Appendix

H

Guidance for Investigating Potential Critical Coarse Sediment Yield Areas

February 26, 2016

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Appendix H Guidance for Investigating Potential Critical Coarse Sediment Yield Areas

The following guidance provides methodologies for protecting CCSYAs:

H.1 Step 1: Identify CCSYAs

A CCSYA is an active or potential source of bed sediment to downstream channel reaches. When a Priority Development Project (PDP) is constructed, it has the potential to negatively impact characteristics of sediment supply and delivery which can lead to degradation of receiving waters. In order to prevent these impacts, PDP applicants must examine the tributary areas delineated in the project's storm water management plans and identify sources of critical coarse sediment within the following locations:

- **Onsite CCSYAs**: CCSYAs identified within the project's property boundary as indicated in the SWQMP. Refer to Section 1.3 for defining a project.
- **Upstream CCSYAs**: CCSYAs identified within the drainage area draining through the project's property boundary as indicated in the SWQMP. Refer to Section 1.3 for defining a project.

Applicants must first identify potential critical coarse sediment yield areas (PCCSYAs) using one of the methods presented in Appendix H.1.1. Once these PCCSYAs are identified, applicants may either accept the PCCSYA mapping as final, or may elect to further refine the results of the mapping through consideration of the refinement methods outlined in Appendix H.1.2. At the end of Step 1, applicants will have identified CCSYAs that must be avoided and bypassed by the project.

H.1.1 Identification Methods

As outlined on the following pages, applicants have two available options to identify PCCSYAs; (1) the RPO Method, and (2) the WMAA Method.

H.1.1.1 RPO Method

The County of San Diego has performed a jurisdictional analysis demonstrating that, in most cases, enforcement of the existing Resource Protection Ordinance (RPO) effectively preserves sources critical coarse sediment within the Unincorporated County of San Diego. This correlation between critical coarse sediment and lands that are currently protected through existing ordinances typically makes it more feasible for a development project to satisfy critical coarse sediment criteria. As outlined below, the process for identifying onsite sources of critical coarse sediment through the RPO Method may vary with respect to the project scenario, while the process for identifying upstream PCCSYAs through the RPO Method is identical for all project types.

Identification of Onsite PCCSYAs

- **Scenario 1:** PDP is subject to and in compliance with RPO requirements (without utilization of RPO exemptions 86.604(e)(2)(cc) or 86.604(e)(3) that result in impacts to more than 15% of the project-scale CCSYAs).
  - Applicant must identify onsite PCCSYAs as areas that are coarse grained[20], ≥25% slope, and ≥50’ in height.
- **Scenario 2:** PDP is entirely exempt/not subject to RPO requirements without utilization of exemptions 86.604(e)(2)(cc) or 86.604(e)(3).
  - Applicant has no obligation to identify and/or avoid onsite critical coarse sediment.
- **Scenario 3:** PDP utilizes exemption(s) via RPO Section 86.604(e)(2)(cc) or 86.604(e)(3) and impacts more than 15% of the project-scale CCSYAs.
  - Applicant is not permitted to use the RPO Method to identify sources of critical coarse sediment. Applicant must instead demonstrate no net impact through utilization of Appendix H.4 of this guidance.

Identification of Upstream PCCSYAs

- **All Scenarios:** All PDP applicants must identify upstream[21] PCCSYAs that drain through their project site as areas that are coarse grained, ≥25% slope and ≥50’ in height.

[20] Refer to Table H.6-1 for a list of geologic units that are anticipated to produce coarse grained sediment.

[21] If an applicant can demonstrate that the entire upstream boundary incorporates drainage elements that bypass the 2 year 24 hour flow rate at a peak velocity of 3 fps, then identification of upstream sources may be omitted from the analysis.

H.1.1.2 WMAA Mapping Method

It is anticipated that most applicants will elect to identify critical coarse sediment yield areas through the RPO Method presented in the section above; however, applicants are not expressly forbidden from utilizing the Watershed Management Area Analysis PCCSYA maps that were developed through previous regional analysis. Applicants electing to pursue this alternate method must identify onsite and/or upstream sources of critical coarse sediment through examination of the PCCSYA maps provided in Appendix H.6.

H.1.2 Refinement Options

After identifying PCCSYAs using one of the methods above, the applicant may either accept the PCCSYA mapping as final, or may elect to further refine the results of the mapping through consideration of one or more of the refinement methods outlined below.

H.1.2.1 Depositional Analysis

Areas identified as PCCSYAs may be removed from consideration if it is demonstrated that these sources are deposited into existing systems prior to reaching the first downstream unlined water of the state. Systems resulting in deposition may include existing natural sinks, existing structural BMPs, existing hardened MS4 systems, or other existing similar features that produce a peak velocity from the discrete 2-year, 24 hour runoff event of less than three feet per second in the system being analyzed. Applicants electing to perform depositional analysis to refine PCCSYA mapping must refer to the detailed guidance provided in Appendix H.7.1.

H.1.2.2 Threshold Channel Analysis

Areas identified as PCCSYAs may be removed from consideration if they discharge to a “threshold channel” that does not exhibit characteristics associated with significant bed load movement during design flows. Applicants electing to perform threshold channel analysis to refine PCCSYA mapping must refer to the detailed guidance provided in Appendix H.7.2.

H.1.2.3 Coarse Sediment Source Area Verification

Areas identified as PCCSYAs may be removed from consideration if an applicant demonstrates that these areas actually consist of fine grained sediment. Applicants electing to perform coarse sediment source area verification to refine PCCSYA mapping must refer to the detailed guidance provided in Appendix H.7.3.

H.1.2.4 Verification of Geomorphic Landscape Units (GLUs)

If an applicant has identified sources of critical coarse sediment via the alternate WMAA Method discussed in Appendix H.1.1, PCCSYAs mapping may be refined through verification of GLUs. If this method is used, applicants must refer to detailed guidance provided in Appendix H.6.1.

H.2 Step 2: Avoidance of Onsite CCSYAs

A key element of preserving the stability of receiving waters is to avoid changes in bed sediment supply by avoiding development on CCSYAs. Avoidance is best achieved through proper site design. The following are some potential strategies that should be considered while determining the site layout to avoid CCSYAs:

- The civil engineer shall designate onsite CCSYAs that are to be avoided (undisturbed) for the purpose of preserving coarse soil supply. When feasible, use and/or access restriction should be established for these areas.
- Minimize new impervious footprint. Refer to SD-3 in Chapter 4 for guidance on minimizing impervious footprint.

If onsite CCSYAs are not avoided per the metrics defined below, the applicant must demonstrate no net impact to the receiving water using guidance in Appendix H.4.

H.2.1 Avoidance Metrics

H.2.1.1 RPO Method

Avoidance of onsite CCSYA does not always mean that 100% of the CCSYAs must be avoided. Applicants that have identified CCSYAs using the RPO Method are typically permitted to encroach anywhere from 10-20% into the onsite CCSYAs that were determined in Step 1. This onsite encroachment is permitted through the existing RPO enforcement mechanism, which allows <u>each lot</u> within a project to encroach into steep slope areas anywhere from 10-20% depending on the percentage of the lot that is comprised of steep slopes. For example, a lot comprised of less than 75% steep slopes is typically permitted a 10% encroachment while a lot comprised of 100% steep slopes is typically permitted a 20% encroachment.

In some instances, a project (or portions of a project) may be exempted from RPO requirements such that encroachments beyond 10-20% may be permitted. Utilization of specific RPO exemptions 86.604(e)(2)(cc) or 86.604(e)(3) will require an applicant to translate conventional lot-level impact values into a single project-level impact value for analysis.

As outlined below, the metric for avoiding impacts to <u>onsite</u> sources of critical coarse sediment through the RPO Method may vary with respect to the project scenario

<u>Avoidance of Onsite CCSYAs</u>

- **Scenario 1:** PDP is subject to and in compliance with RPO requirements (without utilization of RPO exemptions 86.604(e)(2)(cc) or 86.604(e)(3) that result in impacts to more than 15% of the project-scale CCSYAs).
  - Applicant demonstrates avoidance of onsite critical coarse sediment by simply complying with existing RPO encroachment allowances.
- **Scenario 2:** PDP is entirely exempt/not subject to RPO requirements without utilization of exemptions 86.604(e)(2)(cc) or 86.604(e)(3).
  - Applicant has no obligation to identify and/or avoid onsite critical coarse sediment.
- **Scenario 3:** PDP utilizes exemption(s) via RPO Section 86.604(e)(2)(cc) or 86.604(e)(3) and impacts more than 15% of the project-scale CCSYAs.
  - Applicant is not permitted to use the RPO Method to demonstrate avoidance of critical coarse sediment. Applicant must instead demonstrate no net impact through utilization of Appendix H.4 of this guidance.

Avoidance of Upstream CCSYAs

- **All Scenarios:** Upstream CCSYAs must be bypassed per criteria presented in Section H.3 of this guidance.

H.2.1.2 WMAA Mapping Method

If the applicant has identified onsite CCSYAs using the WMAA Mapping Method, encroachments of up to 5% into the onsite CCSYAs may be permitted.

H.3 Step 3: Bypass Onsite and Upstream CCSYAs

Another key element of preserving the stability of receiving waters is to maintain current bed sediment supply characteristics through effective bypass of onsite and upstream sediment sources. Upstream bed sediment sources may include overland flow from CCSYAs and/or concentrated channel flows. Applicants must ensure both onsite and upstream sources of bed sediment are effectively bypassed through their project. If onsite and/or upstream CCSYAs are not effectively bypassed per the criteria below, applicant must demonstrate no net impact to the receiving water per the guidance presented in Appendix H.4.

H.3.1 Bypass CCSYAs from Hillslopes

Both onsite and upstream hillslopes mapped as CCSYAs must be effectively bypassed through and/or around the proposed project site.

- Proposed hardened drainage systems (e.g. storm drains, drainage ditches) that convey the bed sediment from the hillslopes to the downstream waters of the state should maintain a peak velocity from the discrete 2-year, 24-hour runoff event greater than three feet per second.
    - When drainage ditches are proposed for bypass, this velocity may be achieved by designing to the minimum dimensions listed in the San Diego Regional Standard drawing D-75.
    - When an 18" concrete storm drain is proposed for bypass, this velocity may typically be achieved by maintaining a storm drain slope of ≥0.5%. In instances where 2 year, 24-hour peak flow rates associated with the storm drain are less than 1.1 cfs, applicants may refer to the table below for minimum slopes needed to maintain three feet per second. Applicants may interpolate the values from the table below, or may elect to perform more detailed cleansing velocity calculations presented in Appendix H.7.1.

2-Year, 24-Hour Peak Flow (cfs)	Minimum Slope for 18" Concrete Storm Drain
<0.25	n/a, this PCCSYA is considered de-minimis
0.25	2.0%
0.50	1.0%
1.10	0.5%

- Storm water runoff that contains the bed sediment from CCSYAs must not be routed through detention basins or other facilities with restricted outlets that will trap sediment. Bypass systems shall be designed as necessary so that the bed material is conveyed to the downstream receiving water. Structural BMPs (including most flow-thru BMPs) are likely to trap sediment.
- For scenarios where a BMP must be constructed to treat offsite drainage area and there are CCSYAs outside of the project footprint, it may be feasible to achieve mitigation by construction of an outlet structure that can convey the bed load to the downstream receiving water and clear water through a bypass structure to a BMP.
- Proposed crossings (culverts, driveways, etc.) should not impede the transport of upstream critical coarse sediment. Crossings should be designed to avoid headwater conditions that would result in the trapping/settling of sediment.

H.3.2 Bypass CCSYAs from Channels

Projects that effectively avoid and bypass CCSYAs mapped in Step 1 of this guidance are not required to take specific action to ensure bypass of channel flows. This guidance does not set forth channel bypass criteria for this scenario because it recognizes that existing regulator mechanisms (such as 401 certifications, site design requirements, etc) are generally sufficient to preserve the sediment transport functions of onsite channels.

However, projects that do not effectively avoid and bypass the CCSYAs mapped in Step 1, will be required to specifically account for bypass of channel flows as part of the demonstration of no net impact outlined in Appendix H.4.

H.3.3 De Minimis Upstream CCSYA

Applicants have an option to exclude de minimis upstream CCSYAs. De minimis upstream CCSYAs consist of coarse hillslope areas that are not significant contributors of bed sediment yield due to their small size, and are considered by the owner and County as not practicable to bypass to the downstream waters of the state. In limited scenarios where all of the criteria below are satisfied, de minimis upstream CCSYAs may be omitted from consideration.

- De minimis upstream CCSYA is not disturbed through the proposed project activities.
- De minimis upstream CCSYA is not part of an upstream drainage contributing more than 0.31 total acres to the project site.
- Multiple de minimis upstream CCSYAs cannot be adjacent to each other and hydraulically connected.
- The SWQMP must document the reason why each de minimis upstream CCSYA could not be bypassed to the downstream waters of the state.

The 0.31-acre (13,500 square feet) de minimis threshold was established using 0.25 cfs as the cut off peak flow for the 2-year, 24-hour event, rational method equation and the following assumptions:

- C = 0.225 (average runoff coefficient (C) for soil type A and B);
- Average 6-hour, 2-year storm depth = 1.5 inches;
- Time of concentration = 6 minutes; and
- 2-year peak intensity = 3.51 in/hr. (based on procedures from the County Hydrology Manual).

The strategies for sediment bypass do not mitigate for the reduction of CCSYA that have been replaced by development onsite but can only mitigate scenarios where development hinders movement of bed sediment through the project footprint. When preservation of existing channels and/or implementation of sediment bypass measures is not feasible and/or not implemented, the applicant must demonstrate no net impact to the receiving water via the guidance presented in Appendix H.4.

H.4 Step 4: Demonstrate No Net Impact

When impacts to CCSYAs cannot be avoided or effectively bypassed, the applicant must demonstrate that their project generates no net impact to the receiving water per the performance metrics identified herein.

- **Appendix H.4.1** provides background on the state of the current science for predicting hydromodification impacts due to reductions in sediment supply;
- **Appendix H.4.2** defines the management standard that will be the basis for evaluating whether "no net impact to the receiving water" is achieved;
- **Appendix H.4.3** identifies the type of mitigation measures (i.e., additional flow control, stream rehabilitation, and applicant proposed mitigation measures) that can be used to meet the management standard;
- **Appendix H.8** provides the methodology for calculation of Erosion Potential (Ep) and Sediment Supply Potential (Sp); and
- **Appendix H.9** provides fact sheets for implementation of the mitigation measures.

H.4.1 Background

Channel form, by definition, is composed of bed and bank material as well as channel geometry (in plan, cross-section, and profile); however, the dominant forces typically controlling channel form are discharge and sediment supply (notably bed material) since a stream's most basic function is to convey water and sediment (Knighton, 1998). The interaction between form and function is qualitatively described through Lane's relationship:

$$Q_s \times d \propto Q_w \times S$$ Equation H.4.1

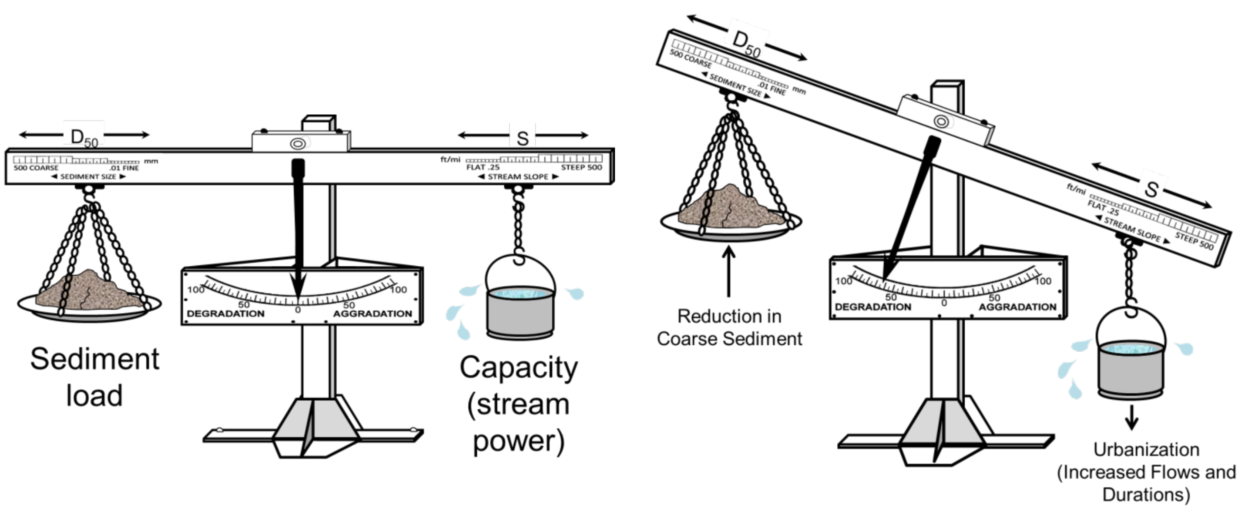
Where Q_s = Sediment discharge
d = Particle diameter or size of sediment
Q_w = Streamflow
S = Stream slope

Lane's relationship qualitatively states that the sediment load (size and volume of sediment), which is the first half of the relationship, is proportional to the stream power (volume of runoff and slope) which is represented by the second half of the relationship. The sediment discharge (Q_s) in the relationship is the coarser part of sediment load, referred to as the "bed sediment", since this is the part of the load which largely molds the bed formation (Lane, 1955). Lane's relationship (Equation H.4.1) cannot be used for quantitative calculations since the proportionality is not necessarily linear.

