions caused by the project.[7] The Reserve will not issue Forecasted Mitigation Units (FMUs) for GHG reductions that are reported or claimed by entities other than the project proponent.

[5] See definition of "forest carbon" in glossary.
[6] *de minimis* control includes access right of ways and residential power line right of ways.
[7] A standard form for this attestation will be posted on the Climate Forward website at https://climateforward.org/program/program-and-project-forms/.

3 Eligibility Rules

MFM projects must fully satisfy the following eligibility rules in order to be registered with Climate Forward. The criteria only apply to projects that meet the definition of an MFM project (Section 2.1).

Eligibility Rule I:	Location	→	On private lands
		→	Under forest cover for at least 20 years
		→	Not on land previously registered as a project, unless the project was closed in good standing
Eligibility Rule II:	Start Date and Crediting Period	→	Start date based on the date of recordation of conservation easement
		→	Crediting period of 100 years
Eligibility Rule III:	Additionality	→	Meets performance standard
		→	Exceeds regulatory requirements
Eligibility Rule IV:	Environmental and Social Safeguards	→	No negative environmental and social impacts
		→	Meets native species composition and diversity standards
Eligibility Rule V:	Regulatory Compliance	→	Compliance with all applicable laws
Eligibility Rule VI:	Ownership and Double Counting	→	Ownership of GHG reductions forecast for the project clearly demonstrated
		→	Compensation for conservation easement does not include foregone timber value resulting from easement restrictions
Eligibility Rule VII:	Project Resilience and Permanence Measures	→	Resilience and permanence ensured by conservation easement and required terms
Eligibility Rule VIII:	Market Expansion Objective	→	Expands opportunities for GHG mitigation to broad set of forest owners
Eligibility Rule IX:	Demonstration of *Ex Ante* Suitability	→	Conservation easement ensures forecasted carbon stock increases will occur over time

3.1 Location

MFM projects must be located on private lands under forest cover (i.e., having greater than ten percent tree[8] canopy cover) for at least 20 years. The most recent MFM Assessment Area Data File available on the Climate Forward website[9] lists eligible assessment areas (distinct forest communities within geographically defined ecoregions) as well as an indication of carbon stocking levels within each assessment area that are the result of regional harvest practices. Section 3.3.1 provides further description of the relevance of assessment areas to project eligibility.

Projects located on lands that were previously registered as a project for the financial recognition of climate benefits are not eligible unless the previous project has been closed in good standing and with the written consent of the Reserve.

3.2 Project Start Date and Crediting Period

The project start date is the date of recordation of a conservation easement that includes the language and restrictions on the project area as described in Section 2.1. The project must be submitted to Climate Forward no more than one year after the project start date, and the confirmation must be completed no later than two years after the project start date.

All projects that pass the eligibility requirements set forth in this methodology as of the project start date are eligible to register FMUs with Climate Forward for the duration of the project's crediting period. A crediting period is the length of time over which GHG emission reductions are quantified and forecast. Emission reductions for each project will be calculated as the sum of the forecasted emission reductions realized over the lifetime of the project. Crediting periods are proposed upon project submittal and established upon successful completion of project confirmation. The project proponent must also provide evidence that actions will be undertaken to maintain the project for the duration of the crediting period. Project proponents using this methodology demonstrate that the emission reductions/removals will be maintained throughout the crediting period through the recordation of a perpetual conservation easement containing the required restrictions as described in Section 2.1.

For MFM projects, the crediting period is based on the baseline established per the requirements outlined in Section 6.1, which is assumed to be valid for 100 years. Thus, a registered MFM project will be eligible to receive FMUs based on projected GHG reductions quantified using this methodology for a period of 100 years following the project's start date. The 100-year crediting period is conservative given that the project is subject to a perpetual conservation easement.

3.3 Additionality

Climate Forward registers only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of the project.

The approach to additionality for MFM projects recognizes increases in the amount of CO_2 removed from the atmosphere relative to "business as usual" management. It also considers the long-term risks to carbon sequestered in the project area presented by "business as usual"

[8] For purposes of this methodology, a tree is defined as a woody perennial plant, typically large and with a well-defined stem or stems carrying a more or less definite crown with the capacity to attain a minimum diameter at breast height of five inches and a minimum height of 15 feet with no branches within three feet from the ground at maturity.
[9] https://climateforward.org/program/methodologies/mature-forest-management/.

management and the potential emissions of such carbon into the atmosphere. Under such an approach, additionality takes into account the following:

- Onsite carbon stocks are at risk on a 100-year time scale.
- Land ownership and management direction are not permanent, except in cases where binding commitments limit management options, such as conservation easements.
- Management goals and objectives are likely to change over time, especially as ownership of a forest changes hands, as often happens between generations of family forest owners[10] or between entities owning forests as a financial investment.[11]
- Over the length of a project lifetime and in the absence of a long-term commitment to an MFM project and associated conservation easement, emissions may have resulted from the clearing of trees to convert a forest to another land cover type or from harvest activities that reduce average onsite carbon stocking.
- Committing a site to forest cover in perpetuity, as required by the conservation easement as defined in Section 2.1.

Furthermore, this methodology acknowledges that the project's baseline, as the way "business as usual" management is represented for quantification purposes, is a counterfactual scenario, i.e., a representation of what may have actually occurred if the project had never happened. Additionality is assured over the 100-year crediting period, during which the terms of the conservation easement ensure forest carbon stocks increase compared to the baseline.

MFM projects must satisfy the following tests to be considered additional:

1. The performance standard test
2. The legal requirement test

3.3.1 The Performance Standard Test

Projects pass the performance standard test by meeting a methodology-wide performance threshold – i.e., a standard of performance applicable to all prospective projects, established on an *ex ante* basis. The performance standard threshold represents "better than business as usual". If the project meets the threshold, then it exceeds what would happen under the "business as usual" scenario and generates additional GHG reductions.

The performance standard test is applied at the time of the project's start date. All projects that pass this test at the project's start date are eligible to register FMUs with Climate Forward for the duration of the project's crediting period, even if the performance standard changes after the project's start date.

MFM project activities meet the performance standard to the extent they are forecasted to produce GHG reductions in excess of those that would have occurred under the "business as usual" scenario outlined by the baseline estimation requirements in Section 6.1. The baseline for an MFM project is determined in relation to the project area's "common practice" value, which is based on the average stocks of aboveground standing live tree carbon associated with the assessment area(s) covered by the project area. Common practice statistics for each

[10] Butler, B. J., *et al*. 2016. "Family Forest Ownerships of the United States, 2013: Findings from the USDA Forest Service's National Woodland Owner Survey." *Journal of Forestry* 114 (6): 638–47. doi:10.5849/jof.15-099.
[11] Bliss, J. C., *et al*. 2010. "Disintegration of the U. S. Industrial Forest Estate: Dynamics, Trajectories, and Questions." *Small-Scale Forestry* 9 (1): 53–66. doi:10.1007/s11842-009-9101-7.

assessment area are calculated from the United States Forest Service Forest Inventory and Analysis program. These common practice statistics act as a project-specific performance standard. Common practice for an MFM project is defined in greater detail in Section 6.1.4.2 below.

3.3.2 The Legal Requirement Test

All projects are subject to a legal requirement test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to any law (including any rules, regulations, or other legally binding mandates) issued by any authority with jurisdiction over the project. The project proponent must also demonstrate that the project was not established or implemented, and was not operated at any time prior to the start date, in anticipation of, or to avoid or satisfy the anticipated requirements of any law.

The legal requirement test is applied at the time of a project's start date. To satisfy the legal requirement test, project proponents must submit a signed Attestation of Legal Additionality form prior to the commencement of confirmation activities. In addition to the attestation, the Project Implementation Report must include procedures that the project proponent will follow to ascertain and demonstrate that the project passes the legal requirement test at the time of a project's start date. All projects that pass this test at the project's start date are eligible to register reductions with Climate Forward for the duration of the crediting period, even if legal requirements change or new legal requirements are enacted during that period. The project proponent should include documentation to justify that the project passes the legal requirement test. The confirmation body must confirm the Attestation of Legal Additionality by reviewing evidence provided by the project proponent, and any other evidence they feel is necessary such as literature reviews, independent expert testimony, or letters from relevant government agency representatives, or other means. Deeded encumbrances, such as timber deeds or conservation easements, may effectively control forest carbon, such that there may be multiple forest owners within the project area. Deeded encumbrances are considered legally binding mandates for the purposes of the legal requirement test, with the exception of the conservation easement recorded as part of the project's start date.

Deeded encumbrances may contain terms that do not directly refer to forest carbon, but that nevertheless restrict the ability of any one forest owner to affect forest carbon stocks. These terms must be interpreted with respect to their effect on forest carbon for the purposes of the legal requirement test and baseline determinations. Where the terms of deeded encumbrances are not explicit with regards to forest carbon, the following assumptions shall be made:

1. Restrictions or references related to canopy cover, basal area, density, volume, carbon or biomass apply to standing live and dead trees of all species.
2. Carbon in other pools (soil, litter, duff, shrubs, etc.) is assumed to be associated with the other defined terms, such as trees.
3. Terms related to forest (tree) growth apply to growth in all tree species.

The project proponent must also identify all applicable legal requirements that cannot be modified by updating a management plan. Such legal constraints must be modelled into project's baseline so FMUs are not issued for legally required activities.

3.4 Environmental and Social Safeguards

MFM projects can create long-term climate benefits as well as provide other environmental benefits, including the sustaining of natural ecosystem processes. To be in conformance with this methodology, MFM projects, at the time of initial project confirmation, must demonstrate that the project will employ sustainable long-term harvesting practices within the project area based on required elements described in Section 2.1. The project area also must satisfy (or describe how its ongoing management will demonstrate progress toward satisfying) the following species composition requirements at the project start date:

1. Project area is composed of at least 90% native species (based on the sum of CO_2e in the standing live tree pool).
2. No single species' prevalence, measured as the percent of the basal area of all live trees in each assessment area, exceeds the percentage value shown under the heading 'Composition of Native Species' in the MFM Assessment Area Data File maintained on the Climate Forward website.[12] Where the project area naturally consists of a single species dominance, the project proponent may obtain a letter from the state forester or his/her representative stating that the project area's species diversity is reflective of background natural species diversity (despite any inconsistencies with the MFM Assessment Area Data File). If unable to obtain a letter from the state forester or his/her representative, an attestation stating the same by the professional forester with oversight of the project may be provided, subject to approval by the Reserve.

The project proponent must describe how management practices within future harvest areas, as guided by the terms of the conservation easement, will ensure the maintenance of the above species composition requirements over the course of the crediting period or, if both are not satisfied at the project start date, will result in progress toward such requirements during the crediting period.

Additionally, the project proponent must demonstrate in the Project Implementation Report how the project will not materially undermine progress on environmental and social issues such as air and water quality, endangered species and natural resource protection, and environmental justice. Any permitting requirements applicable prior to the implementation of the project activities addressed in this methodology (e.g., timber harvest plan, water quality permit) must be described in the Project Implementation Report, including a description of the status in regard to fulfilling any such requirements at the commencement of confirmation activities. The project proponent must provide existing applicable authorizations, permits, and certifications from the appropriate authorities required for project operations to the confirmation body at the commencement of confirmation activities.

Furthermore, the Reserve encourages the project proponent to include information in the Project Implementation Report regarding any non-GHG benefits of the project activities to the environment or society. This may include discussion of how the project aligns with the United Nations' Sustainable Development Goals,[13] as well as additional quantification of any non-GHG benefits (such quantification is not specified by this methodology).

[12] https://climateforward.org/program/methodologies/mature-forest-management/
[13] Additional information regarding the Sustainable Development Goals may be found online at https://sustainabledevelopment.un.org/.

3.5 Regulatory Compliance

The project proponent must sign an Attestation of Regulatory Compliance prior to the commencement of project confirmation activities, attesting that no laws have been broken in the implementation of each project, and provide an assessment of any aspects of the project which may present a risk of future regulatory violations. Where such risks are identified, the project proponent shall describe measures undertaken to reduce and/or mitigate these risks. The confirmation body shall endeavor to confirm that the project implementation did not result in any regulatory noncompliance, and also that appropriate measures have been implemented to avoid potential future noncompliance during the project crediting period, including potentially, with the terms of the conservation easement.

The conservation easement contains harvesting encumbrances that are required to be incorporated into any timber harvest plan submitted to the easement holder, as indicated in Section 2.1. The review of timber harvest plans shall occur as part of regular conservation easement monitoring activities by the holder of the conservation easement and is intended to confirm that the harvest encumbrances outlined in the conservation easement have been appropriately incorporated into any timber harvest plan. Compliance of harvest operations with all harvest encumbrances in the conservation easement, including as incorporated into the timber harvest plan, will be monitored and enforced by the easement holder.

If the project is found to be out of compliance with the conservation easement during the crediting period, remedies pertaining to non-compliance with easement terms, as specifically outlined in the easement and outlined in Section 2.1, will ensure the integrity of the project activities over time.

3.6 Ownership and Double Counting

The project proponent must attest that the project is not being submitted for emission reductions credit under any other carbon crediting program, world-wide. By signing the Attestation of Title, the project proponent attests that the FMUs have not and will not be registered with, reported in, held, transferred or retired via any emissions registry or inventory other than the Climate Forward registry, or registered with Climate Forward under a different project title or location. As described in Section 3.1, if the project area encompasses any land included as part of a prior project that was closed in good-standing with the program in which it was enrolled, the project may still be eligible, subject to approval by the Reserve. For instances in which the project area is owned by multiple forest owners, evidence of transfer of rights of all GHG emission reductions to the project proponent (based on control of carbon stocks, as described in Section 2.2) is required and must be confirmed by the confirmation body. The project proponent must provide a signed Attestation of Title document for each project, attesting to their ownership of all GHG emission reductions generated by the project. This signed attestation, and any necessary supporting evidence, must be provided to the confirmation body. In addition to the Attestation of Title, confirmation bodies may wish to review relevant contracts, agreements, and/or supporting documentation between project proponents, end users, and other parties that may have a claim to the FMUs generated by the project.

The project proponent must attest that the project is not being submitted for emission reduction credits under any other carbon crediting program. The project proponent must also attest and provide clear documentation demonstrating that the project is permanently retaining, contractually retiring, or retiring in an electronic tracking system, the environmental attributes associated with the activity for which FMUs are issued. Confirmation bodies must review contracts, purchase agreements, or tracking system reports as necessary.

Additionally, the monetary value directly realized by the Forest Owner for granting the conservation easement required under this methodology may not include the foregone timber value associated with the forest management restrictions of the easement. This will prevent Forest Owners from being compensated for both the tree-based carbon stocks (via the foregone timber value associated with the restrictions of the easement) and the carbon removals forecasted to be achieved by, and resulting FMUs issued to, the project under this methodology.

3.7 Project Resilience and Permanence Measures

As described in Section 2.1, all MFM projects are required to be secured with a perpetual conservation easement that dedicates the project area permanently to forest use. The easement acts as a legal guarantee that a project's existing and additional forest carbon stocks will remain protected in perpetuity by requiring forest management practices that increase and maintain additional carbon stocks and by ensuring that activities by a forest owner will not prevent increased carbon stocking from being achieved over time. Furthermore, the conservation easement will guarantee that forest cover will be restored on the project area following a natural disturbance.

3.8 Market Expansion Objective

Although this methodology is similar in many respects to existing offset project protocols, many forest owners may not consider undertaking an offset project under such protocols for a variety of reasons, including the long-term monitoring and reporting requirements and their associated costs. This methodology offers an opportunity for a broader contingent of forest owners to undertake meaningful and financially viable climate actions without the obligation of a long-term commitment to measuring and verifying changes to their forest carbon inventory over time. The project proponent must provide a qualitative description of why the project is not suitable under existing offset protocols. For example, the project proponent may describe the barriers to implementation under existing offset protocols and programs, such as financial infeasibility due to the project acreage and scale of anticipated carbon stock increases.

3.9 Demonstration of *Ex Ante* Suitability

By granting a conservation easement to an eligible land trust in accordance with the provisions outlined in this methodology, the project proponent provides assurances as to the administration of the easement by the eligible land trust in perpetuity, which far exceeds the project's 100-year crediting period. The project proponent must demonstrate that the eligible land trust has been granted the legal authority to monitor compliance of management activities with the terms of the conservation easement and enforce the remedies outlined in the conservation easement when violations of such terms occur. The conservation easement and related monitoring and enforcement activities ensure the continued implementation of the MFM project for the duration of the crediting period. As such, the GHG removals and/or reductions represented by the issuance of FMUs for MFM projects are secured over the long-term management of the project area. By fulfilling the requirements of this methodology, all MFM projects automatically meet the standard for demonstrating their suitability for *ex ante* crediting.

4 The Project Area

The geographic boundaries defining the project area must be described in detail at the time an MFM project is listed on the Climate Forward registry. The boundaries must be defined using a map, or maps that displays public and major private roads, major watercourses (fourth order or greater), topography, towns, and Public Land Survey Townships, Ranges, and Sections or latitude and longitude. The maps must be of adequate resolution to clearly identify the required features.

Project proponents must determine the supersection(s) within which the project area is located by consulting maps of supersections provided on the MFM Forecast Methodology page of the Climate Forward website.[14] These maps are available as both PDF files or as a geographical information system (GIS) file. Once a project's supersection(s) has been identified, the assessment area(s) must be determined. A project may do this by comparing dominant species present in the project inventory to the list of native species provided in the Assessment Area Data File. Projects may also utilize LANDFIRE Existing Vegetation Types (EVT) to determine the most appropriate assessment areas for the project. EVT descriptions must be used to identify the species descriptions that most closely match the native species provided in the Assessment Area Data File. The Reserve also reserves the right to provide a spatially explicit map of assessment areas to be used for identification purposes. The project area may also extend across multiple assessment areas within a supersection and across no more than two adjacent supersections.

A GIS file depicting the project area must be submitted to the Reserve with the project. The file must be submitted in the KML file format. Additionally, the current assessor's parcel identification numbers associated with the project area must be submitted to the Reserve.

4.1 Project Configuration and Limitations

To ensure project areas are representative of the forest owners' general forest management, MFM projects must include all forested areas owned by the Forest Owner(s) within an area no smaller than an area defined by HUC 14-digit hydrological units (HUC 14) where available (or HUC 12-digit hydrological units if HUC 14 is unavailable), or the entire area owned by the Forest Owner, whichever is smaller. HUC 14 or HUC 12 hydrological units must be identified using the USGS National Hydrography Dataset.[15] Exceptions may be provided if approved by the Reserve upon submission of the project to Climate Forward, recognizing that forest owners may have valid reasons to exclude portions of their landholdings from the project area. Such reasons may include those portions being already encumbered with legal restrictions that are incompatible with or duplicative of the requirements of this methodology, or presenting access difficulties that suggest inclusion in the project area would be impractical or result in implementation and/or administrative costs that are unreasonable. Regardless the reason, any project proponent wanting to exclude a portion of their ownership within the same watershed of the project area must conduct an analysis of the carbon stocking on such excluded lands at the project start date relative to the stocking on the project area. Such an analysis may be based on proxy measures, including timber volumes on a per acre basis or structural characteristics derived from standardized, publicly available forest cover data (e.g., LANDFIRE vegetation type, cover, and height). The results of the analysis, along with a description of why portions of the holdings of the Forest Owner(s) within the same watershed of the project area are being

[14] https://climateforward.org/program/methodologies/mature-forest-management/.
[15] The National Hydrography Dataset can be accessed via the USGS website: http://nhd.usgs.gov/.

excluded, must be included in the Project Submission form for initial consideration by the Reserve, as well as in Project Implementation Report. Exceptions to the project configuration requirement are made at the sole discretion of the Reserve.

Non-forested areas (brush, rocks, range, etc.), or areas not under forest management, may be excluded from the project area. The project area can be contiguous or separated into tracts or distinct polygons (areas).

4.2 Project Area Acreage

Project acreage shall be based on area calculations derived from GIS analysis, such as ArcGIS or Google Earth. GIS data are generally considered to be improvements over strict adherence to county parcel acreages as they are based on correcting property boundaries to geographic characteristics and/or property corners as described in property deeds or official survey notes. A KML (Google Earth) file depicting the project area shall be included with the PDD.

The project must list the county assessor's parcels (APs), the portion of each AP included in the project as a percentage (if GIS parcel data is available from the relevant state, county, or municipality), the sum of acres derived from the county tax records for all included APs, and the sum of acres derived from the GIS analysis. The sum of acres should be compared between the AP and GIS sources, with the lesser of the two used for the project area.

If there is a discrepancy between AP and GIS acres, the Project Operator has the following options:

- Resolve the acres on a per AP basis by using the lesser of the two area references.
- Work with the county assessor to resolve acreage disputes on AP acres.
- Demonstrate to confirmation body that GIS acres are based on recorded surveyed corners and correctly referenced with GPS.

5 The GHG Assessment Boundary

The GHG Assessment Boundary defines all the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project proponents in order to determine the net change in emissions caused by a project.[16] The GHG Assessment Boundary encompasses all the GHG sources, sinks, and reservoirs that may be significantly affected by MFM project activities, including forest carbon stocks, sources of biological CO_2 emissions, and mobile combustion GHG emissions.

For accounting purposes, the SSRs included in the GHG Assessment Boundary are organized according to whether they are predominantly associated with an MFM project's "primary effect" (i.e., the MFM project's intended changes in carbon stocks, GHG emissions, or GHG removals) or its "secondary effects" (i.e., unintended changes in carbon stocks, GHG emissions, or GHG removals caused by the MFM project). Secondary effects may include increases in mobile combustion CO_2 emissions associated with site preparation, as well as increased CO_2 emissions caused by the shifting of harvesting activities from the project area to other forestlands (often referred to as "leakage"). Projects are required to account for secondary effects following the methods described in Section 6.3.

Table 5.1 provides a comprehensive list of the GHG SSRs that may be affected by an MFM project and indicate which SSRs must be included in the GHG Assessment Boundary for each MFM project. If an SSR is designated as a "reservoir/pool", this means that GHG reductions and removals are accounted for by quantifying changes in carbon stock levels. For SSRs designated as sources or sinks, GHG reductions and removals are accounted for by quantifying changes in GHG emission or removal rates, as described in the tables.

Table 5.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs					
1	Standing live carbon (carbon in all portions of living trees)	CO_2	Yes	**Baseline**: Modeled based on initial field inventory measurements, regulatory environment, and financial feasibility, with common practice as a governor **Project**: Measured initially by field inventory measurements and modeled based on silviculture restrictions, as identified in conservation easement.	Increases in standing live carbon stocks are likely to be the largest primary effect of MFM projects.

[16] The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
2	Shrubs and herbaceous understory carbon	CO_2	No	**Baseline**: N/A **Project**: N/A	Shrubs and herbaceous understory constitute a relatively small proportion of carbon stocks in an MFM project.
3	Standing dead carbon (carbon in all portions of dead, standing trees)	CO_2	No	**Baseline**: N/A **Project**: N/A	MFM projects may significantly increase standing dead carbon stocks over time. Conservation easement restrictions under this methodology will include no harvest areas, which will recruit standing dead material.at natural rates where it will slowly decompose. There will be more standing dead carbon in project under project management than under baseline management and it is conservative not to include this pool.
4	Lying dead wood carbon	CO_2	No	**Baseline**: N/A **Project**: N/A	MFM projects may significantly increase lying dead carbon stocks over time. Conservation easement restrictions under this methodology will include no harvest areas, which will recruit lying dead material at natural rates where it will naturally decompose. There will be more standing dead carbon in project under project management than under baseline management and it is conservative not to include this pool.
5	Litter and duff carbon (carbon in dead plant material)	CO_2	No	**Baseline**: N/A **Project**: N/A	Changes in this reservoir are unlikely to have a significant effect on total quantified GHG reductions/removals. It is a conservative programmatic measure not to include it.
6	Soil carbon	CO_2	No	**Baseline**: Assumed to be static with start date inventory estimates **Project**: Changes assumed to be *de minimis*.	Soil carbon is not anticipated to change significantly as a result of MFM project activities. Furthermore, the nature of the activities that define an MFM project, including the required conservation easement provisions, prevent significant losses of soil carbon.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
7	Carbon in in-use forest products	CO_2	Yes	**Baseline**: Estimated from modeled harvesting volumes **Project**: Estimated from modeled harvesting volumes	Included because many MFM projects may significantly change carbon storage in in-use forest products relative to baseline levels. Treated as a "source/sink" because forest product carbon is quantified according to the change in harvesting volumes, relative to baseline levels. Of this change (increase or decrease), only the average amount of carbon expected to remain stored for 100 years is included in the final quantification of net GHG removals/emissions. This approach accounts for CO_2 emissions from decomposition or disposal of wood products (see SSR 17).
8	Forest product carbon in landfills	CO_2	No, when project harvesting exceeds baseline. Yes, when project harvesting is below baseline	**Baseline**: Estimated from modeled harvesting volumes **Project**: Estimated from modeled harvesting volumes	Because of significant uncertainties associated with forecasting the quantity of forest product carbon that will remain stored in landfills, landfill carbon is excluded from quantification when project harvesting volumes exceed baseline volumes. Landfill carbon is included, however, when project harvesting volumes are below baseline levels. This case-dependent exclusion or inclusion is necessary to ensure that total GHG reductions and removals caused by the MFM project are not overestimated.
Secondary Effect Sources, Sinks, and Reservoirs					
9	Biological emissions from site preparation activities	CO_2	No	**Baseline**: N/A **Project**: N/A	Biological emissions from site preparation are expected to be lower or not significantly different from baseline levels.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
10	Mobile combustion emissions from site preparation activities	CO_2	No	**Baseline**: N/A **Project**: N/A	Mobile combustion CO_2 emissions from site preparation are not expected to be significantly different from baseline levels for MFM projects. In addition, this methodology assumes that combustion emissions in the U.S. will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the MFM project will have no effect on total net emissions.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Changes in CH_4 emissions from mobile combustion associated with site preparation activities are not considered significant.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Changes in N_2O emissions from mobile combustion associated with site preparation activities are not considered significant.
11	Mobile combustion emissions from ongoing project operation and maintenance	CO_2	No	**Baseline**: N/A **Project**: N/A	Mobile combustion CO_2 emissions from ongoing project operation and maintenance are unlikely to be significantly different from baseline levels and are therefore not included in the GHG Assessment Boundary. In addition, this methodology assumes that such emissions will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the MFM project will have no effect on total net emissions.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Changes in CH_4 emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Changes in N_2O emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
12	Stationary combustion emissions from ongoing project operation and maintenance	CO_2	No	**Baseline**: N/A **Project**: N/A	Stationary combustion CO_2 emissions from ongoing project operation and maintenance could include GHG emissions associated with electricity consumption or heating/cooling at project proponent facilities, or at facilities owned or controlled by contractors. These emissions are unlikely to be significantly different from baseline levels and are therefore not included in the GHG Assessment Boundary. In addition, this methodology assumes that such emissions will be controlled under a regulatory cap-and-trade program in the near future, meaning that changes in activity due to the MFM project will have no effect on total net emissions.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Changes in CH_4 emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Changes in N_2O emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
13	Biological emissions from clearing of forestland outside the project area	CO_2	No	**Baseline**: N/A **Project**: N/A	MFM projects are not expected to cause significant shifts in alternative land uses that might lead to clearing of forestland.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
14	Biological emissions/ removals from changes in harvesting on forestland outside the project area	CO_2	Yes, under certain conditions	**Baseline**: N/A **Project**: Estimated "leakage" factor applied based on the proportion of forecasted harvested carbon relative to baseline harvest amounts	MFM projects may either increase or decrease harvesting relative to baseline levels. If harvesting is reduced in the project area, harvesting on other lands may increase to compensate for the lost production. This "leakage" effect is included in the GHG Assessment Boundary. If harvesting is increased in the project area, harvesting on other lands may decrease in response to the increased production. The reduction in harvesting may lead to increased carbon stocks on other lands. Carbon stock increases on other lands are excluded from the GHG Assessment Boundary, however, because it is not possible to ensure their permanence.
15	Combustion emissions from production, transportation, and disposal of forest products	CO_2	No	**Baseline**: N/A **Project**: N/A	This methodology assumes that combustion emissions will be controlled under a regulatory cap-and-trade program in the near future. Thus, for most of an MFM project's duration, changes in activity due to the project will have no effect on total net emissions due to production, transportation, and disposal of forest products. These emissions are therefore excluded from the GHG Assessment Boundary.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Combustion-related CH_4 emissions related to changes in the production, transportation, and disposal of forest products are not considered significant.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Combustion-related N_2O emissions related to changes in the production, transportation, and disposal of forest products are not considered significant.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
16	Combustion emissions from production, transportation, and disposal of alternative materials to forest products	CO_2	No	**Baseline**: N/A **Project**: N/A	Changes in forest-product production may cause consumers of these products to increase or decrease their consumption of substitute materials (such as alternative building materials, including cement or steel). In many cases, alternative materials will have higher combustion GHG emissions associated with their production, transportation, and/or disposal than wood products. This methodology assumes, however, that combustion emissions will be controlled under a regulatory cap-and-trade program in the near future. Thus, for most of an MFM project's duration, changes in activity due to the project will have no effect on total net emissions due to production, transportation, and disposal of alternative materials. These emissions are therefore excluded from the GHG Assessment Boundary.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Combustion-related CH_4 emissions related to changes in the production, transportation, and disposal of alternative materials are not considered significant.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Combustion-related N_2O emissions related to changes in the production, transportation, and disposal of alternative materials are not considered significant.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
17	Biological emissions from decomposition of forest products	CO_2	Yes	**Baseline**: Quantified as a component of calculating carbon stored for 100 years in wood products (SSR 7) and landfills (SSR 8) **Project**: Quantified as a component of calculating carbon stored for 100 years in wood products (SSR 7) and landfills (SSR 8)	CO_2 emissions from the decomposition of forest products are built into calculations of how much forest product carbon will remain in in-use wood products and in landfills, averaged over 100 years (see SSR 7 and Appendix A).
		CH_4	No	**Baseline**: N/A **Project**: N/A	In-use wood products will produce little to no CH_4 emissions. CH_4 emissions can result from anaerobic decomposition of forest products in landfills. This methodology assumes that landfill CH_4 emissions will be largely controlled in the near future due to federal and/or state regulations. Thus, changes in forest-product production are assumed to have no significant effect on future CH_4 emissions from anaerobic decomposition of forest products in landfills. These emissions are therefore excluded from the GHG Assessment Boundary.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Decomposition of forest is not expected to be a significant source of N_2O emissions.

6 Quantifying GHG Emission Reductions

This section provides requirements and guidance for quantifying an MFM project's net GHG reductions. The Reserve will issue FMUs to an MFM project upon confirmation by an ISO-accredited and Reserve-approved confirmation body that the MFM project's GHG reductions and removals have been quantified following the applicable requirements of this section (see Section 9 for confirmation requirements).

