COUNTY OF SAN DIEGO
DEPARTMENT OF PLANNING AND LAND USE

STORMWATER BEST MANAGEMENT PRACTICES

Reference Guide

This guide provides examples of BMPs that can be integrated into a development project to reduce pollutants from entering stormwater conveyances and should be consulted when completing DPLU's Minor Stormwater Management Plan (Form LUEG:SW). Questions relating to County stormwater regulations for building (administrative) permits can be directed to DPLU Building at (858) 565-5920.

Excerpts found in this guide come from the following sources: CalTrans Storm Water Quality Handbook (http://www.dot.ca.gov/hq/construc/stormwater/stormwater1.htm) and CASQA – Stormwater BMP Handbook for New Development and Redevelopment (http://www.cabmphandbooks.com). Complete versions of their handbooks are available at their respective websites.

DPLU#143 – April 2010

TABLE OF CONTENTS

A. CONSTRUCTION BMPS

Construction Best Management Practices are temporary and required during open or active construction in order to prevent pollutant discharge such as sediment, concrete, paint and other by-products of construction. The following BMPs may be used when completing Table I of the Minor Stormwater Management Plan (Form LUEG:SWb).

- Working Details for Temporary Soil Stabilization BMPs (Possible BMP choices for Steps A, B and C in Table I of the Minor Stormwater Management Plan).
  - SS-2 Preservation of Existing Vegetation
  - SS-3 Hydraulic Mulch
  - SS-4 Hydroseeding
  - SS-5 Soil Binders
  - SS-6 Straw Mulch
  - SS-7 Geotextiles, Mats, Plastic Covers & Erosion Control Blankets
  - SS-8 Wood Mulching
  - SS-10 Outlet Protection/Velocity Dissipation Devices

- Working Details for Temporary Sediment Control BMP's (Possible BMP choices for Steps B, C and D in Table I of the Minor Stormwater Management Plan (Form LUEG:SWb).
  - SC-1 Silt Fence
  - SC-2 Sediment/Desilting Basin
  - SC-5 Fiber Rolls
  - SC-6 Gravel Bag Berm
  - SC-8 Sandbag Barrier
  - SC-10 Storm Drain Inlet Protection
  - DPLU 659 Standard Lot Perimeter Protection Design System
  - DPLU 660 County Standard Desilting Basin For Disturbed Areas of 1 Acre or Less

- Working Details for Tracking Control BMP's (Possible BMP choices for Step E in Table I of the Minor Stormwater Management Plan (Form LUEG:SWb).

Excerpts found in this guide come from the following sources: CalTrans Storm Water Quality Handbook (http://www.dot.ca.gov/hq/construc/stormwater/stormwater1.htm) and CASQA – Stormwater BMP Handbook for New Development and Redevelopment (http://www.cabmphandbooks.com). Complete versions of their handbooks are available at their respective websites.

- TC-1 Material Delivery and Storage
- TC-2 Stabilized Construction Roadway
- TC-3 Entrance/Outlet Tire Wash
- SC-7 Street Sweeping and Vacuuming

Working Details for Waste Management and Materials Pollution Control BMP's (Possible BMP choices for Step F in Table I of the Minor Stormwater Management Plan (Form LUEG:SWb).

- WM-1 Material Delivery and Storage
- WM-5 Solid Waste Management
- WM-6 Hazardous Waste Management
- WM-8 Concrete Waste Management
- WM-9 Sanitary/Septic Waste Management

B. LOW IMPACT DEVELOPMENT BMPS

All projects are required to implement Low Impact Development (LID) BMPs. The goal of the County of San Diego's LID program is to protect water quality by preserving and mimicking nature through the use of stormwater planning and management techniques on development sites. Table II contains LID planning and management practices which are outlined in detail in the County of San Diego Low Impact Development Handbook. Additional information and details are available at http://www.sdcounty.ca.gov/dplu/docs/LID-Handbook.pdf and http://www.sdcounty.ca.gov/dplu/docs/LID-Appendices.pdf .

C. POST-CONSTRUCTION BMPS

Post-Construction Best Management Practices are required to infiltrate, filter and/or treat any resulting development runoff such as oils, pesticides, and fertilizer prior to discharge to any receiving water body. Unlike Construction BMPs, Post-Construction BMPs are permanent fixtures that reduce stormwater pollution for the life of the development.

Site Design, Treatment Control and Source Control BMPs (Possible BMP choices for Table III of the Minor Stormwater Management Plan).