For a stream at equilibrium, Lane's relationship states that if one of the variables changes and the other variables do not change proportionately, then the stream channel is no longer in equilibrium.

Sediment load and stream power can change considerably during and following new development, leading to changes in the equilibrium state of the receiving channel.

- Typically, sediment load increases during the construction period, due to the additional exposure of bare soil during the grading and construction process, and before landscaping vegetation has stabilized the soil. This is regulated through the construction-phase BMP requirements established by the Construction General Permit and/or the MS4 Permit.
- Following the construction period, sediment load typically decreases to below pre-development levels, as less sediment is available from areas that have been paved or stabilized by landscape vegetation. When this decrease is not regulated, the bed sediment supplied to the stream (first half of the relationship) is reduced and the sediment transport capacity (stream power) is increased due to increased flows and durations resulting from the addition of impervious areas (second half of the relationship). This may result in degradation of the stream system as illustrated in **Figure H.4-1**.



Stream in equilibrium

Post-construction condition with no flow control and/or sediment supply regulations

Schematics credit: SCCWRP

Figure H.4-1 Illustration of Lane's Relationship

Lane's relationship is useful for making qualitative predictions concerning channel impacts due to changes in runoff and/or sediment loads from the watershed. Although this qualitative assessment is useful for understanding how the watershed responds to development, quantitative predictions are valuable for determining the magnitude of response and they can inform the identification of locations where the greatest management attention should be invested.

Lane's relationship can be supplemented by the use of quantitative predictions which allow the evaluation of the stream under changing conditions. Quantitative predictions will include bed sediment supply calculations for the first half of the Lane relationship, and bed sediment transport capacity calculations for the second half of the Lane relationship. Imbalances between the bed sediment supply rate and transport capacity determines the rate of sediment deposition or erosion in the channel and the associated channel change (Wilcock et al., 2009).

The common practice is to use the Erosion Potential (Ep) metric to evaluate the changes in sediment transport capacity and the Sediment Supply Potential (Sp) metric to evaluate the changes in bed sediment supply for susceptible receiving channels of concern. In regards to Ep metric,

- SCCWRP Technical Report 667 (SCCWRP, 2012) states:

  "The underlying premise of the erosion potential approach advances the concept of flow duration control by addressing in-stream processes related to sediment transport. An erosion potential calculation combines flow parameters with stream geometry to assess long term (decadal) changes in the sediment transport capacity. The cumulative distribution of shear stress, specific stream power and sediment transport capacity across the entire range of relevant flows can be calculated and expressed using an erosion potential metric, Ep."

- SCCWRP Technical Report 753 (SCCWRP, 2013) states the following based on review of field measurements from 61 sites in Southern California:

  "Results indicate that channel enlargement is highly dependent on the ratio of post- to pre-urban sediment-transport capacity over cumulative duration simulations of 25 years (load ratio, a.k.a. erosion potential), which explained nearly 60% of the variance."

For the purposes of implementing mitigation measures within the MS4-permitted region of the County of San Diego: this manual defines Ep as the ratio of post-project/pre-development (natural) long-term transport capacity or work; and Sp as the ratio of post-project/pre-project (existing) long-term bed sediment supply. Guidance for calculating Ep and Sp are provided in Appendix H.8.

H.4.2 Management Standard

This guidance defines a sediment supply management standard through which no net impact to receiving water can be quantitatively indicated. This management standard is demonstrated through the Net Impact Index (NII), a dimensionless index that must be used by the applicant to evaluate if there is, or is not, a net impact to the receiving water. NII is defined in this manual as the ratio of Ep to Sp. Mitigation measures shall be designed to meet the NII management standard shown in Equation H.4.2 to achieve no net impact to the receiving water. The NII management standard is based on Lane's relationship (Ep is directly proportional to Sp) and an allowance of 10% (based on Appendix H.4.2.1). This represents the most appropriate current understanding of how to quantitatively account for sediment supply changes without replacing bed sediment sources (Palhegyi and Rathfelder, 2007 and Parra, 2015).

$$NII = \frac{Ep}{Sp} \leq 1.1 \qquad \text{Equation H.4.2}$$

If NII ≤ 1.1, then the project produces no net impact to the receiving water in terms of coarse sediment yield, and no further analysis is required. If NII > 1.1, then the project generates an impact on the receiving water and the project is required to implement mitigation measures defined in Appendix H.4.3 such that the NII is reduced to a compliant value (NII ≤ 1.1).

H.4.2.1 Allowance to the NII Management Standard

This manual establishes the NII defined in Appendix H.4.2 as the management standard for coarse sediment supply. The 10% allowance to the management standard is supported by the following research studies or projects:

- The authors of the USACE report for channel design (USACE, 2001) state that, "achieving an optimum Capacity-Supply Ratio, within 10 percent of unity, should ensure dynamic stability while allowing the river itself to recover some of the fluvial detail that cannot be engineered."
- The authors of SCCWRP Technical Report 605 (SCCWRP, 2010), "anticipate that changes of less than 10% in either driver [discharge or sediment flux] are unlikely to instigate, on their own, significant channel changes. This value is a conservative estimate of the year-to-year variability in either discharge or sediment flux that can be accommodated by a channel system in a state of dynamic equilibrium."
- Sediment transport and supply measurements and calculations are inherently inexact. Discrepancies of up to 10% should not be a source of concern (PCR et al., 2002).

H.4.3 Types of Mitigation Measures

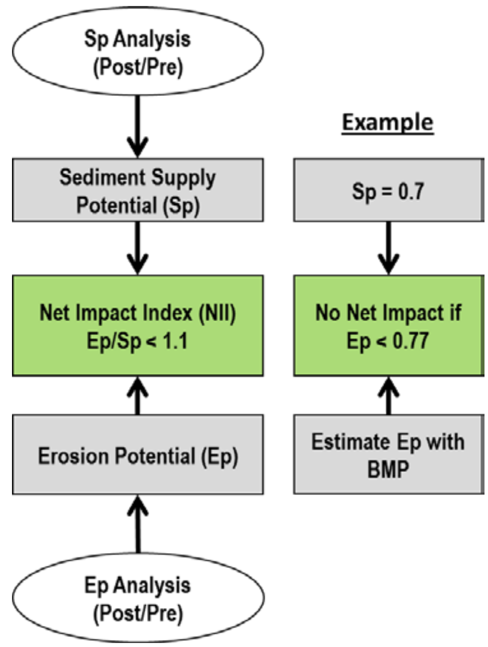
The following text discusses mitigation measures that may be used by the applicant to meet the NII management standard defined in Appendix H.4.2. These include:

- Additional Flow Control;
- Stream Rehabilitation; and
- Applicant Proposed Mitigation Measures

Appendix H.9 provides additional guidance for implementation of these mitigation measures.

H.4.3.1 Additional Flow Control

One option for managing bed sediment supply reductions is to provide additional detention and retention of site runoff to compensate for the reduction of bed sediment supply. This measure requires increasing flow attenuation by adding storage volume in structural BMPs. This management option accounts for changes in hydrology, channel geometry, and bed/bank material, but not sediment supply. For example, if there is a 30% reduction in bed-load due to proposed urbanization, then the sediment supply potential (Sp) equals 0.7. Assuming the appropriate range is +10%, hydromodification controls can be sized and situated such that the post-project effective in-stream work is lowered to less than 77% of the baseline pre-development condition.



Structural BMPs designed for hydromodification control utilize the following two basic principles:

- Detain runoff and release it in a controlled way that either mimics pre-development in-stream sediment transport capacity, mimics flow durations, or reduces flow durations to account for a reduction in bed sediment supply.
- Manage excess runoff volumes through one or more of the following pathways: (1) infiltration; (2) evapotranspiration; (3) storage and use; (4) discharge at a rate below the critical low flowrate; or (5) discharge downstream to a receiving water that is not susceptible to hydromodification impacts.

If desired, structural BMPs can be designed to support flood control and LID objectives in addition to hydromodification control. To the maximum extent possible, structural BMPs should be designed to receive flows from developed areas only. This facilitates design optimization as well as avoiding intercepting coarse sediments from open spaces that should ideally be passed through to the stream channel.

A fact sheet for additional flow control is provided in Appendix H.9.1.

H.4.3.2 Stream Rehabilitation

Hydromodification control can be achieved by stream rehabilitation projects including: drop structures, grade control structures, bed and bank reinforcement, increased channel sinuosity or meandering, increased channel width, and flow diversion. The objective of these in-stream controls, or stream restoration measures, is to reduce or maintain the overall Erosion Potential (Ep) of the receiving channel by modifying its hydraulic properties and/or bed/bank material resistance without fully replacing sediment supply or controlling increases in runoff. Stream rehabilitation is only an option where the receiving channel of concern is already impacted by erosive flows and shows evidence of excessive sediment, erosion, deposition, or is a hardened channel.

Stream rehabilitation projects are subject to the permitting requirements of the resource agencies. Stream rehabilitation projects may require the following permits:

- California Department of Fish and Wildlife – 1602 Streambed Alteration Agreement.
- US Fish and Wildlife Service – Authorization under the Endangered Species Act.
- US Army Corps of Engineers – Clean Water Act Section 404 Permit.
- Regional Water Quality Control Board – Clean Water Act Section 401 Water Quality Certification.
- Local Grading Permit

A fact sheet for stream rehabilitation is provided in Appendix H.9.2.

H.4.3.3 Applicant Proposed Mitigation Measures

The applicant may propose a mitigation measure not identified in this manual if it will achieve no net impact to the receiving water. Additional analysis may be requested by the County prior to approval of the mitigation measure to substantiate the finding of no net impact to the receiving water.

H.5 References

American Society of Civil Engineers and Water Environment Federation. 1992. Design and Construction of Urban Stormwater Management Systems. ASCE Manual No. 77, WEF Manual No. 20, Alexandria, VA.

ASCE, 1970. Design and construction of sanitary and storm sewers, ASCE Manual of Engineering Practice No. 37, WPCF Manual of Practice No. 9. Prepared by the Joint Committee of the American Society of Civil Engineers and the Water Pollution Control Federation

Chow, V.T. 1959. Open-Channel Hydraulics. McGraw-Hill Book Company.

Fischenich, C. 2001. "Stability Thresholds for Stream Restoration Materials." EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-29), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Hawley, R.J., and Bledsoe, B.P. 2011. "How do flow peaks and durations change in suburbanizing semi-arid watersheds? A southern California Study," Journal of Hydrology, Elsevier, Vol 405, pp 69-82.

Knighton D., 1998. Fluvial Forms and Processes: A New Perspective. Arnold Publishers.

Lane, E.W. 1955. The Importance of Fluvial Morphology in Hydraulic Engineering. American Society of Civil Engineers. Proceedings, Vol. 81, Paper No. 745.

Los Angeles Regional Water Quality Control Board (LARWQCB). 2012. Los Angeles County MS4 Permit (Order No. R4-2012-0175).

National Resource Conservation Service (NRCS), 2007. National Engineering Handbook Part 654 - Stream Restoration Design.

Palhegyi, G.E. and Rathfelder, K. 2007. "Applying the Erosion Potential Methodology to Natural Channel Design Procedures in Southern California". Presented at CASQA, Sept 2007, Orange County, California.

Parra, L.A., 2015. Addressing Critical Coarse Sediment Impact by Defining Dimensionless Indexes of Coarse Sediment Production, Transport and Net Impact.

Parra, L.A., 2016. Link between Flow Duration Curve and Erosion Work – Expanded.

PCR Services Corporation, Philip Williams and Associates, and Balance Hydrologics, Inc. 2002. Baseline Geomorphic and Hydrologic Conditions Report, Ranch Mission Viejo: Portions of the San Juan and Western San Mateo Watersheds, prepared for Rancho Mission Viejo.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool and D.C. Yoder, 1997. Predicting Soil Erosion by Water. A guide to conservation planning with Revised Universal Soil Loss Equation (RUSLE). U.S. Department of Agriculture, Agriculture Handbook No. 703.

San Diego, County of. 2011. Final Hydromodification Management Plan.

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP). 2005. Hydromodification Management Plan. April 21, 2005.

Shields, F.D. 1996. Hydraulic and Hydrologic Stability In: A Brooks and FD Shields (Eds.), River Channel Restoration, 23-74.

Shields, F.D., A. Brooks and J. Haltiner. 1999. Geomorphological Approaches to Incised Stream Channel Restoration in the United States and Europe. In: SE Darby and A Simon (Eds.) Incised River Channels.

Southern California Coastal Water Research Project (SCCWRP), 2008. Stream Channel Classification and Mapping Systems: Implications for Assessing Susceptibility to Hydromodification Effects in Southern California, Technical Report 562.

Southern California Coastal Water Research Project (SCCWRP), 2005. Effect of Increases in Peak Flows and Impervious on the Morphology of Southern California Streams, Technical Report 450.

Southern California Coastal Water Research Project (SCCWRP), 2010. Hydromodification Screening Tools: GIS-based catchment analyses of potential changes in runoff and sediment discharge. Technical Report 605.

Southern California Coastal Water Research Project (SCCWRP), 2010a. Hydromodification Screening Tools: Field Manual for Assessing Channel Susceptibility. Technical Report 606.

Southern California Coastal Water Research Project (SCCWRP), 2012. Hydromodification Assessment and Management in California. Technical Report 667.

Southern California Coastal Water Research Project (SCCWRP), 2013. Modeling and Managing Hydromodification Effects: summary of Available Tools and Decision-Making Approach. Technical Report 753.

USACE, 2001. Channel Restoration Design for Meandering Rivers. US Army Corps of Engineers, Final Report, ERDC/CHL CR-01-1. Prepared by Soar, P.J., and Thorne, C.R.

USDA, 1974. Present Sediment Yield Rates for Western United States. U. S. Department of Agriculture Soil Conservation Service.

Wilcock, P., J. Pitlick, and Y. Cui. 2009. Sediment Transport Primer Estimating Bed-Material Transport in Gravel-bed Rivers. USDA General Technical Report, RMRS-GTR-226.

H.5.1 Terms of Reference

The guidance described in Appendix H of this manual was developed by Geosyntec Consultants (Geosyntec) on behalf of the County of San Diego and the City of San Diego. Appendix H was specifically developed to provide PDP applicants guidance to meet the MS4 Permit Provision E.3.c.(2)(b) within the MS4-permitted region within the San Diego County. This guidance is not intended to be used for purposes, other than to meet this MS4 Permit requirement.