Quantification proceeds in seven steps:

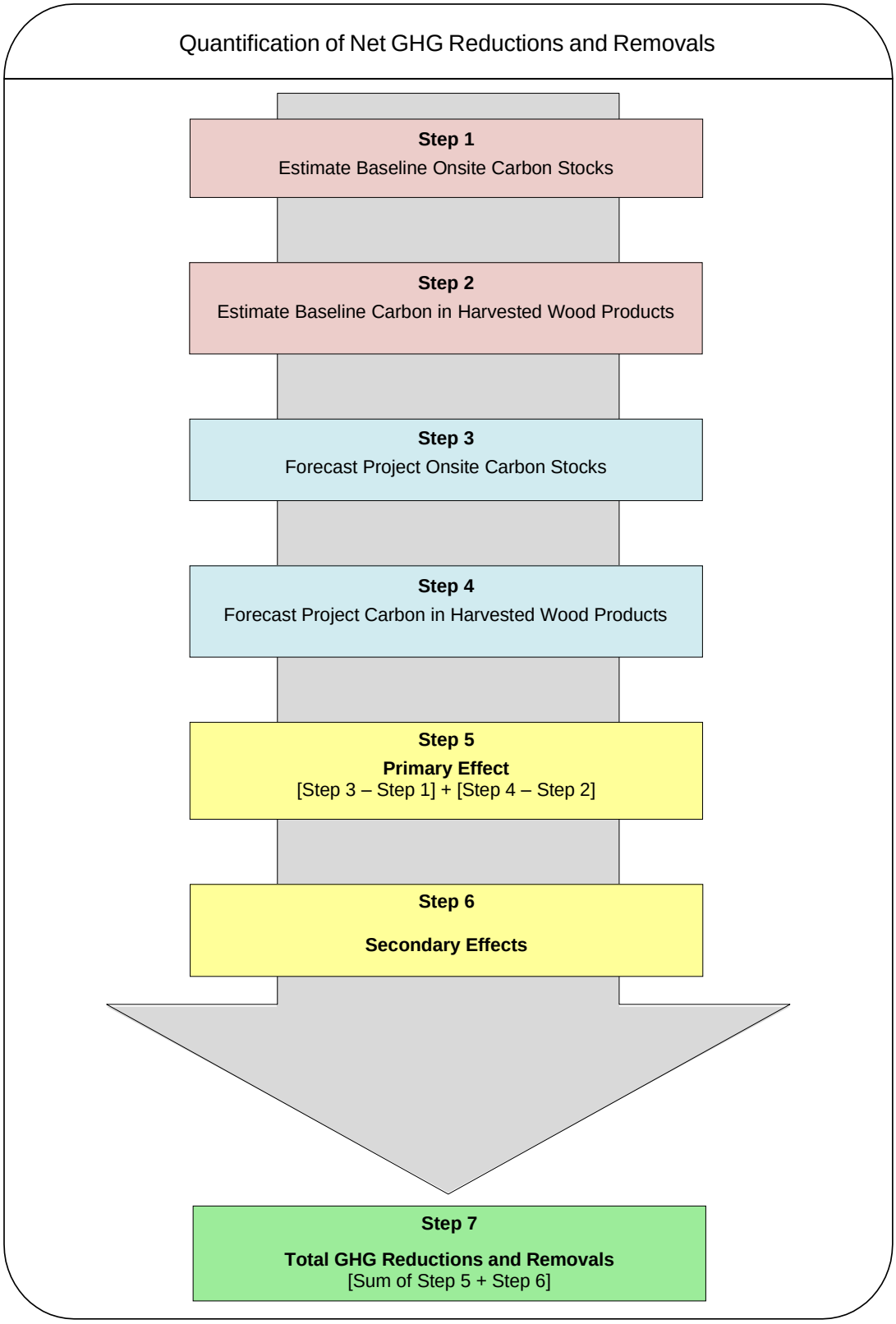
1. **Estimating baseline onsite carbon stocks.** The baseline is an estimate of what would have occurred in the absence of an MFM project. To establish baseline onsite carbon stocks, the project proponent must estimate 100 years of carbon stock changes in each of the MFM project's required onsite carbon pools (identified in Section 5). The baseline must be based on inventoried carbon stocks at the time of the MFM project's initiation, following the applicable requirements in this section for modeling. Onsite carbon stocks are inventoried following the requirements described in the Quantification Guidance in Appendix A. Modeling of onsite carbon stocks over time must be conducted following the requirements in this section and the guidance in Appendix A. Baseline onsite carbon stocks are estimated over an MFM project's entire crediting period (100 years) at the time of the project's initiation and are reported as the average onsite carbon stocking during the crediting period.
2. **Estimating baseline carbon in harvested wood products.** In conjunction with estimating baseline onsite carbon stocks, the project proponent must forecast any harvesting that would have occurred in the baseline. From this, the project proponent must determine the amount of carbon that would have been transferred to long-term storage in wood products. Baseline harvesting is estimated following the guidance in this section and carbon stored in wood products must be calculated following the requirements in the Appendix A.
3. **Forecasting onsite project carbon stocks.** The project proponent must forecast the MFM project's actual onsite carbon stocks based on anticipated management of the project area under the terms of the conservation easement. This must be done by projecting changes to the MFM project's initial forest carbon inventory forward to the end of the crediting period following the guidance in this section and in Appendix A. The estimate of forecasted onsite carbon stocks must be adjusted by an appropriate confidence deduction, as described in Appendix A.
4. **Forecasting project carbon in harvested wood products.** The project proponent must forecast harvesting in the project area based on anticipated management of the project area under the terms of the conservation easement and, from this, estimate the amount of carbon that will be transferred to long-term storage in wood products. Carbon stored in wood products must be calculated following the requirements available in Appendix A.
5. **Calculating the project's primary effect.** The project proponent must quantify the forecasted change in GHG emissions or removals associated with the Forest Project's intended ("Primary") effect, as defined in Section 5. The primary effect for the crediting period is calculated by:

   a. Taking the difference between forecasted actual onsite carbon stocks at the end of the crediting period and the average baseline onsite carbon stocks over the entire Crediting Period
   b. Adding to (a) the calculated difference between forecasted actual and baseline carbon in harvested wood products for the entire crediting period (see Equation 6.1)

6. **Quantifying the project's secondary effects.** The project proponent must quantify the forecasted change in GHG emissions or removals associated with the MFM project's secondary effects, as defined in Section 6.3. Requirements and guidance for quantifying secondary effects are provided below.
7. **Calculating total net GHG reductions and removals.** Total GHG reductions and removals are calculated by summing the project's primary and secondary effects.

Requirements and guidance for how to perform these quantification steps are presented in the remainder of this section.

The required formulae for quantifying net GHG reductions and removals is presented in Equation 6.1. Net GHG reductions and removals must be quantified and reported in units of carbon dioxide-equivalent (CO_2e) metric tons.


Quantification of Net GHG Reductions and Removals
Step 1
Estimate Baseline Onsite Carbon Stocks
Step 2
Estimate Baseline Carbon in Harvested Wood Products
Step 3
Forecast Project Onsite Carbon Stocks
Step 4
Forecast Project Carbon in Harvested Wood Products
Step 5
Primary Effect
[Step 3 – Step 1] + [Step 4 – Step 2]
Step 6
Secondary Effects
Step 7
Total GHG Reductions and Removals
[Sum of Step 5 + Step 6]

Equation 6.1. Net GHG Reductions and Removals

$$\boldsymbol{QR} = \Big(\big((\boldsymbol{AC_{onsite,0}})(\mathbf{1}-\boldsymbol{CD}) - \boldsymbol{BC_{onsite}}\big) + \big(\boldsymbol{AC_{onsite,100}} - \boldsymbol{AC_{onsite,0}}\big)(\mathbf{1}-\boldsymbol{CD})(\mathbf{1}-\boldsymbol{RD}) + \Big(\sum \boldsymbol{AC_{wp}} - \sum \boldsymbol{BC_{wp}}\Big) \times \mathbf{0.80} + \boldsymbol{SE}\Big)$$

Where,			Units
QR	=	Quantified GHG reductions and removals for the entire crediting period	CO_2e
$AC_{onsite,0}$	=	Actual onsite carbon at the project start date	CO_2e
CD	=	Appropriate confidence deduction for the project's inventoried carbon stocks at the start of the project, as determined following the Quantification Guidance in Appendix A	%
BC_{onsite}	=	Baseline onsite carbon as averaged across the entire crediting period	CO_2e
$AC_{onsite,100}$	=	Actual onsite carbon as forecasted for the end of the crediting period	CO_2e
RD	=	Standardized deduction of 15% to accommodate unanticipated changes in carbon stocks resulting from resilience-related management when conservation easement allows ongoing commercial harvesting of live trees and 20% to reflect the heightened risk of the loss of carbon stocks from natural disturbances when the conservation easement does not allow ongoing commercial harvesting of live trees (see Section 6.5.2)	
AC_{wp}	=	Actual carbon in wood products forecasted to be produced over the entire crediting period that is projected to remain stored for at least 100 years (i.e., derived for forecasted harvest volumes following the guidance in Appendix A)	CO_2e
BC_{wp}	=	Baseline carbon in wood products produced over the entire crediting period that would have remained stored for at least 100 years (i.e., derived for baseline harvest volumes following the guidance in Appendix A)	CO_2e
0.80	=	Net change in carbon in harvested wood products, ($AC_{wp,y}$ – $BC_{wp,y}$), is multiplied by 80 percent in Equation 6.1 to reflect market responses to changes in wood-product production. The general assumption in this protocol is that for every tonne of reduced harvesting caused by an MFM project, the market will compensate with an increase in harvesting of 0.2 tonnes on other lands (see Section 6.3). Since wood product production is directly related to harvesting levels, the net change in wood products caused by a project is subject to this same market dynamic. Thus, any one-tonne increase in wood product production by a project will result in only a 0.8 tonne increase overall, because it has been assumed other landowners will decrease production by 0.2 tonnes in response. Similarly, any one-tonne decrease in wood product production by a project will result in only a 0.8 tonne decrease overall, because it has been assumed other landowners will increase production by 0.2 tonnes in response.	
SE	=	Secondary effect GHG emissions caused by the project activity	CO_2e

Note: The term *SE* in Equation 6.1 reflects market responses to changes in wood-product production in the context of the full 100-year crediting period of an MFM project. The general assumption in this methodology is that modifying harvest in an MFM project relative to baseline harvesting levels will lead the market to compensate via modifications to harvesting levels by other landowners. The greater the change in harvest by a MFM project relative to baseline

levels, the greater the response by the market to compensate. Section 6.3 describes in detail the calculation required to account for such market responses.

6.1 Estimating Baseline Carbon Stocks

The baseline approach for MFM projects applies a standardized set of assumptions to project-specific conditions. A project must determine a start date inventory and consider how legal and financial constraints affect the baseline carbon stocks. Furthermore, performance standard criteria are applied to MFM projects based on common practice statistics, described below in this section. MFM projects must estimate baseline onsite carbon stocks following the requirements and procedures described in this section.

The approach to additionality for MFM projects relies on baseline carbon stock values averaged across 100 years. As described in Section 3.2, the crediting period for a project under this methodology is 100 years, and the baseline is a counterfactual representation of one of a multitude of potential legally compliant and financially feasible management scenarios that could play out in reality in the absence of the project. The following steps must be followed to estimate baseline carbon stocks:

1. Determine the start date inventories of aboveground standing live carbon stocks and belowground standing live carbon stocks for the project area.
2. Model a 100-year growth and harvest regime reflecting legal and financial constraints. The result is a *preliminary unadjusted baseline* for aboveground standing live carbon stocks that reasonably reflects the harvesting opportunities present within the project area.
3. Annualize the *preliminary unadjusted baseline* for aboveground standing live carbon stocks based on the periodic modeling output values. Baseline carbon stocks for other carbon pools must be similarly annualized. This results in the *unadjusted averaged baseline* for reported carbon stocks.
4. Apply performance standard criteria to adjust the aboveground standing live portion of the *unadjusted averaged baseline*. The result is an *adjusted averaged baseline* for aboveground standing live carbon stocks.
5. Proportionally adjust other reported carbon stocks to match the *adjusted averaged baseline*.
6. Combine the results to produce the *final baseline* for all onsite carbon stocks.

For all calculations in this section, all values for “carbon stocks” should be expressed in metric tons of CO_2-equivalent.

6.1.1 Inventory Carbon Stocks within the Project Area

The start date inventory of standing live carbon stocks, separated into aboveground and belowground portions must be determined following the Quantification Guidance in Appendix A. Projects may choose to use the Standardized Inventory Methodology (SIM) and/or the Climate Action Reserve Inventory Tool (CARIT),[17] but use of the SIM and CARIT is optional. Further information about the SIM and CARIT is provided in Appendix A.

[17] Both available on the Climate Forward website at https://climateforward.org/program/methodologies/mature-forest-management/.

In the formulas throughout this section, initial carbon stocks are denoted by the variable PUB_0 (i.e., the *preliminary unadjusted baseline* at time zero).

6.1.2 Model Growth and Harvesting Over 100 Years

The *preliminary unadjusted baseline* for onsite carbon stocks must be estimated through a modeling exercise that simulates the growth and harvest of forest inventories. The modeling exercise must use the inventories of the carbon from Section 6.1.1 as a starting point for modeling. The *preliminary unadjusted baseline* will consist of each of the following carbon pools that are maintained separately during this stage of baseline development:

- Aboveground and belowground standing live
- Harvested aboveground and belowground standing live
- Bole portion of harvested standing live

To determine the *preliminary unadjusted baseline,* model the initial inventory of aboveground standing live carbon stocks through a series of growth and harvesting scenarios over a 100-year timeframe, with periodic model output based on a maximum of 10 years. Modeling must be conducted using an approved growth model, as identified in Appendix A, Section A.3. Modeling of the growth and harvesting scenarios must reflect all legal requirements that constrain the ability to harvest carbon stocks in the absence of the conservation easement that serves as the basis for the MFM project. In addition, harvesting assumptions must reflect realistic financial constraints, as described in Section 6.1.2.2.

6.1.2.1 Modeling Legal Constraints

All legal constraints that affect the ability to manage carbon stocks must be included in the model design, with the exception of the conservation easement that is the basis for the MFM project. The *preliminary unadjusted baseline* must represent a growth and harvesting regime that fulfills all legal requirements. Voluntary agreements that can be rescinded, such as rental contracts and forest certifications, are not legal constraints. Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) that are in place more than one year prior to the project's start date shall be modeled as legal constraints. HCPs and SHAs that are approved after the date one year prior to the project's start date are not considered legal constraints for baseline modeling and may be disregarded.

Legal constraints include all laws, regulations, and legally-binding commitments applicable to the project area at the time of the project's initiation that could affect carbon stocks. Legal constraints include:

1. Federal, state/provincial, or local government regulations that are required and might reasonably be anticipated to influence carbon stocking over time including, but not limited to:
    a. Zones with harvest restrictions (e.g., buffers, streamside protection zones, wildlife protection zones)
    b. Harvest adjacency restrictions
    c. Minimum stocking standards
2. Forest practice rules, or applicable Best Management Practices established by federal, state, provincial or local government that relate to forest management.
3. Other legally binding requirements affecting carbon stocks including, but not limited to, covenants, conditions and restrictions, and other title restrictions in place prior to or at

the time of project initiation, including pre-existing conservation easements, HCPs, SHAs, and deed restrictions, excepting an encumbrance that was put in place and/or recorded less than one year prior to the project start date, as defined in Sections 2.1 and 3.3.1.

The *preliminary unadjusted baseline* must be modeled to reflect all silvicultural treatments associated with government-regulated timber harvest plans active within the project area at the time of the project's initiation (i.e., those harvest plans subject to oversight by a government agency and in place prior to the start of the project, as opposed to the timber harvest plan required to be submitted to the conservation easement holder under this methodology, as described in Section 2.1). All legally enforceable silvicultural and operational provisions of a government-regulated timber harvest plan (including for example, in California, those operational provisions designed to meet California Forest Practice Rules requirements for achieving Maximum Sustained Production of High Quality Wood Products [14 CCR 913.11 (933.11, 953.11)]) are considered legal constraints and must be reflected in baseline modeling if the timber harvest plan will remain active. For portions of the project area not subject to government-regulated timber harvest plans (or over time periods for which government-regulated timber harvest plans will not be active), baseline carbon stocks must be modeled by considering any applicable laws, regulations, and legally binding commitments (e.g., California Forest Practice Rules) that could affect onsite carbon stocks. On a case-by-case basis, the state agency with regulatory oversight of forest management (e.g., CAL FIRE) may assist project proponents in identifying minimum carbon stocking levels that would be effectively required under applicable forestry regulations.

6.1.2.2 Modeling Financial Constraints

Harvest assumptions included in the model must be financially viable. The project proponent must demonstrate that the growth and harvesting regime assumed for the *preliminary unadjusted baseline* is financially feasible through a financial analysis of the anticipated growth and harvesting regime that captures all relevant costs and returns, taking into consideration all legal, physical, and biological constraints. Cost and revenue variables in the financial analysis may be based on regional norms or on documented costs and returns for the project area or other properties in the project's Assessment Area.

A financially viable project is defined in this protocol as a project that has a positive net present value using a discount rate of 4% and considering long-term timber revenues and costs of production. This would indicate a management regime that does not lose money in the practice of performing long-term forest management activities, including road management, watercourse restoration, fuels management, etc. Inputs to the analysis include the volume of species harvested, logging and hauling costs, delivered log prices, and forest management costs.

6.1.3 Generate an Averaged Baseline

The periodic modeled outputs from the *preliminary unadjusted baseline* must be standardized according to the following guidance for each carbon pool. The result will be an *unadjusted averaged baseline* for each carbon pool.

Aboveground standing live carbon stocks: The periodic modeled outputs for aboveground standing live carbon stocks must be averaged using Equation 6.2. See Figure 6.1 for a simplified example of the resulting *unadjusted averaged baseline*.

Equation 6.2. Formula for Averaging *Preliminary Unadjusted Baseline* Carbon Stocks

$$UAB = \frac{\sum_{p=0}^{i} PUB_p}{i}$$

Where,			Units
UAB	=	Unadjusted averaged baseline value	tCO_2e/acre
p	=	Modeling output period	
i	=	Final modeling output period at the end of the 100-year crediting period	
PUB_p	=	Preliminary unadjusted baseline value for modeling output period p.	tCO_2e/acre

Belowground standing live carbon stocks: The belowground portion of the standing live carbon stocks must be averaged in the same way as the aboveground standing live carbon stocks.

Carbon stocks in the aboveground and belowground portions of standing live trees harvested for wood products: The carbon stocks shall be calculated as the sum of the periodic outputs for the entire 100-year modeling period.

Carbon stocks in the bole portion of trees harvested for wood products: The carbon stocks shall be calculated as the sum of the periodic outputs for the entire 100-year modeling period.

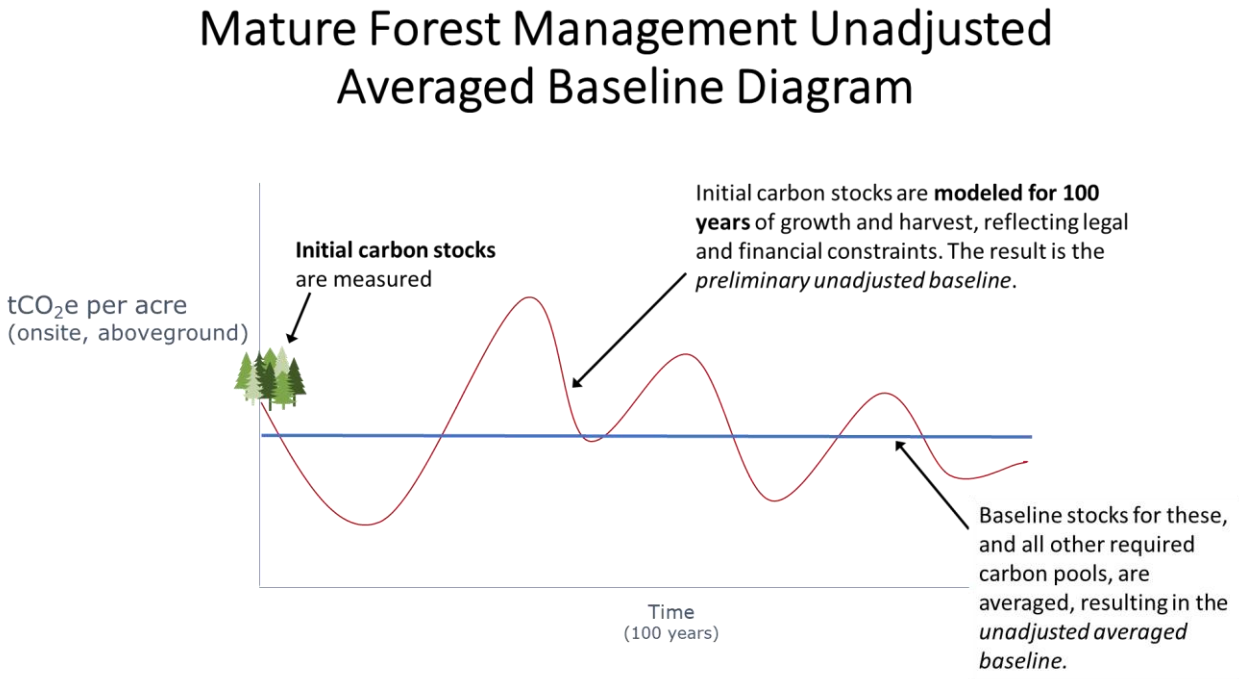


Figure 6.1. Example of an *Unadjusted Averaged Baseline* Resulting from Equation 6.2

6.1.4 Apply Performance-Standard Criteria

Once the components of the *unadjusted averaged baseline* are determined in Section 6.1.3, the aboveground standing live tree component must be adjusted to conform to a set of performance standard criteria, as described below. The result is an *adjusted averaged baseline* for

aboveground standing live tree carbon stocks. Other reported carbon pools are adjusted in Section 6.1.5.

The performance standard criteria establish minimum aboveground standing live tree carbon stock values for the baseline, regardless of what is legally and financially viable. The elements of the performance standard are:

- *The High Stocking Reference:* The High Stocking Reference is a measure of carbon stocks in aboveground standing live tree biomass over the 10 years preceding the project start date. It governs baseline carbon stocks in certain instances where aboveground standing live tree carbon stocks have declined prior to the start date. See further guidance below on how to determine the High Stocking Reference.
- *Comparison of initial carbon stocks to common practice*: The *adjusted averaged baseline* may depend on how the initial carbon stocks compare to common practice levels (see guidance in Section 6.1.4.2 for how to determine common practice). For projects whose initial aboveground standing live tree carbon stocks are above common practice, the *adjusted averaged baseline* for aboveground standing live tree carbon stocks may not be below common practice. For projects whose initial aboveground standing live tree carbon stocks are below common practice, the *adjusted averaged baseline* for aboveground standing live tree carbon stocks may not be below either (1) the initial inventory level or (2) the High Stocking Reference, whichever is greater.

The procedure for determining the *adjusted averaged baseline* is determined based on the following:

- If the project's initial aboveground standing live tree carbon stocks (PUB_0) are above common practice, use Equation 6.3
- If the project's initial aboveground standing live and standing dead carbon stocks (PUB_0) are below common practice, use Equation 6.4

Equation 6.3. Determining the *Adjusted Averaged Baseline* for Aboveground Live Tree Carbon Stocks Where Initial Stocks Are at or Above Common Practice

$$\boldsymbol{AAB = MAX(CP, MIN(PUB_0, UAB))}$$

Where,

			Units
AAB	=	*Adjusted averaged baseline* for aboveground standing live tree carbon stocks value	tCO_2e/acre
CP	=	Common practice (determined according to the guidance in Section 6.1.4.2)	tCO_2e/acre
PUB_0	=	Initial aboveground standing live tree stocks per acre within the project area (as determined in Section 6.1.1)	tCO_2e /acre
UAB	=	Value of the aboveground standing live tree portion of the *unadjusted averaged baseline,* as determined in Section 6.1.3	tCO_2e/acre

Equation 6.4. Determining the *Adjusted Averaged Baseline* for Aboveground Live Tree Carbon Stocks Where Initial Stocks Are Below Common Practice

$$AAB = MAX(MAX(HSR, PUB_0), MIN(CP, UAB))$$

Where,

			Units
AAB	=	*Adjusted averaged baseline* for aboveground standing live tree carbon stocks value	tCO_2e/acre
HSR	=	"High Stocking Reference" for the project area. See guidance below for how the HSR is determined	tCO_2e/acre
CP	=	Common practice (determined according to the guidance in Section6.1.4.2)	tCO_2e/acre
PUB_0	=	Initial aboveground standing live tree carbon stocks per acre within the project area (as determined in Section 6.1.1)	tCO_2e /acre
UAB	=	Value of the aboveground standing live tree portion of the *unadjusted averaged baseline,* as determined in Section 6.1.3	tCO_2e/acre

6.1.4.1 Determining the High Stocking Reference

The High Stocking Reference is defined as 80 percent of the highest value for aboveground standing live tree carbon stocks per acre within the project area during the 10-year period preceding the project start date. To determine the High Stocking Reference, the project proponent must document changes in the project area's aboveground standing live tree carbon stocks over the 10 years prior to the initiation of the project, or for as long as the project proponent has had control of the stocks, whichever is shorter. Figure 6.2 presents a graphical portrayal of a High Stocking Reference determination.

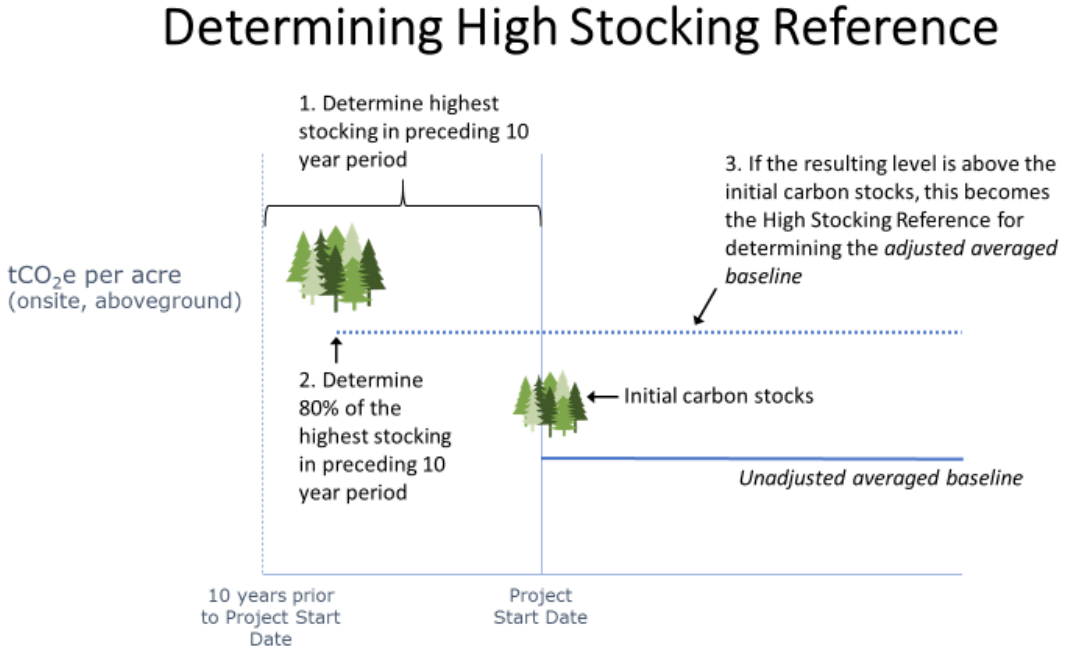


Figure 6.2. Determining a Project Area's High Stocking Reference

*It is possible for the High Stocking Reference to be higher than common practice, even where initial live tree carbon stocks for the project are below common practice.

6.1.4.2 Determining Common Practice and the Initial Baseline

Common practice refers to the average stocks of aboveground standing live tree carbon associated with the Assessment Area(s) covered by the project area. This value represents the result of the suite of management activities taking place within the Assessment Area(s) and is used to approximate a performance standard for MFM projects. The overall intent of this methodology is for projects to contribute to long-term increases in average carbon stocking in the Assessment Area(s) where they are located. Projects with initial stocking below common practice will increase their stocking over time. Projects with initial stocking above common practice will also likely increase their stocking over time, but, as or more importantly, will prevent activities that otherwise would have decreased the stocking on the project site to or below common practice stocking. In the absence of an MFM project, there is no guarantee that a site with stocking above common practice will maintain their stocking levels, especially over the 100-year crediting period committed to by projects.

The common practice statistic applicable to a project can be found by consulting the Assessment Area Data File on the Climate Forward website.[18] If the project area covers multiple Assessment Areas, common practice must be calculated as the average of the values for each Assessment Area, weighted by the percentage of the project area that falls within each Assessment Area.

Common practice statistics are calculated from United States Forest Service Forest Inventory and Analysis (USFS FIA) program. The Reserve will update the common practice statistics in the Assessment Area Data File periodically. The frequency of updating common practice statistics will be subject to the availability of new USFS FIA data but will be no more frequent than once every five years. The Reserve will announce any forthcoming updates to the common practice statistics before they are released, and any updates will not be retroactive.

6.1.5 Proportionally Adjust Other Reported Carbon Stocks

The *adjusted averaged baseline* for other reported carbon stocks must be determined by adjusting carbon stock values to reflect the *adjusted averaged baseline* for aboveground standing live tree carbon stocks. The guidance for adjusting the other reported carbon stocks is shown in Table 6.1.

[18] https://climateforward.org/program/methodologies/mature-forest-management/

Table 6.1. Guidance for Adjusting Other Carbon Pools

Carbon Pool	Relationship to Adjustments of Aboveground Live Carbon Stocks	Adjustment
Belowground Standing Live Carbon Stocks	Directly Proportional	$\boldsymbol{AAB_{bg} = \left(AAB_{ag}/UAB_{ag}\right) \times UAB_{bg}}$ *Where*, AAB_{bg} = *Adjusted averaged baseline* for belowground standing live carbon stocks AAB_{ag} = *Adjusted averaged baseline* for aboveground standing live carbon stocks UAB_{ag} = *Unadjusted averaged baseline* for aboveground standing live carbon stocks $UAB_{bg,}$ = *Unadjusted averaged baseline* for belowground standing live carbon stocks
Harvested Aboveground and Belowground Standing Live Carbon Stocks	Inversely Proportional	$\boldsymbol{TAB_{ht} = \frac{\sum_{p=0}^{i} UB_{ht,p}}{\left(AAB_{ag}/UAB_{ag}\right)}}$ *Where*, AAB_{ht} = *Totaladjusted baseline* for harvested aboveground and belowground standing live carbon stocks across the entire crediting period UB_{ht} = *Unadjusted baseline* for harvested aboveground and belowground standing live carbon stocks for the modeling period *p* UAB_{ag} = *Unadjusted averaged baseline* for aboveground standing live carbon stocks AAB_{ag} = *Adjusted averaged baseline* for aboveground standing live carbon stocks
Harvested Bole Portion of Aboveground and Belowground Standing Live Carbon Stocks	Inversely Proportional	$\boldsymbol{TAB_{htb} = \frac{\sum_{p=0}^{i} UB_{htb,p}}{\left(AAB_{ag}/UAB_{ag}\right)}}$ *Where*, TAB_{htb} = *Total adjusted averaged baseline* for the bole portion of harvested aboveground and belowground standing live carbon stocks $UB_{htb,p}$ = *Unadjusted baseline* for the bole portion of harvested aboveground and belowground standing live carbon stocks for the modeling period *p* UAB_{ag} = *Unadjusted averaged baseline* for aboveground standing live carbon stocks AAB_{ag} = *Adjusted averaged baseline* for aboveground standing live carbon stocks

6.1.6 Final Adjusted Baseline Components

The results from the *adjusted baselines* (*averaged* or *total*) for all reported *onsite* carbon stocks are applied as follows:

- *Adjusted average baseline* aboveground and belowground standing live carbon stocks are summed and are equal to the term BC_{onsite} in Equation 6.1: $\boldsymbol{AAB_{ag} + AAB_{bg} = BC_{onsite}}$
- *Total adjusted baseline* harvested standing live carbon stocks (aboveground and belowground) are equal to the summation of the term $BC_{hv,p}$ in Equation 6.5: $\boldsymbol{AB_{ht} = \sum_{p=1}^{i} BC_{hv,p}}$
- *Total adjusted baseline* harvested wood products carbon stocks are equal to the term BC_{wp} in Equation 6.1: $\boldsymbol{AB_{ag} = BC_{wp}}$

The *total adjusted baselines* for harvested standing live carbon stocks (aboveground and belowground) and the bole portion of harvested standing live carbon stocks must be maintained separately from the live tree carbon stocks *adjusted average baseline* since the reporting of harvested carbon stocks is conducted separately from other reported carbon stocks.