- SD-10 Site Design and Landscape Planning
- SD-12 Implementation of Efficient Irrigation Systems
- SD-13 Storm Drain Stenciling and Posting of Signage
- SD-20 Pervious Pavements

Excerpts found in this guide come from the following sources: CalTrans Storm Water Quality Handbook (http://www.dot.ca.gov/hq/construc/stormwater/stormwater1.htm) and CASQA – Stormwater BMP Handbook for New Development and Redevelopment (http://www.cabmphandbooks.com). Complete versions of their handbooks are available at their respective websites.

- SD-32 Proper Design of Trash Storage Areas
- SD-32 Proper Design of Outdoor Material Storage Areas
- TC-10 Underground Infiltration Trench
- TC-30 Vegetated Swale
- TC-31 Vegetated Buffer Strip
- TC-32 Bioretention
- EC-10 Outlet Protection/Velocity Dissipation Devices

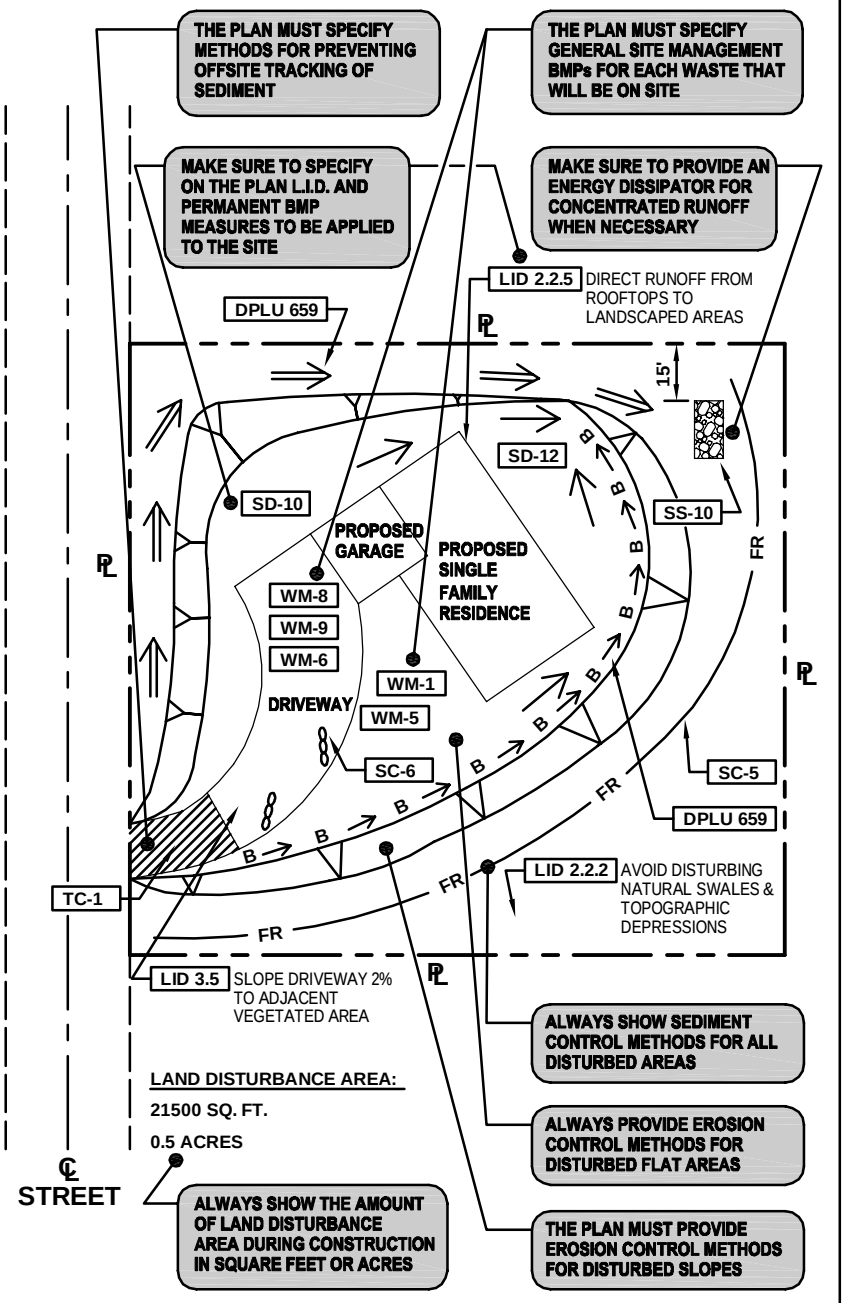
Excerpts found in this guide come from the following sources: CalTrans Storm Water Quality Handbook (http://www.dot.ca.gov/hq/construc/stormwater/stormwater1.htm) and CASQA – Stormwater BMP Handbook for New Development and Redevelopment (http://www.cabmphandbooks.com). Complete versions of their handbooks are available at their respective websites.