The guidance was developed with input from a Technical Advisory Committee (TAC) members through a series of meetings conducted in January 2016. The TAC input resulted in a streamlined guidance enhanced to provide applicants with simplified methods to determine impacts to coarse sediment delivery based on complex scientific principles. TAC participants included:

Bill Woolsey | Brian Haines | Charles Mohrlock | Chris Wolff | Dave Hammar | David Garcia | Emir Williams | Eric Mosolgo | Eric Stein | Erica Ryan | Howard Chang | Jon VanRhyn | Jonard Talamayan| Judd Goodman| Ken Susilo| Laura Henry| Luis Parra| Max Dugan | Rich Lucera | Sheri McPherson | Sumer Hasenin | Trevor Alsop | Venkat Gummadi | Wayne Chiu |

H.6 PCCSYAs: Regional WMAA Maps

PCCSYAs identified by the Regional WMAA were delineated using regional datasets for elevation, land cover, and geology. The methodology used to identify PCCSYAs from these datasets is based on Geomorphic Landscape Unit (GLU) methodology presented in the SCCWRP Technical Report 605. GLUs characterize the magnitude of sediment production from areas through three factors judged to exert the greatest influence on the variability on sediment-production rates: geology types, hillslope gradient, and land cover. The Regional WMAA document and the GIS layers for the map can be found on the Project Clean Water website at the following address:

http://www.projectcleanwater.org/index.php?option=com_content&view=article&id=248&Itemid=219

The regional-level mapping is based on the following sources:

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3rd Arc Second (~10 meter cells) digital elevation model for San Diego County
Land Cover	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS
Geology	Kennedy, M.P., and Tan, S.S.	2002	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale.
	Kennedy, M.P., and Tan, S.S.	2008	Geologic Map of the San Diego 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 3, 1:100,000 scale.
	Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Areal Mapping Project, Open File Report 2004-1361, 1:100,000 scale.
	Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale

The regional data set is a function of the inherent data resolution of the macro-level data sets and may not conform to all site conditions, or does not reflect changes to particular areas that have occurred since the underlying data was developed. This means slopes, geology, or land cover at the project site can be mischaracterized in the regional data set. If an applicant feels the Regional WMAA analysis inaccurately mapped their project area, they may elect to perform a site-specific GLU analysis based on data collected from project-level investigations to refine the mapping as outlined below.

The following PCCSYAs may be removed from the mapping without performing the full GLU analysis described in Appendix H.6.1 a) areas under 10% slope, b) paved areas.

H.6.1 Site-Specific GLU Analysis

In order to perform a site-specific GLU analysis the applicant must first delineate the project boundary and any areas draining through the project boundary. The applicant must then determine appropriate slopes, geology, and land cover categories for this area as identified below.

There are four slope categories in the GLU analysis. Category numbers shown (1 to 4) were assigned for the purpose of GIS processing.

- 0% to 10% (1)
- 10% to 20% (2)
- 20% to 40% (3)
- >40% (4)

There are seven geology categories in the GLU analysis:

- Coarse bedrock (CB)
- Coarse sedimentary impermeable (CSI)
- Coarse sedimentary permeable (CSP)
- Fine bedrock (FB)
- Fine sedimentary impermeable (FSI)
- Fine sedimentary permeable (FSP)
- Other (O)

There are six land cover categories in the GLU analysis:

- Agriculture/grass
- Forest
- Developed
- Scrub/shrub
- Other
- Unknown

Project site slopes shall be classified into the categories based on project-level topography. Project site geology may be determined from geologic maps (may be the same as regional-level information) or classified in the field by a qualified geologist. Table H.6-1 provides information to classify geologic map units into each geology category. Project site land cover shall be determined from aerial photography and/or field visit. For reference, Table H.6-2 provides information to classify land cover categories from the SanGIS Ecology-Vegetation data set into land cover categories. The civil engineer shall not rely on the SanGIS Ecology-Vegetation data set to identify actual land cover at the project site (for project-level investigation land cover must be confirmed by aerial photo or field visit). Intersect the geologic categories, land cover categories, and slope categories within the project boundary to create GLUs. The GLUs listed in Table H.6-3 are considered to be PCCSYAs. Note the GLU nomenclature is presented in the following format: Geology – Land Cover – Slope Category (e.g., "CB-Agricultural/Grass-3" for a GLU consisting of coarse bedrock geology, agricultural/grass land cover, and 20% to 40% slope).

GLUs are created by intersecting the geologic categories, land cover categories, and slope categories. This is a similar procedure to intersecting land uses with soil types to determine runoff coefficients or runoff curve numbers for hydrologic studies, but there are three categories to consider for the GLU analysis (slope, geology, and land cover), and the GLUs are not to be composited into a single GLU. When GLUs have been created, determine whether any of the GLUs listed in Table H.6-3 are found within the project boundary. The GLUs listed in Table H.6-3 are considered to be PCCSYAs.

If none of the GLUs listed in Table H.6-3 are present within the project boundary and area draining through the project boundary, no measures for protection of critical coarse sediment yield areas are necessary. If one or more GLUs listed in Table H.6-3 are present within the project boundary, they shall be considered critical coarse sediment yield areas. Complete Worksheet H.6-1 to document verification of GLUs.

Table H.6-1 Geologic Grouping for Different Map Units

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
gr-m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
grMz	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Jcr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jhc	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jsp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ka	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kdl	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgbf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgd	San Diego &	Coarse	Bedrock	Impermeable	CB

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
	Oceanside 30' x 60'				
Kgdf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgh	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm1	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm2	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm3	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm4	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgu	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Khg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ki	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kis	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJem	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJld	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klb	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klh	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Km	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmgp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpa	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kqbd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kt	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kvc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwsr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Mzd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzq	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzs	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
sch	Jennings; CA	Coarse	Bedrock	Impermeable	CB

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
Kp	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ql	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
QTf	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ec	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
K	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
Kccg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kcs	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kl	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ku	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
Qvof	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tp	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tpm	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tscu	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsd	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdcg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsm	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tso	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tst	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tt	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tta	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmv	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsi	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa11	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa12	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa13	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoc	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
Qvop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop1	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop11	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop11a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop12	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop13	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop2	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop3	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop4	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop5	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop6	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsa	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qof	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Q	Jennings; CA	Coarse	Sedimentary	Permeable	CSP
Qa	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qd	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qmb	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qw	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qt	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa1-2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
Qoa2-6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa5	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa7	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoc	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qc	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qu	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop2-4	San Diego 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop3	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop4	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop6	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qya	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyc	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Mzu	San Diego & Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
gb	Jennings; CA	Fine	Bedrock	Impermeable	FB
JTRm	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kat	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kc	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgb	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
KJvs	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kmv	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Ksp	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kvsp	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kwmt	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Qv	Jennings; CA	Fine	Bedrock	Impermeable	FB
Tba	San Diego 30' x 60'	Fine	Bedrock	Impermeable	FB
Tda	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tv	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tvsr	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgdfg	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Ta	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tcs	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Td	San Diego &	Fine	Sedimentary	Impermeable	FSI

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable / Permeable	Geology Grouping
	Oceanside 30' x 60'				
Td+Tf	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qls	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tm	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tf	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tfr	El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
To	San Diego & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qpe	San Diego & Oceanside 30' x 60'	Fine	Sedimentary	Permeable	FSP
Mexico	San Diego 30' x 60'	NA	NA	Permeable	Other
Kuo	San Diego 30' x 60'	NA (Offshore)	NA	Permeable	Other
Teo	San Diego & Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Tmo	Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Qmo	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
QTso	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
af	San Diego & Oceanside 30' x 60'	Variable, dependent on source material	Sedimentary		Other

TableH.6-2: Land Cover Grouping for SanGIS Ecology-Vegetation Data Set

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
1	42000 Valley and Foothill Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass
2	42100 Native Grassland		Agricultural/Grass
3	42110 Valley Needlegrass Grassland		Agricultural/Grass
4	42120 Valley Sacaton Grassland		Agricultural/Grass
5	42200 Non-Native Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass
6	42300 Wildflower Field		Agriculture/Grass
7	42400 Foothill/Mountain Perennial Grassland		Agriculture/Grass
8	42470 Transmontane Dropseed Grassland		Agriculture/Grass
9	45000 Meadow and Seep		Agriculture/Grass
10	45100 Montane Meadow		Agriculture/Grass
11	45110 Wet Montane Meadow		Agriculture/Grass
12	45120 Dry Montane Meadows		Agriculture/Grass
13	45300 Alkali Meadows and Seeps		Agriculture/Grass
14	45320 Alkali Seep		Agriculture/Grass
15	45400 Freshwater Seep		Agriculture/Grass
16	46000 Alkali Playa Community		Agriculture/Grass

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
17	46100 Badlands/Mudhill Forbs		Agriculture/Grass
18	Non-Native Grassland		Agriculture/Grass
19	18000 General Agriculture	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Agriculture/Grass
20	18100 Orchards and Vineyards		Agriculture/Grass
21	18200 Intensive Agriculture		Agriculture/Grass
22	18200 Intensive Agriculture - Dairies, Nurseries, Chicken Ranches		Agriculture/Grass
23	18300 Extensive Agriculture - Field/Pasture, Row Crops		Agriculture/Grass
24	18310 Field/Pasture		Agriculture/Grass
25	18310 Pasture		Agriculture/Grass
26	18320 Row Crops		Agriculture/Grass
27	12000 Urban/Developed		Developed
28	12000 Urban/Develpped		Developed
29	81100 Mixed Evergreen Forest	Forest	Forest
30	81300 Oak Forest		Forest
31	81310 Coast Live Oak Forest		Forest
32	81320 Canyon Live Oak Forest		Forest
33	81340 Black Oak Forest		Forest
34	83140 Torrey Pine Forest		Forest
35	83230 Southern Interior Cypress Forest		Forest
36	84000 Lower Montane Coniferous Forest		Forest
37	84100 Coast Range, Klamath and Peninsular Coniferous Forest		Forest
38	84140 Coulter Pine Forest	Forest	Forest
39	84150 Bigcone Spruce (Bigcone Douglas Fir)-Canyon Oak Forest		Forest
40	84230 Sierran Mixed Coniferous Forest		Forest
41	84500 Mixed Oak/Coniferous/Bigcone/Coulter		Forest
42	85100 Jeffrey Pine Forest		Forest
43	11100 Eucalyptus Woodland	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Forest
44	60000 RIPARIAN AND BOTTOMLAND HABITAT	Riparian and Bottomland Habitat	Forest
45	61000 Riparian Forests		Forest
46	61300 Southern Riparian Forest		Forest
47	61310 Southern Coast Live Oak Riparian Forest		Forest
48	61320 Southern Arroyo Willow Riparian Forest		Forest
49	61330 Southern Cottonwood-willow Riparian Forest		Forest
50	61510 White Alder Riparian Forest		Forest
51	61810 Sonoran Cottonwood-willow Riparian Forest		Forest

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
52	61820 Mesquite Bosque		Forest
53	62000 Riparian Woodlands		Forest
54	62200 Desert Dry Wash Woodland		Forest
55	62300 Desert Fan Palm Oasis Woodland		Forest
56	62400 Southern Sycamore-alder Riparian Woodland		Forest
57	70000 WOODLAND	Woodland	Forest
58	71000 Cismontane Woodland		Forest
59	71100 Oak Woodland		Forest
60	71120 Black Oak Woodland		Forest
61	71160 Coast Live Oak Woodland		Forest
62	71161 Open Coast Live Oak Woodland		Forest
63	71162 Dense Coast Live Oak Woodland		Forest
64	71162 Dense Coast Love Oak Woodland		Forest
65	71180 Engelmann Oak Woodland	Woodland	Forest
66	71181 Open Engelmann Oak Woodland		Forest
67	71182 Dense Engelmann Oak Woodland		Forest
68	72300 Peninsular Pinon and Juniper Woodlands		Forest
69	72310 Peninsular Pinon Woodland		Forest
70	72320 Peninsular Juniper Woodland and Scrub		Forest
71	75100 Elephant Tree Woodland		Forest
72	77000 Mixed Oak Woodland		Forest
73	78000 Undifferentiated Open Woodland		Forest
74	79000 Undifferentiated Dense Woodland		Forest
75	Engelmann Oak Woodland		Forest
76	52120 Southern Coastal Salt Marsh	Bog and Marsh	Other
77	52300 Alkali Marsh		Other
78	52310 Cismontane Alkali Marsh		Other
79	52400 Freshwater Marsh		Other
80	52410 Coastal and Valley Freshwater Marsh		Other
81	52420 Transmontane Freshwater Marsh		Other
82	52440 Emergent Wetland		Other
83	44000 Vernal Pool	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Other
84	44320 San Diego Mesa Vernal Pool		Other
85	44322 San Diego Mesa Claypan Vernal Pool (southern mesas)		Other
86	13100 Open Water	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
87	13110 Marine		Other
88	13111 Subtidal		Other
89	13112 Intertidal		Other
90	13121 Deep Bay		Other
91	13122 Intermediate Bay		Other
92	13123 Shallow Bay		Other
93	13130 Estuarine		Other

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
94	13131 Subtidal		Other
95	13133 Brackishwater		Other
96	13140 Freshwater	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
97	13200 Non-Vegetated Channel, Floodway, Lakeshore Fringe		Other
98	13300 Saltpan/Mudflats		Other
99	13400 Beach		Other
100	21230 Southern Foredunes	Dune Community	Scrub/Shrub
101	22100 Active Desert Dunes		Scrub/Shrub
102	22300 Stabilized and Partially-Stabilized Desert Sand Field		Scrub/Shrub
103	24000 Stabilized Alkaline Dunes		Scrub/Shrub
104	29000 ACACIA SCRUB		Scrub/Shrub
105	63000 Riparian Scrubs	Riparian and Bottomland Habitat	Scrub/Shrub
106	63300 Southern Riparian Scrub		Scrub/Shrub
107	63310 Mule Fat Scrub		Scrub/Shrub
108	63310 Mulefat Scrub		Scrub/Shrub
109	63320 Southern Willow Scrub		Scrub/Shrub
110	63321 Arundo donnax Dominant/Southern Willow Scrub		Scrub/Shrub
111	63330 Southern Riparian Scrub		Scrub/Shrub
112	63400 Great Valley Scrub		Scrub/Shrub
113	63410 Great Valley Willow Scrub		Scrub/Shrub
114	63800 Colorado Riparian Scrub		Scrub/Shrub
115	63810 Tamarisk Scrub		Scrub/Shrub
116	63820 Arrowweed Scrub		Scrub/Shrub
117	31200 Southern Coastal Bluff Scrub	Scrub and Chaparral	Scrub/Shrub
118	32000 Coastal Scrub		Scrub/Shrub
119	32400 Maritime Succulent Scrub		Scrub/Shrub
120	32500 Diegan Coastal Sage Scrub		Scrub/Shrub
121	32510 Coastal form		Scrub/Shrub
122	32520 Inland form (> 1,000 ft. elevation)		Scrub/Shrub
123	32700 Riversidian Sage Scrub		Scrub/Shrub
124	32710 Riversidian Upland Sage Scrub		Scrub/Shrub
125	32720 Alluvial Fan Scrub		Scrub/Shrub
126	33000 Sonoran Desert Scrub		Scrub/Shrub
127	33100 Sonoran Creosote Bush Scrub		Scrub/Shrub
128	33200 Sonoran Desert Mixed Scrub		Scrub/Shrub
129	33210 Sonoran Mixed Woody Scrub		Scrub/Shrub
130	33220 Sonoran Mixed Woody and Succulent Scrub	Scrub and Chaparral	Scrub/Shrub
131	33230 Sonoran Wash Scrub		Scrub/Shrub
132	33300 Colorado Desert Wash Scrub		Scrub/Shrub
133	33600 Encelia Scrub		Scrub/Shrub
134	34000 Mojavean Desert Scrub		Scrub/Shrub
135	34300 Blackbush Scrub		Scrub/Shrub