6.2 Estimating Project Carbon Stocks

The following steps must be followed to estimate forecasted project carbon stocks:

1. Using the start date inventory of standing live trees for the project area, as described in Section 6.1.1, model a 100-year growth and harvest regime reflecting legal constraints, including harvest constraints outlined in the Conservation Easement. The result of modeling will be periodic standing live tree inventories from which above- and belowground standing live carbon stocks are calculated for the end of the crediting period.
2. Estimate future stocks in harvested wood products based on harvest output from growth and harvest modeling.

For all calculations in this section, all values for “carbon stocks” should be expressed in metric tons of CO_2-equivalent.

6.2.1 Determining Forecasted Project Onsite Carbon Stocks

Forecasted onsite carbon stocks must be estimated through a modeling exercise. The modeling exercise must use the inventory of standing live tree carbon from Section 6.1.1 as a starting point for modeling.

Forecasted project carbon stocks will consist of each of the following carbon pools that are determined during project stock modeling:

- Aboveground and belowground standing live
- Harvested aboveground and belowground standing live
- Bole portion of harvested standing live

To determine forecasted project carbon stocks, model the initial inventory of aboveground standing live carbon stocks through a series of growth and harvesting scenarios over a 100-year timeframe. Modeling must be conducted using the same approved growth model used for

baseline modeling. Modeling of the growth and harvesting scenarios must reflect not only all legal requirements that constrain the ability to harvest carbon stocks, as required for baseline modeling as described in Section 6.1.2.1, but also the terms of the Conservation Easement that serves as the basis for the MFM project. Furthermore, modeling must be performed in a way that reflects a scenario in which harvesting occurs to the full extent allowed under the conservation easement. Project proponents must develop a modeling plan which documents how the forecasted carbon stock values were derived and describes the means by which the projections of forest carbon values adhere to the harvest constraints contained in the conservation easement.

6.2.2 Determining Forecasted Project Carbon in Harvested Wood Products

Perform the following steps to determine forecasted project carbon in harvested wood products:

1. Determine the total forecasted amount of carbon in standing live carbon stocks (prior to delivery to a mill) harvested during periodic harvest events over the entire 100-year crediting period (based on harvest volumes determined in Section 6.2.1).
2. Determine the total amount of forecasted harvested carbon that will remain stored in wood products, averaged over 100 years, following the requirements in Appendix A.

6.3 Estimating Performance Decline

The efficiency of an MFM project's mitigation performance is not expected to decline over the crediting period aside from any short-term variance that may occur in regard to annual carbon stock accrual. The conservation easement over the project area and the enforcement of terms related to forest management ensure mitigation will continue over the long-term duration of the crediting period and that any variance in annual carbon stock accruals is within any limits established by the conservation easement.

6.4 Abandonment Rates

Project abandonment is highly unlikely for any MFM project. The project proponent must grant the conservation easement to an Eligible Land Trust in accordance with the provisions outlined in this methodology. The project proponent must also demonstrate that the Eligible Land Trust has the legal authority to monitor compliance of management activities with the terms of the conservation easement and enforce such terms when violations occur. The conservation easement and related monitoring and enforcement activities ensure the continued implementation of the MFM project for the duration of the crediting period.

6.5 Ensuring Conservativeness of Quantification

6.5.1 Modeling Parameters

To help further ensure baseline and forecasted actual carbon stocks represent reasonable and conservative estimates, modeling parameters appropriate for the project area must be applied. Modeling must be performed with the oversight of a professional forester, with a description of how modeling parameters are reasonable and conservative. Parameters described should include but not be limited to:

- Site indexes, with consideration given to relevant sources of information such as inventory measurements, soil maps that indicate site productivity, and/or past harvest plans on the project area.

- Crown ratios, as reported in the project's inventory and used for modeling must be reasonably accurate, based on review by the confirmation body (see Confirmation Guidance in Section 9.4.4 for further information).
- Mortality, with the mortality function of the growth and yield model used for modeling enabled and default rates applied so that increases in live tree stocks are moderated commensurate with expected rates of natural mortality.

Additionally, modeling scenarios must be developed in a way that reflects conservative estimates of increases in forecasted actual carbon stocks. As outlined in Section 6.2.1, modeling of forecasted stocks must reflect how forest management activities are restricted by the terms of the conservation easement while also reflecting how aggressively increases in carbon stocks could be limited under allowable forest management activities. In other words, the modeling scenario must be performed as if the Forest Owner were intending to harvest as much timber as is allowed under the conservation easement. Modeling in in this way will prevent over-crediting of removals in the event the Forest Owner decides to manage the project area in a way that minimizes carbon stock increases in a manner that still complies with the conservation easement.

6.5.2 Deduction to Allow for Resilience-Related Management

Although this methodology is intended to foster increases in forest carbon stocks via management that promotes to mature forest conditions, it also recognizes that responsible long-term forest management will likely involve actions that help to ensure the resilience of the forest over time. Such actions may include operations to reduce fuel loads, remove safety hazards, and reduce snag densities after high mortality events. Rather than requiring the carbon impacts that result from such sporadic and initially unanticipated activities to be factored into the modeling of forecasted project stocks, a standard 10% deduction will be applied to the total estimated removals, as indicated in Equation 6.1.

If the conservation easement on the project area prohibits ongoing commercial harvesting of live trees, the standard deduction will be increase to 15% to accommodate the increased risk to forest carbon from catastrophic natural disturbances, such as wildfire and pest outbreaks.

6.6 Quantifying Secondary Effects

For MFM projects, significant secondary effects can occur if a project reduces harvesting in the project area, resulting in an increase in harvesting on other properties. Emission reductions due to substituting wood for materials with higher GHG footprints, such as concrete or steel, are not accounted for as an emission reduction in this methodology because the emission reductions are accounted for by the energy sector.

The risk that secondary effects may be occurring is calculated in this methodology. However, the amount of secondary effects is dependent on how much harvesting is projected to occur on the project area relative to the baseline scenario. This methodology considers the cumulative impacts of shifting harvest activities over the entire crediting period of the project. MFM projects, where harvesting is anticipated to be an ongoing activity over the project life, are expected to increase harvest levels over time compared to baseline management due to improved stocking and growth levels and harvesting closer to an optimal age for forest productivity.

Equation 6.5 must be used to estimate secondary effects for the entire crediting period for MFM projects. The evaluation in Equation 6.5 considers how forecasted harvest amounts vary from baseline harvest amounts on a cumulative basis across the entire 100-year crediting period.

Values used for onsite carbon harvested in the project and baseline scenarios ($AC_{hv,p}$ and $BC_{hv,p}$) shall represent all harvested trees, not just merchantable species.

Equation 6.5. Secondary Effects Emissions

$$SE = MIN\left(0, \left(\sum_{p=1}^{i} AC_{hv,p} - \sum_{p=1}^{i} BC_{hv,p}\right) \times 20\%\right)$$

Where,			Units
SE	=	Estimated secondary effects (used in Equation 6.1)	tCO_2e
$AC_{hv,p}$	=	Forecasted actual amount of onsite carbon harvested in model output period *p* (prior to delivery to a mill)	tCO_2e
$BC_{hv,p}$	=	Estimated baseline amount of onsite carbon harvested in model output period *p* (prior to delivery to a mill), as determined in Section 6.1.5	tCO_2e
i	=	Final model output period at the end of the 100-year crediting period	

7 Project Implementation and Monitoring

Climate Forward requires a Project Implementation Report (PIR) to be established for all implementation and reporting activities associated with the project. The PIR will serve as the basis for the confirmation body to confirm that the implementation and reporting requirements in this methodology have been met. The PIR must cover all aspects of implementation and reporting contained in this methodology and must specify how data for all relevant parameters have been collected and recorded.

At a minimum, the PIR shall include the inventory methodology, parameter values, a record keeping plan, and the role of individuals performing each implementation and reporting activities. The PIR must also include procedures that the project proponent has followed to ascertain and demonstrate that the project at all times passed the legal requirement test and will remain in regulatory compliance.

Project proponents are responsible for ensuring that all reporting requirements of this methodology have been met. Other than the initial quantification of carbon stocks and secondary effects, there are no requirements nor guidance for ongoing monitoring activities.

7.1 Quantification Parameters

Each project must include the prescribed parameters necessary to calculate emission reductions. These must be shown in a table, such as below in Table 7.1.

Table 7.1. Project Quantification Parameters

Equation	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r)
Equation 6.1	Onsite baseline stocks	The baseline is the "business as usual" case for MFM projects, with consideration of performance standard criteria.	CO_2e	(c) - Determined from modeling exercise as described in Section 6.1.
Equation 6.1	Onsite project stocks	Project stocks are based on projected values for the project area considering harvest activities that are allowed to occur under the conservation easement. The project stocks are discounted for conservative accounting as a measure against sampling accuracy, future management for resiliency and, in cases where ongoing commercial timber harvesting is prohibited, to address the heightened risk of catastrophic natural disturbances.	CO_2e	(c) - Determined from modeling exercise as described in Section 6.2.1.
Equation 6.1	Confidence deduction	Deduction applied to the projected inventory of onsite project stocks at the end of the crediting period based on sampling error of initial onsite carbon stock inventory.	%	(c) – Determined from sampling data for initial onsite carbon stocks.
Equation 6.1	Resiliency deduction	Standardized deduction applied to the projected inventory of onsite project stocks at the end of the crediting period.	%	(r) – Deduction applied varies as described in Equation Equation 6.1.

Equation	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r)
Equation 6.1	Baseline harvested wood products stocks	Baseline harvested wood products stocks are based on projected harvest volumes under the "business as usual" case for MFM projects, with consideration of performance standard criteria.	CO_2e	(c) - Determined from modeling exercise as described in Section 6.1.
Equation 6.1	Project harvested wood products stocks	Project harvested wood products stocks are based on projected harvest volumes for the project area considering harvest activities that are allowed to occur under the conservation easement.	CO_2e	(c) - Determined from modeling exercise as described in Section 6.2.2.
Equation 6.1, Equation 6.5	Secondary effects	Secondary effects emissions from the shifting of harvest activities to areas outside of the project area as a result of the project activity are based on a comparison of the cumulative harvested tree carbon stocks under the baseline and the project activity over the entire crediting period.	CO_2e	(c) – Determined from baseline and project activity modeling exercises, as described in Sections 6.1, 6.2.1, and 6.6.

7.2 Voluntary Ongoing Monitoring Incentive

Each Climate Forward methodology is designed to ensure the quantification of emission reductions over the crediting period is conservative. Under some methodologies, it may be possible to have additional FMUs issued following *ex post* verification, using data collected by the project through ongoing monitoring from the project sites. MFM projects are not eligible for further issuance of FMUs following *ex post* verification.

8 Reporting and Record Keeping

This section provides requirements and guidance on reporting rules and procedures. A priority of Climate Forward is to facilitate consistent and transparent information disclosure among project proponents.

8.1 Project Submittal and Confirmation Documentation

Project proponents must provide the following documentation for project listing with Climate Forward:

- Project Submission form, including request for exception to project configuration requirement (Section 4.1), if applicable
- Proposed conservation easement terms

After the project is listed, the project proponent must then submit the following documentation for confirmation:

- Project Implementation Report for mature forest management projects (not public)
- KML file delineating project area
- Copy of recorded conservation easement, including forest management restrictions
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form

As a part of the confirmation process, the confirmation body must then submit the following documentation to Climate Forward:

- Confirmation Report
- Confirmation Statement
- Confirmation List of Findings

All reports that reference carbon stocks must be submitted with the oversight of a Professional Forester so that professional standards and project quality are maintained. Any Professional Forester preparing a project in an unfamiliar jurisdiction must consult with a Professional Forester practicing forestry in that jurisdiction to understand all laws and regulations that govern forest practice within the jurisdiction. This requirement does not preclude the project's use of technicians or other unlicensed/uncertified persons working under the supervision of the Professional Forester.

All projects shall submit a KML file depicting the Project Area that matches the maps submitted to depict the project area. The project's reported acres shall be calculated in accordance with the requirements in Section 4. The Reserve will create a file of all forest carbon projects (confirmed Climate Forward projects and verified offset projects) on Google Maps for public dissemination.

The above project documentation will be available to the public via the Climate Forward online registry, unless otherwise noted. Further disclosure and other documentation may be made available on a voluntary basis through the Climate Forward registry.[19]

8.2 Record Keeping

For purposes of independent confirmation and historical documentation, project proponents are required to keep all information outlined in this methodology for a period of seven years after the information is generated. Except for those documents identified in Section 8.1, this information will not be publicly available but may be requested by the confirmation body or the Reserve. Records must be kept in hard copy and/or digital format. For documents that were originally created in hard copy form and for which the original hard copy bears original signatures or other evidence of authenticity (e.g., signed Attestation of Title), hard copies must be retained.

Examples of information the project proponent must retain includes:

- All project submittal documentation, as listed in Section 8.1.
- All data inputs for the calculation of the project GHG reductions and removals, including all required sampled data
- Copies of all permits, formal notices of regulatory violations, and any relevant administrative or legal consent orders dating back at least 3 years prior to the implementation of the project, or for as long as the project proponent has owned the project area in cases where the project proponent acquired the project area less than 3 years prior to the project start date and any such permits, notices, or consent orders are no longer applicable.
- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Legal Additionality forms
- Results of emission reduction calculations
- Confirmation records and results

The Reserve also requires that the following project-related records be retained by the confirmation body for a minimum of seven years after completing confirmation activities. It must be noted that some records may be subject to fiscal or other legal requirements that are longer than the Reserve's mandated period.

Confirmation bodies shall retain electronic copies, as applicable, of:

- The Project Implementation Report
- The project proponent's SSR and/or project activity data as well as evidence cited
- The confirmation plan
- The sampling plan
- Measurement data from site visit, including sequential sampling results, as well as calculations of SSRs by confirmation body
- The Confirmation Report
- The List of Findings
- The Confirmation Statement

Each confirmation body must have an easily accessible record-keeping system, preferably electronic, that provides readily available access to project information. Copies of the original

[19] Climate Forward documents and forms are available at https://climateforward.org/program/program-and-project-forms/.

activity and source data records shall be maintained within said record-keeping system. Records must be kept in both hard copy and/or digital format, where possible. For documents that were originally created in hard copy form and for which the original hard copy bears original signatures or other evidence of authenticity (e.g., signed Confirmation Statement), hard copies must be retained. The Reserve may at any time request access to the record-keeping system or any supporting documentation for oversight or auditing purposes

8.3 Reporting and Confirmation Period

For *ex ante* GHG mitigation projects, the reporting period is equivalent to the crediting period. Project proponents must report forecasted GHG reductions from the project for the entire crediting period.

A confirmation period is the period of time over which forecasted GHG reductions are confirmed. A confirmation period begins with the project start date and ends with the submission of the final Confirmation Report to Climate Forward. The end date of any confirmation period may not extend past the project crediting end date.

Confirmation activities cannot commence until the project is submitted by the project proponent and approved by the Reserve, and at least one year following the beginning of project implementation. Under extenuating circumstances, exceptions to the requirement to wait at least one year following the project start date may be made at the sole discretion of the Reserve. In such instances, terms and conditions to be fulfilled by the project proponent are determined by the Reserve to ensure the overall integrity of the FMUs issued are maintained. See the Climate Forward Program Manual for further details.

9 Confirmation Guidance

This section provides confirmation bodies with guidance on confirming GHG emission reductions associated with the project activity. This confirmation guidance supplements the Climate Forward Confirmation Manual and describes confirmation activities specifically related to this methodology.

Confirmation bodies trained to confirm projects registering under this methodology must be familiar with the following documents:

- Climate Forward Program Manual
- Climate Forward Confirmation Manual
- Mature Forest Management Forecast Methodology (this document)

The Climate Forward Program Manual, Climate Forward Confirmation Manual, and Climate Forward methodologies are designed to be compatible with each other and are posted on the Climate Forward website at http://www.climateforeward.org.

In cases where the Climate Forward Program Manual or Climate Forward Confirmation Manual differs from the guidance in this methodology, this methodology takes precedent.

Only confirmation bodies trained and accredited by the Reserve are eligible to confirm project reports. Information about confirmation body accreditation and training can be found on the Climate Forward website at http://www.climateforward.org/program/confirmation/.

9.1 Standard of Confirmation

While there is no possibility for *ex post* verification of MFM projects under Climate Forward, there is a requirement for an accredited confirmation body to confirm each MFM project has been implemented as described in this methodology and that the estimated emission reductions or removals have been calculated accurately. The confirmation process incorporates both a desktop documentation review and a site visit assessment of the MFM project.

Beyond criteria for the confirmation of MFM project implementation, the confirmation body also confirms any provisions specified in this methodology that are to be undertaken to ensure the continued implementation of the mitigation project for the duration of its crediting period. The confirmation body assesses whether such measures have been appropriately implemented.

9.2 Confirming the Project Implementation Report

The PIR serves as the basis for confirmation bodies to confirm that the implementation and reporting requirements have been met. Confirmation bodies shall confirm that the PIR covers all aspects of implementation and reporting contained in this methodology and specifies how data for all relevant parameters were collected and recorded.

When assessing the PIR, the confirmation body shall:

a) Assess the compliance of the PIR with the requirements of this methodology Climate Forward Program Manual, and Climate Forward Confirmation Manual;

b) Identify the list of parameters required by this methodology and confirm that the PIR accounted for all necessary parameters;

c) Assess the means of implementation of the project data capture, including data management and quality assurance and quality control procedures, and determine whether these are sufficient to ensure the accuracy of forecasted GHG reductions to be achieved by the project;

Where the project proponent has applied a sampling approach to determine data and parameters, the confirmation body shall assess the proposed sampling plan in accordance with sampling requirements in section 6.1.3.6.3 of ISO 14064-3: 2019.

9.3 Core Confirmation Activities

Confirmation is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The core confirmation activities are:

1. Reviewing project documentation for project compliance with eligibility requirements, conformance of the conservation easement terms, estimates of the carbon stock inventory, and modeling of future stocks under the baseline and project scenarios
2. Confirming emission reduction estimates
3. Undertaking site visits to evaluate the project's inventory estimates

9.4 Confirmation Items

Confirmation bodies are expected to use their professional judgment to confirm that methodology requirements have been met in instances where the methodology does not provide sufficiently prescriptive guidance. For more information on the confirmation process and professional judgment, please see the Climate Forward Confirmation Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for confirmation activities, but rather guidance on areas specific to mitigation projects that must be addressed during confirmation.

9.4.1 Project Eligibility

To determine that a project is eligible under this methodology, it must meet a set of criteria that a confirmation body shall confirm during the confirmation process. These requirements determine if an MFM project is eligible to register with Climate Forward and/or have credits issued. If any requirement is not met, the project may be determined ineligible. Table 9.1 outlines the eligibility criteria for MFM Projects.

Table 9.1.Eligibility Confirmation Items

Confirmation Items		Section of Methodology	Apply Professional Judgment?
1. **Project Definition**	a. Conservation easement that serves as the basis for the MFM project has been granted to an eligible land trust that has the legal authority to enforce the terms of the easement against others, including the landowner. b. Conservation easement has been recorded with the county or counties in which the project is located. c. Conservation easement contains the required terms that restrict timber harvesting during the crediting period in accordance with the requirements described in this methodology. d. Conservation easement properly references the state enabling statute for conservation easements in the state in which the project is located.	2.1	No
2. **Project Ownership**	Forest Owners are identified, including documentation of control of carbon within the project area.	2.2, 3.6	No
3. **Project Location**	a. Project is on private land. b. Assessment Area(s) containing the project area are identified. c. Evidence is provided indicating the canopy cover exceeds 10% and has existed on the project area for at least 20 years. d. Project is not on lands under a prior carbon project, unless the prior project was	3.1	No
4. **Start Date**	Evidence of date of recordation of Conservation Easement	3.2	No
5. **Legal Requirement Test**	Proof that a signed Attestation of Voluntary Implementation form is on file with the Reserve	3.3.1	No
6. **Native Species**	Evidence that the project area comprises at least 90% Native Species (based on the sum of carbon in the standing live tree pool) at the project start date, or that the conservation easement will guide management practices in future harvest areas to ensure progress toward satisfying the requirement over the course of the crediting period.	3.4	No
7. **Composition of Native Species**	Completed inventory demonstrates distribution of average basal area of standing live tree species meets composition of native species goal or an exception has been made through a letter from the State Forester or by a Professional Forester, as described in Section 3.4. If composition goal is not achieved at the	3.4	No

	project start date, evidence has been provided that the conservation easement will guide management practices in future harvest areas to ensure progress toward satisfying the requirement over the course of the crediting period.		
8. **Attestation of Regulatory Compliance**	Proof that a signed Attestation of Regulatory Compliance form is on file with the Reserve. In addition to reviewing this form, the confirmation body must perform a risk-based assessment to confirm the statements made by the project proponent in the Attestation of Regulatory Compliance form.	3.5	Yes
9. **Ex Ante Suitability**	Proof that the conservation easement, containing the terms as specified in Section 2.1, has been granted to an Eligible Land Trust	2.1 ,3.5	No
10. **Attestation of Title**	Proof that a signed Attestation of Title is on file at the Reserve for the initial confirmation. In addition to reviewing this form, the confirmation body must conduct a review to confirm ownership and claims to GHG reductions/removals that are anticipated as part of the project activity.	3.6	Yes
11. **Compensation for Conservation Easement**	Evidence that the Forest Owner has not been compensated (via cash value or tax deductions owing to the conservation easement) for the foregone timber value associated with the forest management restrictions contained within the conservation easement.	3.6	No
12. **Project Resilience and Permanence Measures**	Conservation easement contains terms that ensure the resilience of GHG reductions/removals associated with the project.	3.7	No

9.4.2 Quantification

Confirmation bodies shall include quantifications within the confirmation process such as recalculations and risk assessment. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before FMUs are issued.

Use the following table to list the items that confirmation bodies shall include in their risk assessment and recalculation of the project's GHG emission reductions.

Table 9.2. Quantification Confirmation Items

Confirmation Items		Section of Methodology	Apply Professional Judgment?
1. **Project Area Delineation**	Proof that a description, KML layer, and maps of the geographic boundaries defining the project area are on file at the Reserve.	4, 7.1	No
2. **Inventory of Onsite Carbon Stocks**	An inventory of the project area's carbon stocks in required pools has been conducted in accordance with the requirements of this methodology (see Section 9.4.3 for further confirmation guidance).	6.1	Yes
3. **Description of Project Activities**	A description has been provided of the management activities that will lead to increased carbon stocks in the project area compared to the baseline, as supported by the conservation easement.	2.1, 6.2	Yes
4. **Compare Initial Aboveground Standing Live Carbon Stocks with the Minimum Baseline Level**	a. Initial aboveground standing live carbon stocks have been estimated correctly following the requirements of this methodology. b. The baseline analysis utilizes the correct value for common practice c. The project has undertaken the correct baseline analysis, according to whether initial carbon stocks are above or below common practice.	6.1, Assessment Area Data File, Appendix A	No
5. **Carbon Stock Modeling**	a. A 100-year forest management simulation of baseline standing live carbon stocks has been conducted in accordance with the requirements and guidance in Section 6.1.2 (see Section 9.4.4 for further confirmation guidance). b. Project scenario stocks have been projected using a 100-year forest management simulation of standing live carbon stocks in accordance with the requirements and guidance in Sections 6.2.1 and 6.5, including the restrictions on forest management described in the Conservation Easement.	6.1.2, 6.2.1, Appendix A	Yes. Professional judgement shall be based on review of growth model used and parameters (site class, mortality, regeneration, etc.) included.
6. **Harvest Volume**	a. The total volume of harvesting in the baseline has been derived from the growth and harvesting regime used to develop the baseline for onsite carbon stocks, following the requirements and guidance in Section 6.1 (see Section 9.4.5 for further confirmation guidance). b. The total volume of harvesting forecasted for the project has been derived from the growth and harvesting regime used to develop the forecasted project scenario simulation for onsite carbon stocks, following the requirements and guidance in	6.1, 6.2, Appendix A	No

	Section 6.2 (see Section 9.4.5 for further confirmation guidance).		
7. **Long-Term Storage in Wood Products**	a. The total amount of carbon expected to be transferred to wood products under the baseline and stored over the long-term (100 years) has been calculated following the requirements of Section 6.1 and guidance of Appendix A (see Section 9.4.5 for further confirmation guidance). b. The total amount of carbon expected to be transferred to wood products under the forecasted project scenario and stored over the long-term (100 years) has been calculated following the requirements of Section 6.2 and guidance of Appendix A (see Section 9.4.5 for further confirmation guidance).	6.1, 6.2, Appendix A	No
8. **Quantification of Primary Effect**	Calculations for the primary effect are complete and accurate for both onsite carbon stocks and harvested wood products.	6	No
9. **Quantification of Secondary Effects**	Calculations for quantifying secondary effects are complete and accurate.	6.3	No
10. **Approach to Quantification Conservative-ness**	Parameters used to model the forecasted project scenario reflect appropriately conservative values as outlined in Section 6.5, with oversight by a professional forester and a description of how parameters were determined included in the PIR. Standard deduction to accommodate for future resilience-related management activities has been applied properly. For projects involving a conservation easement that prohibits commercial harvesting of live trees, the increased standard deduction has been applied to reflect the elevated risk of natural disturbances,	6.5, 6.5.2	Yes, to review whether modeling parameters are reasonable

9.4.3 Confirming Carbon Inventories

Confirmation bodies are required to confirm carbon stock inventory estimates of all sampled carbon pools within the project area. Inventories of carbon stocks are used to determine the project baseline and to forecast GHG reductions and removals against the project baseline over time. Confirmation of carbon inventories consists of ensuring the project proponent's sampling implementation conforms to requirements listed in the methodology and that the Project's inventory sample plots are within specified tolerances when compared to the confirmation body's sample plots. Confirmation is effectively an audit to infer that the inventory estimate is sound. Confirmation of the project's initial onsite stocks must occur during the confirmation site visit and focus on ensuring that the project's inventory methodology is technically sound and has been correctly implemented.

The project must meet the inventory standards in Table 9.3 prior to the confirmation body initiating field sampling activities. The confirmation body will install sample plots or re-measure existing monumented sample plots consistent with the objectives of a random, risk-based, and efficient approach. In doing so, the confirmation body may weigh the probability of selecting strata and plots based on various criteria – including carbon stocking, access difficulty, and vegetation heterogeneity. Confirmation bodies may choose to sample project plots within a given stratum with a cluster design. The selection of a stratum may use probability proportional to carbon stocks or probability proportional to the risk of errors (as hypothesized by the confirmation body).

9.4.3.1 Sequential Sampling for Confirmation

As a policy to ensure a trend of agreement with sampled data is sustained between the confirmation body and project proponent, this methodology requires a sequential sampling method for confirmation of project estimates. Sequential sampling is intended to provide an efficient sampling method for the confirmation body to determine if randomly selected project measurements are within specified tolerance bounds established by the methodology.

Confirmation using the sequential sampling methodology requires the confirmation body to sequentially sample successive plots. Sequential approaches have stopping rules rather than fixed sample sizes. Confirmation is successful after a minimum number of successive plots in a sequence indicate agreement. Where the stopping rules indicate the potential presence of a bias, additional confirmation plots may be collected after that time if it is felt that random chance may have caused the test to fail and a convergence towards agreement is expected with additional confirmation samples. The results of any additional confirmation plot may also be inconclusive and require additional confirmation plots for a determination to be made. For effective application of the sequential statistics in the field, the determination of when the stopping rule is met is done when convenient for the confirmation team, which will include the full set of plots measured in that timeframe.

Worksheets are provided for use by confirmation bodies to assist in confirmation sampled data. Confirmation bodies will review the descriptive statistics of the carbon stocks for the standing live tree pool.

To increase efficiency in the confirmation process, three nested levels of sequential sampling are processed in the sequential sampling worksheets, based on a single sampling exercise performed by the confirmation body. All tests are performed with the same randomly selected plots and can only be completed by analysis of the plots in the sequential order they were randomly selected. However, inventory data is only considered successfully confirmed when the stopping rules for the CO_2e/acre test have been met. Passing the diameter and height tests (only applicable to paired sequential sampling) only improves the overall efficiency of the confirmation effort. The data identified below used for each test are input into the appropriate sequential sampling tool.

- CO_2e/acre: The testing of inventory data can only be satisfied when the CO_2e/acre comparison between the confirmation body and project proponent is completed. This test is conducted on a plot by plot basis using estimates of CO_2e/acre. The confirmation body's estimates of CO_2e/acre are derived by measurements of diameter and height (measured by confirmation body or using project proponent's data, as described below), species determinations, defect and decay determinations, and a determination of the appropriate trees to be included in the sample ("in" or "out" trees).

- Diameter Test (paired sequential sampling only): A comparison of diameter data between the confirmation body and the project proponent is conducted on a tree by tree basis until sequential sampling stopping rules have been achieved, indicating that the confirmation body and project proponent measurements of diameter are aligned within acceptable tolerance levels. If the stopping rule for diameter is met before the sequential sampling exercise has ended for CO_2e/acre, confirmation bodies may stop taking their own diameter measurements and may instead use the diameter data provided for each tree from the project proponent's database for any additional data inputs needed for the CO_2e/acre comparison. If this happens, the focus of the sampling exercise from that point on will be measuring height (if applicable, see below), making species determinations, defect and decay determinations, and "in" or "out" tree assessments.
- Height Test (paired sequential sampling only): Like the diameter test, a comparison of height data is performed between the confirmation body and the project proponent until sequential sampling stopping rules have been achieved, indicating that the confirmation body and project proponent measurements of height are aligned within acceptable tolerance levels. If the stopping rule for height is met before the sequential sampling exercise has ended for CO_2e/acre, confirmation bodies may stop taking their own height measurements and may instead use the height data provided for each tree from the project proponent's database for any additional data inputs needed for the CO_2e/acre comparison. If this happens, the focus of the sampling exercise from that point on will be measuring diameter (if applicable, see above), making species determinations, defect and decay determinations, and "in" or "out" tree assessments.

Separate worksheets have been developed to assess both monumented (paired) and non-monumented (unpaired) plots as well as for DBH, height, and CO_2e/acre. Worksheets are found on the Climate Forward website.[20]

The Reserve has established a ten percent allowance as an acceptable level of agreement between CO_2e/acre estimates of the confirmation body and the project proponent, without adjusting the project estimates for uncertainty.

9.4.3.2 Inventory Estimates

The items in Table 9.3 are evaluations that should be made before the confirmation body goes to the field and analyzes the plots. If a project opts to utilize the SIM, the methodology need not be assessed beyond correct implementation.

[20] https://climateforward.org/program/methodologies/mature-forest-management/

Table 9.3. Inventory Methodology Confirmation Items

Confirmation/Evaluation Standards	
1.a	Inventory methodology describes the methodology for plot location in the field. The plot locations are either random or systematic with a random initial point.
1.b	If inventory methodology describes a stratification design: The stratification methodology, including rules for stratification, is clearly defined. The stratification design is relevant for the sampling of biomass. In particular, the stratification design applies to all tree species without a bias for commercial tree species. Confirmation Body shall randomly select 10% of the vegetation units, or strata polygons, by area, or 500 acres (whichever is least) to evaluate that the vegetation (or stratum) label assigned to the polygon is consistent with the stratification rules documented in the inventory methodology. The selection shall be made from a database or spreadsheet list of all vegetation (stratum) polygons within the project area that have not experienced a harvest or disturbance that affects carbon stocks by more than 10%, using confirmation body judgment, within the past 10 years. Evaluation for consistency shall be conducted through comparison with aerial photos or other remotely sensed data, and/or field observation. During evaluation, a confirmation body must use professional judgment to determine if a polygon is consistent or inconsistent with the stratification rules. Inconsistent means the existing vegetation (stratum) label is grossly incorrect to an extent that would substantially alter the associated carbon stocks. If more than 10% of the polygons evaluated are determined to be inconsistent with the stratification rules documented in the inventory methodology, the confirmation shall expand the assessment to an additional 10% of the vegetation units (stratum polygons), or an additional 500 acres (whichever is least) and expand the analysis or determine that the project has failed to meet the standard.
1.e	The inventory methodology describes the volume and biomass equations used to compute the project's carbon stocks and these equations are consistent with those required by this methodology. Appropriate use of biomass equations is demonstrated. The carbon tonnes per acre, computed using the project proponent's calculation tools, replicate output computed by the confirmation body. All conversions and expansions are accurate.