SAMPLE PRESENTATION FOR
STORMWATER BEST MANAGEMENT PRACTICES (BMPs) PLOT PLAN

TO BE USED IN CONJUNCTION WITH THE DPLU MINOR STORMWATER MANAGEMENT PLAN (LUEG:SW)

COUNTY OF SAN DIEGO

DEPARTMENT OF PLANNING AND LAND USE
BUILDING DIVISION



BMP LEGEND

DPLU 659 BROW DITCH

DPLU 659 BERM B

DIRECTION OF LOT DRAINAGE

MATERIALS & WASTE MANAGEMENT CONTROL BMPs:

- WM-1 MATERIAL DELIVERY & STORAGE
- WM-4 SPILL PREVENTION AND CONTROL
- WM-8 CONCRETE WASTE MANAGEMENT
- WM-5 SOLID WASTE MANAGEMENT
- WM-9 SANITARY WASTE MANAGEMENT
- WM-6 HAZARDOUS WASTE MANAGEMENT

TEMPORARY RUNOFF CONTROL BMPs:

- SS-2 PRESERVATION OF EXISTING VEGETATION PEV PEV
- SS-3 BONDED OR STABILIZED FIBER MATRIX (WINTER) M M
- SS-4 HYDROSEEDING (SUMMER) TSP TSP
- SS-6 / SS-8 STRAW OR WOOD MULCH S/W S/W
- SS-7 PHYSICAL STABILIZATION (WINTER) EBM EBM
- SS-10 ENERGY DISSIPATOR
- SC-1 SILT FENCE
- SC-2 SEDIMENT / DESILTING BASIN
- SC-5 FIBER ROLLS FR FR
- SC-6 / SC-8 GRAVEL OR SAND BAGS
- SC-7 STREET SWEEPING AND VACUUMING
- SC-10 STORM DRAIN INLET PROTECTION
- NS-2 DEWATERING FILTRATION DW DW
- TC-1 STABILIZED CONSTRUCTION ENTRANCE
- TC-2 CONSTRUCTION ROAD STABILIZATION
- TC-3 ENTRANCE / EXIT TIRE WASH

PERMANENT BMPs:

- SD-10 PROTECTION OF CHANNEL BANKS / MANUFACTURED SLOPES AND FLAT PAD AREA COVERAGE
- SD-12 IMPLEMENTATION OF EFFICIENT IRRIGATION SYSTEMS
- SD-13 STORM DRAIN STENCILING AND POSTING OF SIGNAGE
- SD-32 PROPER DESIGN OF TRASH STORAGE AREAS
- SD-34 PROPER DESIGN OF OUTDOOR MATERIAL STORAGE AREAS
- EC-10 OUTLET PROTECTION
- TC-10 UNDERGROUND INFILTRATION TRENCH

LOW IMPACT DEVELOPMENT BMPs:

- LID 2.2.1 CONSERVATION OF NATURAL DRAINAGES, WELL DRAINED SOILS AND SIGNIFICANT VEGETATION
- LID 2.2.2 MINIMIZE DISTURBANCES TO NATURAL DRAINAGES
- LID 2.2.3 MINIMIZE AND DISCONNECT IMPERVIOUS SURFACES
- LID 2.2.4 MINIMIZE SOIL COMPACTION
- LID 2.2.5 DRAIN RUNOFF FROM IMPERVIOUS SURFACES TO PERVIOUS AREAS
- LID 3.1 HYDROLOGIC DESIGN
- LID 3.2 PERMEABLE PAVEMENT DESIGN
- LID 3.3 ROAD DESIGN FOR DEVELOPMENTS
- LID 3.4 PARKING LOT DESIGN FOR COMMERCIAL PROJECTS
- LID 3.5 DRIVEWAY, SIDEWALK, AND BIKE PATH DESIGN
- LID 3.6 BUILDING DESIGN
- LID 3.7 LANDSCAPING DESIGN

NOTE: THIS IS A SAMPLE ONLY. SEE COUNTY OF SAN DIEGO STORMWATER BEST MANAGEMENT PRACTICES - REFERENCE GUIDE (PUBLICATION DPLU #143) FOR ALTERNATE STORMWATER MEASURES. YOUR PROJECT MAY NOT USE ALL OF THE BMP MEASURES SHOWN OR MAY REQUIRE ALTERNATE / ADDITONAL BMP TYPES GIVEN PROJECT SPECIFICS.