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
136	35000 Great Basin Scrub		Scrub/Shrub
137	35200 Sagebrush Scrub		Scrub/Shrub
138	35210 Big Sagebrush Scrub		Scrub/Shrub
139	35210 Sagebrush Scrub		Scrub/Shrub
140	36110 Desert Saltbush Scrub		Scrub/Shrub
141	36120 Desert Sink Scrub		Scrub/Shrub
142	37000 Chaparral		Scrub/Shrub
143	37120 Southern Mixed Chaparral		Scrub/Shrub
144	37120 Southern Mixed Chapparal		Scrub/Shrub
145	37121 Granitic Southern Mixed Chaparral		Scrub/Shrub
146	37121 Southern Mixed Chaparral		Scrub/Shrub
147	37122 Mafic Southern Mixed Chaparral		Scrub/Shrub
148	37130 Northern Mixed Chaparral		Scrub/Shrub
149	37131 Granitic Northern Mixed Chaparral		Scrub/Shrub
150	37132 Mafic Northern Mixed Chaparral		Scrub/Shrub
151	37200 Chamise Chaparral		Scrub/Shrub
152	37210 Granitic Chamise Chaparral		Scrub/Shrub
153	37220 Mafic Chamise Chaparral		Scrub/Shrub
154	37300 Red Shank Chaparral		Scrub/Shrub
155	37400 Semi-Desert Chaparral		Scrub/Shrub
156	37500 Montane Chaparral		Scrub/Shrub
157	37510 Mixed Montane Chaparral		Scrub/Shrub
158	37520 Montane Manzanita Chaparral		Scrub/Shrub
159	37530 Montane Ceanothus Chaparral		Scrub/Shrub
160	37540 Montane Scrub Oak Chaparral		Scrub/Shrub
161	37800 Upper Sonoran Ceanothus Chaparral		Scrub/Shrub
162	37830 Ceanothus crassifolius Chaparral		Scrub/Shrub
163	37900 Scrub Oak Chaparral		Scrub/Shrub
164	37A00 Interior Live Oak Chaparral		Scrub/Shrub
165	37C30 Southern Maritime Chaparral		Scrub/Shrub
166	37G00 Coastal Sage-Chaparral Scrub		Scrub/Shrub
167	37K00 Flat-topped Buckwheat		Scrub/Shrub
168	39000 Upper Sonoran Subshrub Scrub	Scrub and Chaparral	Scrub/Shrub
169	Diegan Coastal Sage Scrub		Scrub/Shrub
170	Granitic Northern Mixed Chaparral		Scrub/Shrub
171	Southern Mixed Chaparral		Scrub/Shrub
172	11000 Non-Native Vegetation		Unknown
173	11000 Non-Native VegetionVegetation		Unknown
174	11200 Disturbed Wetland	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Unknown
175	11300 Disturbed Habitat		Unknown
176	13000 Unvegetated Habitat		Unknown
177	Disturbed Habitat		Unknown

Table H.6-8: Potential Critical Coarse Sediment Yield Areas

GLU	Geology	Land Cover	Slope (%)
CB-Agricultural/Grass-3	Coarse Bedrock	Agricultural/Grass	20% - 40%
CB-Agricultural/Grass-4	Coarse Bedrock	Agricultural/Grass	>40%
CB-Forest-2	Coarse Bedrock	Forest	10 – 20%
CB-Forest-3	Coarse Bedrock	Forest	20% - 40%
CB-Forest-4	Coarse Bedrock	Forest	>40%
CB-Scrub/Shrub-4	Coarse Bedrock	Scrub/Shrub	>40%
CB-Unknown-4	Coarse Bedrock	Unknown	>40%
CSI-Agricultural/Grass-2	Coarse Sedimentary Impermeable	Agricultural/Grass	10 – 20%
CSI-Agricultural/Grass-3	Coarse Sedimentary Impermeable	Agricultural/Grass	20% - 40%
CSI-Agricultural/Grass-4	Coarse Sedimentary Impermeable	Agricultural/Grass	>40%
CSP-Agricultural/Grass-4	Coarse Sedimentary Permeable	Agricultural/Grass	>40%
CSP-Forest-3	Coarse Sedimentary Permeable	Forest	20% - 40%
CSP-Forest-4	Coarse Sedimentary Permeable	Forest	>40%
CSP-Scrub/Shrub-4	Coarse Sedimentary Permeable	Scrub/Shrub	>40%

<table>
<tr><th colspan="2">Verification of GLUs</th><th>Worksheet H.6-1</th></tr>
<tr><td colspan="3">Detailed project-level review of GLUs may be performed to verify the presence or absence of potential critical coarse sediment yield areas within the project site and/or upstream areas. Use this form to document the evaluation of slope, geology, and land cover combined to determine the site-specific GLUs. Complete all sections of this form.</td></tr>
<tr><td colspan="3">Project Name:</td></tr>
<tr><td colspan="3">Project Tracking Number / Permit Application Number:</td></tr>
<tr><td>1</td><td>What are the pre-project slopes?</td><td>☐ 0% to 10% (1)
☐ 10% to 20% (2)
☐ 20% to 40% (3)
☐ >40% (4)</td></tr>
<tr><td>2</td><td>What is the underlying geology? Refer to Appendix H.6 to classify geologic categories into a geology grouping.

Note: site-specific geology may be determined in the field by a qualified geologist.</td><td>☐ Coarse bedrock (CB)
☐ Coarse sedimentary impermeable (CSI)
☐ Coarse sedimentary permeable (CSP)
☐ Fine bedrock (FB)
☐ Fine sedimentary impermeable (FSI)
☐ Fine sedimentary permeable (FSP)
☐ Other (O)</td></tr>
<tr><td>3</td><td>What is the pre-project land cover? Refer to Appendix H.6 for land cover category definitions.

Note: Land cover shall be determined from aerial photography and/or field visit.</td><td>☐ Agriculture/grass
☐ Forest
☐ Developed
☐ Scrub/shrub
☐ Other
☐ Unknown</td></tr>
<tr><td>4</td><td>List the GLU(s) within the project site and/or upstream areas.
Note the GLU nomenclature format is as follows: Geology – Land Cover – Slope Category (e.g. “CB-Agricultural/Grass-3” for a GLU consisting of coarse bedrock geology, agricultural/grass land cover, and 20% to 40% slope).</td><td></td></tr>
</table>

Worksheet H.6-1; Page 2 of 2			
5	Photo(s) Insert photos representative of the slopes, land cover, and geology.		
6	Are any of the GLUs found within the project boundary and/or upstream areas listed in Table H.6-3?	☐ Yes	Go to 7
		☐ No	Go to 8
7	End – Provide management measures for preservation of coarse sediment supply as described in this guidance document, or the project applicant may elect to determine whether downstream systems would be sensitive to reduction of coarse sediment yield from the project site and/or perform site-specific method for mapping critical coarse sediment yield areas.		
8	End – Site-specific GLUs do not warrant preservation of coarse sediment supply, no measures for protection of critical coarse sediment yield areas onsite are necessary. Optional: use the note section below to provide justification for these findings.		
9	Notes		

H.6.2 Assumptions for Regional WMAA PCCSYA Maps

This appendix summarizes the assumptions used while developing Regional WMAA PCCSYA maps that are not discussed in Appendix H.6.1:

- Critical coarse sediment would be generated from GLUs that are
  - composed of geologic units likely to generate coarse sediment (i.e. produces greater than 50% sand (0.074 mm; no. 200 sieve) by weight when weathered); and
  - have a potential for high relative sediment production (GLUs that produce soil loss greater than 8.4 tons/acre/year are assigned a high relative rating, this corresponds to 42% of the total coarse soil loss from the MS4-permitted region within the County of San Diego)
- Relative sediment production was assigned using RUSLE analysis of GLUs. It was assumed that this relative rating represents sediment production from sheet erosion, rill erosion, gullies and lower order channels, since these features are mostly on the hillslopes that are represented by the GLUs.
  - While performing the RUSLE analysis to assign the relative ranking, C factor from the regional maps from USEPA was adjusted to 0 for developed land covers to account for management actions implemented on developed sites (e.g. impervious surfaces).
- WMAA mapping does not account for sediment production from in-stream sediment supply (since these are mostly protected through other regulations) and sediment production from mass failures like landslides which are difficult to estimate on a regional scale without performing extensive field investigations.
- Regional WMAA map assumes that all receiving waters require coarse sediment and the map also does not account for potential existing impediments that may hinder delivery of coarse sediment to receiving waters.

For additional details refer to the Regional WMAA document on the Project Clean Water website at the following address:

http://www.projectcleanwater.org/index.php?option=com_content&view=article&id=248&Itemid=219

H.6.3 Encroachment Allowance for Regional PCCSYA WMAA Map

When an applicant uses the regional PCCSYA map from WMAA to define onsite CCSYAs an encroachment allowance of up to 5% is allowed.

The following provides the supporting rational for 5% encroachment:

Step 1. Sp has to be greater than 0.5, based on current understanding of risks to receiving waters arising from changes in sediment production (SCCWRP Technical Report 605, 2010).

Step 2. Estimated Sp (Equation H.8.11) = $0.7*SY_{RUSLE}+0.3*SY_{NHD} = 0.7*0.42 + 0.3*1 = 0.59$

a. Based on RUSLE analysis conducted during Regional WMAA the GLUs mapped as PCCSYAs contribute 42% of the bed sediment yield (i.e. $SY_{RUSLE} = 0.42$)

b. Disturbance to NHDPlus channels are protected through 401 water quality certifications issued by the RWQCB, so it is assumed that $SY_{NHD} =1$

Step 3. Dividing the Sp estimate from Step 2 by the required Sp in Step 1 provides the factor of safety that is currently implicit in the regional WMAA PCCSYA map = 0.59/0.5 = 1.18 or 18% factor of safety

Step 4. The remaining factor of safety after accounting for the proposed encroachment of 5% = 18% - 5% = 13%

H.7 PCCSYAs: Refinement Options

If an applicant has identified onsite and/or upstream PCCSYAs and elects to perform additional optional analyses to refine the PCCSYA designation, the guidance presented below should be followed. Protection of critical coarse sediment yield areas is a necessary element of hydromodification management because coarse sediment supply is as much an issue for causing erosive conditions to receiving streams as are accelerated flows. However, not all downstream systems warrant preservation of coarse sediment supply nor all source areas need to be protected. The following guidance shall be used to refine PCCSYA designations:

- Depositional Analysis (Appendix H.7.1)
- Threshold Channel Analysis (Appendix H.7.2)
- Coarse Sediment Source Area Verification (Appendix H.7.3)

H.7.1 Depositional Analysis

Areas identified as PCCSYAs may be removed from consideration if it is demonstrated that these sources are deposited into existing systems prior to reaching the first downstream unlined water of the state. Systems resulting in deposition may include existing natural sinks, existing structural BMPs, existing hardened MS4 systems, or other existing similar features. Applicants electing to perform depositional analysis to refine PCCSYA mapping must meet the following criteria to qualify for exemption from CCSYA designation:

- The existing hardened MS4 system that is being analyzed should be upstream of the first downstream unlined waters of the state; and
- The peak velocity from the discrete 2-year, 24-hour runoff event for the existing hardened MS4 system that is being analyzed is less than three feet per second.

The three feet per second criteria is consistent with the recommended minimum velocity for storm and sanitary sewers in ASCE Manual of Engineering Practice No. 37 (ASCE, 1970).

In limited scenarios, applicant may have the option to establish site specific minimum self-cleansing velocity using Equation H.7-1 or other appropriate equations instead of using the default three feet per second criteria. This site specific analysis must be documented in the SWQMP and the County has the discretion to request additional analysis prior to approving a site specific minimum self-cleansing velocity. If an applicant chooses to establish a site specific minimum self-cleansing velocity for refinement, then the applicant must design any new bypass hardened conveyance systems proposed by the project to meet the site specific criteria.

Equation H.7-1: Minimum Self Cleansing Velocity

$$V = \frac{1.486}{n} R^{1/6} \left[B \left(s_g - 1 \right) D_g \right]^{1/2}$$

Where:

V = minimum self-cleansing velocity (ft/sec)

R = hydraulic radius (ft)

n = Manning's roughness coefficient (unitless)

B = constant equal to 0.04 for clean granular particles (unitless)

s_g = specific gravity of sediment particle (unitless): **Use 2.65**

D_g = sediment particle diameter (inches): **Use 0.20 in**

H.7.2 Threshold Channel Analysis

A threshold channel is a stream channel in which channel boundary material has no significant movement during the design flow. If there is no movement of bed load in the stream channel, then it is not anticipated that reductions in sediment supply will be detrimental to stream stability because the channel bed consists of the parent material and not coarse sediment supplied from upstream. In such a situation, changes in sediment supply are not considered a geomorphic condition of concern. SCCWRP Technical Report 562 (2008) states the following in regards to sand vs. gravel bed behavior/threshold vs. live-bed contrasts:

> "Sand and gravel systems are quite varied in their transport of sediment and their sensitivity to sediment supply. On the former, sand-bed channels typically have live beds, which transport sediment continuously even at relatively low flows. Conversely, gravel/cobble-bed channels generally transport the bulk of their bed sediment load more episodically, requiring higher flow events for bed mobility (i.e., threshold behavior)."

> "Sand-bed streams without vertical control are much more sensitive to perturbations in flow and sediment regimes than coarse-grain (gravel/cobble) threshold channels. This has clear implications in their respective management regarding hydromodification (i.e., sand systems being relatively more susceptible than coarser systems). This also has direct implications for the issue of sediment trapping by storm water practices in watersheds draining to sand-bed streams, as well as general loss of sediment supply following the conversion from undeveloped sparsely-vegetated to developed well-vegetated via irrigation."

The following provides guidance for evaluating whether a stream channel is a threshold channel or not. This determination is important because while accounting for changes in bed sediment supply is appropriate for quantifying geomorphic impacts in non-threshold stream channels, it is not considered appropriate for threshold channels. The domain of analysis for this evaluation shall be the same as that used to evaluate susceptibility, per SCCWRP Technical Report 606, Field Manual for Assessing Channel Susceptibility (2010). This domain is defined by the following upstream and downstream boundaries:

- From the point of compliance proceed downstream until reaching one of the following:
  - At least one reach downstream of the first grade-control point (preferably second downstream grade control location);
  - Tidal backwater/lentic (still water) waterbody;
  - Equal order tributary (Strahler 1952);
  - A 2-fold increase in drainage area.

OR demonstrate sufficient flow attenuation through existing hydrologic modeling.

- From the point of compliance proceed upstream for 20 channel top widths OR to the first grade control in good condition, whichever comes first.

Applicant must complete Worksheet H.7-1 to document selection of the domain of analysis. If the entire domain of analysis is classified as a threshold channel, then the PDP can be exempt from the MS4 Permit requirement for sediment supply. The following definitions from the Natural Resources Conservation Service's (NRCS) National Engineering Handbook Part 654 - Stream Restoration Design (2007) are helpful in understanding what a threshold channel is.

- **Alluvial Channel**: Streams and channels that have bed and banks formed of material transported by the stream. There is an exchange of material between the inflowing sediment load and the bed and banks of an alluvial channel (NRCS, 2007).
- **Threshold Channel**: A channel in which channel boundary material has no significant movement during the design flow (NRCS, 2007).

The key factor for determining whether a channel is a threshold channel is the composition of its bed material. Larger bed sediment consisting primarily of cobbles and boulders are typically immobile, unless the channel is a large river with sufficient discharge to regularly transport such grain sizes as bed load. As a rule-of-thumb, channels with bed material that can withstand a 10-year peak discharge without incipient motion are considered threshold channels and not live-bed alluvial channels. Threshold channel beds typically consist of cobbles, boulders, bedrock, or very dense vegetation (e.g., a thicket). Threshold channels also includes channels that have existing grade control structures that protect the stream channels from hydromodification impacts.

For a project to be exempt from coarse sediment supply requirements, the applicant must submit the following for approval by the County:

- Photographic documentation and grain size analysis used to determine the d_{50} of the bed material; and

- Calculations that show that the receiving water of concern meets the specific stream power criteria defined below <u>or</u> a finding from a geomorphologist that the stream channel has existing grade control structures that protect the stream channel from hydromodification impacts.

<u>Specific Stream Power</u>

Specific (i.e., unit) stream power is the rate at which the energy of flowing water is expended on the bed and banks of a channel (refer to Equation H.7-2). SCCWRP studies have found that locating channels on a plot of Specific Stream Power at Q_{10} (as calculated by the Hawley et al. method optimized for Southern California watersheds – Figure H.7-2) versus median channel grain size is a good predictor of channel stability. The Q_{10} equation from SCCWRP TR 606 is presented as Equation H.7-3.