Each applicable pool/combination of pools must meet the minimum precision threshold of +/- 20 percent at the 90 percent confidence interval.

Use of the SIM (available on the Climate Forward website[21]) will be considered to automatically meet the evaluation standards in Table 9.3 and does not need to be confirmed beyond ensuring proper implementation. The Reserve has also developed CARIT, an inventory management computer application that project proponents may also optionally use to manage their forest inventories. The use of the SIM does not obligate a project proponent to use CARIT, nor does the use of CARIT obligate a project proponent to use the SIM. However, CARIT will only

[21] https://climateforward.org/program/methodologies/mature-forest-management/

function properly if certain inventory standards are followed. Refer to Appendix A for more information.

9.4.3.3 Measurement Specifics for Confirmation Body

Confirmation bodies must use the highest standard to conduct measurements during field measurements because the confirmation bodies' measurements have precedence. Measurements utilized by confirmation bodies during field inspections shall be consistent with the tolerance standards for measurements identified in Appendix A, with the following exceptions:

1. Confirmation bodies shall measure the heights of all trees, unless stopping rules are achieved as described above, according to the height measurement used for the species-specific biomass equation on the Climate Forward website for comparison with project proponent's values. Confirmation bodies shall not use regression equations to generate height measurements.
2. Tools and methods used for distance measurements for plot boundaries should be accurate within 1"/30'.
3. Tools and methods used for distance measurements for height measurements must be able to obtain an accuracy of 6"/100'.
4. All borderline trees should be measured to determine status as an 'in' or 'out' tree.
5. Confirmation bodies shall insert their own determination of species for each tree included in the confirmation body's inventory.
6. For defect and decay, confirmation bodies may first consider the inputs of the Forest Owner and determine whether they were reasonable. If considered reasonable, the confirmation body may insert the same classification as the Forest Owner for each tree included in the confirmation body's inventory. If, however, not considered reasonable, or not recorded by the Forest Owner, the confirmation body shall insert its own determination.

9.4.3.4 Confirming a Stratified Inventory

If the project proponent's inventory is based on a stratified design, confirmation shall be based on the measurement error that can be assessed at the stratum level, using the sequential sampling tools developed by the Reserve. Individual plots within the strata selected for assessment shall be selected randomly. The confirmation body shall perform independent assessments on a minimum of three strata, unless the stratification design has less than three strata, in which case the assessment is conducted on two strata. Confirmation bodies shall select the strata used to perform the assessment based on their own professional judgement of where the risks of measurement error are likely to have the biggest effect on the overall inventory estimate. This may be based on criteria related to:

- Carbon stocking levels
- Area of a particular stratum relative to other strata
- Strata that may be found in difficult to access areas due to remoteness or terrain which could lead to a reduced effort by forest inventory personnel

9.4.3.5 Confirming a Non-Stratified Inventory

If the project is not stratified for each applicable pool, the confirmation body shall select the plots randomly (if plot center can be located) or allocate the plots systematically or in clusters for

efficiency. Plots may be measured and assessed one at a time or in reasonable batches that correspond to logistical realities of fieldwork.

9.4.3.6 Confirmation Within Strata

Plots must also be independently selected using a random or systematic design. The project passes sequential sampling when the minimum number of passing plots in sequence is achieved (as identified in Table 9.4), or the first passing plot after a minimum of 12 plots (paired) or 30 plots (unpaired) have been measured – whichever is achieved first.

Table 9.4. Number of Passing Plots in Sequence, as a Function of Project Size

Test	Number of Strata Confirmed	Project Acres				
			<100 – 500	501 - 5,000	5,001 – 10,000	>10,000
Paired/Unpaired	3		3	4	5	6
	2		4	6	8	10
	1		8	10	12	12

There are two possible statistical procedures that can be applied to the stratum-level confirmations. A paired test can be applied when plot locations can be found and it is statistically appropriate to use a paired test (i.e., plot measurements can be replicated). An unpaired test can be applied when plots cannot be relocated. The range of acceptable error (***δ*, delta**) is fixed at ten percent for both tests.

Paired Plots

The statistical test is based on a comparison of the confirmation body's measurements of plots within a selected stratum, calculated as CO_2e compared to the project proponent's measurements of plots, which may include any adjustments for growth.

Use α**=0.05** and β**=0.20** to control for error.

The null hypothesis (H_0) is that the confirmation and project plots are equal.

1. Perform confirmation sampling on at least the minimum number of passing plots required in a sequence from Section 9.4.3.4.

2. If $n \geq ((Z_\alpha + Z_\beta)^2 \times S_n^2) / D^2$ then stop and evaluate. Otherwise take another sample.

   Where,
   n = Number of confirmation plots measured
   $Z_\alpha = \alpha\%\ N(0,1) = 1.645$
   $Z_\beta = \beta\%\ N(0,1) = 0.8416$
   S_n^2 = sample variance of the differences
   $D = \delta \times$ project average estimate

3. If stopped, then evaluate.

   If $\bar{X}_N \leq K$ then accept H_0,
   If $\bar{X}_N > K$ then reject H_0.

Where,
$\bar{X}_N$ = sample mean of the differences
N = total number of plots measured
$K = (Z_\alpha \times D) / (Z_\alpha + Z_\beta)$.

4. If H_0 was rejected, then additional samples may be taken as long as the confirmation body is of the opinion that there is a chance that H_0 may be accepted based on the variability and trend observed.

Unpaired Plots

The statistical test is based on comparing the average CO_2e estimates for each stratum from the confirmation body's plots to the project proponent's plots.

Use $\boldsymbol{\alpha}$**=0.05** to control for error; the β is not specified because we are constructing a confidence interval not a test. The null hypothesis (H_0) is that the confirmation and stratum averages are equal. The following procedure is appropriate for the unpaired test.

1. Perform confirmation sampling on at least the minimum number of plots required in a sequence from Section 9.4.3.5. Calculate *n* as the sum of the number of plots from both the stratum and the confirmation.

2. Calculate the following:

$$T_n = \bar{X}_P - \bar{X}_n$$

Where,
T_n = the difference between the means
$\bar{X}_P$ = stratum mean,
$\bar{X}_n$ = confirmation mean after sample n.

3. If $\boldsymbol{n \geq (a^2/D^2) \times (S_n^2 + S_P^2)}$ then stop and evaluate. Otherwise take another sample.

Where,
$n = n_p + n_v$
a = the percentile from a standard normal distribution for one half of alpha; 1.96 for α=0.05
S_n^2 = sample variance of the confirmation plots
S_P^2 = sample variance of the stratum plots
$D = \delta \times$ stratum average estimate

4. If stopped, then evaluate. Construct a confidence interval $T_n \pm D$.
If the confidence interval includes zero then accept H_0,
Otherwise reject H_0.

5. If H_0 was rejected, then additional samples may be taken until as long as the confirmation body is of the opinion that there is a chance that H_0 may be accepted based on the variability and trend observed.

If the stopping rule in step (3) above cannot be attained within 100 plots then apply a standard unpaired t-test comparison using α**=0.05** and β**=0.80**.

9.4.3.7 Determining if the Stopping Rules Have Been Met

The confirmation body must determine if the stopping rules have been met for each stratum as soon as is convenient for the confirmation body. The Reserve provides tools to assist confirmation bodies with determining if the stopping rules have been met or not. The tools are Microsoft Excel based and are distinct for paired designs and for unpaired designs.

The confirmation body must enter their data into the appropriate spreadsheet based upon use of a paired or unpaired test. It is required that the confirmation body apply the random order selection in the sampling process. The confirmation body is free to measure the set of plots that were randomly selected in any order that provides the greatest efficiency while sampling in the field, but when the confirmation body inputs data into the spreadsheet, the confirmation body must follow the random selection order in order to properly conduct the analysis and maintain the integrity of sequential analysis. This may provide significant efficiencies when selected stands and/or plots are in close geographic proximity and it is hypothesized that the stopping rules will require the full number of plots.

The statistical test is based on a comparison of the confirmation body's measurements of plots, calculated as CO_2e per acre compared to the Forest Owner's measurements of plots, which may include any adjustments for growth. The inventory confirmation is complete based on the stopping rules detailed in Section 9.4.3.1. Passing of the plot height and/or diameters (DBH) is not required to pass the inventory confirmation; however, as discussed above, confirmation bodies may separately compare their measurements for height and diameter with the Forest Owner's measurements in the sequential sampling tool. When those inputs have met the sequential sampling requirements, confirmation bodies shall use the height and diameter data provided for each tree from the Forest Owner's database for any additional data inputs needed for the CO_2e/acre comparison.

9.4.4 Baseline and Forecasted Project Stock Estimation

Confirmation bodies are required to confirm the baseline and forecasted project stock estimates for MFM projects. Baselines and forecasts of project stocks include assumptions about forest growth and harvest, as influenced by legal and financial constraints, as well as assumptions regarding the extent of harvest operations under "business as usual" conditions (for the baseline) or regarding how harvests are constrained by the terms of the conservation easement (for project stock forecasts), as described in Section 6.

All reports that reference carbon stocks must be submitted by the project proponent with the oversight of a Professional Forester, as described in Section 8.1.

Table 9.5 shows specific items that must be confirmed. A summary of these items must be included in the PIR.

Table 9.5. Modeled Baseline and Forecasted Project Stocks Confirmation Items

Confirmation Items		Section of Methodology	Apply Professional Judgment?
1. **Document**	A modeling document exists that contains all the confirmation items in this table.	8	No
2. **Qualitative Characterization**	A sufficiently detailed qualitative characterization has been included in the modeling document that documents the general assumptions of the project's baseline and forecasted project projection. The qualitative assessment addresses the vegetative conditions and activities that would have occurred.	6.2	Yes
3. **Model Choice and Calibration**	a. The model used is an approved model. b. The project proponent has provided a rationale for any model calibrations or a sufficient explanation of why calibrations were not incorporated. c. The project proponent has provided, with the oversight of a professional forester, a description of the site indexes used for each species and the basis for each value, citing relevant supporting information, such as inventory measurements, soil maps covering the project area, and/or the site classes indicated in past harvest plans on the project area,. d. Reported crown ratios are reasonably accurate, based on the weighted average of the crown ratios reported for sequential sampling plots being no more than 10% greater than the confirmation body's estimate. e. Mortality function of the model used is demonstrated as being used, with default rates applied.	6.5, Appendix A	Yes
4. **Legal Constraints**	A list of legal constraints is provided that includes an accurate description of the type and effect of each constraint on the ability to harvest trees and the area constrained.	3.3.1, 6.1.2, 6.2.1	Yes
5. **Financial Constraints**	a. A sufficient qualitative description is provided indicating that the harvesting activity modeled in the baseline is a financially viable activity. b. The project proponent has provided a financial analysis of the anticipated growth and harvesting regime for the baseline that captures all relevant costs and returns, taking into	3.3.2, 6.1.2, 6.2.1	Yes

Confirmation Items		Section of Methodology	Apply Professional Judgment?
	consideration all legal, physical, and biological constraints.		
6. **Silviculture Guidelines**	The silviculture guidelines incorporated in the model demonstrate all legal constraints and Conservation Easement terms (for forecasted project stock modeling) are applied appropriately. The silviculture guidelines must include: i. A description of the trees retained by species group (commercial vs. non-commercial) ii. The level of retention iii. Harvest frequency iv. Regeneration assumptions v. Any other variables included in the conservation easement for forecasted project stock modeling.	Appendix A	No
7. **Modeling Guidelines**	Modeling is conducted per Section 6.1 (for baseline) and Section 6.2 (for forecasted project scenario).	6.1, 6.2	No
8. **Modeling Outputs**	a. The project proponent has provided reports that display periodic harvest, inventory, and growth estimates for the entire project area for both baseline and forecasted project stocks, presented as total carbon tonnes and carbon tonnes per acre. b. Estimates are within the range of expected growth patterns for the project area.	8, Appendix A	Yes

9.4.5 Confirming Estimates of Carbon in Harvested Wood Products

Confirmation bodies are required to confirm the estimates of carbon that are likely to remain stored in wood products over a 100-year period, as submitted in the PIR for both baseline estimates and for project stock forecasts under terms of the conservation easement.

Table 9.6. Carbon in Harvested Wood Products Confirmation Items for Both Baseline and Forecasted Project Stocks.

Confirmation Items		Section of Methodology	Apply Professional Judgment?
1. **Carbon in Harvested Wood Delivered to Mills**	a. Amount of wood harvested that will be delivered to mills has been estimated and reported. b. The appropriate wood density factor has been applied and/or water weight subtracted to result in pounds of biomass with zero moisture content. c. Total dry weights for all harvested wood have been calculated. d. Total carbon weight has been computed. e. The total has been converted to metric tons of carbon.	Appendix A	No
2. **Account for Mill Efficiencies**	The correct mill efficiency factors have been used to calculate total carbon transferred into wood products.	Appendix A	No
3. **Wood Product Classification**	The percentages of harvest by wood product class has been determined correctly with confirmed reports from the mill(s) where the project area's logs are sold; or by looking up default wood product classes for the project's Assessment Area(s); or if not available from either of these sources, by classifying all wood products as "miscellaneous."	Appendix A	No
4. **Calculation of In-Use and Landfill Carbon Storage**	a. The amount of carbon stored in in-use wood products over 100 years has been calculated correctly using the worksheets referenced in Quantification Guidance. These values are summed across the entire crediting period for both the baseline and forecasted project harvesting. b. If applicable, the amount of carbon stored in landfilled wood products over 100 years has been calculated correctly using the worksheets referenced in Quantification Guidance. These values are summed across the entire crediting period for both the baseline and forecasted project harvesting.	Appendix A	No
5. **Total Average Carbon Storage in Wood Products Over 100 Years**	Total average carbon storage in wood products over 100 years for harvest volume has been calculated and reported for both the baseline and forecasted project harvesting.	Appendix A	No

9.5 Completing Confirmation

The Climate Forward Confirmation Manual provides detailed information and instructions for confirmation bodies to finalize the confirmation process. It describes completing a Confirmation Report, preparing a Confirmation Statement, submitting the necessary documents to Climate Forward, and notifying the Reserve of the project's confirmed status.

10 Glossary of Terms

Additionality	Project activities that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the carbon cycle (i.e., fossil fuel destruction, de-forestation, etc.).
Assessment area	A distinct forest community within geographically identified ecoregions defined by the Reserve that consists of common regulatory and political boundaries that affect forest management. The size of the assessment areas is determined by efforts to achieve optimal statistical confidence across multiple scales using U.S. Forest Service Forest Inventory and Analysis Program (FIA) plots for biomass. Maps of the assessment areas and the associated data may be found on the Climate Forward website.[22]
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2-equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Confirmation	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions
Confirmation body	An organization or company that has been ISO-accredited and approved by the Reserve to perform GHG confirmation activities for this forecast methodology.
Conservation easement	For the purposes of this forecast methodology, a deeded title interest granted in perpetuity to an eligible land trust, with terms relating to forest management in conformance with the requirements outlined in Section 2.1. The easement must outline the general monitoring obligations of the land trust, as well as identify remedies should a violation of the terms of the easement be identified during easement monitoring.
Crediting period	The amount of time in years that project benefits can be calculated as applied to the project's baseline.
Direct emissions	GHG emissions from sources that are owned or controlled by the reporting entity.
Effective Date	The date of adoption of this methodology by the Reserve: March 24, 2020.

[22] https://climateforward.org/program/methodologies/mature-forest-management/

Eligible Land Trust	A nonprofit corporation described in sections 501(c)(3), 509(a)(1), and 170(h) of the Internal Revenue Code of 1986, as amended, and the regulations promulgated thereunder, 26 U.S.C. §§ 501(c)(3), 509(a)(1), and 170(h). Authorized to acquire and hold title to interests in real property under the laws of the state in which the project is located. An Eligible Land Trust must be accredited through the Land Trust Alliance.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Forecasted Mitigation Unit (FMU)	The unit of mitigation credits used by the Reserve's Climate Forward Program. One FMU represents one metric ton of carbon dioxide equivalent (CO_2e) expected to be reduced or sequestered.
Forest carbon	The carbon found in forestland resulting from photosynthesis in trees and associated vegetation, historically and in the present. Forest Carbon is found in soils, litter and duff, plants and trees, both dead and alive.
Forest Owner	See description in Section 2.2.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Metric ton (t, tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 28, consisting of a single carbon atom and four hydrogen atoms.
Mobile combustion	Emissions from the transportation of employees, materials, products, and waste resulting from the combustion of fuels in

	company owned or controlled mobile combustion sources (e.g., cars, trucks, tractors, dozers, etc.).
Professional Forester	A professional engaged in the science and profession of forestry. A professional forester is credentialed in jurisdictions that have professional forester licensing laws and regulations. Where a jurisdiction does not have a professional forester law or regulation then a professional forester is defined as having the Certified Forester credentials managed by the Society of American Foresters (see www.certifiedforester.org).
Project Area	The area inscribed by the geographic boundaries of an MFM project, as defined following the requirements in Section 4 of this methodology. Also, the property associated with this area.
Project baseline	The level of GHG emissions, removals, and/or carbon stocks at sources, sinks or reservoirs affected by an MFM project that would have occurred under a ”business as usual” scenario. For the purposes of this protocol, a project’s baseline must be estimated following standard procedures in Section 6.
Project Implementation Report	The primary document used by a project proponent to describe how the MFM project meets eligibility requirements, quantifies carbon stock estimates, and complies with terms for additionality. It also identifies how forest management, as guided by the terms of the conservation easement, will increase carbon stocking on the project area during the crediting period.
Project proponent	An organization or individual that registers mitigation projects for the purpose of generating emission reductions or removals. In the Reserve software system, project proponents may be issued FMUs for the confirmed emission reductions or removals that their mitigation projects achieve. They can also transfer and manage FMUs.
Timber Harvest Plan	A document that addresses environmental impacts and timber harvest operations submitted to state government agencies with regulatory oversight of forestry for review. In California, Timber Harvest Plans are considered functionally equivalent to the environmental analysis and review conducted as part of California Environmental Quality Act compliance. Timber Harvest Plans must be submitted by Professional Foresters, who are also responsible for the implementation of the plan. Once approved, the document provides implementation guidelines for harvest activities.

Appendix A Quantification Guidance for MFM Projects

This appendix provides guidance for quantifying a Mature Forest Management (MFM) Project's onsite carbon stocks and carbon in harvested wood products, both for purposes of estimating a project's baseline as well as providing estimates of forecasted project carbon stocks throughout the project's crediting period.

A.1 Reporting Requirements for Forest Carbon Pools

Onsite forest carbon pools are broadly grouped into living biomass, dead biomass, and soils. Living biomass includes biomass in live trees and shrubs and herbaceous understory (live non-tree biomass). Onsite dead biomass includes biomass in dead trees, lying dead wood, and litter. Offsite dead biomass includes harvested wood products.

For standardized reporting, all estimates of forest carbon stocks must be provided in terms of metric tons (tonnes) of CO_2-equivalent (CO_2e) on a project and a per acre basis. Unless otherwise required in the referenced biomass equations, the following conversion formulae shall be used:

Base Unit	Conversion		Final Unit
Biomass	0.5 **x** biomass		Carbon
Carbon	3.667 **x** carbon	=	CO_2e
Pounds	lbs **/** 2204.6		Metric tons or tonnes (t)
Acres	0.404686 **x** acres		Hectares

Reporting requirements vary for each of the carbon pools. The estimates for the pools that are derived from sampling must meet the quality standards described later in this document. Table A.1 displays the reporting requirements for each of the carbon pools.

Table A.1. Reserve Requirements for Carbon Pool Categories and Determination of Value for Pool

Category	Carbon Pool	Reporting Status
Living Biomass	Live Trees	Required for project reporting
	Shrubs and Herbaceous Understory	Not allowed for project reporting
Onsite Dead Biomass	Standing Dead Trees	Not allowed for project reporting
	Lying Dead Wood	Not allowed for project reporting
	Litter	Not allowed for project reporting
Soil	Soil	Not allowed for project reporting
Offsite Dead Biomass	Harvested Wood Products	Required for project reporting

A.2 Guidance for Estimating Carbon in Forest Carbon Pools

This section describes requirements for the development of values for the forest carbon pools described in Table A.1. Project proponents must include an inventory methodology in the Project Implementation Report (PIR). The inventory methodology must include the required provisions identified in this section.

A.2.1 Inventory Methodologies

All inventory methodologies must be based on randomized or systematic sampling and include the minimum quality parameters described in this section for each carbon pool. Inventory methodologies must describe the process for locating sample plots. Sample plot locations may be monumented in such a way to assist in relocating them for quantification and confirmation purposes. Plot monument strategies that incorporate Global Positioning Systems (GPS) along with additional navigational strategies at close range to plot centers (that direct confirmation bodies to the precise plot location) that are resistant to weather, wildlife, and other environmental factors, can substantially reduce confirmation costs. Project proponents are advised to consider the confirmation guidance (Section 9 of the MFM methodology) associated with confirmation of sampled carbon pools (in particular, the sequential sampling guidance) prior to settling on a strategy to monument plot locations.

To increase the efficiency of both project development by project proponents and confirmation by confirmation bodies, the Reserve has developed a Standardized Inventory Methodology (SIM) that project proponents may optionally use to determine how to collect sample data. The SIM is available on the Climate Forward website[23] and draws on observations about the standards and methodologies that have performed well for registered forest carbon projects. Designed in consultation with experienced project developers, verifiers and forest mensuration experts, it was created in consideration of a variety of factors, such as being suitable for use in a variety of forest conditions, achieving consistent results in consecutive plot measurements, and minimizing ambiguity in interpretation of conditions in the field.

Additionally, the SIM was developed to be consistent with the Climate Action Reserve Inventory Tool (CARIT), an inventory management computer application that project proponents may also optionally use to manage and update their forest inventories. CARIT is available on the Climate Forward website at no cost. With CARIT, project proponents will be able to manage forest inventories and calculate timber and carbon stocking. The volume and biomass equations required by the MFM methodology are already programmed into CARIT, eliminating the need for project proponents to apply such equations on their own and ensure they are correctly applied. Additionally, CARIT generates reports that are tailored specifically to the reporting requirements of the MFM methodology.

The use of the SIM does not obligate a project proponent to use CARIT, nor does the use of CARIT obligate a project proponent to use the SIM. However, CARIT will only function properly if certain inventory standards are followed. For example, only fixed area plots may be used—variable radius plots are not allowed.

A.2.2 Requirements for Estimating Carbon in Standing Live Trees

It is required that both standing live trees be sampled.

Inventory methodologies must include a description of the process for archiving sampled data, consistent with the MFM methodology's record retention requirements, and the analytical tools that will be included in the analysis of carbon stocks. The tree lists that are developed from inventory sampling and used to expand inventory estimates to the project level must be available for confirmation review. It is acceptable for the tree list to be presented and reviewed in an electronic format, such as in a database or spreadsheet application. Table A.2 displays the requirements that all project inventory methodologies must include for standing live trees.

[23] https://climateforward.org/program/methodologies/mature-forest-management/

Table A.2. Requirements for Sampling Standing Live Trees

Species	1. All trees sampled must include a species identifier. The inventory methodology must provide a crosswalk between any codes used to identify a species and the species name the codes represent. 2. Since all trees contain carbon, the inventory methodology must indicate that the sample methodology will include all species present within the project area.
Diameter at Breast Height (DBH) Measurements	1. Inventory estimates must include all trees 5 inches DBH and larger. It is acceptable that inventory methodologies include trees with DBH less than 5 inches. 2. The location of the measurement of DBH must follow U.S. FIA sampling guidelines (can be found on the Climate Forward website). 3. Measurement precision must be no greater than the nearest inch.
Height	1. Inventory methodology must describe whether all trees on sample plots are measured for height or whether a subset of the sample plot heights is measured and regression estimators are developed for unmeasured heights. 2. Inventory methodology must describe whether height measurements describe the tree's total height or some other top height measurement (regression estimators, or published form equations, may also be used to estimate top heights from a partial height or vice versa). Where regression estimators are used for tree heights, the inventory methodology must describe the populations from which the regression estimators were acquired. 3. If site indexes for project modeling are based on site tree measurements, the inventory methodology must describe site tree selection requirements and measurement procedures. Site indexes are not required to be based on measured site trees under the MFM Methodology, though project proponents should keep in mind that a description of information sources for site indexes used for project modeling must be provided for confirmation. 4. The sampling precision for tree heights (when measured) and crown ratios must be stated in the inventory methodology. Stated acceptable precision for standard measured heights not to be greater than +/- 10 feet and for measured heights of site trees, if applicable, not to be greater than +/- 5 feet. 5. The inventory methodology must include a description of the maximum angle accepted for measuring tree heights. The stated maximum acceptable slope to the measured height shall not exceed 120 percent.
Weight (Plot Area and Forest Strata)	1. All methodologies must describe the sample plot areas used to determine which trees are included for measurement. 2. All tree lists must include a field(s) that displays the weighting of each sampled tree in order to expand the sampled tree to a per acre value. 3. Where inventories are stratified, the governing rules for stratification and stratification methodology must be described. 4. Where inventories are stratified, stratum areas must be provided at confirmation with maps and tabular outputs.
Biomass Equations	1. All projects must calculate the biomass in each tree using the biomass equations provided by the Reserve (available on the Climate Forward website). 2. The project's inventory methodology must include a list of the equations and cite the version of the Reserve's equation file from which they were copied. a. CARIT (optional) includes approved biomass equations to reduce the burden of confirmation.

Deductions for Missing Biomass	1. Live trees may have cavities, broken tops or other deformities that reduce the biomass in the trees. Therefore, the inventory methodology must include a description of how deductions are estimated to account for missing biomass. The Reserve has provided guidance below that is acceptable. Alternative methods that address deductions for missing biomass are subject to approval by the Reserve.

A.2.3 Use of Regression Equations

It is acceptable to develop carbon inventories using regression estimators to estimate tree heights. Project proponents must keep in mind that plots or (sub) populations will be randomly selected for confirmation and that regression estimators should be used where a high level of certainty can be developed from the estimators. Failure to do so will result in increased effort and cost to meet the standards of confirmation.

A.2.4 Forest Vegetation Stratification

Stratification is not required, but it may simplify confirmation and possibly lower the costs of confirmation. Where forest vegetation is stratified, inventory methodologies must describe the guidelines used for stratification. Traditional stratification decisions are usually based on species composition, forest stem size (DBH or height), and density. It is important that the stratification be relevant to sampling forest carbon. The minimum polygon size to which the stratification guidelines apply must be included in the methodology. A map of current forest strata must be included in the PIR.

A.2.5 Quantification of Carbon in Live Trees from Project Data

All projects must use the appropriate biomass equations for the assessment areas the project is located in. The required biomass equations are found on the Climate Forward website.[24] The calculation of CO_2e for each tree must be conducted in a manner that provides project estimates for:

- Whole tree biomass (roots, stump, bark, bole, top, and branches). Whole tree estimates are used to provide project totals and estimates of emissions associated with harvest activities.
- Bole biomass. The bole must be calculated when the bole portion of harvested trees are delivered to manufacturing facilities for processing. It is used as the basis for determining carbon persisting in long-term wood products.
- Aboveground portion (stump, bark, bole, top, and branches) used to compare project data to common practice statistics.

Projects outside of California, Oregon, Washington, Alaska, and Hawaii use estimators for non-bole portions of the tree referred to as the Component Ratio Method (CRM). The CRM must be used to compute the various portions of the tree mentioned above. Guidance for the use of the CRM is provided in the biomass equations section of the Climate Forward website.

Projects in California, Oregon, Washington, Alaska, and Hawaii must use the biomass equations provided on the Climate Forward website to calculate the aboveground portion of the trees. The Cairns equation (Equation A.1, Equation A.2, or Equation A.3) must be used to calculate CO_2e in the belowground portion of the trees (Cairns, Brown, Helmer, & Baumgardner,

[24] https://climateforward.org/program/methodologies/mature-forest-management/

1997) and must be applied at the plot level. The Cairns equation for the appropriate latitude for the project must be used:

Equation A.1. Belowground biomass for trees in California, Oregon, Washington (Temperate Equation for 26-50° Latitude)

BBD = exp[-0.7747 + 0.8836 x ln(ABD)]

Where,			Units
BBD	=	Belowground biomass density of standing live trees	tonnes/hectare
ABD	=	Aboveground biomass density of standing live trees	tonnes/hectare

Equation A.2. Belowground biomass for trees in Alaska (Boreal Equation for ≥51° Latitude)

BBD = exp[-0.8713 + 0.8836 x ln(ABD)]

Where,			Units
BBD	=	Belowground biomass density of standing live trees	tonnes/hectare
ABD	=	Aboveground biomass density of standing live trees	tonnes/hectare

Equation A.3. Belowground biomass for trees in Hawaii (Tropical Equation for 0-25° Latitude)

BBD = exp[-1.0587 + 0.8836 x ln(ABD)]

Where,			Units
BBD	=	Belowground biomass density of standing live trees	tonnes/hectare
ABD	=	Aboveground biomass density of standing live trees	tonnes/hectare

This estimate must be converted from biomass in tonnes per hectare to CO_2e in tonnes per acre using the conversions identified earlier in this guidance.

A.2.6 Adjustments to Standing Live Trees for Missing Volume

Standing live trees may be missing portions of the tree as the result of physical and biological disturbances. Tree biomass needs to be adjusted for missing parts to produce an improved estimate of the tree's biomass. The guidance in this section provides a standardized method to account for such biomass adjustments.

The first step is to estimate the gross biomass in the tree as if it were whole, using the biomass equations (the first step in the biomass and carbon calculations) provided on the Climate Forward website.[25] The tree's biomass is then adjusted based on the tree's 'net' biomass. To standardize, the tree is divided into four parts: top, middle, bottom (visually estimating the original disposition of the aboveground portion of the tree when it was alive and vigorous), and the belowground portion. The belowground portion must be calculated as it would for a normal, healthy tree, using the Cairn's equation. It is assumed that the belowground portion is intact and complete. The standardized percentages assumed to be in each aboveground portion of the tree are shown in Table A.3.

[25] https://climateforward.org/program/methodologies/mature-forest-management/

Table A.3. Assumed Percentages of Biomass in Each Aboveground Portion of the Tree

Tree Portion	Percent of Aboveground Tree Biomass
Top 1/3	10%
Middle 1/3	30%
Bottom 1/3	60%

An ocular estimate is made of the portion remaining in each section of the tree during field sampling. Deductions from gross volume are made for anything that reduces the tree's gross biomass, including breakage and cavities. The percentage remaining in each third is then summed to calculate the net biomass remaining in the tree, as shown in Table A.4 using a tree with a gross biomass of 0.1 tonnes CO_2e.

Table A.4. Example: Calculating Net Biomass in a Tree

Tree Portion	Percent of Tree Biomass	Gross Biomass	Percent Remaining in Tree	Net Biomass
	(from Table A.3)	(tonnes CO_2e) Percent of tree biomass **x** tree biomass		(tonnes CO_2e) Percent remaining in tree **x** gross biomass
Top 1/3	10%	10% **x** 0.1 **=** 0.01	0%	0.000
Middle 1/3	30%	30% **x** 0.1 **=** 0.03	50%	0.015
Bottom 1/3	60%	60% **x** 0.1 = 0.06	100%	0.060
Total Biomass				0.075

A.2.7 Total Onsite Carbon Stocks and Calculating the Confidence Deduction

To determine the GHG reductions and removals forecasted to be achieved by the project at the end of the crediting period, the carbon stocks in all of the relevant carbon sources, sinks, and reservoirs must be summed. The Reserve has developed an MFM Calculation Worksheet to assist in the reporting of relevant pools and calculation of FMUs. The worksheet is available on the Climate Forward website[26] in a bundle with the Harvested Wood Products Calculation Worksheet, and contains instructions for its use. The live tree pool is sampled and the mean estimate is used for reporting. The number reported for the live tree pool is adjusted based on the confidence in the estimate of the carbon. The sampling error is calculated for each of the sampled pools at the 90 percent confidence level and subsequently calculated as a percentage of the mean, using the following steps:

Step 1: Calculate the mean and the standard error[27] of the inventory estimate.