CLARIFYING SAMPLE FOR
STEP 1 OF THE MINOR STORMWATER MANAGEMENT PLAN

STEP 1. IDENTIFY RELEVANT PROJECT INFORMATION

Permit Application Number: APN#:

Project Description:

INCLUDES ADDED SQUARE FOOTAGE OF PROJECT, RETAINING WALLS DRIVEWAYS, AND LEACH FIELDS, ETC. (IF APPLICABLE)

Project address or location:

Project Contact & Phone #:

ESTIMATE DATE OF PERMIT ISSUANCE

ESTIMATE DATE PERMIT WILL RECEIVE FINAL

Square Foot of Improvements:

Estimated project start date:

Estimated project finish date:

Estimated amount of disturbed acreage: _____ (Acres or ft^2)

TOTAL AREA OF PROJECT FOOTPRINT, RETAINING WALL FOOTINGS, DRIVEWAYS, AND LEACH FIELDS, ETC. PLUS ADDITIONAL 10% FOR DISTURBED AREA BY MISC. CONSTRUCTION ACTIVITIES

(If >1 acre, you must also provide a WDID number from the SWRCB) WDID: _____

SPECIFY "N/A" IF LESS THAN 1 ACRE

Complete A through C and the calculations below to determine the amount of impervious surface on your project before and after construction.

A. Total Lot Size: _____ (Acres or ft^2)

B. Total impervious area (including roof tops) before construction _____ (Acres or ft^2)

EXISTING IMPERVIOUS AREA

C. Total impervious area (including roof tops) after construction _____ (Acres or ft^2)

EXISTING PLUS NEW IMPERVIOUS AREA

Calculate percent impervious before construction: B÷A x 100% = _____%

Calculate percent impervious after construction: C÷A x 100% = _____%

IMPERVIOUS AREA: GROUND AREA COVERED OR SHELTERED BY A SURFACE THAT CANNOT EFFECTIVELY INFILTRATE RAINFALL. (i.e. BUILDING ROOF TOPS, PATIO COVERS, ACCESSORY STRUCTURES, PAVED FLATWORK FOR DRIVEWAYS & WALKWAYS, ETC.)

County of San Diego

STORMWATER INTAKE FORM FOR DEVELOPMENT PROJECTS

This form must be completed in its entirety and accompany applications for any of the discretionary or ministerial permits and approvals referenced in Sections 67.803(c)(1) and 67.803(c)(2) of the County of San Diego Watershed Protection, Stormwater Management and Discharge Control Ordinance (WPO).

STEP 1: IDENTIFY RELEVANT PROJECT INFORMATION	
Applicant Name:	Contact Information:
Project Address:	APN(s):
Permit Application Number:	

STEP 2: DETERMINE PRIORITY DEVELOPMENT PROJECT STATUS

WPO Section 67.802(w) defines the criteria for determining whether your project is considered a Priority Development Project (PDP). First, select the proposed project type category. Then select "Yes" or "No" for all of the categories in Table A, Priority Development Project Categories. If you answer "Yes" for any of the categories in Table A, your project is a PDP subject to review and approval of a Major Stormwater Management Plan (SWMP). If you answer "No" to all of the categories in Table A, your project is subject to review and approval of a Minor SWMP.

❑ **New Development Project:**

Projects on previously undeveloped land are Priority Development Projects if they are in one or more of the categories listed below.

❑ **Previously Developed Site:**

Projects on previously developed sites ("redevelopment projects") are Priority Development Projects if they create, add, or replace 5,000 sq. ft. or more of impervious surface and also are in one of the categories listed below.

❑ **Pollutant Generating Project:**

Projects that generate pollutants at levels greater than background levels which disturb one acre or more of land and include housing subdivisions of 10 or more dwelling units are considered Priority Development Projects.

If project is exempt please list the exemption: _____

*PROJECT WILL STILL NEED TO COMPLETE A MINOR SWMP

If you answer "YES" for any category in Table A, please complete a Major SWMP for your project.
Instructions and an example of the form can be downloaded from:
http://www.co.san-diego.ca.us/dpw/watersheds/land_dev/susmp.html

If you answer "NO" to all of the categories in Table A, please complete a Minor SWMP for your project.
Instructions and an example of the form can be downloaded from:
http://www.sdcounty.ca.gov/dplu/docs/LUEG-SW.pdf