Equation H.7-2: Calculation of Specific Stream Power

$$Specific\ Stream\ Power = \frac{Total\ Stream\ Power}{Channel\ Width} = \frac{\gamma QS}{w}$$

<u>Where:</u>

γ: Specific Weight of Water (9810 N/m^3)
Q: Flow Rate (dominant discharge in many cases, m^3/sec)
S: Slope of Channel
w: Channel Width (meters)

Equation H.7-3: Calculation of Q_{10} using the Hawley et al. method

$$Q_{10cfs} = 18.2 * A^{0.87} * P^{0.77}$$

<u>Where:</u>

Q_{10cfs}: 10 year Flow Rate in cubic feet per second
A: Drainage Area in sq. miles
P: Mean Annual Precipitation in inches

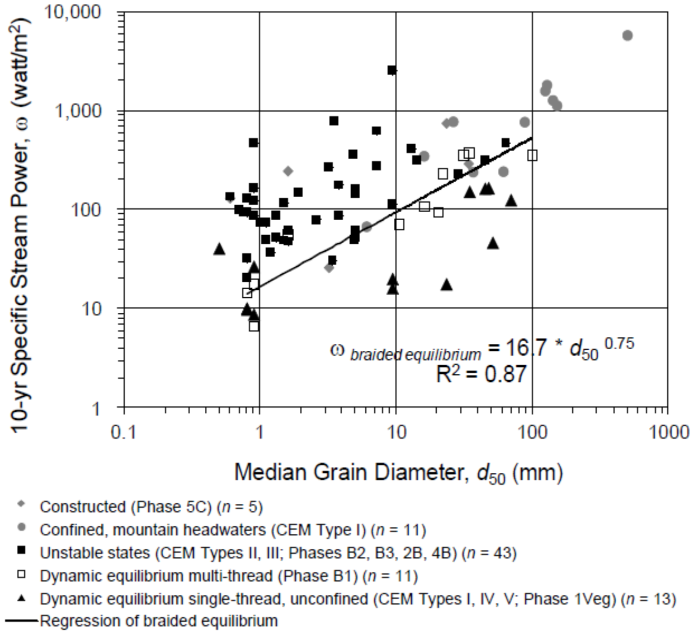


Figure H.7-1: Threshold of stream instability based on specific stream power and channel sediment diameter

Since the SCCWRP TR 606 Q_{10} (Equation H.7-3) does not explicitly consider watershed imperviousness, adjustment factors (AF) shown in Figure H.7-2 were developed using the following Equation H.7-4 for Q_{10} from SCCWRP TR 654 to account for imperviousness while estimating Q_{10}.

Equation H.7-4: Calculation of Q_{10} using equation from SCCWRP TR 654

$$Q_{10} = e^{3.61} * A^{0.865} * DD^{0.804} * P_{224}{}^{0.778} * IMP^{0.096}$$

Where:

Q_{10}: 10 year Flow Rate
A: Drainage Area in sq. miles
DD: Drainage Density
P_{224}: 2-Year 24-Hour Precipitation in inches
IMP: Watershed Imperviousness

Adjustment factors were developed as part of this methodology by changing the watershed imperviousness in Equation H.7-4 and keeping the remaining terms constant. Adjustment factor for imperviousness of 3.6% was set to 1; since it is the mean imperviousness of the dataset used to develop the stability curve in Figure H.7-1. Updated Q_{10} equation with adjustment factor is presented as Equation H.7-5 below:

Equation H.7-5: Calculation of Q_{10} with Adjustment Factor for Watershed Imperviousness

$$Q_{10cfs} = AF * 18.2 * A^{0.87} * P^{0.77}$$

Where:

Q_{10cfs}: 10 year Flow Rate in cubic feet per second
AF: Adjustment Factor
A: Drainage Area in sq. miles
P: Mean Annual Precipitation in inches

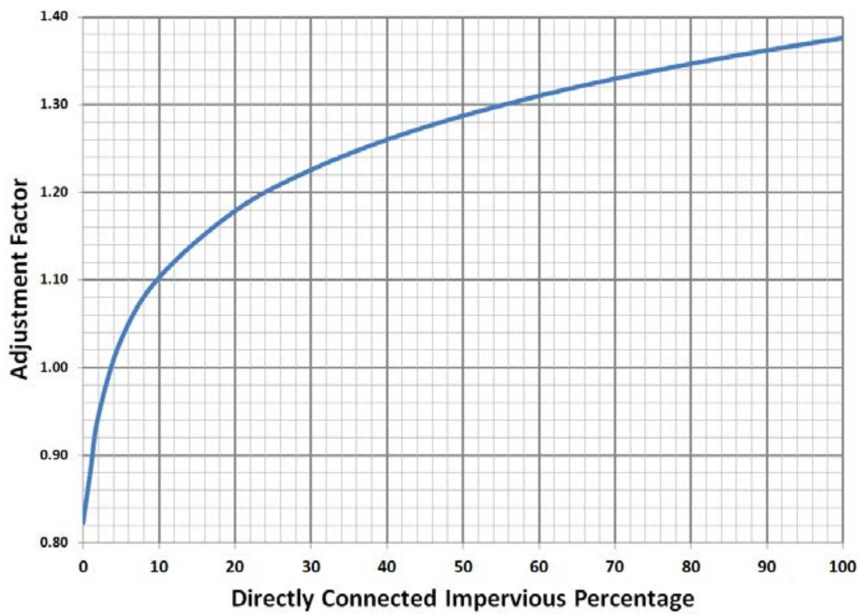


Figure H.7-2: Adjustment factor to account for imperviousness while estimating Q_{10}

Steps for evaluating the specific stream power criteria are presented below:

- **Step 1**: Calculate the specific stream power for the receiving water. Use Equation H.7-2, H.7-5 and Figure H.7-2. Directly connected imperviousness shall be estimated using guidance provided in the Water Quality Equivalency guidance document.
- **Step 2**: Determine the d_{50} of representative cross section within the domain of analysis.
- **Step 3**: Use results from Step 1 and Step 2; and Figure H.7-1 to determine if the receiving water meets the specific stream power criteria. Receiving water shall be considered meeting the specific stream power criteria when the point plotted based on results from Step 1 and Step 2 is below the solid line in Figure H.7-1.

H.7.3 Coarse Sediment Source Area Verification

When it has been determined that PCCSYAs are present, and it has been determined that downstream systems require protection, additional analysis may be performed that may refine the extents of actual CCSYAs to be protected onsite. The following analysis shall be performed to determine if the mapped PCCSYAs are a significant source of bed sediment supply to the receiving water, based on the coarse sediment proportion of the soil onsite

- Obtain a grain size distribution per ASTM D422 for the project's PCCSYA that is being evaluated.
- Identify whether the source material is a coarse grained or fine grained soil. Coarse grained is defined as over 50% by weight coarse than no. 200 sieve (i.e., $d_{50} > 0.074$ mm).
- By performing this analysis, the applicant can exclude PCCSYAs that are determined to be fine grained (i.e., $d_{50} < 0.074$ mm). Fine grained soils are not considered significant sources of bed sediment supply.
- Applicant shall include the following information in the SWQMP when this refinement option is performed:
    - Map with locations on where the grain size distribution analysis was performed;
    - Photographic documentation; and
    - Grain size distribution.
- Additional grain size distribution analysis may be requested at specific locations by the County prior to approval of this refinement.

Areas that are not expected to be a significant source of bed sediment supply (i.e. fine grained soils) to the receiving stream do not require protection and are not considered CCSYAs.

If it is determined that the PCCSYAs are producing sediment that is critical to receiving streams, or if the optional additional analysis presented above has not been performed, the project must provide management measures for protection of critical coarse sediment yield (refer to Appendix H.2, H.3 and H.4).

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Domain of Analysis		Worksheet H.7-1
Use this form to document the domain of analysis		
Project Name:		
Project Tracking Number / Permit Application Number:		
Part 1: Identify Domain of Analysis		
Project Location (at proposed storm water discharge point)		
1	Address:	
2	Latitude (decimal degrees):	
3	Longitude (decimal degrees):	
4	Watershed:	
Basis for determining downstream limit:		
Channel length from discharge point to downstream limit:		
Basis for determining upstream limit:		
Channel length from discharge point to upstream limit:		

Worksheet H.7-1; Page 2 of 2
Photo(s) Map or aerial photo of site. Include channel alignment and tributaries, project discharge point, upstream and downstream limits of analysis, ID number and boundaries of geomorphic channel units, and any other features used to determine limits (e.g. exempt water body, grade control).

H.8 Calculation Methodology for Ep and Sp

One method for quantifying hydromodification impacts to stream channels, which takes into account changes in the four factors in Lane's relationship (i.e., hydrology, channel geometry, bed and bank material, and sediment supply), is to compare long-term changes in sediment transport capacity, or in-stream work, to bed sediment supply. For the purposes of demonstrating no net impact within the MS4-permitted region of the County of San Diego, Erosion Potential (Ep) is defined as the ratio of post-project/pre-development (natural) long-term transport capacity or work. To calculate Ep, the hydrology, channel geometry, and bed/bank material factors mentioned above need to be characterized for both land use scenarios. Sediment Supply Potential (Sp) is defined as the ratio of post-project/pre-project (existing) long-term bed sediment supply. While evaluating changes in discharge and sediment supply is done primarily as a desktop analysis, geomorphic field assessment is often necessary to characterize channel geometry and bed/bank material, and to ground truth assumptions for the desktop analyses. This appendix provides methodologies for the following:

- Calculation of Ep, and
- Calculation of Sp.

H.8.1 Calculation of Ep

Erosion Potential (Ep) is defined as the ratio of post-project/pre-development (natural) long-term transport capacity or work. To calculate Ep, the hydrology, channel geometry, and bed/bank material factors mentioned above need to be characterized for both land use scenarios. Traditionally, Ep is calculated based on a watershed-scale analysis (using future built out conditions) of the area tributary to a given receiving channel of concern at the point of compliance. However, watershed-scale continuous hydrologic modeling might not be feasible for small projects, with this understanding specific simplification steps for project-scale modeling are provided in this appendix. The applicant shall perform Ep calculations using one of the following methods, as applicable:

- **Simplified Ep Method**: Applicable when the default low flow threshold of $0.1Q_2$ is used and no changes to the receiving water are proposed. Refer to Appendix H.8.1.1.
- **Standard Ep Method**: Applicable for all scenarios. Refer to Appendix H.8.1.2.

H.8.1.1 Simplified Ep Method

The simplified method is based on the relationships developed by Parra (2016) between the flow duration curve in the pre-development and post-project conditions and the standard simplified work equation. These relationships were developed using standard hydraulic equations and approximations that are applicable for channels of any lateral slope and the following geometrical cross sections: (a) wide rectangular sections; (b) relatively wide parabolic sections, and (c) triangular sections. The simplified Ep method is only applicable when the default low flow threshold of $0.1Q_2$ has been selected by the applicant for flow duration control and no changes to the receiving water geometry are proposed. Applicants shall follow Steps 1 through 3 to calculate Ep using the simplified methodology:

1. Perform continuous hydrologic simulation for the pre-development and post-project condition following guidelines in Appendix G. Generate flow bins and flow duration tables for the range of flows from $0.1Q_2$ to Q_{10}.
2. Calculate the total work in the pre-development and the post-project condition using Equation H.8.1

$$W_t = \sum_{j=1}^{n} \Delta t_j . \left(Q^{3m/2} - (0.1Q_2)^{3m/2}\right)^{1.5} Q^m$$

Equation H.8.1

Where:

W_t = Total Work [dimensionless]

Δt_j = Duration per flow bin

Q = Flow Rates estimated in STEP 1 [cfs] for a typical bin "j". Usually, in Flow Duration Curve (FDC) analyses, the number of bins is 100, so j = 1 to n (with n= 100). However, the number of bins can be as small as 20 (n = 20).

Q_2 = Pre-development 2-year peak flow [cfs]

m = exponent based on the function of the receiving channels geometry.

- For narrow creek where the top width is 7 times or less the corresponding depth, m = 1/4.
- For intermediate creeks, where the top width is more than 7 times but less than 25 times the depth, m = 4/13.
- For wide creeks, where the top width is more than 25 times the depth, m = 2/5.

3. Ep is calculated by dividing the total work of the post-project condition by that of the pre-development (natural) condition. Ep is expressed as:

$E_p = W_{t,post} / W_{t,pre}$ Equation H.8.2

Where:

E_p = Erosion Potential [unitless]

$W_{t,post}$ = Total Work associated with the post-project condition [unitless]

$W_{t,pre}$ = Total Work associated with the pre-development condition [unitless]

H.8.1.2 Standard Ep Method

While using the standard method, Ep calculation must be performed using the receiving water information from the point of compliance. Suggested steps for performing an Ep analysis are shown in the Figure H.8-1 below. This appendix describes each analysis step shown in Figure H.8-1, including the inputs and outputs of each step.

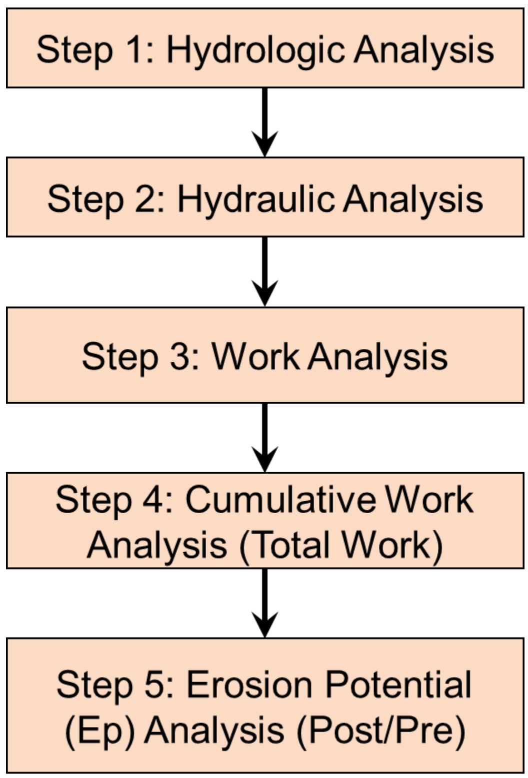

Figure H.8-1 Erosion Potential Flow Chart

STEP 1: CONTINUOUS HYDROLOGIC ANALYSIS

Hydrologic models are applied to simulate the hydrologic response of the watershed under pre-development and post-project conditions for a continuous period of record. Modeling software appropriate for this type of simulation includes USEPA's Storm Water Management Model (SWMM), Hydrological Simulation Program – Fortran (HSPF) developed by the USGS and USEPA, USACE's Hydrologic Modeling System (HEC-HMS), and the San Diego Hydrology Model (SDHM) developed by Clear Creek Solutions, Inc. SDHM uses an HSPF computational engine, long-term precipitation data, and is a visually-oriented interactive tool for automated modeling and facility sizing.

Input parameters for these continuous simulations are hourly precipitation data for a long-term (>30 years) record, sub-catchment delineation, impervious cover, soil type, vegetative cover, terrain steepness, lag time or flow path length, and monthly evapotranspiration rate. The primary output is a simulated discharge record associated with the receiving channel of concern. Flow routing through drainage conveyances is necessary for continuous hydrologic analysis at the watershed scale. Appendix G provides guidance for developing continuous simulation models.

Traditionally, a hydrograph (Figure H.8-2) is the primary means for graphically comparing discharge records; however, a hydrograph is not ideal because long-term flow records span several decades.

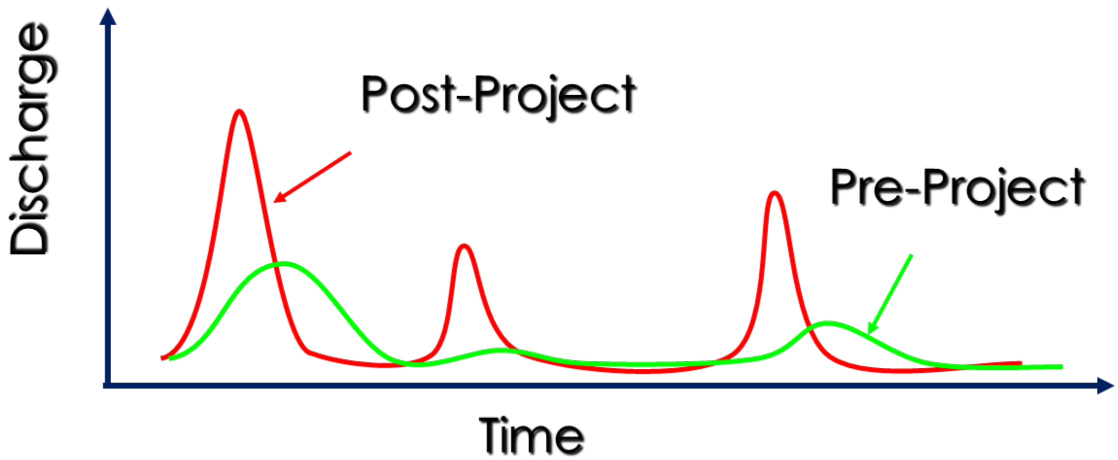

Figure H.8-2 Example Hydrograph Comparison

Instead, a more effective means for comparing long-term continuous discharge records is to create a flow histogram, which differentiates the simulated flowrates into distinct "flow bins" so that the duration of flow for each bin can be tabulated. One method for establishing the distribution of flow bins is to increment the flow bins according to increments of flow stage using a hydraulic analysis, such as the normal depth equation. In this way, the hydraulic analysis step (Step 2) can be considered an input to the continuous hydrologic analysis step. While there is no established rule of thumb for how many flow bins are necessary, it is suggested that no less than 20 be used for an Ep analysis. An example of a flow histogram is provided on Figure H.8-3.