Step 2: Multiply the standard error by 1.645.

[26] https://climateforward.org/program/methodologies/mature-forest-management/

[27] Under certain circumstances, the finite population correction factor is normally required for the calculation of the standard error. As a conservative measure, Project Proponents may opt not to apply the finite population correction factor.

Step 3: Divide the result in Step 2 by the total inventory estimate and multiply by 100. This establishes the sampling error (expressed as a percentage of the mean inventory estimate from field sampling) for a 90 percent confidence level.

The per-acre unit must be expanded to the project area based on the number of acres in the project. The onsite CO_2e tonnes for the project is input into the MFM Calculation Worksheet for reporting.

A.2.7.1 Applying a Confidence Deduction to Sampled Estimates

Any forest carbon inventory derived from sampling will be subject to statistical uncertainty. Where statistical confidence is low, there is an increased risk of overestimating a project's carbon stocks and therefore a higher risk of over-quantifying GHG reductions and removals. To help ensure that estimates of GHG reductions and removals are conservative, project proponents are required to apply a confidence deduction to the inventory of onsite carbon stocks forecasted for the end of the 100-year crediting period. A confidence deduction is *not* applied to the forest carbon inventory when it is used to model baseline carbon stocks. Confidence deductions are applied, where appropriate, to estimated onsite forest carbon stocks.

The target sampling error for the inventory estimate is +/- 10 percent of the mean at the 90 percent confidence level. Projects that cannot meet this target statistic are still eligible but may have to take a "confidence deduction" that reduces their net reported carbon stocks. The sampling error must be compared to Table A.5 to determine the confidence deduction. The percent deduction from the table below is input into the calculation worksheet which calculates the net reported onsite stocks.

Table A.5. Forest Carbon Inventory Confidence Deductions Based on Level of Confidence in the Estimate Derived from Field Sampling

Sampling Error (Percent of Inventory Estimate)	Confidence Deduction
0 to 10%	0%
10.1 to 19.9%	(Sampling Error – 10%) to the nearest 1/10 percentage
20% or greater	100%

A.2.8 Requirements for Calculating Carbon in Harvested Wood Products

A portion of the carbon in harvested trees continues to be sequestered for long periods of time as wood products. Standardized guidance is provided to account for forest carbon that remains sequestered in harvested wood products. The methodology bases the accounting of harvested wood products on the average amount of carbon sequestered over a 100-year period. The 100-year period is consistent with the methodology's definition of permanence. The average amount of carbon remaining sequestered over the 100-year period is determined by calculating the amount of carbon delivered to the mills, the portion of the carbon that is converted to wood products using a coefficient that estimates the mill's efficiency, and determining the wood product classes manufactured by the mill, as different wood products have different decay rates.

An estimate of the average carbon remaining in use over the 100-year term is provided for each wood product class, which is the basis of baseline and forecasted project reporting of harvested wood products. Furthermore, some wood products eventually end up in landfills where anaerobic conditions serve to reduce the rate of further decomposition. Since the amount of

harvested wood products that end up in landfills and the actual decay rate of the wood products in landfills are highly uncertain, the accounting of harvested wood products in landfills is included only when it is conservative to do so. Conservative in this case means that if, over the 100-year crediting period, the amount of harvested wood products in the baseline exceeds the amount of harvested wood products in the project activity, the carbon in landfills is reported. If there is more harvesting of wood products in the project case than in the baseline case, harvested wood products are not considered in either the baseline or the project case.

The Reserve has developed a spreadsheet tool to assist in the calculation of harvested wood products, which is available on the Climate Forward website.[28] The Harvested Wood Products Calculation Worksheet, bundled with the MFM Calculation Worksheet, contains step by step instructions for its use. The reporting of harvested wood products is based on periodic model outputs for both the baseline and the forecasted project across the 100-year crediting period. Default mill efficiencies and wood product classes must be applied to both the baseline harvested wood products and forecasted project harvested wood products.

The spreadsheet is designed with default values for converting volumetric units from logs delivered to mills to cubic feet and default values of mill efficiencies, on a geographic basis, which must be used.

A.2.9 Leakage

Secondary effects, or leakage, reflect market responses to changes in wood product production. The general assumption in this protocol is that modifying harvest in an MFM project relative to baseline harvesting levels will lead the market to compensate via modifications to harvesting levels by other landowners. The greater the change in harvest by an MFM project relative to baseline levels, the greater the response by the market to compensate.

Market leakage effects are accounted for under MFM projects by considering the impacts of shifting activities over the entire crediting period of the project. Recognizing that secondary effects from a project may be influenced by long term harvesting trends, the evaluation in Equation 6.5 of the MFM methodology considers cumulative harvest amounts from project inception to the end of the crediting period. Although secondary effects may be negative if forecasted project harvesting is below baseline harvesting, under no circumstances shall secondary effects be positive. If forecasted project harvesting exceeds baseline harvesting, secondary effects is zero.

A.3 Modeling Carbon Stocks

This methodology requires the use of certain empirical models to estimate the baseline carbon stocks and forecasted project stocks of selected carbon pools within the project area .

A.3.1 Models and their Eligibility for Use with Forest Projects

Empirical models are used to forecast the estimations derived from direct sampling into the future. Field measurements (standing live trees) provide the base input data for these models. Project proponents should be careful to ensure that all required data inputs for the models are included in the inventory methodology.

The models that simulate growth projections provide a critical function in the development and management of an MFM project. They project the results of direct sampling through simulated

[28] https://climateforward.org/program/methodologies/mature-forest-management/

forest management activity. These models, often referred to as growth and yield simulation models, may project information regarding tree growth, harvesting, and mortality over time – values that must ultimately be converted into carbon in an additional step. Other models may combine steps and estimate tree growth and mortality, as well as changes in other carbon pools and conversions to carbon, to create estimated projections of carbon stocks over time.

The following growth models have been approved:

- CACTOS: California Conifer Timber Output Simulator
- CRYPTOS: Cooperative Redwood Yield and Timber Output Simulator
- FVS: Forest Vegetation Simulator
- FPS: Forest Projection System
- FREIGHTS: Forest Resource Inventory, Growth, and Harvest Tracking System
- CRYPTOS Emulator
- FORESEE

The Reserve may include additional models following approval of a state forestry authority (i.e., a state agency responsible for oversight of forests) who will acknowledge in writing that the model:

- Has been peer reviewed in a process that 1) primarily involved reviewers with necessary technical expertise (e.g., modeling specialists and relevant fields of biology, forestry, ecology, etc.), and 2) was open and rigorous
- Is parameterized for the specific conditions of the project area
- Limits use to the scope for which the model was developed and evaluated
- Is clearly documented with respect to the scope of the model, assumptions, known limitations, embedded hypotheses, assessment of uncertainties, and sources for equations, data sets, factors or parameters, etc.
- Underwent a sensitivity analysis to assess model behavior for the range of parameters for which the model is applied
- Is periodically reviewed

A.3.2 Using Models to Forecast Carbon Stocks

The use of simulation models is required for estimating a project's baseline and forecasted project carbon stocks.

Standing live tree information must be incorporated into the simulation models to project carbon stocks over time. If a model has the ability to convert biomass to carbon, it must include all the carbon pools required by this methodology.

Projected baseline and forecasted project carbon stocks must be portrayed in a graph depicting time in the x-axis and carbon tonnes in the y-axis. Carbon stocks must be projected forward from the project's start date. The graph should be supported with written characterizations that explain any annual changes in baseline and forecasted project carbon stocks over time. These characterizations must be consistent with the baseline and forecasted project analyses required in Section 6 of the MFM methodology.

A.3.3 Modeling Requirements

A modeling plan must be prepared that addresses all required projecting of baseline and forecasted project carbon stocks for the project. The modeling plan shall contain the following elements:

1. A description of all silviculture methods modeled for the baseline and the forecasted project. The description of each silviculture method will include:
    a. A description of the trees retained (by species groups if appropriate) at harvest.
    b. The harvest frequency (years between harvests) for each silviculture method modeled.
    c. Regeneration assumptions.
2. A list of all legal constraints that affect management activities on the project area under both the baseline and the forecasted project scenarios. This list must identify and describe the legal constraint, how the legal constraint affects the project area, and discusses the silviculture methods that will be modeled to ensure the constraint is respected.
3. A description of the site indexes used for each species, an explanation of the source of the site index values used, and a description of the adjustment made to the site index values applied to the modeling of forecasted project stocks.
4. A description of the model used and an explanation of how the model was calibrated for local use, if applicable.

Modeling outputs must include:

1. Periodic harvest, inventory, and growth estimates for the entire project area presented as total carbon tonnes and carbon tonnes per acre.

Harvest yield streams on modeled stands, averaged by silviculture method and constraints, which must include the period over which the harvest occurred and the estimated CO_2e of wood (CO_2e in logs delivered to mills) removed.

CLIMATE FORWARD

Reforestation Forecast Methodology

Version 1.1 | May 15, 2020

A program of the CLIMATE ACTION RESERVE

Climate Forward, a program of the Climate Action Reserve
www.climateforward.org

Released May 15, 2020

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Table of Contents

Abbreviations and Acronyms 1
1 Introduction 2
1.1 About Forests, Carbon Dioxide, and Climate Change 3
1.2 Conceptual Approach to Quantifying GHG Removals from Reforestation Projects with *Ex Ante* and *Ex Post* Crediting Options 3
2 The GHG Enhancement Project 5
2.1 Project Definition 5
2.2 The Project Proponent 5
3 Eligibility Rules 6
3.1 Location 7
3.2 Project Start Date and Crediting Period 7
3.3 Additionality 8
3.3.1 The Performance Standard Test 8
3.3.2 The Legal Requirement Test 8
3.4 Environmental and Social Safeguards 9
3.5 Regulatory Compliance 9
3.6 Ownership and Double Counting 10
3.7 Project Resilience Measures 10
3.8 Ensuring Permanence 10
3.8.1 Tonne-Tonne Accounting 10
3.8.2 Tonne-Year Accounting 11
3.8.3 Conservative Crediting 14
3.9 Market Expansion Objective 15
3.10 Demonstration of *Ex Ante* Suitability 15
4 The GHG Assessment Boundary 16
5 Quantifying GHG Emission Removals 22
5.1 Estimating Baseline Carbon Stocks 22
5.2 Estimating Project Carbon Stocks 22
5.2.1 Basis for Estimates of Forecasted GHG Removals 22
5.2.2 Determining Gross Forecasted GHG Removals 24
5.3 Estimating Performance Decline 25
5.4 Estimating Abandonment Rates 25
5.5 Accounting for Secondary Effects 25
5.5.1 Combustion Emissions Associated with Machinery Use in Site Preparation 25
5.5.2 Activity-Shifting Leakage 26

6 Project Implementation and Monitoring 28
6.1 Quantification Parameters 28
6.2 Voluntary Ongoing Monitoring Incentive 28
7 Reporting and Record Keeping 30
7.1 Project Submittal and Confirmation Documentation 30
7.2 Record Keeping 30
7.3 Reporting and Confirmation Period 31
8 Confirmation Guidance 32
8.1 Standard of Confirmation 32
8.2 Confirming the Project Implementation Report 33
8.3 Core Confirmation Activities 33
8.3.1 Reviewing GHG Management Systems and Estimation Methodologies 33
8.3.2 Confirming Emission Enhancement Estimates 33
8.3.3 Undertaking Site Visits 33
8.4 Confirmation Items 33
8.4.1 Project Eligibility and Credit Issuance 34
8.4.2 Quantification 35
8.5 Completing Confirmation 37
9 Glossary of Terms 38
10 References 41
Appendix A Confirmation of Seedling Stocking 42
Appendix B Quantification of Brush Cover Removed as Part of Site Preparation Activities 45

List of Tables

Table 3.1. Basis for Determining Length of a Project's Crediting Period....13
Table 4.1. Description of all Sources, Sinks, and Reservoirs....16
Table 5.1. Example of Tonne-Year Values and Cumulative Crediting....23
Table 5.2. Example of Tonne-Year Values and Cumulative Crediting when Conservation Easement with Required RM Terms....24
Table 6.1. Project Implementation Parameters....28
Table 8.1. Eligibility Confirmation Items....34
Table 8.2. Quantification Confirmation Items....36

List of Figures

Figure 1.1. Relationship between Crediting in Climate Forward and the Reserve's Offset Program.... 4
Figure 3.1. Example of Gross FMUs that are Issued Based on Landowner Class or Conservation Easement Term Length for the Lodgepole Pine PWE Forest Community....14
Figure 5.1. Activity Shifting ("Leakage") Risk Assessment for Reforestation Projects....27
Figure A.1. Examples of the Application of the Uniform Plot Distribution Requirement....42
Figure B.1. i-Tree Canopy Startup Screen Step 1....46
Figure B.2. i-Tree Canopy Startup Screen Step 2....46
Figure B.3. Cover Class Configuration Screen....47
Figure B.4. Tree Benefit Valuation Screen....47
Figure B.5. Adding and Classifying Sample Points....48
Figure B.6. Adding Sample Points Until Standard Error Less Than +/- 10 Percent Achieved....49
Figure B.7. Saving Data in i-Tree Canopy....49
Figure B.8. Starting Over with i-Tree Canopy....50
Figure B.9. Loading Analysis Data for Comparison to Historical Imagery....50
Figure B.10. Exporting KMZ File....50
Figure B.11. Loading Re-Survey Project Data to Add More Sample Points....51

List of Equations

Equation 5.1. Calculating GHG Removals....22
Equation 5.2. Combustion Emissions Associated with Site Preparation for Each Forest Type....26
Equation 5.3. Emissions from Shifting Cropland and Grazing Activities....26
Equation 5.4. Total Secondary Effect Emissions....27

Abbreviations and Acronyms

CalFire	California Department of Forestry and Fire Protection
C	Carbon
CO_2	Carbon dioxide
CMAI	Culmination of mean annual increment
CRT	Climate Reserve Tonne
FIA	USFS Forest Inventory and Analysis
FMU	Forecasted Mitigation Unit
GHG	Greenhouse gas
t	Metric ton (or tonne)
Reserve	Climate Action Reserve
RM	Reforestation Methodology
SSR	Source, sink, and reservoir
USFS	United States Forest Service

1 Introduction

The Climate Action Reserve (Reserve) is an environmental nonprofit organization that promotes and fosters the reduction and removal of greenhouse gas (GHG) emissions through credible market-based policies and solutions. Based in Los Angeles, the Reserve is the foremost carbon offset registry in North America with internationally recognized expertise in project-level GHG accounting. The Reserve establishes regulatory-quality standards for the development and quantification of GHG emission reduction and removal projects; issues GHG emission reduction and removal credits for use in compliance and voluntary carbon programs; and tracks the transaction of credits over time in transparent, publicly accessible systems. Adherence to the Reserve's standards ensures that emission reductions and removals associated with projects are real, permanent, and additional, thereby instilling confidence in the environmental benefit, credibility, and efficiency of carbon markets.

Climate Forward, a greenhouse gas mitigation program of the Climate Action Reserve, provides a practical solution to companies and organizations seeking cost-effective mitigation of anticipated (i.e., future) operational and/or project related GHG emissions. Climate Forward facilitates investments in GHG reduction and removal activities that are practical, scientifically-sound, transparent, and aligned with forward-looking mitigation needs such as the California Environmental Quality Act (CEQA). Climate Forward will drive forward-looking investment into actions expected to result in GHG reductions, with a goal of expanding the scope and scale of feasible emission reduction and removal project types.

Climate Forward is designed to provide companies, organizations, developers, and other entities with a conservative, robust, and methodologically rigorous option to mitigate an estimate of expected GHG emissions, on a voluntary or compliance basis, using FMUs generated from mitigation projects under this program. Climate Forward fundamentally differs from existing carbon credit programs through its focus on projecting and crediting estimated emission reductions and removals on an *ex ante* basis.

Under Climate Forward, estimated GHG reductions and removals from the mitigation project are recognized as Forecasted Mitigation Units (FMUs), which are each equal to one metric ton of carbon dioxide equivalent (CO_2e) expected to be reduced or sequestered. FMUs can be retired for multiple purposes, including for CEQA mitigation or for other voluntary mitigation purposes.

The Reforestation Forecast Methodology (Reforestation Methodology, RM) provides guidance to account for, report, and confirm forecasted (i.e., *ex ante*) GHG emission removals associated with reforestation activities, or site preparation activities that encourage site occupancy by forest species. Project proponents that initiate RM projects use this document to quantify and register forecasted GHG emission reductions and removals with Climate Forward on an *ex ante* basis. The methodology provides eligibility rules and methods to calculate expected reductions and removals, performance-monitoring instructions, and procedures for reporting project information to Climate Forward. Additionally, a Project Implementation Report (PIR) will receive independent confirmation by a Reserve-approved confirmation body selected by the project proponent. Guidance for confirmation bodies to confirm reductions and removals is provided in the Climate Forward Confirmation Manual and Section 8 of this methodology.

This methodology is designed to ensure the complete, consistent, transparent, accurate, and conservative *ex ante* quantification and confirmation of GHG emission reductions and removals associated with RM projects.[1]

1.1 About Forests, Carbon Dioxide, and Climate Change

Forests have the capacity to both emit and sequester carbon dioxide (CO_2), a leading greenhouse gas that contributes to climate change. Trees, through the process of photosynthesis, naturally absorb CO_2 from the atmosphere and store the gas as carbon in their biomass, i.e., trunk (bole), leaves, branches, and roots. Carbon is also stored in the soils that support the forest, as well as the understory plants and litter on the forest floor. Wood products that are harvested from forests can also provide long-term storage of carbon.

When trees are disturbed, through events like fire, disease, pests or harvest, some of their stored carbon may oxidize or decay over time releasing CO_2 into the atmosphere. The quantity and rate of CO_2 that is emitted may vary, depending on the circumstances of the disturbance. Forests function as reservoirs in storing CO_2.Depending on how forests are managed or impacted by natural events, they can be a net source of emissions, resulting in a decrease to the reservoir, or a net sink, resulting in an increase of CO_2 to the reservoir. In other words, forests may have a net negative or net positive impact on the climate.

Through the protection of forests against conversion, sustainable management, and reforestation, forests can play a positive and significant role to help address global climate change. The Climate Forward Reforestation Forecast Methodology is designed to address the forest sector's unique capacity to sequester and store and to facilitate the positive role that reforestation activities can play to combat climate change and do so in an efficient manner to avoid the costs associated with previous approaches to reforestation activities within carbon markets.

1.2 Conceptual Approach to Quantifying GHG Removals from Reforestation Projects with *Ex Ante* and *Ex Post* Crediting Options

The conceptual approach to developing this methodology is based on the biological increase of carbon in trees that have been planted or become established naturally as part of a restoration activity on forestlands. Trees planted following a rotational harvest are not eligible for this methodology. *Ex ante* credits (credits issued prior to the carbon having been sequestered) are issued based on default growth projections to a future point prior to the trees being considered for regeneration harvest. The credit issuance for the *ex ante* approach is based on the value the sequestered carbon has provided in terms of mitigating climate warming effects according to the time-value of maintaining CO_2 out of the atmosphere (tonne-year accounting).

This accounting approach maintains assurances that the GHG benefits are real while providing an incentive to reforest trees by aligning some of the costs of reforestation with conservative crediting. Project proponents can opt to transition the project into the Climate Action Reserve's offset program under the Reforestation Protocol anytime and commit to ongoing monitoring, reporting, and verification for *ex post* crediting. Those choosing to transition to the Reserve's offset program may benefit financially by doing so. The timing of the transition will be determined by the landowner and will likely be when the estimated quantity of *ex post* credits is

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

adequate to justify the costs associated with monitoring and verification requirements in the offset protocol. *Ex post* credit issuances are based on accounting for the entire amount of carbon that has been sequestered for each monitoring period, which must be secured for the permanence period of 100 years (tonne-tonne accounting). Figure 1.1 displays the relationship between *ex ante* crediting in Climate Forward and *ex post* crediting in the Climate Action Reserve's offset program. Regardless a landowner's intent or actual decisions made for the future of the project, the RM is a Climate Forward methodology and limited to *ex ante* crediting.

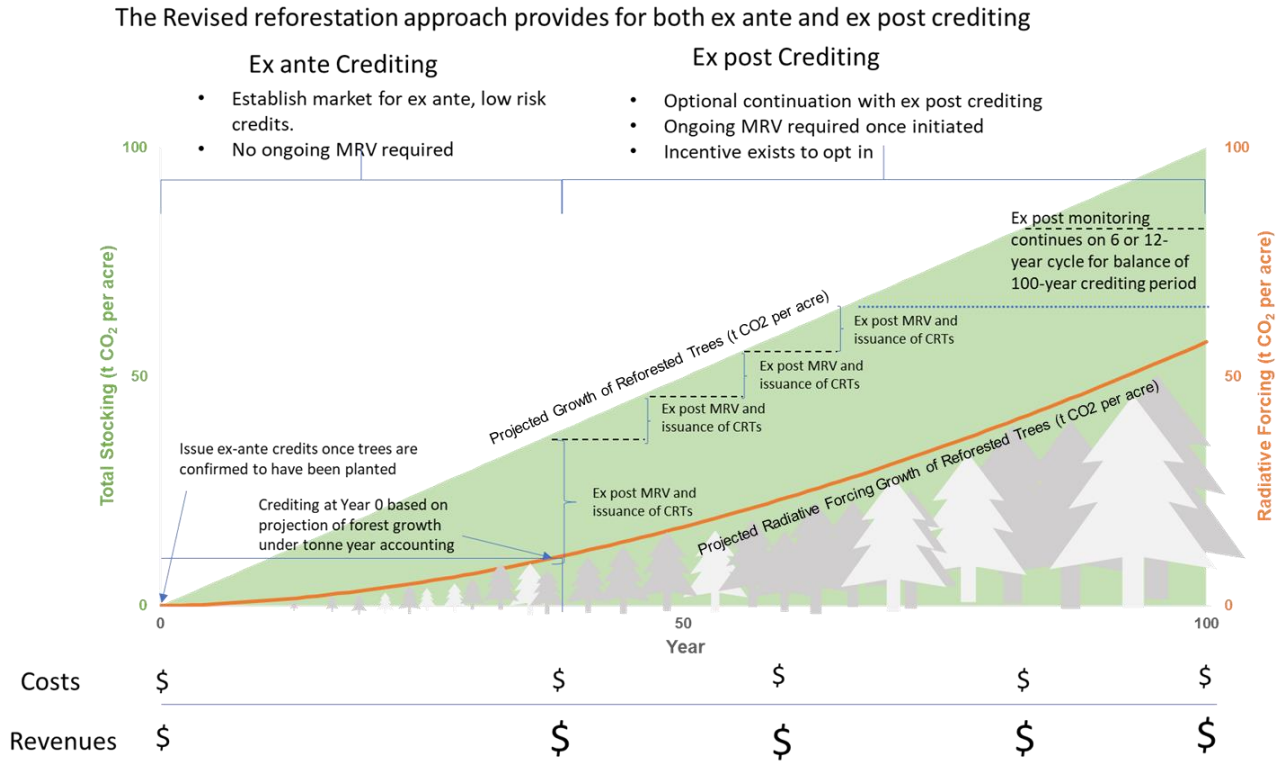

Figure 1.1. Relationship between Crediting in Climate Forward and the Reserve's Offset Program
The radiative forcing curve displays the time-value of CO_2 out of the atmosphere.

2 The GHG Enhancement Project

2.1 Project Definition

For the purposes of the RM, a reforestation project is a planned set of activities designed to increase removals of CO_2 from the atmosphere by the direct planting of trees, or site preparation activities that promote the natural regeneration of tree seedlings, resulting in forest growth that occurs above "business as usual" conditions. Implementation of reforestation activities are deemed successful under the RM if the project area is stocked with seedlings at a rate of 70 percent or greater at the time of confirmation, as described in Appendix A.

A glossary of terms related to reforestation projects is provided in Section 9 of this methodology (e.g., "site preparation").

In developing a reforestation project, the project proponent must prepare a Reforestation Project Goals Form[2] that addresses the site's need and suitability for reforestation and how the project will meet certain requirements described in this document. The Reforestation Project Goals Form must be included with a signature by a Professional Forester or Professional Ecologist with project submission documents. The elements required to be addressed in the Reforestation Project Goals Form are explicitly called out in this methodology.

All other reporting requirements must be submitted with the Reforestation Project Implementation Report (PIR) prior to confirmation. A template of the PIR is also available on the Climate Forward website. The Reforestation Project Implementation Report template provides a clear outline to the reporting requirements.

2.2 The Project Proponent

The "project proponent" is an entity that has an active account on the Climate Forward registry, submits a project for listing and registration with Climate Forward, and is ultimately responsible for all project reporting and confirmation. In all cases, the project proponent must attest to the Reserve that they have exclusive claim to the GHG removals resulting from the project. The assumption under this methodology is that the landowner owns the trees on the project area and therefore owns the GHG removals attributed to the project. At the time a project is confirmed, the project proponent must attest that no other entities are reporting or claiming (e.g., for voluntary reporting or regulatory compliance purposes) the GHG reductions or removals claimed by the project.[3] The Reserve will not issue FMUs for GHG reductions or removals that are reported or claimed by entities other than the project proponent.

The owner of the trees is usually the fee owner of the property, unless an easement or lease has been recorded that cedes timber ownership, or any part thereof, to a third party, in which case the specific legal agreement must be reviewed to determine ownership. If the project proponent is an entity that does not have any claim of ownership to the trees, an agreement transferring the claim to GHG removals resulting from the project must exist and be referenced in the Project Implementation Report, as well as be reviewed by the confirmation body. See Section 3.6 for additional information about FMU ownership and Section 8.4.1 for guidance around confirmation of this requirement.

[2] Available on the Reforestation Forecast Methodology webpage at https://climateforward.org/program/methodologies/reforestation/.
[3] A standard form for this attestation will be posted on the Climate Forward website at https://climateforward.org/program/program-and-project-forms/.

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to be registered with Climate Forward. The criteria only apply to projects that meet the definition of a GHG enhancement project (Section 2.1).

Eligibility Rule I:	Location	→	Geographic area for which eligible tree growth projections exist
		→	Project area requires intervention to re-establish tree cover, with low risk of conversion to non-forest uses
		→	Not on land previously registered as a project, unless the project was closed in good standing
Eligibility Rule II:	Start Date and Crediting Period	→	Submitted within one year of completion of planting or site preparation activities
		→	Crediting period varies by forest community, landowner class, and optional measures that provide long-term security to carbon stocks
Eligibility Rule III:	Additionality	→	Meet performance standard
		→	Exceed regulatory requirements
Eligibility Rule IV:	Environmental and Social Safeguards	→	Appropriate native tree species planted or regenerated
		→	No negative environmental and social impacts
Eligibility Rule V:	Regulatory Compliance	→	Compliance with all applicable laws
Eligibility Rule VI:	Ownership and Double Counting	→	Must not receive credits from more than one program, where GHG boundaries overlap
		→	Demonstrate ownership of rights to GHG emission reductions/removals from the project
Eligibility Rule VII:	Project Resilience Measures	→	Demonstrate by meeting project definition and location requirements
Eligibility Rule VIII:	Permanence	→	Determined by forest community, landowner class, and optional measures that provide long-term security to carbon stocks
Eligibility Rule IX:	Market Expansion Objective	→	Expand opportunities for GHG mitigation
Eligibility Rule X:	Demonstration of *Ex Ante* Suitability	→	Project activity must be suitable for *ex ante* crediting

3.1 Location

Projects can be initiated in any geographic area for which tree seedling growth projections have been developed in a scientifically rigorous manner and are published in the Reforestation Communities Data File (a separate document available on the Climate Forward website that displays eligible forest communities). Projects cannot take place on any part of an area where an existing or previously existing project was located that received any amount of financial recognition for climate benefits, unless the previous project has been closed in good-standing and with the written consent of the Reserve.

The project proponent must identify a project area as the geographic area where activities take place as defined in Section 2.1 and ensure that the entire area is eligible as described above. Projects may be composed of separate tracts or distinct polygons. Project acreage shall be based on area calculations derived from GIS analysis using software such as ArcGIS or Google Earth to delineate areas where reforestation activities have been implemented. Contiguous areas within the project area that are not conducive to seedling establishment (watercourses, roads, landings, bogs, rocky areas, etc.) and are larger than 1000 square feet or 1 percent of the project area, whichever is greater, must not be included within the project area.

The Reforestation Project Goals Form[4] provides a template for the Professional Forester or Professional Ecologist to address site aspects related to the area being reforested. The form must provide a description of why the project area is a site that requires intervention to achieve stocking levels that will allow it to trend toward forest cover, how the environmental characteristics are favorable for the establishment and growth of tree seedlings, and why it does not appear to be at a heightened risk of conversion to non-forest uses.[5] For project areas that are being reforested following a natural disturbance, the form must include a description of how the management action will enable the project area to trend toward previous forest conditions due to the intervention. The site selection section of the Reforestation Project Goals Form must be completed and submitted with the signature of a Professional Forester or Professional Ecologist at the time of project submission to provide assurance that these characteristics are met by the Project Site.

3.2 Project Start Date and Crediting Period

The project start date is the first date that trees have been planted or site preparation activities have been initiated for the natural regeneration of trees. The project start date can be no earlier than January 1, 2018.

The project submission must occur within one year of the project start date, with the exception of projects with a start date prior to the original release of this methodology (March 2, 2020), which must submit the project no later than March 1, 2021. However, project activities (planting or site preparation for natural regeneration) need not be completed before the project is submitted.

All projects that pass the eligibility requirements set forth in this methodology as of the project start date are eligible to register FMUs with Climate Forward for the duration of the project's crediting period. The crediting period is the period in which future projections of sequestered carbon are recognized for crediting purposes. This period varies by forest community, by

[4] Available on the Reforestation Forecast Methodology webpage at https://climateforward.org/program/methodologies/reforestation/.
[5] Guidance for these descriptions is provided in the Reforestation Project Goals Form.

landowner class, and by any additional protective measures that may secure future carbon tonnes, such as conservation easements, that contain explicit language related to the maintenance and enforcement of prescribed levels of sequestered carbon. The crediting periods are provided as reference values in the Reforestation Communities Data File, which is an annex to this methodology.

3.3 Additionality

Climate Forward registers only projects that yield surplus GHG reductions and/or removals that are additional to what would have occurred in the absence of the project.

Projects must satisfy the following tests to be considered additional:

1. The performance standard test
2. The legal requirement test

3.3.1 The Performance Standard Test

Projects pass the performance standard test by meeting a methodology-wide performance threshold – i.e., a standard of performance applicable to all prospective projects, established on an *ex ante* basis. The performance standard threshold represents "better than business as usual". If the project meets the threshold, then it exceeds what would happen under the "business as usual" scenario and generates additional GHG reductions.

The performance standard test is applied at the time of the project's start date. All projects that pass this test at the project's start date are eligible to register FMUs with Climate Forward for the duration of the project's crediting period, even if the performance standard changes after the project's start date.

Under this RM, the project area must not have been in a forest landcover for a period of at least ten years prior to the start date or must have been affected by a natural disturbance within the past 10 years that resulted in the forest canopy cover levels of live trees within the project area being less than 25 percent, as assessed on the project start date. It is understood that recently disturbed areas may have canopy cover levels greater than 25 percent in need of reforestation. Regardless of whether these areas are reforested or not during the planting effort, areas of contiguous forest canopy cover in excess of 4,356 square feet (1/10th acre) must be excluded from the project area.