TABLE A:
PRIORITY DEVELOPMENT PROJECT CATEGORIES

Yes	No		
❑	❑	A	Housing subdivisions of 10 or more dwelling units. Examples: single-family homes, multi-family homes, condominiums, and apartments.
❑	❑	B	Commercial - greater than one acre. Any development other than heavy industry or residential. Examples: hospitals; laboratories and other medical facilities; educational institutions; recreational facilities; municipal facilities; commercial nurseries; multi-apartment buildings; car wash facilities; mini-malls and other business complexes; shopping malls; hotels; office buildings; public warehouses; automotive dealerships; airfields; and other light industrial facilities.
❑	❑	C	Heavy industry - greater than one acre. Examples: manufacturing plants, food processing plants, metal working facilities, printing plants, and fleet storage areas (bus, truck, etc.).
❑	❑	D	Automotive repair shops. A facility categorized in any one of Standard Industrial Classification (SIC) codes 5013, 5014, 5541, 7532-7534, or 7536-7539.
❑	❑	E	Restaurants. Any facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC code 5812), where the land area for development is greater than 5,000 sq. ft.. Restaurants where land development is less than 5,000 sq. ft. shall meet all SUSMP requirements except for structural treatment BMP and numeric sizing criteria requirements and hydromodification requirements.
❑	❑	F	Hillside development greater than 5,000 square feet. Any development that creates 5,000 sq. ft. of impervious surface located in an area with known erosive soil conditions, where development will grade on any natural slope that is 25% or greater. (1)
❑	❑	G	Environmentally Sensitive Areas (ESAs). All development located within or directly adjacent to or discharging directly to an ESA (where discharges from the development or redevelopment will enter receiving waters within the ESA), which either creates 2,500 sq. ft. of impervious surface on a proposed project site or increases the area of imperviousness of a proposed project site to 10% or more of its naturally occurring condition. "Directly adjacent" means situated within 200 feet of the ESA. "Discharging directly to" means outflow from a drainage conveyance system that is composed entirely of flows from the subject development or redevelopment site, and not commingled with flows from adjacent lands.(1) (2)
❑	❑	H	Parking lots 5,000 square feet or more or with 15 or more parking spaces and potentially exposed to urban runoff. (3)
❑	❑	I	Street, roads, highways, and freeways. Any paved surface ≥ 5,000 sq. ft. used for transportation of automobiles, trucks, motorcycles, and other vehicles. (3)
❑	❑	J	Retail Gasoline Outlets (RGOs) that are: (a) ≥ 5,000 sq. ft. or (b) projected Average Daily Traffic (ADT) ≥ 100 vehicles per day.

(1) In lieu of a Major SWMP, Ministerial Permit Applications for residential dwellings/additions on an existing legal lot answering "Yes" may be able to utilize the Minor SWMP upon approval of a county official. Please note that upon further analysis, staff may determine that a Major SWMP will be required.

(2) Counter staff will assist you in determining whether your project is located within 200 feet of an Environmentally Sensitive Area.

(3) PDP Exemptions: interior remodels, trenching and resurfacing associated with utility work, routine maintenance or repair, roof or exterior surface replacement, resurfacing and reconfiguring surface parking lots and existing roadways, new sidewalk construction, pedestrian ramps, or bike lanes on existing roads, and routine replacement of damaged pavement such as pothole repair.

STEP 3: SIGN AND DATE THE CERTIFICATION

APPLICANT CERTIFICATION: I have read and understand that the County of San Diego has adopted minimum requirements for managing urban runoff, including stormwater, from construction and land development activities. I certify that this intake form has been completed to the best of my ability and accurately reflects the project being proposed. I also understand that non-compliance with the County's WPO and Grading Ordinance may result in enforcement by the County, including fines, cease and desist orders, or other actions.

Applicant: _____ *Date:* _____

County of San Diego

MINOR STORMWATER MANAGEMENT PLAN

This Minor Stormwater Management Plan (Minor SWMP) must be completed in its entirety and accompany applications to the County for a permit or approval associated with certain types of development projects. To determine whether your project is required to submit a Minor or Major SWMP please reference the County's Stormwater Intake Form for Development Projects. Minor SWMPs are typically required for building and minor grading permit applications and certain discretionary permit applications (See note #1 on page 6).

STEP 1: IDENTIFY RELEVANT PROJECT INFORMATION

Permit Application Number:		APN#:	
Project Description:		Project address or location:	
		Project Contact & Phone #:	
	Square Foot of Improvements:	Estimated project start date:	Estimated project finish date:

Estimated amount of disturbed acreage: _____ (Acres or ft^2)
(If >1 acre, you must also provide a WDID number from the SWRCB) WDID: _____

Complete A through C and the calculations below to determine the amount of impervious surface on your project before and after construction.

A. Total Lot Size: _____ (Acres or ft^2)

B. Total impervious area (including roof tops) before construction _____ (Acres or ft^2)

C. Total impervious area (including roof tops) after construction _____ (Acres or ft^2)

Calculate percent impervious before construction: B÷A x 100% = [ ] %

Calculate percent impervious after construction: C÷A x 100% = [ ] %

STEP 2: IDENTIFY CONSTRUCTION STORMWATER BMPs

Unprotected construction sites have the potential to discharge sediment and other pollutants into local waterways. All construction projects are required to reduce pollution to the maximum extent practicable by implementing best management practices (BMPs). Sections 67.806 (General Best Management Practice Requirements) and 67.811 (Additional Requirements for Land Disturbance Activities) of the County of San Diego Watershed Protection, Stormwater Management and Discharge Control Ordinance (WPO) outline the requirements for Construction Stormwater BMPs. There are five categories:

1. Erosion control practices
2. Velocity reduction
3. Sediment control practices
4. Offsite sediment tracking control
5. General site and materials management

BMPs from each of the five categories must be used together as a system in order to prevent potential discharges.