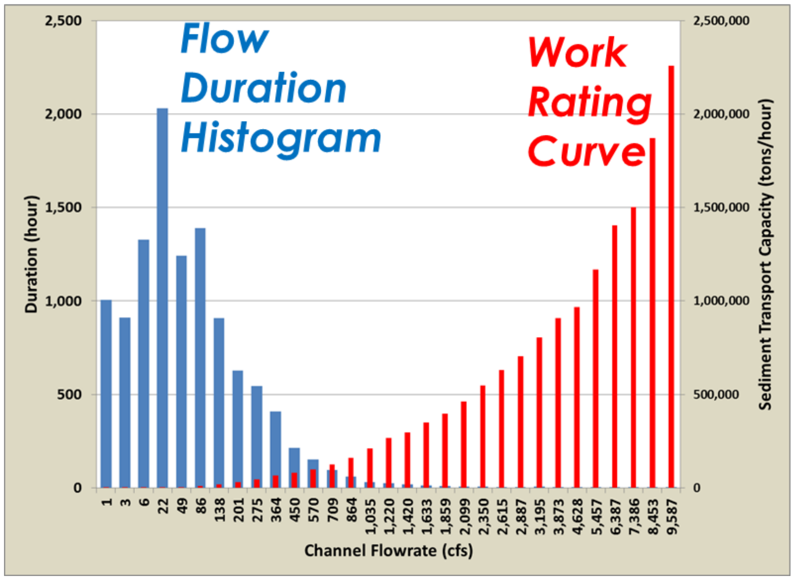

Figure H.8-3 Example Flow Duration Histogram

Flow duration curves are another commonly used method for graphically interpreting long-term flow records. A flow duration curve is simply a plot of flowrate (y-axis) versus the cumulative duration, or percentage of time, that a flowrate is equaled or exceeded in the simulation record (x-axis). Figure H.8-4 provides an example flow duration curve comparison.

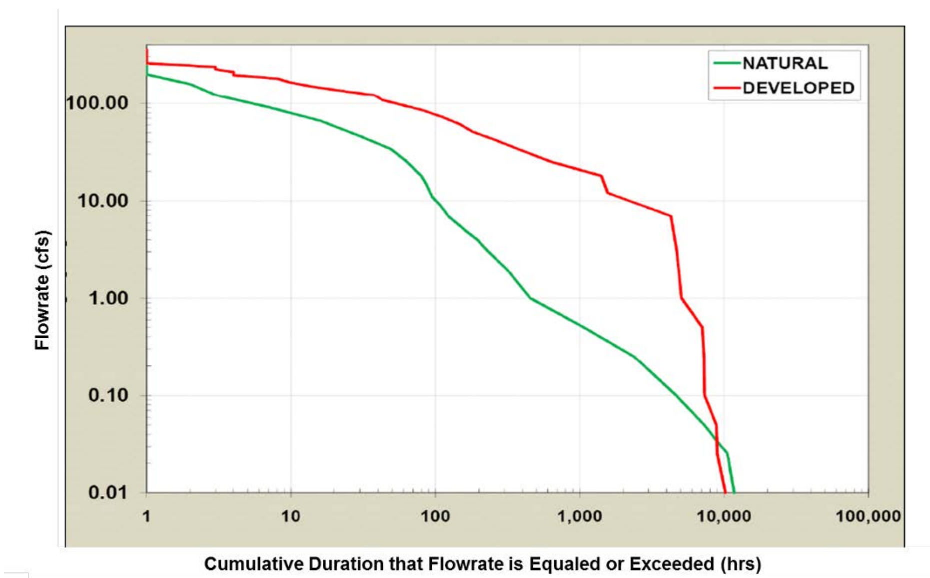

Figure H.8-4 Example Flow Duration Curve

Scaling Factor for Project-Scale Modeling

Project-scale flow rates derived from continuous hydrologic simulation can be scaled using the ratio of the pre-development 2-year peak discharge for the watershed and project catchment (i.e., Q_2 watershed / Q_2 project catchment) so that hydraulic and effective work calculations can be performed at the point of compliance with a larger tributary watershed. This scaling translates the runoff from the project catchment to its contribution to erosivity in the down gradient receiving channel, without the need for a complex watershed-scale continuous hydrologic model.

Applicant can estimate the scaling factor using Equation H.8.3. The scaling factor equation was developed using the 2-year peak flow rate empirical equation from Hawley and Bledsoe (2011) and removing the terms (average annual precipitation and imperviousness (pre-development condition as required by the MS4 Permit) that are constant.

$$Scaling\ Factor = \left(\frac{A_{watershed}}{A_{project}}\right)^{0.667} \qquad \text{Equation H.8.3}$$

Where:

$A_{watershed}$ = total watershed drainage area at the point of compliance(mi^2)

$A_{project}$ = total project drainage area (mi^2)

STEP 2: HYDRAULIC ANALYSIS

Hydraulic parameters, such as stage, effective shear stress, and flow velocity, are computed for each designated flow bin using channel geometry and roughness data. Hydraulic calculations can be as simple as using the normal flow equation and obtaining results for the central channel or as complicated as using hydraulic models which account for backwater effects, such as HEC-RAS.

Using the formula for unit tractive force (Chow 1959), effective shear stress is expressed using equation H.8.4

$$\tau = \gamma RS \qquad \text{Equation H.8.4}$$

Where:

τ = Effective Shear Stress [lb/ft^2]

γ = Unit Weight of Water [62.4 lb/ft^3]

R= Hydraulic Radius [ft]

S = Energy Gradient Assumed Equal to Longitudinal Slope [ft/ft].

Normal depth can be estimated using Manning's equation (Equation H.8.5). Several sources provide lists of roughness coefficients for use in hydraulic analysis (Chow, 1959).

$$Q = \frac{1.49AR^{0.67}S^{0.5}}{n} \; or \; V = \frac{1.49R^{0.67}S^{0.5}}{n} \qquad \text{Equation H.8.5}$$

Where

Q = Peak Flowrate [cfs]

V = Average Flow Velocity [ft/s]

A = Cross-Section Flow Area [ft^2]

R = Hydraulic Radius [ft] = A/P

P = Wetted Perimeter [ft]

S = Energy Gradient Assumed Equal to Longitudinal Slope [ft/ft]

n = Manning Roughness [unit less]

Channel geometry inputs should be characterized by surveying cross-sections and longitudinal profiles of the active channel at strategic locations. Methods of collecting topographic survey data can range from traditional survey techniques (auto level, cloth tape, and survey rod), to conducting a detailed ground-based LiDAR survey.

STEP 3: WORK ANALYSIS

Hydraulic results for each flow bin along with the critical bed/bank material strength parameters are input into a work or sediment transport function in order to produce a work or transport rating curve. An example of such a rating curve is provided on Figure H.8-3. The work equations can range from simplistic indices, material-specific sediment transport equations, or more complex functions based on site-calibrated sediment transport rating curves.

- **Simplistic indices:** An acceptable equation for effective work, as stated in the Los Angeles Regional MS4 Permit (LARWQCB, 2012) is expressed using equation H.8.6:

  $$W = (\tau - \tau_c)^{1.5} V \qquad \text{Equation H.8.6}$$

  Where:

  W = Work [dimensionless];

  τ = Effective Shear Stress [lb/ft^2];

  τ_c = Critical Shear Stress [lb/ft^2];

  V = Mid-Channel Flow Velocity [ft/s]

- **Material-specific sediment transport equations**: Material specific sediment transport equations are allowed to estimate the sediment transport capacity in the post-project and pre-development condition.
- **Site-calibrated sediment transport curves**: Applicants may have an option to use site-calibrated sediment transport curves. In the future these may be available based on monitoring efforts being performed to support the County of San Diego's Hydromodification Management Plan.

The critical shear stress to be used in equation H.8.6 must be estimated using one of the following:

- Shear stress corresponding to the critical flow rate or low flow threshold (Qc). Qc is the flowrate that results in incipient motion of bed or bank material, whichever is least resistant. Qc is expressed as a fraction of the pre-development 2-year peak flow. The allowable low flow threshold Qc can be estimated as 10%, 30%, or 50% of the pre-development 2-year peak flow ($0.1Q_2$, $0.3Q_2$, or $0.5Q_2$) depending on the receiving stream susceptibility to erosion, per SCCWRP Technical Report 606, Field Manual for Assessing Channel Susceptibility (SCCWRP, 2010). If a channel susceptibility assessment is not performed, then the conservative default is a Qc equal to $0.1Q_2$.
- Bed and bank material can also be characterized through a geomorphic field assessment. For each stream location analyzed, a measure of critical shear stress can be obtained for the weakest bed or bank material prevalent in the channel. For non-cohesive material, a Wolman pebble count or sieve analysis can be used to obtain a grain size distribution, which can be converted to a critical shear stress using empirical relationships or published reference tables.

For cohesive material, an in-situ jet test or reference tables are used. For banks reinforced with vegetation, reference tables are generally used. Appropriate references for critical shear stress values are provided in ASCE No.77 (1992) and Fischenich (2001). To account for the effects of vegetation density and channel irregularities, the applied shear stress can be partitioned into channel form and bed/bank roughness components. SCCWRP Technical Report 667 also has guidance for estimating critical shear stress.

STEP 4: CUMULATIVE WORK ANALYSIS

Cumulative work is a measure of the long-term total work or sediment transport capacity performed at a creek location. It incorporates the distribution of both discharge magnitude and duration for the flow rates simulated. The cumulative work analysis must be performed up to the maximum geomorphically significant flow of Q_{10}. To calculate cumulative work, first multiply the work (from STEP 3) and duration associated with each flow bin (from STEP 1). Then, the total work is obtained by summing the cumulative for all flow binds (Q_c to Q_{10}). This analysis can be expressed as:

$$W_t = \sum_{i=1}^{n} W_i \, \Delta t_i$$ Equation H.8.7

Where:

W_t = Total Work [dimensionless]

W_i = Work per flow bin [dimensionless]

Δt = Duration per flow bin [hours]

n = number of flow bins

The distribution of cumulative work, also referred to as a work curve (or work histogram), is helpful in understanding which flow rates are performing the most work on the channel of interest. An example work curve is provided in Figure H.8-5.

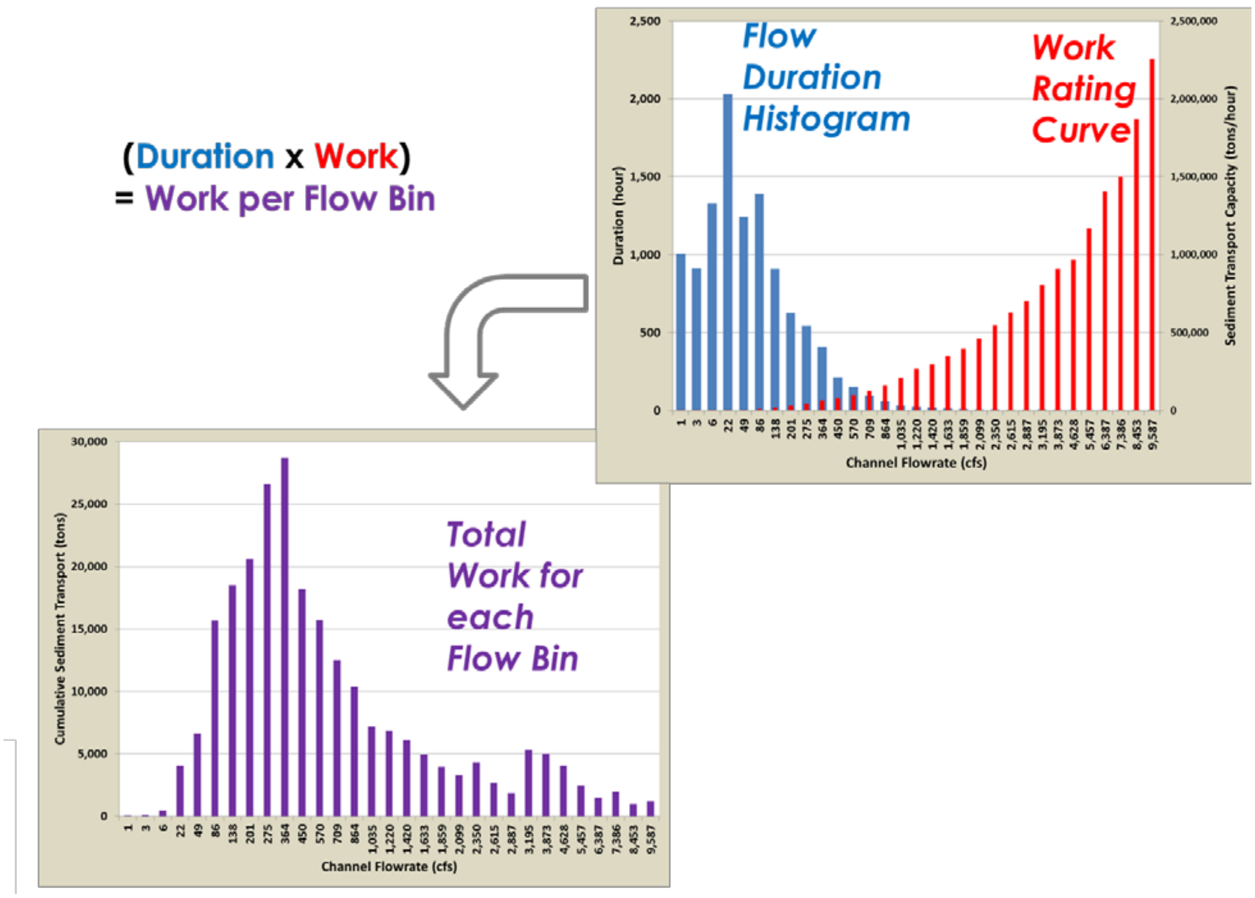

Figure H.8-5 Example Work Curve

STEP 5: EROSION POTENTIAL ANALYSIS

Ep is calculated by simply dividing the total work of the post-project condition by that of the pre-development (natural) condition. Ep is expressed as:

$$E_p = W_{t,post} / W_{t,pre} \qquad \text{Equation H.8.8}$$

Where:

E_p = Erosion Potential [unitless]

$W_{t,post}$ = Total Work associated with the post-project condition [unitless]

$W_{t,pre}$ = Total Work associated with the pre-development condition [unitless]

As applicable, the applicant must use Worksheet H.8.1-1 and H.8.1-2 to document the Ep calculations for each point of compliance.

Erosion Potential (Ep) Analysis		Worksheet H.8.1-1	
Background Information			
1	Low Flow Threshold: results of SCCWRP channel susceptibility analysis (Select 0.1*Q_2 if analysis has not been performed).	☐ 0.1*Q2 ☐ 0.3*Q2 ☐ 0.5*Q2	
2	Selected Ep Method	☐ Simplified Ep Method ☐ Standard Ep Method	
2	Hydrologic Analysis: Select hydrologic analysis method.	☐ Project-Scale ☐ Project-Scale and Watershed-Scale Continuous Simulation	
4	Number of Points of Compliance (Copy and complete worksheet for each Point of Compliance)		unitless
Step 1: Hydrologic Analysis (not applicable for Simplified Ep Method)			
5	Project-Scale Q_2 (from continuous simulation)		cfs
6	Project Area draining to the point of compliance		sq. miles
7	Watershed Area draining to the point of compliance		sq. miles
8	Scaling Factor for Flows $(\text{Line 7}/\text{Line 6})^{0.667}$		unitless
9	Low flow threshold (factor from Line 1 x Line 6)		cfs
10	Watershed-Scale Q_{10} at Point of Compliance (from continuous simulation or Project Q_{10} * Line 8)		cfs
	Hydrologic analysis results (Attach results of continuous simulation including: full pre-development runoff time series at POC, full post-development runoff time series at POC, and flow duration histogram and/or cumulative flow duration curve for each POC).		☐ Yes ☐ No
Step 2: Hydraulic Analysis (not applicable for Simplified Ep Method)			
11	Provide details about the cross-section (width, depth, slope, roughness, etc.)		