3.3.2 The Legal Requirement Test

All project crediting must be based on GHG enhancements that are not legally required through regulation, conservation easement, contract, or any other legally binding requirement, excepting management obligations within conservation easements[6] with Required RM Terms used to secure long-term carbon specifically for this RM, which can defer legally binding requirements associated with the conservation easement with Required RM Terms until confirmation activities have been completed. Conservation easements that existed on the project area prior to the project being initiated and that neither prohibit nor require reforestation do not affect project eligibility. A legal obligation to reforest the project area site at any level renders the project ineligible. Such legal obligations include those that have been adopted but have not entered into

[6] Other deed restrictions or legally binding agreements that are maintained with the land in cases of ownership transfers are applicable in lieu of a conservation easement. The term "conservation easement" will be used throughout this methodology to represent any such legally binding restrictions on land use activities.

force yet, e.g., legislation that has been signed into law but does not take effect until after a later, specified date.

The legal requirement test is applied at the time of a project's start date. To satisfy the legal requirement test, project proponents must submit a signed Attestation of Legal Additionality form prior to the commencement of confirmation activities. In addition to the attestation, the Project Implementation Report must include a description of any laws that reference requirements to reforest the project area. Portions of the project area with requirements to reforest are not eligible. The confirmation body must confirm the Attestation of Legal Additionality by reviewing evidence provided by the project proponent, and any other evidence they feel is necessary such as literature reviews, independent expert testimony, or letters from relevant government agency representatives, or other means. All projects that pass this test at the project start date are eligible to register reductions or removals with Climate Forward for the duration of the crediting period, even if legal requirements change or new legal requirements are enacted during that period.

3.4 Environmental and Social Safeguards

Projects must support and/or enhance native ecosystems. Only projects that adhere to the objective of initiating a forest of diverse native tree species are eligible. The strategy to achieve this objective must be explained and justified in the Reforestation Project Goals Form and submitted, with Professional Forester or Professional Ecologist approval, at the time of project submission. Considerations for achieving the objective may include site conditions, landowner economic objectives, seedling availability, successional events that occur following initial plantings, etc.

Project proponents must describe in the PIR the project's effects (positive and negative) on air and water quality, water supply, habitat, flora and fauna, jobs, recreation, scenic views, employment, and environmental justice. This may include a discussion of how the project aligns with the United Nations' Sustainable Development Goals,[7] as well as additional quantification of any non-GHG benefits (such quantification is not specified by this methodology).

The project proponent must attest that the project will not materially undermine progress on environmental and social issues such as air and water quality, endangered species and natural resource protection, and environmental justice. The project proponent must provide applicable authorizations, permits, and certifications from the appropriate authorities required for project operations to the confirmation body at the commencement of confirmation activities.

3.5 Regulatory Compliance

The project proponent must sign an Attestation of Regulatory Compliance prior to the commencement of project confirmation activities, attesting that no laws have been broken in the implementation of the project, and provide an assessment of any aspects of the project which may present a risk of future regulatory violations. Where such risks are identified, the project proponent shall describe measures undertaken to reduce and/or mitigate these risks. The confirmation body shall endeavor to confirm that the project implementation did not result in any regulatory noncompliance, and also that appropriate measures have been implemented to avoid potential future noncompliance during the project crediting period.

[7] Additional information regarding the Sustainable Development Goals may be found online at: https://sustainabledevelopment.un.org/.

3.6 Ownership and Double Counting

The ownership of the FMUs is assumed to be the entity that has legal ownership of the trees, unless an agreement transferring FMU ownership to another entity is in place, as described in Section 2.2. The project proponent must submit an affidavit within the PIR outlining the names and contact information of the legal owner(s) of timber rights within the project area.

The project proponent must submit a signed Attestation of Title form indicating that the project proponent has exclusive ownership rights to the emission reductions and removals resulting from the mitigation project and that the project is not being submitted for emission reduction credits under any other carbon crediting program, world-wide. As indicated in Section 2.2, any agreements transferring FMU ownership must be referenced in the PIR and reviewed by the confirmation body. By signing the Attestation of Title, the project proponent attests that the FMUs have not and will not be registered with, reported in, held, transferred or retired via any emissions registry or inventory other than the Climate Forward registry, or registered with Climate Forward under a different project title or location. Evidence of transfer of rights of all GHG emission reductions to the project proponent is required and must be confirmed by the confirmation body. The project proponent must provide a signed Attestation of Title document for each project, attesting to their ownership of all GHG emission reductions generated by the project. This signed attestation, and any necessary supporting evidence, must be provided to the confirmation body. In addition to the Attestation of Title, confirmation bodies may wish to review relevant contracts, agreements, and/or supporting documentation between project proponents, end users, and other parties that may have a claim to the FMUs generated by the project.

A map must be provided prior to confirmation as a KML file that identifies the area in which the reforestation project has been undertaken. The map may be used to display the project site as part of public sharing and ensuring that project boundaries do not overlap.

3.7 Project Resilience Measures

Project proponents must only include areas that are conducive to growing trees and not subject to conversion to non-forest uses, as explained and addressed in Sections 2.1 and 3.1. Additionally, tree planting is limited to a diversity of native species, as described and addressed in Section 3.4.

3.8 Ensuring Permanence

The mechanisms to ensure permanence of the *ex ante* FMUs resulting from sequestered CO_2 from reforestation activities include:

- Tonne-year accounting
- An optional conservation easement (perpetual or term) with Required RM Terms or public ownership where management objectives can be demonstrated as being consistent with the long-term maintenance of projected increases in carbon stocks
- Conservative estimates of carbon projections

3.8.1 Tonne-Tonne Accounting

Additional removals of atmospheric CO_2 begin immediately when CO_2 is sequestered in biomass at levels beyond “business as usual”. The additional sequestered CO_2 completely mitigates an equal GHG emission elsewhere when the additional sequestered CO_2 has been maintained out of the atmosphere for at least 100 years.

Tonne-tonne accounting recognizes the entire CO_2e value that has been sequestered in cases where the sequestered value can be reasonably assured to be sustained for a 100-year period following the sequestration. Projects with perpetual conservation easements with the Required RM Terms meet the permanence requirement using tonne-tonne accounting. For reforestation projects with perpetual conservation easements with Required RM Terms, the timeframe for assessing the *tonne-tonne* values (i.e., crediting period) is the projected growth of the forest stand to year 100. Projects on government-owned lands also meet the permanence requirement using tonne-tonne accounting under certain conditions. To be eligible to use tonne-tonne accounting, projects on public lands must be able to demonstrate that management is expected to lead to increases in carbon stocks that: 1) meet or exceed those stocks projected for the project area for the lesser of either 100 years or the year at which the Culmination of Mean Annual Increment (CMAI) occurs, and 2) are maintained at or above such projected stocking levels. CMAI is a benchmark for measuring forest maturity which can be determined from the growth projections. Forest stands at CMAI are at a high risk of regeneration harvest. Although forests on public lands may very well grow beyond CMAI, considering the accumulation of carbon only to the point of CMAI is a conservative approach to quantification. To demonstrate consistency of management with the 100-year permanency of projected stock increases on a project area on public lands, the project proponent must provide a description of the following:

- Management history
- Management objectives
- Likelihood of management plan changing in the future in a way that will prevent projected increases in carbon stocks from being achieved

In the case of a project either with a perpetual conservation easement including the Required RM Terms or on public lands capable of demonstrating management consistency with the long-term maintenance of projected carbon stock increases (hereafter referred to under the landowner class “government (secured)”), FMU issuance would be based on the tonne-tonne value projected for the crediting period, net of the resiliency discount (see Section 5.3). As an example, if a project with a perpetual conservation easement with Required RM Terms were predicted to have sequestered 225 tonnes per acre, after the resiliency discount has been applied, the project would be credited 225 tonnes per acre.

3.8.2 Tonne-Year Accounting

Tonne-year accounting recognizes the time value of CO_2 held out of the atmosphere for time periods less than the full permanence period of 100 years. Where the ability to secure the additional sequestered CO_2 is less than 100 years, the amount of credits issued is proportional to the 100-year permanence timeframe, at a rate of 1 percent per year. As an example, if the methodological approach to crediting provides reasonable assurance that the CO_2 in reforested trees will be secured for the next 30 years, 100 tonnes sequestered today would be credited at a value of 30 tonnes.

Tonne-year accounting is applied to reforestation projects with non-perpetual conservation easements that include the Required RM Terms. The timeframe for assessing the tonne-year values in such cases, and the resulting amount of FMUs to be issued, is the term length of the easement, up to a maximum of 100 years from the project start date. Absent a conservation easement with Required RM Terms that provides security to mature forest stands through ongoing monitoring and enforcement by qualified land trusts, the temporal portion of the reforested stand’s growth projection that is deemed secure (i.e., the sequestered carbon is

extremely likely to remain sequestered) is linked to the stand's growth rate and the proximity of the trees on the projection curve to achieving commercial dimensions and being at risk for regeneration harvest.

Growth rates in reforested stands start high and gradually slow as the forest stand trends toward a mature condition. The forest growth rates represent a return on investment to the forest landowner. Forest investments remain attractive during the period of rapid growth and become less attractive as growth rates slow, at which point landowners may choose to capture the value in standing timber (i.e., through harvest activities) and seek an alternative investment vehicle. This methodology operates with an assumption that expectations of financial returns vary based on defined landowner classes.

The Reserve has developed a companion document called the Reforestation Communities Data File in which threshold growth rates are provided by landowner class for the eligible forest communities. The data file defines the temporal length of growth projections for each forest community prior to the point at which the forest stands are at heightened risk of regeneration harvest (i.e., the length of time until the projected growth rate becomes lower than the assumed threshold rate of return) for each landowner class. This period is referred to as the crediting period.

Landowner classes recognized under this methodology are government, non-profit, tribal, and private. The private landowner class is further divided into two sub-classes in recognition that expectations of financial returns can vary considerably among private landowners. Under this methodology, private landowners with forestland holdings of 45,000 acres or more are assumed to manage their forests for timber production and the revenue derived from timber harvests. Such large private landowners are therefore more likely to harvest earlier in growth cycles to achieve financially-driven management objectives and are therefore assumed to harvest when growth rates are relatively high. All other private landowners are assumed to be less financially driven when making management decisions, with the risk of harvest heightened after growth rates have decreased further.

Projects taking place on large private forestlands may be eligible to use the growth rate threshold for other private landowners if they can demonstrate that the large private landowner has: 1) a history of managing its forests in a way that is consistent with the harvest rotation length suggested by the stand age at which harvest risk increases for other private landowners, as indicated by the Reforestation Communities Data File for the relevant forest type, and 2) a management plan in place that is similarly consistent.

Although growth rate thresholds will define the crediting period for most forest type and landowner class combinations, some forest types achieve maturity (based on CMAI) at nearly the same time as the growth rate thresholds are achieved. In such cases, crediting periods are defined by the proximity of forested stands to CMAI rather than by threshold growth rates. Therefore, a secondary threshold condition is established based on years as a percent of the year in which CMAI occurs. This condition only applies to forest types for which growth is expected to culminate quickly. This ensures that the risk of a regeneration harvest remains extremely low during the period credited by this methodology. Thus, this methodology considers both growth rates and proximity to CMAI to define the length of time during which CO_2e will be quantified on a tonne-year basis and issued as FMUs in the absence of a conservation easement as described above. The FMUs issued to reforestation projects using tonne-year accounting are the tonne-year values associated with the CO_2e projected at the defined crediting period.

Table 3.1 displays the threshold growth rates or percent of CMAI (in years) used to determine the crediting period and ensure conservative crediting. These values are applied to each forest community, as growth characteristics of forest communities vary widely. Table 3.1 also displays the basis for crediting period length for projects with conservation easements with Required RM Terms and for public lands where management is demonstrated to be consistent with project carbon stock increases.

Table 3.1. Basis for Determining Length of a Project's Crediting Period

Landowner Class	**Basis for Length of Crediting Period**		**Tonne-Tonne (TT) or Tonne-Year (TY)**
	No Conservation Easement with Required RM Terms		
	Threshold value identified as the lesser of column A or column B for a given forest community		
	A	B	
	Growth rate	Percent of the year (in terms of years) at which CMAI occurs	
Large Private	4%	80%	TY
Other Private or Tribal	3%		TY
Non-Profit or Government (Non-Secured)[8]	2%		TY
	Management Demonstrated to be Consistent with Maintenance of Projected Carbon Stock Increases		
Government (Secured)	The lesser of the year at which CMAI occurs or 100 years.		TT
	Conservation Easement with Required RM Terms		
Any Ownership Class	Length of term in conservation easement (with Required RM Terms) up to 100 years, assessed at the tonne-year value for projects with term conservation easements and the tonne-tonne value for projects with perpetual conservation easements.		TY or TT

A project may record a conservation easement with the Required RM Terms at any time during the crediting period and transition to landowner class with a conservation easement and be awarded the balance of FMUs associated with the landowner class. At such a time, the conservation easement baseline documentation must provide evidence that the reforested trees are generally shifting the land cover within the project area back to forest cover. The Forest Owner must submit a request to the Reserve for the additional FMUs and include as part of the request evidence for tree survival, a copy of the conservation easement (that complies with the Required RM Terms), and quantification documents, including both original and updated accounting.

Figure 3.1 displays an example of the gross FMUs that are issued (without consideration of discounts discussed in Section 5.3) based on the tonne-year values associated with each landowner class (or conservation easement with a term less than 100 years) and how such issuances relate to the increasing risk of rotational harvest. It also shows the FMUs issued based on the tonne-tonne values associated with a perpetual conservation easement with Required RM Terms or with government (secured) lands.

[8] Government-owned lands for which management is not demonstrated to be consistent with the long-term maintenance of projected carbon stock increases.

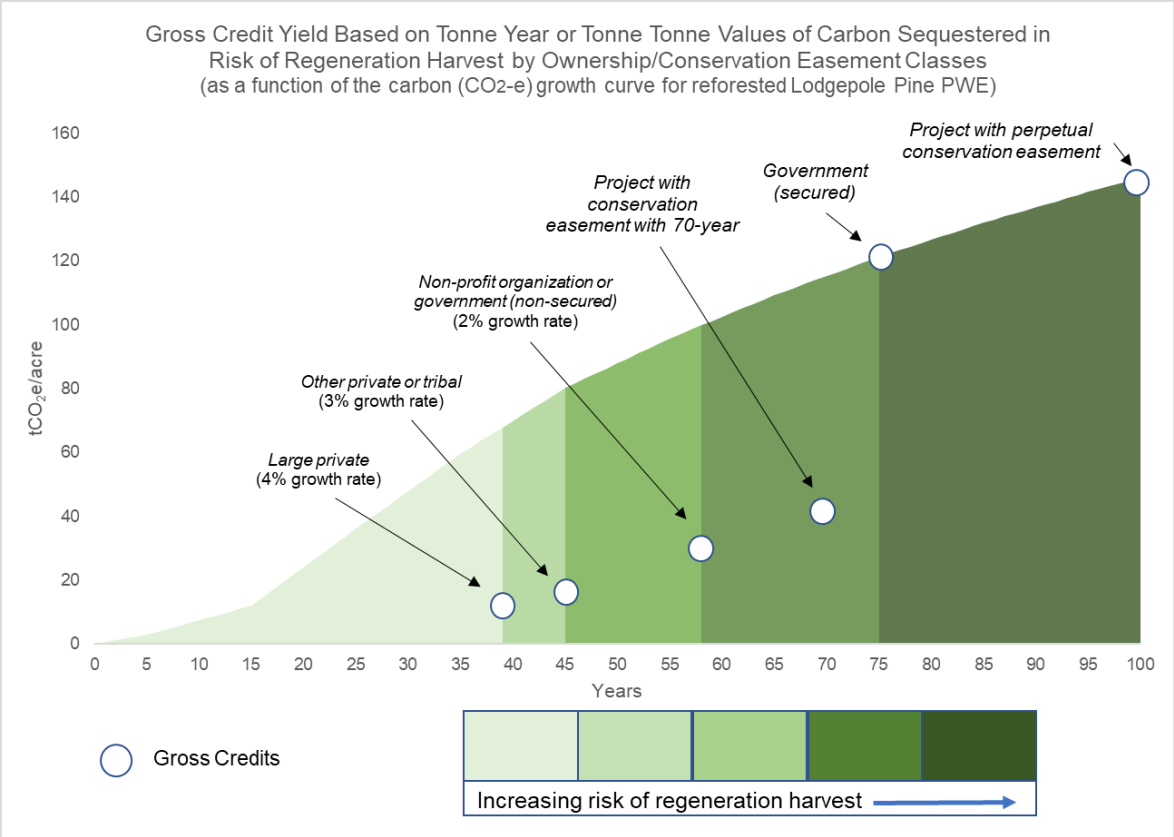

Figure 3.1. Example of Gross FMUs that are Issued Based on Landowner Class or Conservation Easement Term Length for the Lodgepole Pine PWE Forest Community

3.8.3 Conservative Crediting

There are several elements of conservatism as part of the methodology design, including the following:

1. Confirmation activities are initiated only after the trees in the reforested project area have been in the ground for a year from planted seedlings or seedlings established from natural regeneration. As such, the seedlings will have passed a highly vulnerable period and have a high probability of aligning with the projected growth.
2. Projects without conservation easements or on public lands which are crediting only during the early phase of forest growth are credited based on 98 percent of the mean growth projection. This establishes a virtual buffer pool that will ensure that the population of all projects in the system will achieve greater emissions removals than the sum of credits issued. It is anticipated that thinning operations may occur in the young forest stands, which will promote resilient stand conditions and encourage growth among retained trees, but these operations will not significantly alter growth projections and will serve, when they occur, to reduce the incidence of high-severity wildfire and pest infestations.
3. Projects with conservation easements including the Required RM Terms and projects on government (secured) lands are credited at 90 percent of the mean growth projection. These projects are credited for growth projections more distant in the future. The discount addresses both the emissions associated with biomass removals to ensure the

forest is resilient to natural disturbances, but also addresses the potential for natural disturbances to occur.

4. In the absence of a conservation easement with Required RM Terms to provide ongoing reporting and monitoring activities, project crediting is based on forward projections of carbon accrual that extend only to a conservative point in time prior to a heightened risk of project failure due to regeneration harvest.
5. For projects that use conservation easement with Required RM Terms, the terms must include a provision for reforestation activities in the event that a natural disturbance modifies the landcover such that it is no longer in forest cover. In such cases, the reforestation activity ensures the credited emissions removals will be achieved with time. This methodology does not require that the emissions removals are absolutely met at the projected times.

3.9 Market Expansion Objective

Crediting of reforestation projects does not provide the financial resources needed to address the high upfront costs associated with site preparation and tree planting. Financial incentives to perform reforestation activities are not well-served by *ex post* methodologies, since high project initiation costs are not balanced with payments from carbon markets, due to the length of time following the establishment of trees before projects contain appreciable levels of carbon. This *ex ante* approach recognizes the future value of carbon in reforested sites to finance a substantial portion, if not all, of site preparation and planting costs.

3.10 Demonstration of *Ex Ante* Suitability

The focus of this methodology is to provide FMUs to landowners/project proponents at a time that aligns with the demand for financial resources to cover the costs of seedling establishment. The *ex ante* crediting within the RM addresses this need by providing credits based on future projections of forest growth. Furthermore, the RM only recognizes future projections based on tree seedlings that are reasonably established in the ground and only for a time frame when commercial opportunities for the harvest of the planted trees are highly limited.

The first year following tree establishment is a period of high vulnerability for tree seedlings. It is a time in which the seedlings have a heightened risk of mortality due particularly to drought. Also, poor planting practices are often revealed within the first year with heightened mortality. The predictability that tree seedlings will survive is greatly improved if they remain alive a year after the reforestation effort. The next substantial risk to carbon sequestration in the life of the reforested stand is the commercial exploitation that might occur in the future at a point in time depending on the rate of commercial maturation of the tree species planted and laws that regulate the timing of stand rotation. This methodology quantifies the projection of future carbon values based on a determination of adequate stocking of live trees a year after the reforestation effort is completed. At this point, early mortality risks have been avoided and credits will only be provided to a predetermined point in time when harvesting risk is heightened, based on forest community and landowner class, which establishes the crediting period for FMUs.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project proponents in order to determine the net change in emissions caused by a project.[9] Table 4.1 outlines SSRs that may be related to reforestation activities and explains and justifies the accounting approach to the specific SSR.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs					
1	Standing live carbon (carbon in all portions of living trees)	CO_2	Yes	**Baseline**: Assumed to be 0 **Project**: Estimated from predetermined forecasted values as described in Section 5.2	Increases in standing live carbon stocks are likely to be the largest primary effect of reforestation projects. Any pre-existing trees on the project area do not need to be considered in accounting of the live tree pool, since the site must be approved by a Professional Forester or Professional Biologist as a site that would trend toward forest cover as the result of active efforts to reforest the site.
2	Shrubs and herbaceous understory carbon	CO_2	No	**Baseline**: N/A **Project**: N/A	Shrubs and herbaceous understory may constitute a significant portion of carbon affected by reforestation projects as part of site preparation. However, such stocks are assumed to recover fully over the course of the crediting period.

[9] The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
3	Standing dead carbon (carbon in all portions of dead, standing trees)	CO_2	No/Yes	**Baseline**: N/A **Project**: N/A	No crediting is provided for standing dead wood. The primary effect of reforestation projects is the carbon sequestration associated with growing trees that originated through project activities. The projections used for crediting the reforested trees are net of mortality, which would be very low considering the young trees included in the timeframe for crediting. Projects that move standing dead wood out of the forest must demonstrate that the use of the material offsite (biomass energy, heat, wood products, etc.) results in an improved GHG permanence than would have occurred if the standing dead trees would have been left on site. If burned on site, projects must use conservation burning techniques to enhance biochar production that will persist longer than the decay of the dead trees absent controlled pyrolysis.
4	Lying dead wood carbon	CO_2	No/Yes	**Baseline**: N/A **Project**: N/A	Lying dead wood cannot be used for crediting as it has no relevance to the primary effect. Projects that move lying dead wood out of the forest must demonstrate that the use of the material offsite (biomass energy, heat, wood products, etc.) results in an improved GHG permanence than would have occurred if the lying dead trees would have been left on site. If burned on site, projects must use conservation burning techniques to enhance biochar production that will persist longer than the decay of the dead trees absent controlled pyrolysis.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
5	Litter and duff carbon (carbon in dead plant material)	CO_2	No	**Baseline**: N/A **Project**: N/A	Carbon from litter and duff may be affected by reforestation projects as part of site preparation, but the emission source is assumed to be *de minimis*.
6	Soil carbon	CO_2	No	**Baseline**: N/A **Project**: N/A	In cases where reforestation activities follow disturbance events, soil carbon is expected to at least remain the same and may increase. Since baseline and project soil carbon quantification is difficult and expensive, soil carbon is not included in quantification at this time. It is conservative not to include it.
7	Carbon in in-use forest products	CO_2	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
8	Forest product carbon in landfills	CO_2	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
Secondary Effect Sources, Sinks, and Reservoirs					
9	Biological emissions from site preparation activities	CO_2	No	**Baseline**: N/A **Project**: N/A	Biological emissions from site preparation addressed in SSR 2 – 8.
10	Mobile combustion emissions from site preparation activities	CO_2	Yes	**Baseline**: N/A **Project**: Yes	Mobile combustion emissions from site preparation are included when tractors are used for brush clearing.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Changes in CH_4 emissions from mobile combustion associated with site preparation activities are not considered significant.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Changes in N_2O emissions from mobile combustion associated with site preparation activities are not considered significant.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
11	Mobile combustion emissions from ongoing project operation and maintenance	CO_2	No	**Baseline**: N/A **Project**: N/A	Mobile combustion emissions from ongoing project operation and maintenance are unlikely to be significantly different from baseline levels and are therefore not included in the GHG Assessment Boundary.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Changes in CH_4 emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Changes in N_2O emissions from mobile combustion associated with ongoing project operation and maintenance activities are not considered significant.
12	Stationary combustion emissions from ongoing project operation and maintenance	CO_2	No	**Baseline**: N/A **Project**: N/A	Stationary combustion CO_2 emissions from ongoing project operation and maintenance could include GHG emissions associated with electricity consumption or heating/cooling at project proponent facilities, or at facilities owned or controlled by contractors. These emissions are unlikely to be significantly different from baseline levels and are therefore not included in the GHG Assessment Boundary.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Changes in CH_4 emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Changes in N_2O emissions from stationary combustion associated with ongoing project operation and maintenance activities are not considered significant.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
13	Biological emissions from clearing of forestland outside the project area	CO_2	No/Yes	**Baseline**: N/A **Project**: Estimated using default land-use conversion factors for non-project land	Reforestation projects on land currently used for grazing or growing crops may cause displacement of these activities to other lands, leading to a decline in carbon stocks on those lands (e.g., due to clearing of trees and shrubs). The shift may be either a market or physical response to the project activity. Emission associated with shifting land uses are estimated using default "leakage" factors, as detailed in Figure 5.1.
14	Biological emissions/ removals from changes in harvesting on forestland outside the project area	CO_2	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
15	Combustion emissions from production, transportation, and disposal of forest products	CO_2	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.

SSR	Source Description	GHG	Included?	Baseline/ Project	Justification/Explanation
16	Combustion emissions from production, transportation, and disposal of alternative materials to forest products	CO_2	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
17	Biological emissions from decomposition of forest products	CO_2	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
		CH_4	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.
		N_2O	No	**Baseline**: N/A **Project**: N/A	Not included because no harvesting is expected to occur during the crediting period under the baseline or under the project activity, as further described in Section 5.2.1.

5 Quantifying GHG Emission Removals

GHG removals are calculated by comparing the baseline to the forecasted mitigation project performance over a certain time period. GHG removals are achieved when the mitigation project results in higher CO_2 sequestration over a certain time period compared to what would have happened absent the mitigation project. The general formula for calculating GHG removals is:

GHG Removals = [(Incremental Forecasted Mitigation Project Sequestration – Incremental Forecasted Baseline Sequestration) + (Forecasted Baseline Emissions – Forecasted Mitigation Project Emissions)] + Secondary Effects, as shown in equation form in Equation 5.1.

Equation 5.1. Calculating GHG Removals

$$\boldsymbol{ER_{total} = \sum \left(ER_f + SE_f \right)}$$

Where,

			Units
ER_{total}	=	Total project emissions removals	tCO_2e
SE_f	=	Secondary effect GHG emissions caused by the project activity for forest type *f* (see Section 5.5)	tCO_2e

And,

$$\boldsymbol{ER_f = \sum_{y=1}^{CP_f} \left(\Delta AC_{f,y} \times 1\% \times \left(CP_f - y + 1 \right) \right)}$$

Where,

ER_f	=	Total emissions removals for forest type *f*	tCO_2e
Y	=	Years since project initiation	Years
CP_f	=	Duration of crediting period for forest type *f*	Years
$\Delta AC_{f,y}$	=	Increase in actual live tree carbon as forecasted for year *y* from prior year *y*-1 for forest type *f*†	tCO_2e

†Baseline live tree carbon stocks are assumed to remain at 0 tCO_2e during the crediting period.

5.1 Estimating Baseline Carbon Stocks

For quantification purposes under this methodology, baseline live tree carbon stocks are assumed to be zero, in accordance with project eligibility requirements related to additionality specified in Section 3.3, the GHG assessment boundary specified in Section 4, and the intended primary effect of the project activity – the increase in live tree carbon stocks that results from reforestation. Any pre-existing seedlings that may be present prior to the reforestation activities are assumed to be *de minimis* since a determination is required at project submission that the project area is understocked and in need of management activities to achieve stocking levels that would convert the project area to forest cover or restore an area to full forest cover (in the event of reforestation following natural disturbance).

5.2 Estimating Project Carbon Stocks

5.2.1 Basis for Estimates of Forecasted GHG Removals

Per the GHG assessment boundaries detailed in Section 4, estimates of future GHG removals are based on increases in carbon stocking in the live tree pool. This methodology relies on the results of projected regenerated forest stands from credible sources, with the assumption that a seedling stocking rate of 70 percent or greater at the time of confirmation, as determined by

confirmation body sampling as outlined in Appendix A, is sufficient to achieve the increases in carbon stocks forecasted for the project area. The Reserve shall be the arbiter in determining which studies are adequately rigorous for inclusion in this methodology. The data projections for included forest communities are presented in the Reforestation Communities Data File, which is an associated document to the RM available on the Climate Forward website.

Since a reforested stand results in additional carbon being sequestered over time, for projects without a permanent conservation easements with Required RM Terms or on public lands for which management of the site cannot be demonstrated to be consistent with the long-term maintenance of expected increases in carbon stocks, the amount recognized for crediting under this methodology is based on the tonne-year value of the carbon sequestered during each year of the project, up to the point where the thresholds discussed in Section 3.8 (Ensuring Permanence) are surpassed. In other words, a given tonne of carbon sequestered during the first year of the project will have a different tonne-year value than another tonne sequestered in any subsequent year of the project. See Table 5.1 for an example of how tonne-year values are attributed to a project.

Table 5.1. Example of Tonne-Year Values and Cumulative Crediting

This example uses a project that is sequestering 100 additional tonnes of CO_2e per year across the entire project area, with a forest type and discount rate of 4 percent for a large private landowner, for which the risk of regeneration harvest is assumed to take place 36 years after project initiation.

Years since project inception	Tonnes sequestered (tCO_2e)		Years since project initiation						Cumulative tonne-year value (tCO_2e)
			1	**2**	**3**	**…**	**35**	**36**	
1	100	**Annual achieved tonne-year value (tCO_2e)**	1	1	1	…	1	0	35
2	100			1	1	…	1	0	34
3	100				1	…	1	0	33
…	…					…	…	…	…
35	100						1	0	1
36	Risk threshold achieved							0	0
Total	**0**							**Total**	**630**

If the entire project area has a conservation easement with Required RM Terms, the rate of return for the applicable landowner type will be disregarded and the project will be issued FMUs on a tonne-year basis as if the project area were not eligible for harvest until the term of the easement is completed, up to a maximum of 100 years. In other words, if the landowner of the project in the example displayed in Table 5.1 is a large private landowner, the project would be awarded 630 FMUs based on a threshold rate of return of 4 percent, which results in a high risk of regeneration harvest 36 years after the project was initiated. However, if the same landowner placed a conservation easement with Required RM Terms on their land before the project was initiated that prevented regeneration harvest throughout the term of the easement, which for the example is set to 55 years, the applicable threshold rate of return would be disregarded and the project would be awarded 1,540 FMUs, based on the assumption that all additional tonnes of CO_2e are maintained through 55 years after project initiation, as shown in Table 5.2.

Table 5.2. Example of Tonne-Year Values and Cumulative Crediting when Conservation Easement with Required RM Terms

This example uses the same project conditions as shown in Table 5.1, except the project area has a conservation easement with Required RM Terms, resulting in a high risk of rotational harvest assumed to take place 55 years after project initiation.

Years since project inception	Tonnes sequestered (tCO_2e)		Annual Years since project initiation						Cumulative tonne-year value (tCO_2e)
			1	**2**	**3**	**…**	**55**	**56**	
1	100	**Annual achieved tonne-year value (tCO_2e)**	1	1	1	…	1	0	55
2	100			1	1	…	1	0	54
3	100				1	…	1	0	53
…	…					…	…	…	…
55	100						1	0	1
56	Risk of -5,500							0	0
Total	**0**							**Total**	**1,540**

For projects with perpetual conservation easements with Required RM Terms, the project is issued FMUs on a tonne-tonne basis, as opposed to a tonne-year basis. The basis for gross crediting, prior to the application of any discounts and deductions for secondary effects and management for resilience, is the full amount of CO_2e projected to be sequestered at 100 years. These projects will continue to undergo project monitoring by the conservation easement holder as part of the conservation easement terms. Projects on public lands where ongoing management of the site is shown to be consistent with the long-term maintenance of expected increases in carbon stocks are also issued FMUs on a tonne-tonne basis. Gross crediting for such projects is the full amount of CO_2e projected to be sequestered at the lesser of the point in time when CMAI is achieved or 100 years.