If you answer "Yes" to any of the questions below, your project is subject to Table I on the following page (Minimum Required Standard Construction Stormwater BMPs). As noted in the table, please select at least the minimum number of required BMPs, or as many as are feasible for your project. If no BMP is selected, an explanation must be given in the box provided. The following questions are intended to aid in determining construction BMP requirements for your project.

1. *Will there be soil disturbing activities that will result in exposed soil areas? (This includes minor grading and trenching.)*[1] ..... *Yes* *No*
   Reference Table I items A, B, D and E
2. *Will there be asphalt paving, including patching?* ..... *Yes* *No*
   Reference Table I items D and F
3. *Will there be slurries from mortar mixing, coring, or concrete saw cutting?* ..... *Yes* *No*
   Reference Table I items D and F
4. *Will there be solid wastes from concrete demolition and removal, wall construction, or form work?* ..... *Yes* *No*
   Reference Table I items D and F
5. *Will there be stockpiling (soil, compost, asphalt, concrete, solid waste) for over 24 hours?* ..... *Yes* *No*
   Reference Table I items D and F
6. *Will there be dewatering operations?* ..... *Yes* *No*
   Reference Table I items C and D
7. *Will there be temporary on-site storage of construction materials, including mortar mix, raw landscaping and soil stabilization materials, treated lumber, rebar, and plated metal fencing materials?* ..... *Yes* *No*
   Reference Table I items E and F
8. *Will trash or solid waste product be generated from this project?* ..... *Yes* *No*
   Reference Table I item F
9. *Will construction equipment be stored on site (e.g.: fuels, oils, trucks, etc.?)* ..... *Yes* *No*
   Reference Table I item F
10. *Will Portable Sanitary Services ("Porta-potty") be used on the site?* ..... *Yes* *No*
    Reference Table I item F

---

(1) Soil disturbances NOT considered significant include, but are not limited to, change in use, mechanical/electrical/plumbing activities, signs, temporary trailers, interior remodeling, and minor tenant improvement

TABLE I. MINIMUM REQUIRED STANDARD CONSTRUCTION STORMWATER BMPs (1) (2)			
Minimum Required Best Management Practices (BMPs)	CALTRANS Stormwater Handbook Detail	✔ *BMP* Selected	*Each selected BMP must be shown on the Plan. If No BMP is selected, an explanation must be provided.*
A. Select Erosion Control method for Disturbed Slopes (Choose at least one for the appropriate season)			
Vegetation Stabilization Planting (3) (Summer)	SS-2, SS-4		
Hydraulic Stabilization Hydroseeding(3) (Summer)	SS-4		
Bonded Fiber Matrix or Stabilized Fiber Matrix(4) (Winter)	SS-3		
Physical Stabilization Erosion Control Blanket(4) (Winter)	SS-7		
B. Select Erosion Control method for Disturbed Flat Areas (slope < 5%) (Choose at least one)			
County Standard Lot Perimeter Protection Detail	DPLU 659, SC-2		
Will use erosion control measures from Item A on flat areas also	SS-3,4,7		
County Standard Desilting Basin (must treat all site runoff)	DPLU 660, SC-2		
Mulch, straw, wood chips, soil application	SS-6, SS-8		
C. If Runoff or Dewatering Operation is concentrated, velocity must be controlled using an energy dissipater			
Energy Dissipater Outlet Protection(5)	SS-10		
D. Select Sediment Control method for all disturbed areas (Choose at least one)			
Silt Fence	SC-1		
Fiber Rolls (Straw Wattles)	SC-5		
Gravel Bags	SC-6 & 8		
Dewatering Filtration	NS-2		
Storm Drain Inlet Protection	SC-10		
Engineered Desilting Basin (sized for 10-year flow)	SC-2		
E. Select method for preventing offsite tracking of sediment (Choose at least one)			
Stabilized Construction Entrance	TC-1		
Construction Road Stabilization	TC-2		
Entrance/Exit Tire Wash	TC-3		
Entrance/Exit Inspection & Cleaning Facility	-		
Street Sweeping and Vacuuming	SC-7		
F. Select the General Site Management BMPs for each waste that will be on site(5)			
Materials Management Material Delivery & Storage	WM-1		
Spill Prevention and Control	WM-4		
Waste Management Concrete Waste Management	WM-8		
Solid Waste Management	WM-5		
Sanitary Waste Management	WM-9		
Hazardous Waste Management	WM-6		