Erosion Potential (Ep) Analysis		Worksheet H.8.1-1	
Step 3: Work Analysis (not applicable for Simplified Ep Method)			
12	Select work index, equation, or transport curve method for use in work analysis.	☐ Equation H.8.6 ☐ Sediment Transport Equation ☐ Sediment Transport Curve ☐ Other: ______________	
13	Describe/Justify selection in Line 12 above:		
14	Calculate work done for each flow bin under the pre-development and post-project condition using Worksheet H.8.1-2. Or similar documentation for sediment transport modeling or transport curve analysis.	☐ Yes ☐ No	
Step 4: Cumulative Work Analysis			
14	Cumulative pre-development work (Equation H.8.1 for Simplified Ep Method) (from Worksheet H.8.1-2 for Standard Ep Method)		
15	Cumulative post-project work (Equation H.8.1 for Simplified Ep Method) (from Worksheet H.8.1-2 for Standard Ep Method)		
Step 5: Erosion Potential Analysis			
16	Erosion Potential (Line 15 / Line 14)		unitless

Work Calculations (Supplement to Worksheet H.8.1-1)									Worksheet H.8.1-2	
1	Channel Slope								(ft/ft)	
2	Channel Roughness (n)								(unitless)	
3	Low Flow Threshold (Line 9 from Worksheet H.8.1-1)								cfs	
4	Critical Shear Stress								(lb/ft^2)	
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Bin	**Flow (cfs)**			**Duration (hours)**		**Hydraulic Radius (ft)**	**Average Velocity (ft/s)**	**Shear Stress (lb/ft^2)**	**Work (unitless)**	
	Lower Limit	**Upper Limit**	**Average**	**Pre-development**	**Post-Project**				**Pre-development**	**Post-Project**
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
n										
Sum (Bins 1 to n) =										

Worksheet H.8.2-2 Key

A Number of flow bins, add additional rows as needed

B Lower limit for the corresponding flow bin

C Upper limit for the corresponding flow bin

D Average flow for the corresponding flow bin; [(**B** + **C**)/2]

E Duration in hours for the corresponding flow bin in pre development condition

F Duration in hours for the corresponding flow bin in post project condition

G Hydraulic radius (in feet) associated with the average flow for the corresponding flow bin (from Manning's equation and/or hydraulic analysis)

H Average flow velocity (in fps) associated with the average flow for the corresponding flow bin (from Manning's equation and/or hydraulic analysis)

I Shear stress (lb/ft^2) associated with the average flow for the corresponding flow bin = γ * Hydraulic Radius*Slope = 62.4 * **G** * Line 1

J Pre-development work for associated flow bin

J = 0; If (**I** – Line 4) ≤ 0

J = **E** * (**I** – Line 4)$^{1.5}$ * **H**; If (**I** – Line 4) > 0

K Post-project work for associated flow bin

K = 0; If (**I** – Line 4) ≤ 0

K = **F** * (**I** – Line 4)$^{1.5}$ * **H**; If (**I** – Line 4) > 0

Note: If the receiving water dimensions are different in pre-development and post-project condition then Worksheet H.8.1-2 is not valid for work calculations.

H.8.2 Calculation of Sp

While there are many categories of erosion processes (e.g., landslides, debris flows, gullies, tree throw, animal burrows, sheetwash erosion, wind erosion, dry ravel, bank erosion), in this evaluation processes will be simplified to sediment production from hillslopes and channels. Under ideal circumstances, the total bed sediment supply rate (tons/year) would be calculated for both the post-project built-out condition and pre-project condition using a watershed-scale Geomorphic Landscape Unit (GLU) and Geomorphic Channel Unit (GCU) approach which:

(1) identifies different sources of sediment supply based on categories of terrain slope, geology, land cover, and stream order;
(2) estimates the base erosion rate of those sources (GLUs and GCUs);
(3) approximates the sediment delivery ratio (SDR) to the receiving channel;
(4) evaluates the coarse bed-load fraction of the sources; and
(5) integrates these considerations into a bed-load yield rate for both the existing condition and proposed built-out condition.

However, calculation of sediment yield rates for each GLU (tons/mi^2-yr) and GCU (tons/mi-yr) using the available science is inherently inexact and requires extensive field calibration. Additionally, performing the geospatial calculations necessary for such a comprehensive GLU and GCU analysis may not be straightforward for some project applicants. Since the objective is to determine the fraction of reduction in bed sediment supply in the post-project condition compared to the pre-project condition, but not to determine the bed sediment yield in physical units (tons/year/acre, for example) the following simplifications are allowed. These simplifications take into consideration the regional sediment yield map shown in Figure H.8.6.

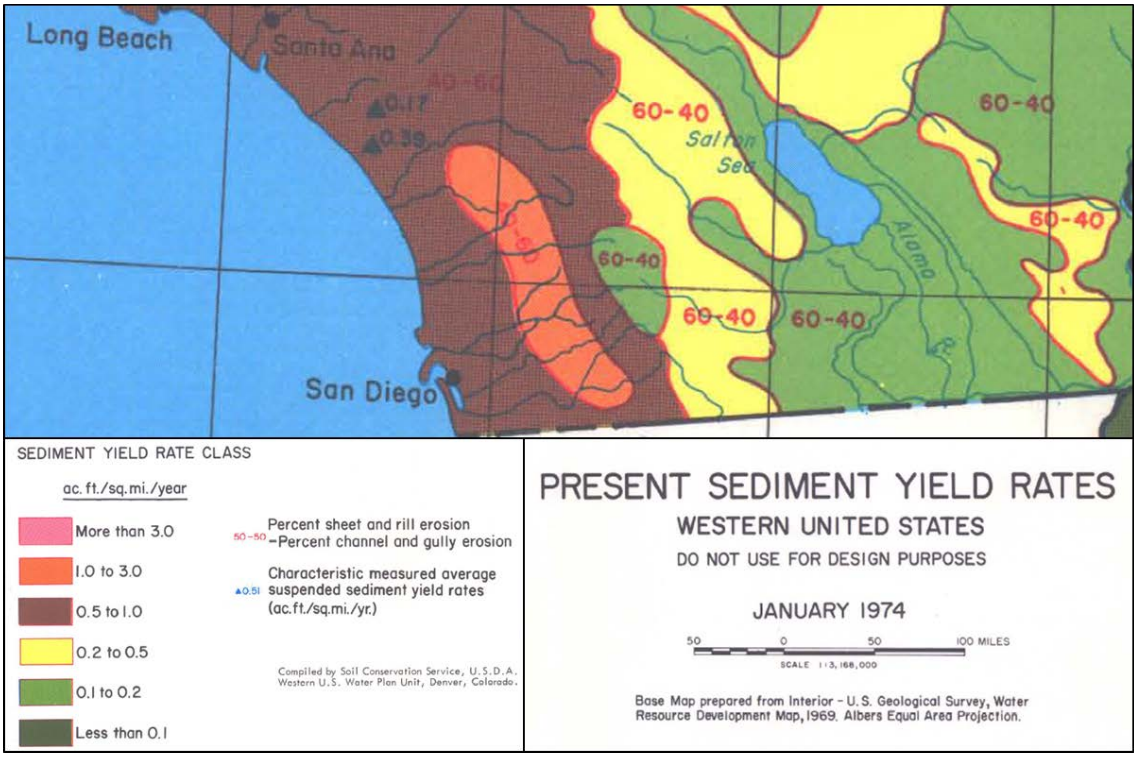

Figure H.8-6 Regional Sediment Yield Map

According to a regional sediment yield map of the Western US (USDA, 1974), hillslope processes (sheet and rill erosion) account for approximately 40% of the sediment yield in the San Diego County region, while channel processes (in-stream and gully erosion) account for approximately 60% of the sediment yield. Figure H.8-7 shows the different erosion processes. Provision E.3.a.(3)(a) of the MS4 Permit requires, "maintenance or restoration of natural storage reservoirs and drainage corridors (including topographic depressions, areas of permeable soils, natural swales, and ephemeral and intermittent streams)", effectively making maintenance or restoration of channels and gullies within a project site a site design requirement.

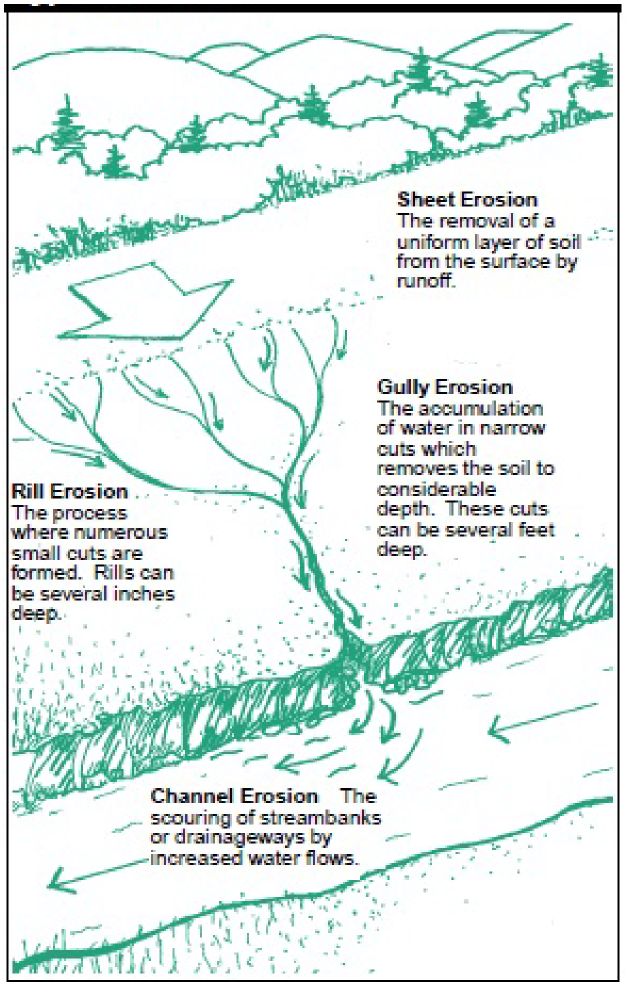

Figure H.8-7 Different Erosion Processes that Contribute Sediment

Source: http://www.fairfaxcounty.gov/nvswcd/youyourland/soil.htm

Sediment yield from hillslope processes (sheet and rill erosion) can be estimated using the Revised Universal Soil Loss Equation (RUSLE) and a sediment delivery ratio. For channel processes, the best available regional datasets are the USGS National Hydrography Dataset (NHD) and the NHDPlus dataset from USEPA and USGS (http://www.horizon-systems.com/nhdplus/). Both these datasets may not include the lowest order channels or gullies in the stream network, which can contribute a considerable amount of sediment produced from channel processes. Since the lower order channels and gullies originate and are mostly on the hillslopes, it is assumed for the Sp analysis that the sediment yield from lower order channels and gullies is proportional to the sediment yield from hill slopes. Based on feedback received during the TAC meetings (Appendix H.5.1) the following distribution is proposed for the calculation of Sp:

- 70% of bed sediment yield ratio from RUSLE analysis (assumed to account for sediment yield from hillslope processes (sheet and rill erosion) and channels and gullies not part of the NHDPlus dataset); and

- 30% of bed sediment yield ratio from channels in the NHDPlus dataset.

Note:

- If an applicant elects to map the waters of the state, the Sp distribution shall be revised to
    - 40% of bed sediment yield ratio from RUSLE analysis;
    - 30% of bed sediment yield ratio from waters of the state that are not part of NHDPlus dataset; and
    - 30% of bed sediment yield ratio from channels in the NHDPlus dataset.

SCALE OF ANALYSIS

The project applicant shall perform the Sp analysis at point (or points) where runoff leaves the project site[22]. The steps for performing an Sp analysis are shown in Figure H.8-8 and described below.

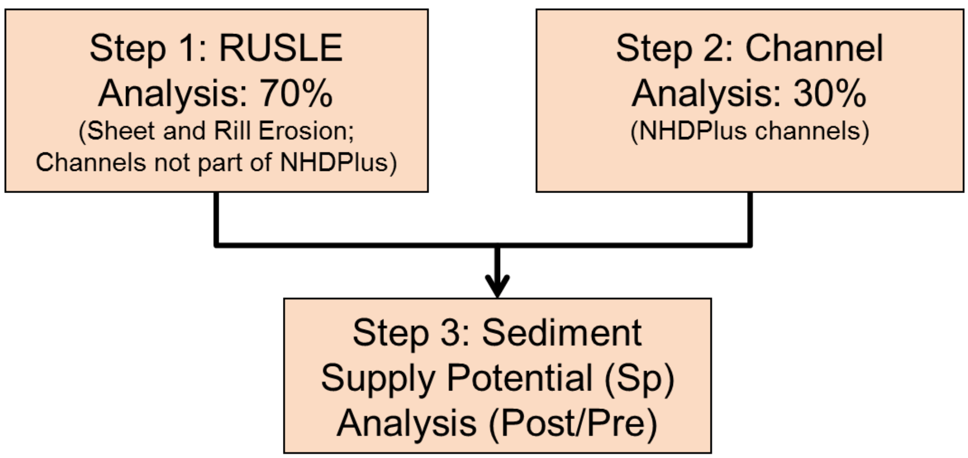

Figure H.8-8 Sediment Supply Potential Flow Chart

STEP 1: RUSLE ANALYSIS

RUSLE analysis is assumed to account for sediment yield from hillslope processes (sheet and rill erosion) and channels and gullies not part of the NHDPlus dataset. The change in bed sediment yield in the post-project condition compared to the pre-project condition using the RUSLE analysis must be estimated using equation H.8.9. This equation is a modified form of the standard RUSLE equation. Only hillslopes that are anticipated to generate coarse sediment must be used in this

[22] In limited scenarios, the County has the discretion allow for a watershed-scale Sp analysis to be performed at the point of compliance it the future built-out conditions of the watershed are used in the analysis.

analysis. Since Sp is a dimensionless index the terms that are relatively constant in the pre and post project condition, such as rainfall factor, have been removed.

$$SY_{RUSLE} = \frac{Post\text{-}Project \sum\{A \times K \times LS \times C \times P\}}{Pre\text{-}Project \sum\{A \times K \times LS \times C\}}$$ Equation H.8.9

Where:

A = Hillslope Area (acres)

K = Soil erodibility factor, this value can be obtained from regional K factor map from SWRCB or web soil survey or site-specific grain size analysis

LS = Slope length and steepness factor, this value can be obtained from the regional LS factor map from SWRCB or site-specific determination using look up tables based on slope and horizontal slope length from USDA Agriculture Handbook Number 703 (Renard et al., 1997) or other relevant sources

C= Cover management factor, use regional C factor map from USEPA or site-specific information; this is the reciprocal of the amount of surface cover on soil, whether it be vegetation, temporary mulch or other material. It is roughly the percentage of exposed soil, i.e., 95 percent cover yields a "C" value of 0.05. Use C=0 for areas where management actions are implemented (e.g. impervious areas)

P = Practice factor, only included in post-project condition. This term is added to account for sediment yield from engineered slopes. Practice factor of 0.25 shall be used for fill slopes and a practice factor of 0.50 shall be used for cut slopes. Use a practice factor of 1 for undisturbed areas.

The applicant may be allowed to receive credit for bed sediment yield from engineered slopes on the project perimeter directly discharging to conveyance systems if <u>all</u> of the following criteria are met:

- The engineered slopes consist of coarse bed material. This is confirmed by performing grain size distribution per ASTM D422 for the engineered slope and verifying that the d_{50} is greater than no. 200 sieve (0.074 mm).
- Cover factor in the post project condition shall not be greater than the cover factor used in the pre project condition for the same area.
- A maximum practice factor of 0.25 may applied to proposed fill slopes. A maximum practice factor of 0.50 may be applied to proposed cut slopes.
- A statement from the geotechnical engineer is included in the SWQMP certifying that the engineered slope will be stable even after accounting for bed sediment generation and the anticipated soil loss during the planned lifetime of the engineered slope is acceptable.

Additional analysis and/or documentation may be requested by the County prior to approval of the credit for bed sediment yield from engineered slopes.