5.2.2 Determining Gross Forecasted GHG Removals

The following steps are used to determine the gross forecasted live tree carbon stocks and associated FMUs for a project:

1. Identify the landowner class, which is the ownership class of the Forest Owner where the project area exists, or whether a conservation easement (perpetual or term) with Required RM Terms as identified above encumbers the entire project area.
2. Using the Reforestation Communities Data File, determine the forest type that corresponds to the project's geography and species composition of the trees planted or regenerating on the project area. If the geography and/or species composition varies in such a way that the project area can be stratified into different forest types, determine the forest type and corresponding acreage for each stratum. Forest types in the Reforestation Communities Data File may have limited areas of applicability. See the Forest Type Applicability Map (available in both PDF and GIS file formats on the Climate Forward website) to determine the forest types applicable to the project site.
3. Based on steps 1 and 2, determine the tonne-year carbon stocking value (t CO_2e/acre) for the forest type(s) on the project area. If the project includes a perpetual conservation easement with the Required RM Terms, the tonne-tonne value must be used. This data is provided in the Reforestation Communities Data File.

4. Calculate the total FMUs associated with the entire project area by multiplying the tonne-year or tonne-tonne value for each forest type on the project area by the corresponding acreage represented by that forest type.

The Reforestation Communities Data File facilitates the calculation of the FMUs a project proponent may claim for a project according to these steps and is provided on the Climate Forward website.[10] The data file performs the calculations specified in Equation 5.1 and Equation 5.4.

5.3 Estimating Performance Decline

The carbon projections used in this Reforestation Methodology are expected to perform as predicted without decline. Climate change may be a factor in the future carbon sequestration, but whether the effect will be negative, as in prolonged droughts, or positive, as with CO_2 fertilization, lacks certainty and does not, therefore, merit any modifications to the published growth projections. Nevertheless, to ensure a conservative accounting (across the suite of projects) against the unlikely event of project site conversion and/or performance decline, a discount of 2 percent is applied to account for the potential abandonment of projects that do not have a conservation easement or are on government (non-secured) lands. This discount is applied automatically by the Reforestation Methodology Calculation Tool.

Where conservation easements are used to secure further credits associated with the growth curves or on government (secured) lands, a 10 percent resiliency discount is applied to crediting. The discount is intended to address the potential need in maturing forests for active management for forest resilience that may involve thinning forested stands so that the stands can resist catastrophic losses associated with ecological perturbations, such as wildfire, insects, or disease. The Required RM Terms for conservation easements include provisions for forest thinning to address resilience.

5.4 Estimating Abandonment Rates

The likelihood of projects being abandoned is expected to be very low given the lack of economic incentive for landowners to harvest their trees prior to the point when the risk of regeneration harvest is high. That point in time is identified as described in Section 5.2.1. Additionally, the project area must be validated by a Professional Forester or Professional Ecologist as being favorable for the establishment and growth of tree seedlings and not at an elevated risk of conversion to non-forest uses, as described in Section 3.1. As described in Section 5.3, a discount of 2 percent is applied to account for the potential abandonment of projects, which serves as a virtual buffer pool against the unlikely event of project area conversion and/or performance decline. As indicated above, this discount is applied automatically by the Reforestation Communities Data File.

5.5 Accounting for Secondary Effects

For reforestation projects, significant secondary effects can arise from two sources, detailed in the sections below.

5.5.1 Combustion Emissions Associated with Machinery Use in Site Preparation

To quantify combustion emissions associated with site preparation, project proponents must use the standard emission factor provided in Equation 5.2, as well as the level of brush cover

[10] https://climateforward.org/program/methodologies/reforestation/

associated with the site preparation area and the number of acres treated for each forest type where site preparation activities occur. An estimate of percent brush cover can be determined through remote sensing. The Reserve has provided a methodology for this approach in Appendix B. Alternative approaches to quantifying site preparation emissions must be submitted to and approved by the Reserve prior to confirmation activities.

Project proponents must only quantify these emissions for the areas where mechanical equipment, i.e., brush raking or mastication, is used for the removal of competing vegetation site preparation. Mobile combustion emissions must be added to secondary effect emissions (SE in Equation 5.4) for the project.

Equation 5.2. Combustion Emissions Associated with Site Preparation for Each Forest Type

$$\boldsymbol{MC_f = (-1) \times \left(0.65 \times BC_{PA,f} \times PA_f\right)}$$

Where,			Units
MC_f	=	Secondary effect emissions due to mobile combustion from site preparation for forest type *f*	tCO_2e
0.65	=	Mobile combustion emission factor,[11] assuming diesel fuel use, 8 gallons of fuel consumed per hour of equipment use,[12] and 8 hours of equipment use to clear an acre with 100 percent brush cover	tCO_2e/acre
$BC_{PA,f}$	=	Brush cover as a percentage of the site preparation area *PA* for forest type *f*	
PA_f	=	Size of the site preparation area for forest type *f*	acres

5.5.2 Activity-Shifting Leakage

The shifting of cropland or grazing activities to forestland outside the project area (which may be both a market and/or physical response to the project activity) is accounted for over the life of the project. To quantify emissions from the shifting of cropland and grazing activities each year, project proponents must determine the appropriate "leakage" risk percentage for the project following the decision tree in Figure 5.1.This percentage must be applied to the projected tonne-year value for the project to determine the secondary effects due to shifting of cropland or grazing activities (Equation 5.3).

Equation 5.3. Emissions from Shifting Cropland and Grazing Activities

$$\boldsymbol{AS_f = (-1) \times L_f \times ER_f}$$

Where,			Units
AS_f	=	Secondary effect emissions due to shifting of cropland or grazing activities for forest type *f*	tCO_2e
L_f	=	Leakage risk percentage, as determined from Figure 5.1	%
ER_f	=	Total emissions removals for forest type *f*	tCO_2e

[11] From U.S. EPA Greenhouse Gas Inventory Guidance, Direct Emissions from Mobile Combustion Sources, https://www.epa.gov/sites/production/files/2016-03/documents/mobileemissions_3_2016.pdf

[12] Based on upper end of fuel consumption range for 'high' load factor application for D6 (175 HP) track-type tractor, from Caterpillar Performance Handbook #48, Caterpillar, Peoria, IL, https://wheelercat.com/wp-content/uploads/2018/07/SEBD0351_ED48.pdf.

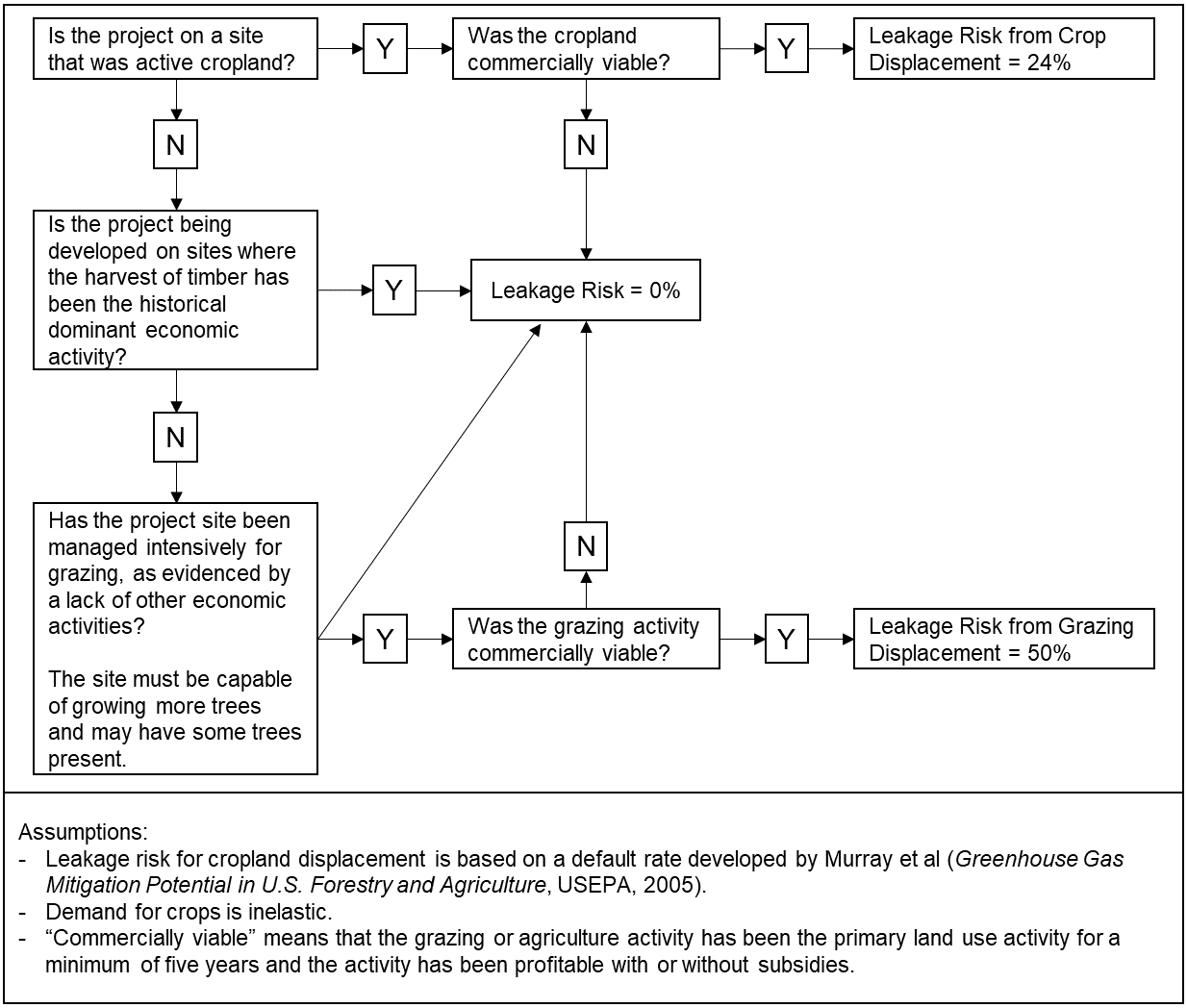

Figure 5.1. Activity Shifting ("Leakage") Risk Assessment for Reforestation Projects

Total secondary effect emissions for reforestation projects are calculated in Equation 5.4. The value for secondary effect emissions will always be negative or zero.

Equation 5.4. Total Secondary Effect Emissions

$$SE_f = \left(AS_f + MC_f\right) \text{ or } 0, \text{ whichever is lower}$$

6 Project Implementation and Monitoring

Climate Forward requires that a PIR be established for all implementation and reporting activities associated with the project.[13] A template PIR form is available from the Reserve to help to ensure all aspects of required reporting are included. The PIR, and its associated companion documents (Reforestation Project Goals Form and Reforestation Communities Data File), will serve as the basis to communicate the project's attributes to the public, including any co-benefits associated with the project, and will serve as the basis for the confirmation body's review of project data to confirm compliance with the methodology.

Other than the initial quantification of carbon projections and secondary effects, there are no requirements nor guidance for ongoing monitoring activities. Projects that choose to optionally transition to the Climate Action Reserve's Reforestation Protocol are subject to monitoring, reporting, and verification requirements found within that protocol.

6.1 Quantification Parameters

Each project must include the prescribed implementation parameters necessary to calculate GHG emission removals. These must be shown in a table, such as below in Table 6.1.

Table 6.1. Project Implementation Parameters

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)
Baseline stocks	Baseline is the "business as usual" case for reforestation projects. As only seedlings are being assessed as the primary effect of a project, older, pre-existing trees are not included. Baseline carbon stocks are assumed to be zero.	CO_2 equivalent	(r) - The value is referenced as zero.
Project stocks	Project stocks are based on projected values for each forest type and sometimes species within the forest type, as they relate to the seedlings planted by the project, assuming adequate seedling stocking at the time of project confirmation. The project stocks are discounted for conservative accounting as a measure against project failure and, in cases where conservation easements are used, to address management for resiliency.	CO_2 equivalent	(r) - The values and adjustments are described in the Reforestation Communities Data File.

6.2 Voluntary Ongoing Monitoring Incentive

Projects developed under this methodology can optionally decide to migrate the project to *ex post* monitoring under the Climate Action Reserve's voluntary offset program. Since the integrity of *ex ante* crediting is based on only recognizing the *tonne-year value* of the projected sequestered tonnes (except projects for which the long-term maintenance of sequestered

[13] A copy of the Project Implementation Report template can be accessed at https://climateforward.org/program/program-and-project-forms/.

carbon is assured and *ex ante* credits are issued based on tonne-tonne values), submitting the project to the Climate Action Reserve voluntary offset program can result in the issuance of CRTs commensurate with the *actual* tonnes verified at the submission date, less any tonnes that were issued previously as FMUs. Figure 1.1 in Section 1.2 displays the relationship of crediting under Climate Forward and the Reserve's offset program. The Reserve's offset program recognizes actual sequestered carbon and ensures permanence through a commitment to maintain, monitor and report on the sequestered tonnes as defined by the Reserve's Reforestation Protocol.

7 Reporting and Record Keeping

This section provides requirements and guidance on reporting rules and procedures. A priority of Climate Forward is to facilitate consistent and transparent information disclosure among project proponents. Project proponents must submit an emission removal report as part of the Project Implementation Report to Climate Forward.

7.1 Project Submittal and Confirmation Documentation

Project submission must be within one year of the project start date. The documents below are required for project listing, confirmation, and registration with Climate Forward. Templates for these documents can be accessed on the Climate Forward website.[14]

Listing:

- Project Submission form
- Reforestation Project Goals Form (not public)
- Signed Attestation of Title form

Confirmation:

- Signed Attestation of Title form
- Signed Attestation of Legal Additionality form
- Signed Attestation of Regulatory Compliance form
- Project Implementation Report (not public)
- Reforestation Communities Data File (not public)

Registration:

- Confirmation Report
- Confirmation Statement
- Confirmation List of Findings

The above project documentation will be available to the public via the Climate Forward online registry, unless otherwise noted. Further disclosure and other documentation may be made available on a voluntary basis through the Climate Forward registry.

7.2 Record Keeping

For purposes of independent confirmation and historical documentation, project proponents are required to keep all information outlined in this methodology for a period equal to either the project crediting period or seven years after the information is generated (whichever is less). This information will not be publicly available, but may be requested by the confirmation body or the Reserve. Records must be kept in both hard copy and digital format, where possible.

Examples of information the project proponent must retain includes:

- All data inputs for the calculation of the project carbon enhancements, including all required sampled data, which will be included in the PIR
- Copies of all project-related permits, formal notices of regulatory violations, and any relevant administrative or legal consent orders dating back at least 3 years prior to the implementation of the project

[14] Climate Forward documents and forms are available at https://climateforward.org/program/program-and-project-forms/.

- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Legal Additionality forms
- Results of emission removal calculations, which will be included within the PIR
- Confirmation records and results
- All evidence relating to continued implementation

The Reserve also requires that the following project-related records be retained by the confirmation body for a minimum of seven years after completing confirmation activities. It must be noted that some records may be subject to fiscal or other legal requirements that are longer than the Reserve's mandated period.

Confirmation bodies shall retain electronic copies, as applicable, of the:

- Project Implementation Report
- Project proponent's SSR and/or project activity data as well as evidence cited
- Confirmation plan
- Sampling plan
- Confirmation Report
- List of Findings
- Confirmation Statement

Each confirmation body must have an easily accessible record-keeping system, preferably electronic, that provides readily available access to project information. Copies of the original activity and source data records shall be maintained within said record-keeping system. Records must be kept in both hard copy and digital format, where possible. The Reserve may at any time request access to the record-keeping system or any supporting documentation for oversight or auditing purposes.

7.3 Reporting and Confirmation Period

Project proponents must report forecasted GHG removals from the project for the entire crediting period. The project's report will include all forecasted carbon enhancements for the entire crediting period. A confirmation period is the period of time over which forecasted GHG removals are confirmed. A confirmation period begins with the project start date and ends with the submission of the final Confirmation Report to Climate Forward. The end date of any confirmation period may not extend past the project crediting end date. Confirmation activities cannot commence until the project is submitted by the project proponent and approved by the Reserve, and at least one year following the completion of the activity that led to seedling establishment (tree planting or site preparation to enable natural establishment of tree seedlings). For projects employing site preparation to allow for the natural regeneration of trees, the project proponent may wish to delay confirmation more than one year to ensure seedlings have established well enough to be considered healthy and viable during sampling by the confirmation body at the time of the confirmation site visit, as outlined in Appendix A.

Under extenuating circumstances, exceptions to the requirement to wait at least one year following the completion of activities leading to seedling establishment may be made at the sole discretion of the Reserve. In such instances, terms and conditions to be fulfilled by the project proponent are determined by the Reserve to ensure the overall integrity of the FMUs issued are maintained. See the Climate Forward Program Manual for further details.

8 Confirmation Guidance

This section provides confirmation bodies with guidance on confirming GHG emission removals associated with the project activity. This confirmation guidance supplements the Climate Forward Confirmation Manual and describes confirmation activities specifically related to this methodology.

Confirmation bodies trained to confirm a reforestation project must be familiar with the following documents:

- Climate Forward Program Manual
- Climate Forward Confirmation Manual
- Reforestation Forecast Methodology (this document)

The Climate Forward Program Manual, Climate Forward Confirmation Manual, and Climate Forward methodologies are designed to be compatible with each other and are posted on the Climate Forward website at http://www.climateforward.org/.

In cases where the Climate Forward Program Manual or Climate Forward Confirmation Manual differs from the guidance in this methodology, this methodology takes precedent.

Only confirmation bodies trained and accredited by the Reserve are eligible to confirm project reports. Information about confirmation body accreditation and Climate Forward project confirmation training can be found on the Climate Forward website at http://www.climateforward.org/program/confirmation/.

The confirmation of the project must be conducted with the oversight of a Professional Forester so that professional standards and project quality are maintained, including with respect to sampling procedures to confirm seedling stocking, as outlined in Appendix A Confirmation of Seedling Stocking. Any Professional Forester confirming a project in an unfamiliar jurisdiction must consult with a Professional Forester practicing in that jurisdiction to understand all laws and regulations that govern reforestation activities within the jurisdiction, as well as factors that may influence seedling viability.

8.1 Standard of Confirmation

Confirmation bodies must confirm that all project activities and related documentation are in conformance with this document and with any related documents, such as the Reforestation Communities Data File, and that the estimated emission removals have been calculated accurately. The confirmation process incorporates both a desktop documentation review and a site visit assessment of the mitigation project.

Beyond criteria for the confirmation of mitigation project implementation, the confirmation body also confirms any provisions specified in the forecast methodology that are to be undertaken to ensure the continued implementation of the mitigation project for the duration of its crediting period. The confirmation body assesses whether such measures have been appropriately implemented.

8.2 Confirming the Project Implementation Report

The Project Implementation Report serves as the basis for confirmation bodies to confirm that the monitoring and reporting requirements have been met. Confirmation bodies shall confirm that the PIR covers all aspects of monitoring and reporting contained in this methodology and specifies how data for all relevant parameters were collected and recorded.

When assessing the Project Implementation Report, the confirmation body shall:

(a) Assess the compliance of the Project Implementation Report with the requirements of the methodology, Climate Forward Program Manual, and Climate Forward Confirmation Manual

(b) Identify the list of parameters required by the methodology and confirm that the Project Implementation Report accounted for all necessary parameters

(c) Assess the means of implementation of the project data capture, including data management and quality assurance and quality control procedures, and determine whether these are sufficient to ensure the accuracy of forecasted GHG emission removals to be achieved by the batch/project/program

8.3 Core Confirmation Activities

The Climate Forward Confirmation Manual describes the core confirmation activities that shall be performed by confirmation bodies for all project confirmations. Confirmation is an audit of reported data whereby risks of errors and omissions are assessed. The core confirmation activities are described in the subsections below.

8.3.1 Reviewing GHG Management Systems and Estimation Methodologies

The Reforestation Methodology relies largely on default values in reference tables.

8.3.2 Confirming Emission Enhancement Estimates

The confirmation body further investigates areas that have the greatest potential for material misstatements and then confirms whether material misstatements have occurred.

8.3.3 Undertaking Site Visits

In addition to undertaking a desk review, the Reforestation Methodology requires one site visit at least one year after trees have been planted or otherwise established naturally following a site preparation event. The specific itinerary for a site visit and the scheduling of activities shall be specified in the confirmation plan.

8.4 Confirmation Items

Confirmation bodies are expected to use their professional judgment to confirm that methodology requirements have been met in instances where the methodology does not provide sufficiently prescriptive guidance. For more information on Climate Forward's confirmation process and professional judgment, please see the Climate Forward Confirmation Manual.

Note: The tables below shall not be viewed as a comprehensive list or plan for confirmation activities, but rather guidance on areas specific to mitigation projects that must be addressed during confirmation.

8.4.1 Project Eligibility and Credit Issuance

To determine that a project is eligible under a given forecast methodology, it must meet a set of criteria that a confirmation body shall confirm during the confirmation process. These requirements determine if a project is eligible to register with Climate Forward and/or have credits issued. If any requirement is not met, the project may be determined ineligible.

Use the following table to list the criteria for reasonable assurance with respect to eligibility and credit issuance for a given project.

Table 8.1. Eligibility Confirmation Items

Methodology Section	Eligibility Qualification Item	Apply Professional Judgment?
2.1 Project Definition	Activities implemented on the project area are based on the planting of trees or site preparation to allow for natural regeneration.	No
2.1 Project Definition	Seedling stocking at the time of the confirmation site visit rate of 70 percent or greater at the time of confirmation, as determined by confirmation body sampling per guidance in Appendix A.	Yes, for determination of seedling health and viability
3.1 Location	The project is in a geographic area for which tree seedling growth projections are published in the Reforestation Communities Data File.	No
3.1 Location	No other project exists or previously existed and received financial recognition for climate benefits, unless the previous project was closed in good-standing and the Reserve has provided written consent.	No
3.1 Location	A project area has been identified that meets requirements for the project definition (Section 2.1) and the performance standard test (Section 3.3.1)	Yes, but only for the canopy level estimates in 3.3.1
3.1 Location	The Reforestation Project Goals Form has been completed and signed by a Professional Forester or Professional Ecologist at the time of project submission.	No
3.2 Project Start Date	The project start date is aligned with the initiation of planting of trees or site preparation activities.	Yes, to confirm trees are consistent with project start date
3.2 Project Start Date	The project meets the date restrictions for the submission date relative to the project start date.	No
3.3.1 Performance Standard Test	The project area must not have been in forest land cover for at least the past ten years prior to the start date or was affected by a natural disturbance within the past 10 years that resulted in the forest canopy levels of live trees being less than 25 percent, as assessed on the start date.	Yes
3.3.2 Legal Requirement Test	A signed Attestation of Legal Additionality form has been submitted to the Reserve.	No
3.3.2 Legal Requirement Test	The PIR includes a description of any laws that reference requirements to reforest the project area.	No
3.4 Environmental and Social Safeguards	The Reforestation Project Goals Form is provided with an explanation of the type and quantity of each species used is provided with a signature from a Professional Forester or a Professional Ecologist	No

Methodology Section	Eligibility Qualification Item	Apply Professional Judgment?
3.4 Environmental and Social Safeguards	PIR contains a description of the project's effects on air and water quality, habitat, flora and fauna, jobs, recreation, scenic views, employment, and environmental justice.	No
3.4 Environmental and Social Safeguards	Project proponent has included an attestation within the PIR that the project will not materially undermine progress on environmental and social issues.	No
3.5 Regulatory Compliance	The project proponent has provided an assessment in the PIR of the risks and actions to reduce or mitigate risks of future regulatory violations and an attestation that no laws have been violated in the implementation of the project.	No, the required elements must be present Yes, to the appropriateness of the reduction or mitigation of future risks
3.6 Ownership and Double Counting	The PIR contains an affidavit outlining the names and contact information of the legal entity that controls the trees (timber) and a signature of each owner is provided.	No
3.6 Ownership and Double Counting	If project proponent is not the owner of the trees, the PIR contains a reference to any external agreement transferring the right to claim emissions reductions credits to the project proponent, with such agreements reviewed by the confirmation body to ascertain whether the agreement indicates the following: ▪ The date the agreement starts; ▪ The agreement is made between the project proponent and the entity with legal control of the trees identified in the affidavit indicating all entity/entities with any legal claim to the trees (timber); ▪ The project area is being reforested under this methodology and will generate emissions reductions and removals which will be recognized by FMU issuance under the Climate Forward program; ▪ The time frame for the FMUs issued to the project proponent are aligned with the time frame for projected increases in carbon stocks identified for the project area according to the Reforestation Communities Data File (i.e., the crediting period); ▪ The ability to be issued FMUs and transact such FMUs via the Climate Forward registry is transferred to the project proponent.	No
3.6 Ownership and Double Counting	A KML file has been provided outlining the area where reforestation has been applied.	No

8.4.2 Quantification

Confirmation bodies shall include quantifications within the confirmation process such as recalculations and risk assessment. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission

enhancement calculations. If there are material misstatements, the calculations must be revised before FMUs are issued.

Use the following table to list the items that confirmation bodies shall include in their risk assessment and recalculation of the project's GHG emission removals.

Table 8.2. Quantification Confirmation Items

Methodology Section	Quantification Item	Apply Professional Judgment?
5.1 Estimating Baseline Carbon Stocks	The baseline carbon stocks are reported as zero.	No
5.2.2 (1) Determining Gross Forecasted GHG Removals	The landowner class has been correctly reported, with supporting descriptions and documentation provided for projects employing a conservation easement with Required RM Terms or projects on public lands where management is consistent with the long-term maintenance of the projected increases in carbon stocks for the project area, as described in Section 3.8.1.	No
5.2.2 (2) Determining Gross Forecasted GHG Removals	The forest communities have been properly identified and reported.	Yes, there may be some subjectivity in defining boundaries between forest communities
5.2.2 (3) Determining Gross Forecasted GHG Removals	The tonne-year or tonne-tonne carbon stocking value has been correctly reported for the forest type and landowner class.	No
5.2.2 (4) Determining Gross Forecasted GHG Removals	The expansion of the per acre values reported in the Reforestation Communities Data File to the project area has been correctly calculated.	No
5.3 Estimating Performance Decline	The discounts identified in Section 5.3 have been correctly applied.	No
5.5.1 Accounting for Secondary Effects	The PIR displays the results of the analysis for combustion emissions associated with site preparation activities and confirms the brush cover analysis, per Appendix B, was conducted correctly, with estimated brush cover prior to site preparation made by the project proponent within +/- 5 percent of an estimate produced by the confirmation body.	No

Methodology Section	Quantification Item	Apply Professional Judgment?
5.5 Accounting for Secondary Effects	The emissions associated with shifting cropland and grazing activities have been correctly calculated based on variables determined by project proponent and the level of crop and grassland displacement appears correct based onsite visit observations.	No, for the calculation Yes, for the stated level of crop and grassland displacement
Equation 5.1 Calculating GHG Enhancements	The final assessment of FMUs is correctly calculated based on adjustments associated with secondary effects and proportional stocking levels and correctly reported in the PIR.	No

8.5 Completing Confirmation

The Climate Forward Confirmation Manual provides detailed information and instructions for confirmation bodies to finalize the confirmation process. It describes completing a Confirmation Report, preparing a Confirmation Statement, submitting the necessary documents to Climate Forward, and notifying the Reserve of the project's confirmed status.

9 Glossary of Terms

Additionality	Project activities that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e., fossil fuel destruction, de-forestation, etc.).
Batch	The implementation of the reforestation activities at multiple sites over a finite period of time, not to exceed 365 days between the activities.
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Confirmation	The process used to ensure that a given participant's GHG emissions or emission removals have met the minimum quality standard and complied with the Reserve's procedures and methodologies for calculating and reporting GHG emissions and emission removals.
Confirmation body	An entity that has been trained and authorized by the Reserve to confirm the proper implementation of mitigation projects.
Conservation easement	A conservation easement is a voluntary, legal agreement that restricts defined uses of the land in order to protect its conservation values. Conservation easements, for this methodology, may have defined temporal terms or be perpetual. In order for projects to recognize the crediting benefits of conservation easements under this protocol, the easements must include the Required RM Terms.
Direct emissions	GHG emissions from sources that are owned or controlled by the reporting entity.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Forest landcover (cover)	Landscapes with vegetation capable of achieving at least 15 feet in height and with a canopy cover of the same vegetation of at least 10 percent canopy closure.
Forest community	A collection or association of forest tree species within a designated geographical unit, which forms a relatively uniform patch, distinguishable from neighboring patches of different vegetation types.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.

Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the enhancement activity is implemented, and/or at sources not owned or controlled by project participants.
Metric ton (t, tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Professional Ecologist	An ecologist who meets the requirements of professional registrations within jurisdictions where professional or certified ecologists exist. For purposes of this methodology, an affiliation with state or national registries or certification by a professional society (e.g., Ecological Society of America) is adequate for the professional to perform the role of a Professional Ecologist wherever the methodology is used, unless jurisdictional requirements otherwise prohibit this designation, in which case the jurisdiction's laws are assumed. Additionally, ecologists with appropriate educational and professional experience (minimum: BA/BS or higher in forestry/natural resources with at least 2 years professional field experience, including experience with reforestation) may perform the role of Professional Ecologist under the methodology within jurisdictions where no professional or certified ecologist requirements exist.
Professional Forester	A forester who meets the requirements of professional registrations within jurisdictions where professional or certified foresters exist. For purposes of this methodology, an affiliation with state or national registries or certification by a professional society (e.g., Society of American Foresters) is adequate for the professional to perform the role of a Professional Forester wherever the methodology is used, unless jurisdictional requirements otherwise prohibit this designation, in which case the jurisdiction's laws are assumed. Additionally, foresters with appropriate educational and professional experience (minimum: BA/BS or higher in forestry/natural resources with at least 2 years professional field experience, including experience with reforestation) may perform the role of Professional Forester under the methodology within jurisdictions where no professional or certified forester requirements exist.
Project baseline	A "business as usual" GHG emission assessment against which GHG enhancements are measured.
Project proponent	An entity that undertakes a GHG project, as identified in Section 2.1 of this methodology.

Project Resilience Measures	Activities tailored to the specific project that are undertaken to ensure the continuing implementation of the project for the duration of the crediting period.
Reforestation Project Goals Template	A form that outlines required project information and includes a signature line that must be signed by a Professional Forester or Professional Ecologist. The form must be submitted at the time of project submission. The form is available on the Climate Forward website.
Required RM Terms	Terms that must be included within an optional conservation easement (or other deed restrictions or legally binding agreements that are maintained with the land in cases of ownership transfers) for the crediting terms in this Reforestation Methodology to be applied, as described in Section 3.8. Terms used to encumber timber harvest must limit harvest activities to management for forest resiliency (thinnings), human safety, or salvage (in the event of an ecological perturbation, such as wildfire, insect infestation, or disease). Other than salvage harvesting, harvest activities conducted prior to the end of the crediting period for the project, as determined according to this methodology, shall increase Quadratic Mean Diameter (QMD) in all trees greater than 12 inches and shall not reduce canopy cover, on a continuous analysis area of every 10 acres, below 60 percent. Terms shall also include a requirement to reforest any portion of the project area where forest landcover is lost as the result of a natural disturbance. The entity granted the easement must be a qualified holder according to the conservation easement enabling statute of the state in which the project is located.
Site preparation	Activities that improve the success of planted trees and/or enable natural regeneration of trees to occur. These activities include but are not limited to management activities that reduce competing vegetation, soil scarification, and the cessation of other management practices, such as farming or grazing, that inhibit the natural establishment of trees.

10 References

International Organization for Standardization, ISO 14064-2:2006 Greenhouse gases — Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements (2006).

World Resource Institute and World Business Counsel for Sustainable Development, Greenhouse Gas Protocol for Project Accounting (November 2005).