STEP 3: IDENTIFY LOW IMPACT DEVELOPMENT BMPs

WPO Section 67.806(c)(2) requires all development projects, regardless of priority, to implement Low Impact Development (LID) BMPs. The goal of the County of San Diego's LID program is to protect water quality by preserving and mimicking nature through the use of stormwater planning and management techniques such as small-scale detention and retention on development sites. Table II contains LID planning and management practices which are outlined in detail in the County of San Diego Low Impact Development Handbook. You are required to select a minimum of two LID Planning Practices and at least one LID Management Practice to reduce runoff from your site, and are encouraged to select additional BMPs as applicable. Additional information and details are available at http://www.sdcounty.ca.gov/dplu/docs/LID-Handbook.pdf and http://www.sdcounty.ca.gov/dplu/docs/LID-Appendices.pdf .

TABLE II. MINIMUM REQUIRED LOW IMPACT DEVELOPMENT BMPs

Minimum Required Low Impact Development (BMPs)	County LID Handbook Detail	✔ *BMP* Selected	*Each selected BMP must be shown on the Plan. If No BMP is selected, an explanation must be provided.*
LID Planning Practices (Reference Section 2.2 of the County LID Handbook) (Choose at least two)			
Conservation of Natural Drainages, Well Drained Soils and Significant Vegetation (e.g., minimize disturbance of natural areas; construct in least environmentally sensitive areas of the site)	2.2.1		
Minimize Disturbances to Natural Drainages (e.g., avoid disturbing natural swales & topographic depressions; construction setback from creek)	2.2.2		
Minimize Impervious Surfaces (e.g., preserve existing vegetation; permeable pavement for walkways, excess parking/driveway areas, exterior exposed slabs, etc.)	2.2.3		
Disconnect Impervious Surfaces (e.g., disconnect continuously paved areas with landscaping; direct roof runoff to permeable areas)	2.2.3		
Minimize Soil Compaction (e.g., protect native soil & vegetation from construction equipment; avoid compaction in planned landscaping areas)	2.2.4		
Drain Runoff from Impervious Surfaces to Pervious Areas (e.g., direct runoff from rooftops, patio slabs, walkways, parking lots, etc. to landscaped areas)	2.2.5		
LID Management Practices (Reference Section 3 of the County LID Handbook) (Choose at least one)			
Hydrologic Design (e.g., infiltration trench or basin; depression area in a lawn for infiltration; bio-filters such as vegetated or rock swales)	3.1		
Permeable Pavement Design (e.g., pervious concrete; permeable asphalt concrete/pavers; granular materials)	3.2		
LID Road Design for Developments (e.g., reduce overall road coverage; direct surface flow to vegetated swales)	3.3		
LID Parking Lot Design for Commercial Projects (e.g., use permeable materials for overflow parking; perimeter landscaping)	3.4		
LID Driveway, Sidewalk and Bike Path Design (e.g., single lane driveway flared at multi-car garage; slope driveways 2% to adjacent vegetated area)	3.5		
LID Building Design (e.g., dry-well; roof downspout to landscaped area or swale; cisterns and rain barrels)	3.6		
LID Landscaping Design (e.g., concave area of lawn; save and reuse native topsoil for landscaped areas; protect areas of native vegetation; street trees adjacent to sidewalks and driveways)	3.7		

STEP 4: IDENTIFY POST-CONSTRUCTION (PERMANENT) BMPs

WPO Section 67.806 (c)(1) requires development projects with the potential to add pollutants to stormwater or to affect the flow rate or velocity of stormwater runoff after construction is completed to employ post-construction (permanent) BMPs, as feasible, to ensure that pollutants and runoff from the development are reduced to the maximum extent practicable. Using Table III below, select the post-construction BMPs that will be implemented on your project.

TABLE III. POST-CONSTRUCTION (PERMANENT) BMPs

Best Management Practices (BMPs)	CASQA Stormwater Handbook	✔ *BMP* Selected	*Each selected BMP must be shown on the Plan.* If No BMP is selected, an explanation must be provided.
Source Control BMPs (Select all that apply)			
Implementation of Efficient Irrigation Systems	SD-12		
Storm Drain Stenciling and Posting of Signage	SD-13		
Proper Design of Trash Storage Areas	SD-32		
Proper Design of Outdoor Material Storage Areas	SD-34		
Buffer Zones			
Design project to include a buffer zone for natural water bodies. Where buffer zones are not feasible, other equally serving methods may be implemented such as trees or access restrictions.	N/A		
Additional Permanent Stormwater BMPs			
Protection of Channel Banks/Manufactured Slopes	SD-10		
Outlet Protection (Velocity Dissipation Devices)	EC-10		
Flat Pad Area Coverage (Permanent Landscaping / Groundcover)	SD-10		
Underground Infiltration Trench	TC-10		

STEP 5: CERTIFICATION

The applicant must sign the following certification before a permit will be issued.