STEP 2: CHANNEL ANALYSIS

If an NHDPlus mapped channel exists within the project property boundary, applicants must consider the sediment production from this existing channel system. The change is bed sediment yield in the post-project condition compared to the pre-project condition from channels in the NHDPlus dataset must be estimated using equation H.8.10 (SY_{NHD}). This equation is based on screening-level GIS calculations of stream length that will be contributing sediment in the post-project condition in the watershed tributary to the point of compliance.

$$SY_{NHD} = \frac{L_{post}}{L_{pre}}$$ Equation H.8.10

Where:

L_{post} = Length of NHDplus streams in the watershed contributing to bed sediment supply in the post-project condition [miles]

L_{pre} = Length of NHDplus streams in the watershed contributing to bed sediment supply in the pre-project existing condition [miles]

STEP 3: SEDIMENT SUPPLY POTENTIAL ANALYSIS

Sediment Supply Potential (Sp) is defined as the ratio of post-project/pre-project (existing) long-term bed sediment supply. Sp must be calculated using equation H.8.11 presented below:

$$S_p = 0.7 \times SY_{RUSLE} + 0.3 \times SY_{NHD}$$ Equation H.8.11

Where:

S_p = Sediment Supply Potential [unitless]

SY_{RUSLE} = Change in bed sediment yield from hillslopes and lower order channels and gullies not part of NHDPlus dataset [unitless]

SY_{NHD} = Change in bed sediment yield from channels in NHDPlus dataset [unitless]

When estimating Sp the following additional conditions apply:

- Projects that do not have onsite NHDPlus channels shall omit consideration of SY_{NHD} and weighting factors depicted in Equation H.8.11. This simply results in Sp = $SY_{RUSLE.}$
- It must be assumed that the sediment yield from an area that drains to a structural BMP is zero. Consideration of sediment yield from an area draining to the structural BMP may be allowed if sediment bypass measures are implemented upstream of the structural BMP. However, additional analysis may be requested by the County to substantiate the sediment yield estimates proposed by the applicant from implementing sediment bypass measures.
- For scenarios where an upstream coarse sediment yield area drains through the project footprint and the project footprint cuts off conveyance of bed sediment generated upstream

of the project footprint to the point of compliance, (e.g., via debris basins) the contribution from the upstream area shall be assumed to be zero.

As applicable, the applicant must use Worksheet H.8.2-1 to document the Sp calculations for each point of compliance.

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Sediment Supply Potential (Sp) Analysis												Worksheet H.8.2-1
1	Scale of Analysis						☐ Project Scale ☐ Watershed Scale (built-out condition)					
Step 1: RUSLE Analysis												
2	GLU	Pre-Project					Post-Project					
		A	K	LS	C	A*K*LS*C	A	K	LS	C	P	A*K*LS*C*P
	1											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	Add additional rows as needed											
3	Sum Pre-Project						Sum Post-Project					
4	SY_{RUSLE}: (Sum Post-Project/ Sum Pre-Project) (From Line 3)											unitless
Step 2: Channel Analysis: NHDPlus Channels												
5	L_{pre} (from GIS analysis of pre-project existing condition)											miles
6	L_{post} (from GIS analysis of post-project condition)											miles
7	SY_{NHD}: (Line 6 / Line 5)											unitless
Step 3: Sediment Supply Potential Analysis												
8	RUSLE Analysis Bed Sediment Yield Ratio Calculated (Line 4)											unitless
9	Channel Bed Sediment Yield Ratio from NHDPlus dataset (Line 7)											unitless
10	Sediment Supply Potential Calculated using Equation H.8.11. (0.7 x Line 8 + 0.3 x Line 9)											unitless

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H.9 Mitigation Measures Fact Sheets

The following fact sheets were developed to assist the project applicants with designing mitigation measures:

- Additional flow control
- Stream Rehabilitation

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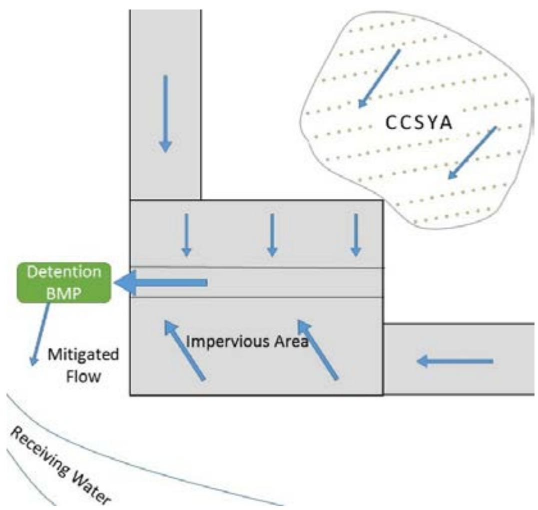
H.9.1 Additional Flow Control



Description

Additional flow control refers to the modification of post-development flow rates and durations beyond the levels required by standard HMP criteria (i.e. control of flow rates and durations from Q_c to Q10). Additional flow control can mitigate the effect of decreased sediment delivery by equivalently limiting sediment transport capacity. BMPs providing additional flow control are detention/retention type BMPs and will typically be larger than those that meet HMP criteria only. The performance standard for additional flow control can be demonstrated through the NII management standard.

Management Standard and Sizing Approach

The management standard additional flow control BMPs need to meet to demonstrate that there is no net impact to the receiving waters is presented in the equation below:

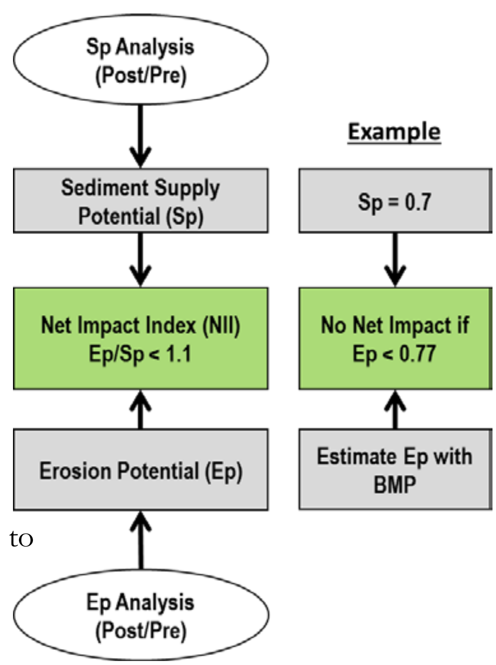
$$NII = \frac{Ep}{Sp} \leq 1.1$$

Where:

Ep: is the ratio of post-project/pre-development sediment transport capacity

Sp: ratio of post-project/pre-project (existing) long-term bed sediment supply

Note: Redevelopment projects typically do not have critical coarse sediment yield areas onsite because management actions have been implemented onsite (e.g. impervious areas, etc.). Refer to Appendix H.8 for methodologies to calculate Ep and Sp.



Project applicants must demonstrate that the NII management standard will be met under the post-project scenario through the following steps:

1. Calculate the Sp at the point of compliance using guidance in Appendix H.8.2.

2. Determine the Target Ep: $Ep_{Target} \leq 1.1 * Sp$
3. Calculate the pre-development sediment transport capacity or work (Ep denominator). Refer to Section 6.3.3 for definition of pre-development and refer to Appendix H.8.1 for guidance on calculating the sediment transport capacity or work.
4. Iteratively size additional flow control BMPs and calculate the post-project sediment transport capacity (Ep numerator) until the target Ep is reached.
5. Summarize the calculations performed to size the BMPs in the SWQMP.

In addition to the general approach outlined above, additional flow control BMPs must meet the design criteria presented in the Appendix E Fact Sheets. Deviations from these criteria may be approved at the discretion of the County if it is determined appropriate.

Design Adaption for Project Goals

NII management standard is met by additional flow control. Larger BMPs may be able to provide adequate additional flow control to meet the required performance standard. In this scenario no additional sediment BMPs are required.

For example, project that has an Sp = 0 (i.e. 100% of the bed sediment in the drainage area to the point of compliance is impacted by the project) can be mitigated by designing a BMP such that there is no discharge within the geomorphically significant flow range (i.e. Q_c to Q_{10}).

NII management standard is not fully met by additional flow control. Additional flow control alone may not be able to entirely meet the NII management standard due to site, or other, constraints. In scenarios where the target Ep cannot be met by additional flow control, additional BMPs that increase the supply of bed sediment or reduce the susceptibility of the receiving channel will be required.

Note: Additional flow control BMPs can be independent BMPs that provide flow control only or they can be integrated with storm water pollutant control BMPs.

Conceptual Design and Sizing Approach

The following steps detail an approach that can be used to appropriately size BMPs that provide additional flow control:

Step 1: **Calculate the Sediment Supply Potential (Sp) based on pre- and post-project condition at the point of compliance.**

- Refer to Appendix H.8.2 for methodology to calculate Sp. Applicant must document this analysis using Worksheet H.8.2-1.

Step 2: **Determine the Target Ep based on the results of Step 1.**

- $Ep_{Target} \leq 1.1 * Sp$

Step 3: **Perform continuous simulation modeling for pre-development condition.**

- Perform continuous simulation (refer to Appendix G) for the pre-development condition.
- Determine the flow durations for the pre-project scenario as described in Appendix G.1.6.2.

Step 4: Perform pre-development work analysis.

- Calculate the cumulative work performed by the range of geomorphically significant flows for the pre-development scenario, (refer to Step 3 and Step 4 in Appendix H.8.1 for calculation of work).

Step 5: **Implement flow control BMPs and perform continuous simulation modeling for post-project scenario.**

- Appropriately size pollutant control and hydromodification management BMPs according to the procedures presented in this manual.
- Perform continuous simulation (refer to Appendix G) for the post-project condition.
- Determine the flow durations for the post-project scenario as described in Appendix G.1.6.2.
- Typically, BMPs sized to satisfy the flow duration control will provide for some level of Sp reduction and will ensure that the minimum design standards and sizing requirements are met.

Step 6: **Perform post-project work analysis.**

- Follow the steps presented in Step 4 to determine the post-project total work.

Step 7: **Calculate Ep and determine if Target Ep has been met.**

- Divide the post-project total work by the pre-development total work and determine if the target Ep has been met.
- If the target Ep is met by the standard BMPs, document results and compliance with hydrologic and sediment supply performance standards.
- If the target Ep is not met, proceed to Step 8.

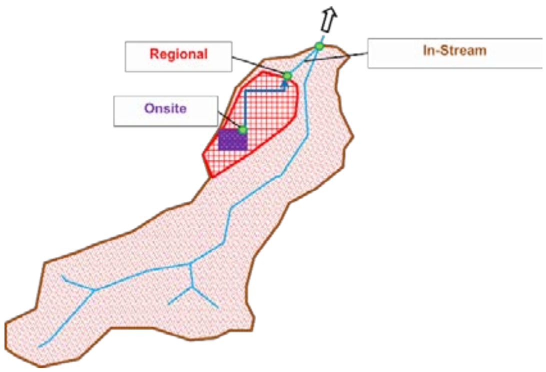
Step 8: Provide additional flow control storage and calculate Ep.

- Following the procedures presented in the previous steps, iteratively calculate Ep for increasingly large BMPs until the target Ep is met.
- Document results and compliance with hydrologic and NII management standard.

As applicable, the applicant must use Worksheet H.8.1-1, Worksheet H.8.2-1 and Worksheet H.9.1-1 to document sizing of the additional flow control mitigation measure.

	Additional Flow Control Mitigation Measure	Worksheet H.9.1-1	
1	Sediment Supply Potential (Line 10 of Worksheet H.8.2-1)		unitless
2	Attached completed Worksheet H.8.2-1 and associated documentation	☐ Yes ☐ No	
3	Target Ep ≤ 1.1 * Line 1		unitless
4	Erosion Potential (Line 16 of Worksheet H.8.1-1)		unitless
5	Attached completed Worksheet H.8.1-1 and associated documentation	☐ Yes ☐ No	
6	Is Line 4 ≤ Line 3? If Yes, NII management standard is met. If No, increase the size of the BMP and recalculate Line 4.	☐ Yes ☐ No	

H.9.2 Stream Rehabilitation



Description

Hydromodification control can be achieved by stream rehabilitation projects including: drop structures, grade control structures, bed and bank reinforcement, increased channel sinuosity or meandering, increased channel width, and flow diversion. The objective of these in-stream controls, or stream restoration measures, is to reduce or maintain the overall Erosion Potential (Ep) of the receiving channel. Stream rehabilitation option is only available when the receiving channel of concern is already impacted by erosive flows and shows evidence of excessive sediment, erosion, deposition, or is a hardened channel.

Management Standard and Sizing Approach

The management standard stream rehabilitation projects need to meet to demonstrate that there is no net impact to the receiving waters is presented in the equation below:

$$NII = \frac{Ep}{Sp} \leq 1.1$$

Where:

Ep: is the ratio of post-project/pre-development sediment transport capacity

Sp: ratio of post-project/pre-project (existing) long-term bed sediment supply

Note: Stream rehabilitation project reduce Ep by modifying the stream's hydraulic properties and/or bed/bank material resistance without fully replacing sediment supply or controlling increases in runoff. Refer to Appendix H.8 for methodologies to calculate Ep and Sp.

Design Adaption for Project Goals

The following describes different types of stream rehabilitation projects that could be implemented to meet the NII management standard by reducing or maintaining the overall Ep:

Drop Structures: Drop structures are designed to reduce the average channel slope, thereby reducing the shear stresses generated by stream flows. These controls can be incorporated as natural looking rock structures with a step-pool design which allows drop energy to be dissipated into the pools while providing a reduced longitudinal slope between structures.

Grade Control Structures: Grade control structures are designed to maintain the existing channel slope while allowing for minor amounts of local scour. These control measures are often buried and entail a narrow trench across the width of the stream backfilled with concrete or similar material, as well as the creation of a "plunge pool" feature by placing boulders and vegetation on the downstream side of the sill. A grade control structure provides a reduced footprint and impact as compared to drop structures, which are designed to alter the channel slope.

Bed and Bank Reinforcement: Channel reinforcement serves to increase bed and bank resistance to instream erosion. A number of vegetated approaches are widely used. Such approaches include large woody debris, live crib walls, vegetated mechanically stabilized earth, live siltation, live brushlayering, willow posts and poles, live staking, live fascine, rootwad revetment, live brush mattresses, and vegetated reinforcement mats. These technologies provide erosion control that stabilizes bed and bank surfaces and allows for re-establishment of native plants, which serves to further increase channel stability.

Channel Sinuosity: Increasing channel sinuosity (meandering) can serve to reduce the channel slope, thereby reducing the shear stresses generated by stream flows. However, forcing a channel to be too sinuous is likely to lead to subsequent channel avulsion (cutting a new stream path) to a straighter course. Channel sinuosity needs to be supported by a geomorphic basis of design that shows the proposed form and gradient are appropriate for the valley slope, sediment, and water regime. This support may take the form of reference reaches in similar watersheds that have supported the proposed morphology over a significant period of time, or comparison between the proposed form and typical literature values.

Channel Widening: Increasing the width-to-depth ratio of a stream's cross section is meant to spread flows out over a wider cross section with lower depths, thereby reducing shear stress for a given flow rate. This approach can be a useful management strategy in incised creeks to restore them to equilibrium conditions once vertical incision has ceased. As with sinuosity, it is important to develop a robust geomorphic basis of design that shows the increase in width-to-depth ratio to be sustainable.

Flow Diversion: Flow diversions can be designed to divert the excess flows caused by development to an hydromodification management exempt water body so that the shear stresses do no increase in the susceptible receiving water. When diversions are proposed to a water body exempt through watershed management area analysis, the applicant is required to provide a supporting analysis that the excess flows diverted to the exempt water body do not invalidate the exemption.

Design Considerations

Each stream rehabilitation project is to some degree unique because of differences in geomorphic process, morphology and previous watershed history. For this reason, this fact sheet does not provide a prescriptive 'cookery book' approach for rehabilitating streams, but instead provides guidelines and recommendations. Shields (1996) provides a helpful overview of the analytical steps involved in stream restoration and Shields et al. (1999) provides examples of approaches used to rehabilitate incised channels. Applicant will need to provide geomorphic and engineering information to support their proposed project approach. It is recommended that multiple lines of technical evidence be used by applicants to develop creek restoration plans based on the preponderance of evidence for design criteria such as channel width, depth, slope and planform. It is also important to understand that all creek rehabilitation projects must comply with relevant Federal, State and local regulations and permits. These will likely include obtaining permits from the RWQCB, USACE and California DF&W, and may involve additional permits or consultation with USDF&W and FEMA, as well as permits from the local jurisdiction. The proposed design shall also meet local drainage design guidelines for channel design.