Climate Forward Program Manual. https://climateforward.org/program/program-and-project-forms/

Climate Forward Confirmation Manual. https://climateforward.org/program/program-and-project-forms/

Appendix A Confirmation of Seedling Stocking

Confirmation bodies must confirm that the reforested project area is stocked at rate of at least 70 percent based on sampling at the time of the confirmation site visit. The sampling approach to confirmation activities is described in the steps below and is to be applied once for every 1,000 acres comprising the project area. For example, the sampling approach would be applied once by a confirmation body reviewing a project composed of 650 acres and three times for a project made up of 2,700 acres. Confirmation bodies must allocate all portions of the project area into "sampling divisions" that represent those portions of the project from which sample areas will be selected, as described below. Sampling divisions may be delineated in consideration of a variety of factors deemed appropriate by the confirmation body, such as logistical practicality and logical geographic features (e.g., watershed boundaries, groupings of non-contiguous parcels in the same vicinity), but should be no larger than 1,000 acres. A map of sampling divisions must be included in the Confirmation Report.

1. **Identifying the 'least stocked area'**
   Confirmation body shall perform visual reconnaissance throughout each sampling division and determine where the likely least stocked 40 acres is found. This shall be referred to as the sample area. If the sampling division is less than 40 acres, the sample area includes the entire project area.

2. **Developing sample plots**
   Sample plots shall be placed on the sample area in a uniform grid. A minimum of 40 plots must be included in the grid once placed over the sample area. The grid shall be considered uniform if the distance between lines does not exceed by two- and one-half times the distance between plots on the lines. See Figure A.1.

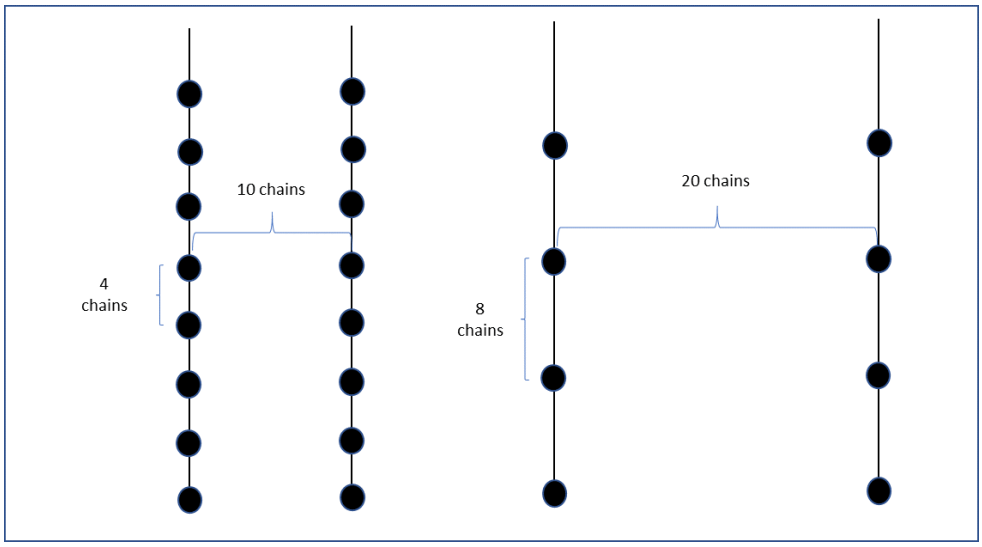

Figure A.1. Examples of the Application of the Uniform Plot Distribution Requirement
The distance between the plot lines cannot exceed 2.5 times the distance between the plots on a line.

3. **Field sampling**
    a. A starting point must be established in the field that can be relocated within at least a 6-month period. Flagging should generally be acceptable for this, except in cases of extreme weather, animals (curious bears), or other, in which case other approaches to more resilient landmarks should be used.
    b. Hand compasses and pacing may be used to navigate from plot center to plot center, as minimal technological requirements.
    c. All sample plots are fixed plots with a plot radius of 8.3 feet using a measuring tape or other calibrated measuring device.
    d. Plot centers must be flagged with three pieces of flagging at least 16 inches long.
    e. A plot is considered stocked if at least one 'countable' seedling is found within the plot area. A countable seedling is a seedling that meets the native tree requirements per Section 3.4 and is healthy. Healthy means the seedling appears vigorous and likely will continue growing.
    f. A plot location may be excluded by the confirmation body only if the plot center is located on a site not conducive to seedling establishment, such as a road, landing, watercourse, rocky area, bog, wetland, or other such site. Confirmation body shall proceed to the next plot in such a case.

4. **Quantifying the stocking level percentage and determining if the sampling division is stocked.**
    Confirmation body shall tally each sampled plot as being 'stocked' or 'unstocked.' A stocked plot percentage shall be calculated once all the plots located within the sample area have been sampled. If the stocked plot percentage represents 70 percent or more of all plots sampled, the sampling division is determined to meet the stocking requirement. If the stocked plot percentage falls below the 70 percent threshold, the sampling division is determined not to meet the stocking requirement and cannot be issued FMUs. The determination of stocking of each sampling division is made independent of other sampling divisions.

5. **Next steps for a sampling division that fails to meet the stocking requirements.**
    For sampling divisions that fail to meet the stocking requirements, project proponents have two options:
    a. Option 1 – the project proponent can request that the confirmation body expand the sampling survey to the next least stocked area within the same sampling division and proceed through an additional round of sampling, in which case the additional sampling results must be added to the original sampling results to calculate the combined stocking percentage, with the sampling division considered stocked if the combined stocking percentage is at least 70 percent.
    b. Option 2 – the original sample area may be removed from the project area, in which case the PIR must be revised. A subsequent confirmation effort to confirm stocking must proceed as before, but without the unstocked sample area that has been removed from the project area.

6. **Confirmation body reporting of field sampling activities**
    The following required documents must be presented in the confirmation report.

    a. The confirmation body must include a map(s) within the confirmation report that identifies the sample area and the plot locations within each sampling division. The map must indicate the compass bearings (Azimuth) of the lines and the distance between plots and lines. Each plot must be identified on the map with a

unique identifier (1 to n). The map must display the starting point in the field that indicates the initiation of sampling activities.

b. The confirmation body must include a list of all plots sampled and whether they were determined to be stocked or unstocked.

Appendix B Quantification of Brush Cover Removed as Part of Site Preparation Activities

The following is a description of the recommended method for determining the percentage brush cover comprising those portions of a project area where site preparation activities involving mechanical equipment (e.g., brush raking, mastication) occurred as a part of reforestation activities. The quantification of secondary effects emissions related to the combustion emissions associated with site preparation activities under the Reforestation Methodology assumes that all brush is removed on areas where site preparation activities occur. The percentage brush cover must be determined for each site preparation area by forest type. The results from the analysis described below are entered as $BC_{PA,f}$ in Equation 5.2. Sampling must achieve a standard error that is +/- 10 percent or less of the estimate of percent canopy cover for both brush cover and non-brush cover (e.g., if percent brush cover is estimated as 35 percent, a standard error of 3.5 percent would have to be achieved to halt sampling).

The methodology presented below is based on the use of i-Tree Canopy, which does not allow for the selection of specific imagery dates. Since the brush cover analysis must be completed using remote imagery as close to but before the date when site preparation activities were initiated, the analysis should be performed using i-Tree Canopy's instructions for comparing results to historical imagery. As a result, the project proponent should estimate the number of sample points required to achieve the target standard error of +/- 10 percent of the percent cover estimate for both brush and non-brush cover types. Alternatively, sample points may be added in i-Tree Canopy until the target standard error is achieved based on the provided imagery; however, a comparison of the points initially sampled in i-Tree Canopy to the appropriate historical remote imagery may result in the need to add more sample points to properly achieve the target standard error.

The instructions here indicate the general i-Tree Canopy analysis process, with specific guidance for how to conduct the analysis using historical imagery provided at the end.

1. Navigate to the i-tree Canopy website: https://canopy.itreetools.org/index.php

2. Upload a Shapefile of the site preparation area by selecting the [Load ESRI Shapefile] button (Figure B.1).

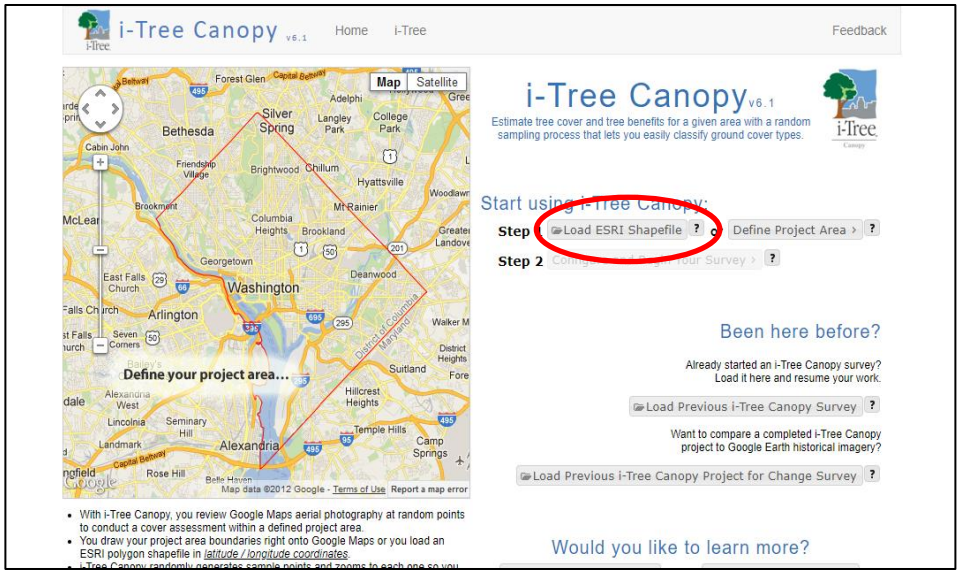

Figure B.1. i-Tree Canopy Startup Screen Step 1

3. Select the [Configure and Begin Your Survey] button (Figure B.2).

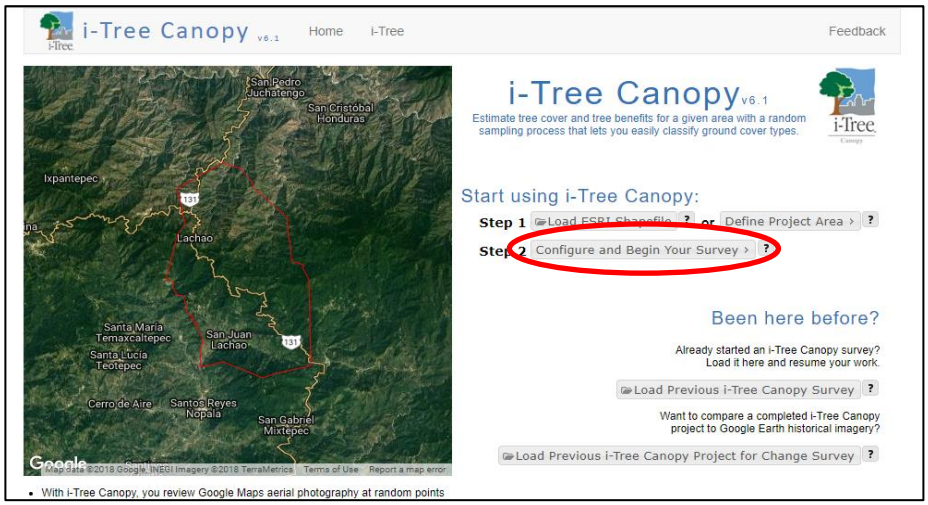

Figure B.2. i-Tree Canopy Startup Screen Step 2

4. On the Cover Class Configuration screen, modify the attributes of each over class by selecting the cover class to edit, clicking on the pencil icon below the left side of the table, editing the attributes, and submitting the edits for each to save the modifications (Figure B.3). Change the ‘Tree’ cover class to ‘Brush’ to represent brush cover (and any residual tree cover also assumed to be removed during site preparation). Change the ‘Non-Tree’ cover class to ‘Non-Brush’ to represent all other cover.

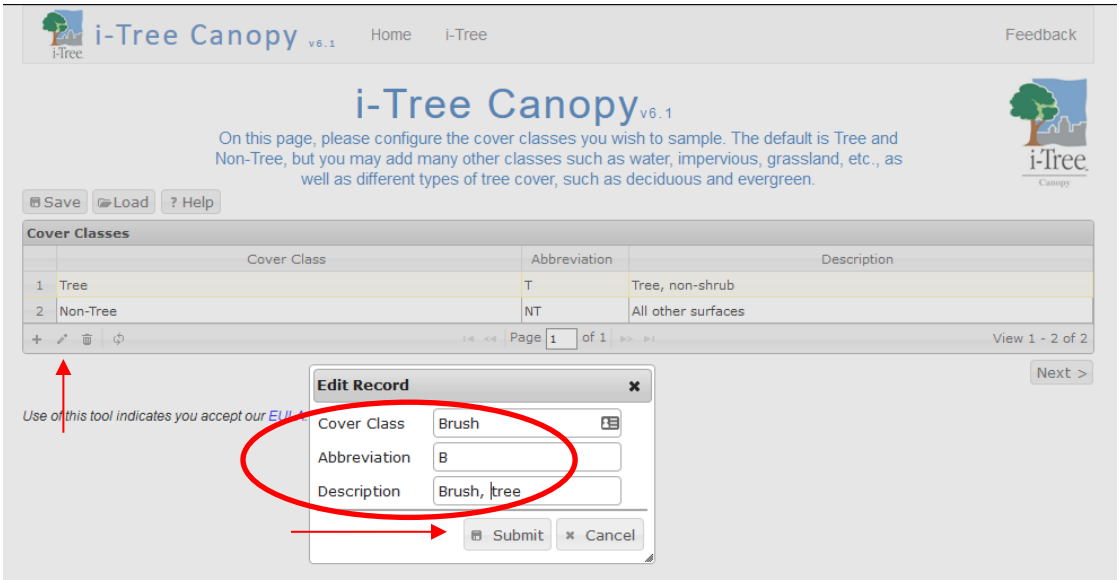

Figure B.3. Cover Class Configuration Screen

5. Skip through the Tree Benefit Valuation screen (Figure B.4).

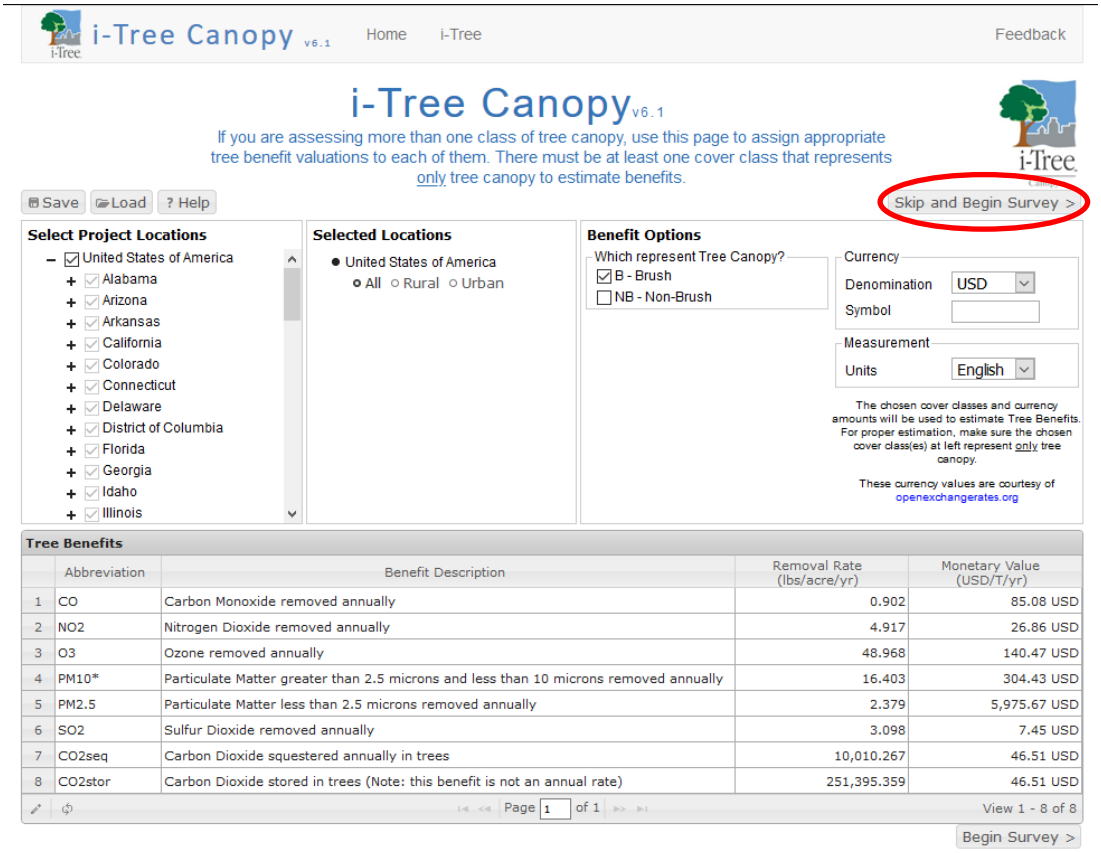

Figure B.4. Tree Benefit Valuation Screen

6. Add points and classify the points as [Brush] or [Non-Brush] based on the presence of brush canopy or no brush canopy at each sample point (Figure B.5). Positive identification of brush canopy is based on the presence of brush (or tree) cover at the center of the yellow crosshair on the aerial image. Once the cover class is determined, select the corresponding cover class name from the cover class attribute dropdown menu for the current sample point. Zoom in and out on the aerial image by using the [+] and [-] buttons on the bottom right corner of the image as needed to more easily identify the cover class for each point.

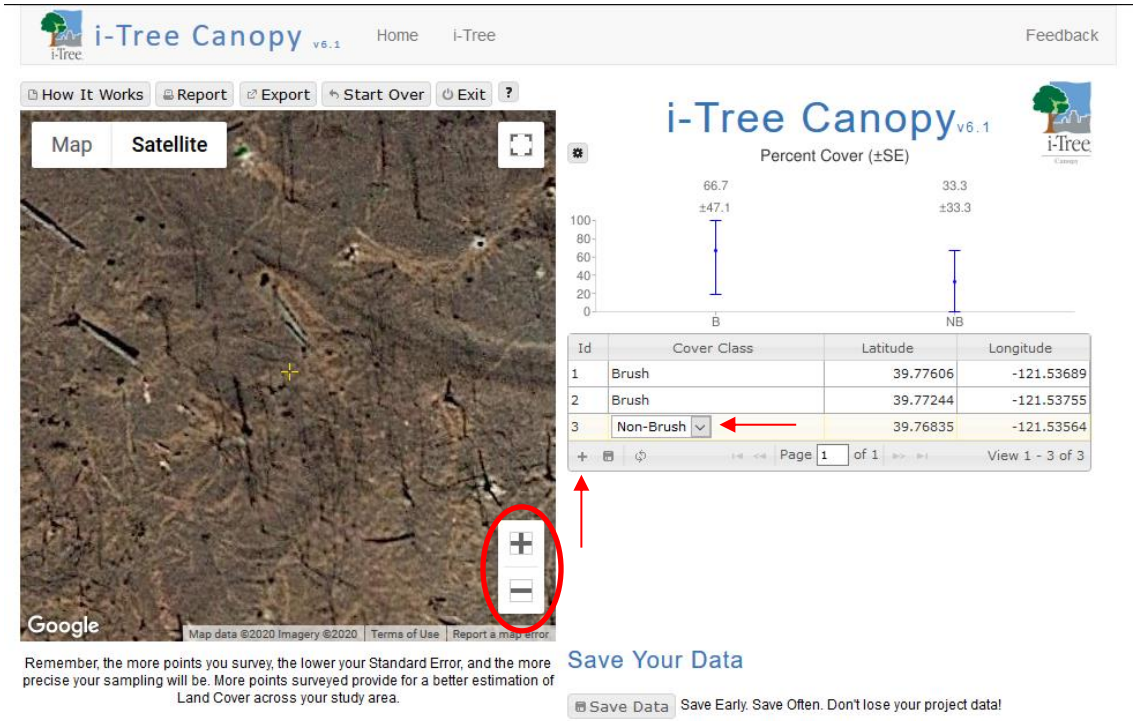

Figure B.5. Adding and Classifying Sample Points

7. Continue adding points until a confidence estimate for average canopy cover meets or exceeds a standard error of +/- 10 percent of the percent cover estimate for both brush and non-brush cover classes (Figure B.6). For example, the project proponent would stop adding points for the project in Figure B6 since the standard error (SE) for both the 'Brush' and 'Non-Brush' cover classes are +/- 10 percent (or lower) of the percent cover for each cover class—the SE is less than +/-3.45 (10 percent of 34.5) for the 'Brush' cover class and the SE for the 'Non-Brush' cover class is less than to +/-6.55 (10 percent of 65.5).

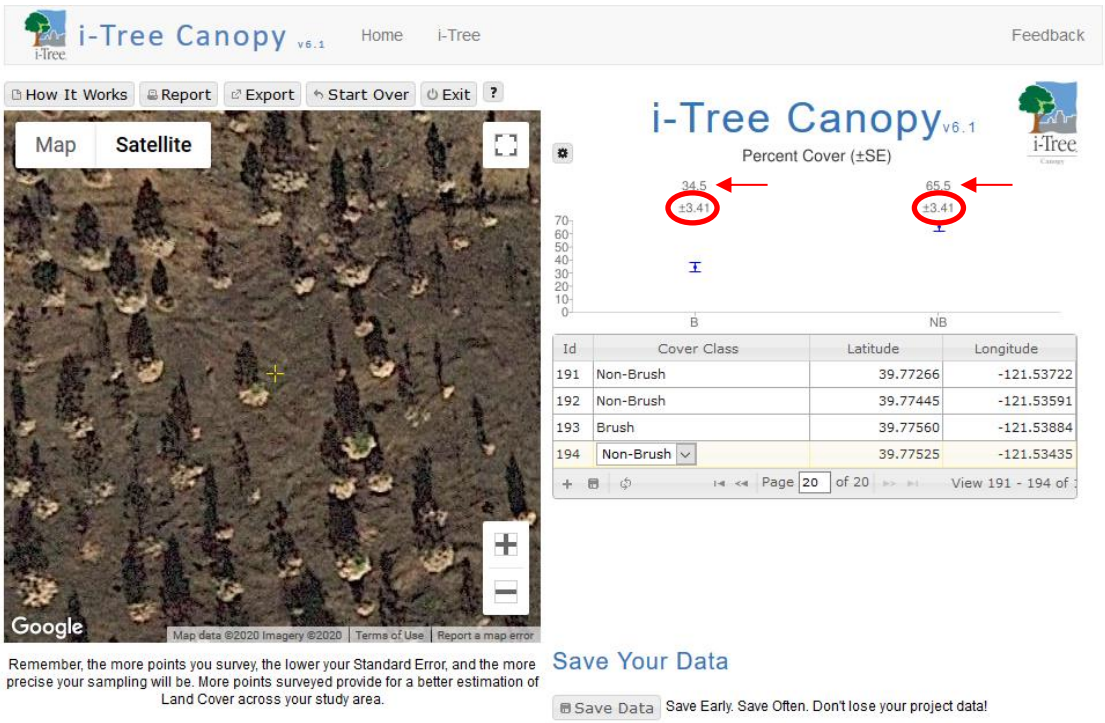

Figure B.6. Adding Sample Points Until Standard Error Less Than +/- 10 Percent Achieved

8. Save analysis data as you go along (Figure B.7). Upon clicking the [Save Data] button for the first time, specify the file name of choice, using the file type extension .dat, and saving to the location of choice.

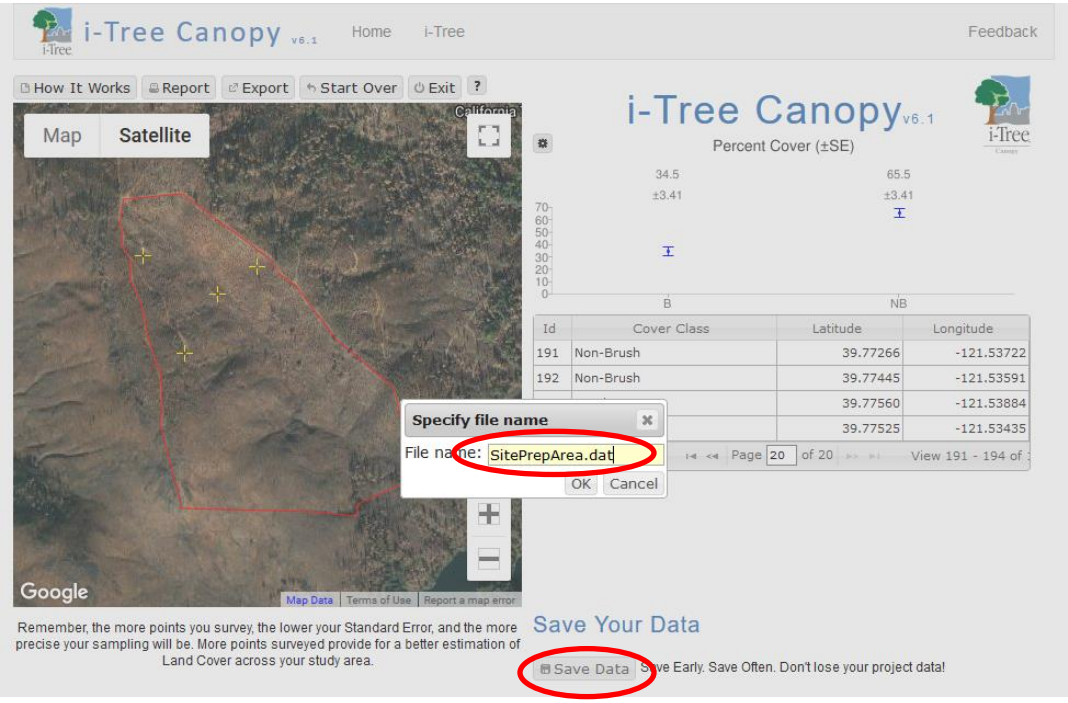

Figure B.7. Saving Data in i-Tree Canopy

9. Once the target standard error is achieved or the target number of sample points have been taken, save the data and click on the [Start Over] button (Figure B.8), confirming in the pop-up window that appears that you want to delete all data and start over.

Figure B.8. Starting Over with i-Tree Canopy

10. Click the [Load Previous i-Tree Canopy Project for Survey Change] button (Figure B.9).

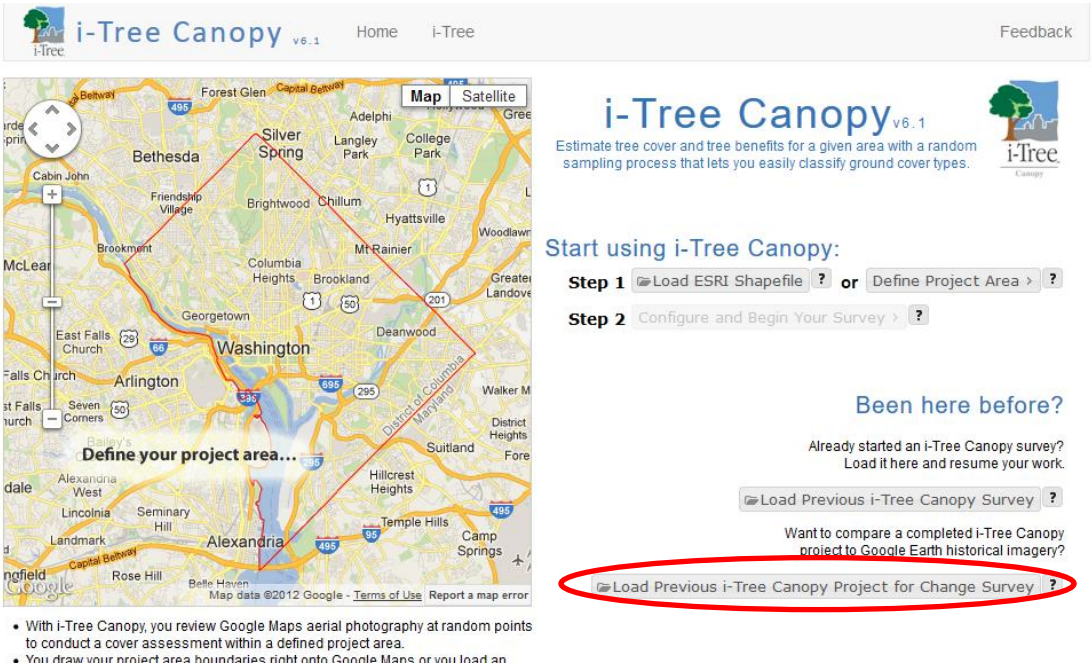

Figure B.9. Loading Analysis Data for Comparison to Historical Imagery

11. Click on the [KMZ Out] button (Figure B.10) to save the file as a KMZ version and open it in Google Earth (requires a separate download).

Figure B.10. Exporting KMZ File

12. Place i-Tree Canopy and Google Earth windows side-by-side.

13. Click the first survey point table record in i-Tree Canopy to zoom to it.

14. Click the first survey point in Google Earth's table of contents to zoom to it.

15. Use the Google Earth historical imagery slider to view imagery corresponding to the date closest to but before the date that site preparation activities were initiated.

16. In i-Tree Canopy, change the point's classification accordingly as needed.

17. Repeat these steps for your remaining i-Tree Canopy points.

18. Periodically save your re-survey project, using the .dat file type extension.

19. If standard error exceeds +/- 10 percent for either cover class after reclassifying using the historical imagery, additional sample points should be added by saving the re-survey project data, exiting the change survey mode in i-Tree Canopy by clicking on the [Start Over] button, and reloading the re-survey project data from the i-Tree Canopy startup screen by clicking on the [Load Previous i-Tree Canopy Survey] button (Figure B.11).

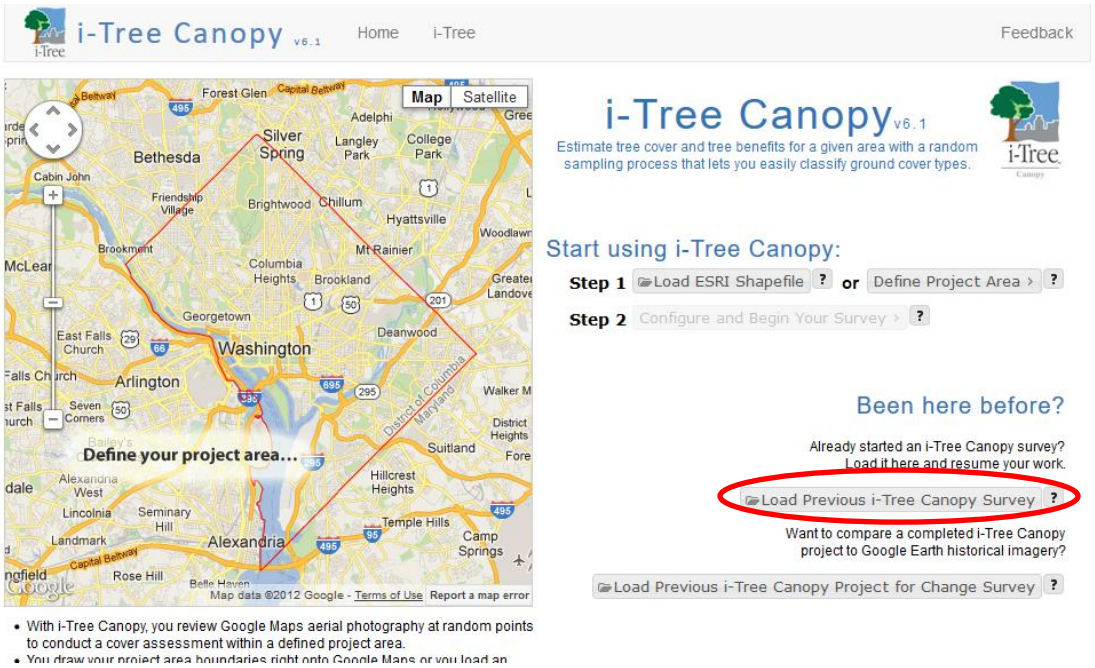

Figure B.11. Loading Re-Survey Project Data to Add More Sample Points

20. Add additional sample points as needed and repeating the comparison using Google Earth with the updated KMZ file until the target standard error is achieved for both cover classes.