I have read and understand that the County of San Diego has adopted minimum requirements for managing urban runoff, including stormwater, from construction and land development activities. I certify that the BMPs selected on this form will be implemented to minimize the potentially negative impacts of this project's construction and land development activities on water quality. I further agree to install, monitor, maintain, or revise the selected BMPs to ensure their effectiveness. I also understand that non-compliance with the County's WPO and Grading Ordinance may result in enforcement by the County, including fines, cease and desist orders, or other actions.

Applicant: _____ *Date:* _____

Notes

1. *Discretionary Permits that may be eligible to use this form include Tentative Parcel Maps, Construction Right of Way Permits, Encroachment Permits or Minor Use Permits. Please be aware that if it is determined during the review process that the permit has the potential to significantly impact water quality after construction, a Major Stormwater Management Plan shall be required.*

2. *In accordance with the Municipal Stormwater Permit that is issued by the Regional Water Quality Control Board, each construction site with construction stormwater BMP requirements must be designated with a "priority" to determine inspection frequency. The criteria used to determine the stormwater inspection frequency is outlined below. Please note that the County reserves the right to adjust the priority of the projects both before and during construction. Further, the construction priority only establishes the required inspection frequency and does NOT change construction BMP requirements that apply to projects.*

   - *High Priority – Bi-Weekly inspections during the rainy season (October 1st through April 30th)*

     a) *The project is a single family dwelling located in a new residential subdivision (1014 permit); or,*

     b) *The project disturbs one acre or more of soil; AND*

        - *Is located within a watershed that is listed as 303(d) impaired for sediment (904.21, 904.31, 904.61) or,*
        - *Is located within 200 feet of lands designated with the RARE beneficial use; or,*
        - *Is located within 200 feet of lands designated as Areas of Significant Biological Concern (ASBC);or,*
        - *Is located within 200 feet of lands designated Multiple Species Conservation Program (MSCP)*

   - *Medium Priority – Monthly inspections during the rainy season (October 1st through April 30th)*

     a) *The project is a DPLU Minor grading permit; or*

     b) *The project disturbs an area greater than one acre;*

   - *Low Priority – At least two inspections during the rainy season (October 1st through April 30th)*

     a) *The project will disturb soil, and none of the above criteria apply*

   Stormwater inspections during the dry season are conducted as part of the regular inspection process (e.g. foundation, frame, lath/drywall, etc.).

3. *If Vegetation Stabilization (Planting or Hydroseeding) is proposed for erosion control it may be installed between May 1st and August 15th Slope irrigation is in place and to be operable for slopes >3'. Vegetation must be watered and established prior to October 1st. The owner shall implement a contingency physical BMP by August 15th if vegetation establishment does not occur by that date. If landscaping is proposed, erosion control measures must also be used while landscaping is being established. Established vegetation shall have a subsurface mat of intertwined mature roots with a uniform vegetative coverage of 70 percent of the natural vegetative coverage or more on all disturbed areas.*

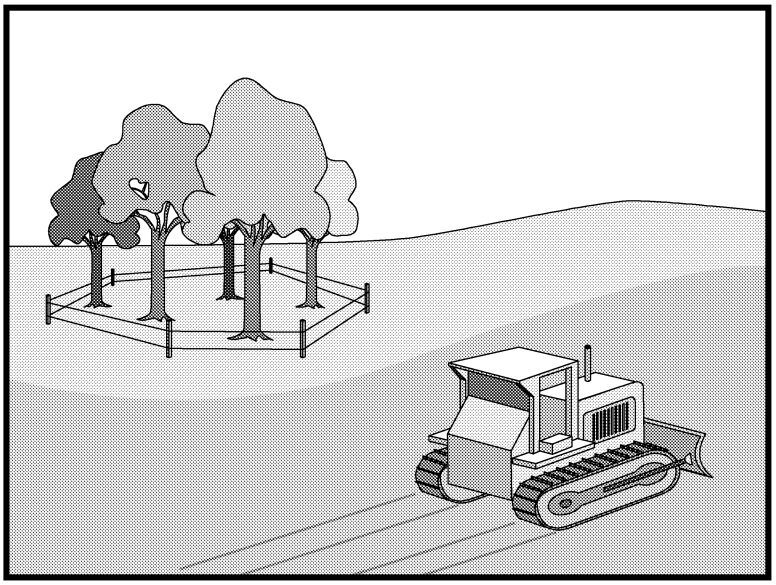
4. *All slopes over three feet must have established vegetative cover prior to final permit approval.*

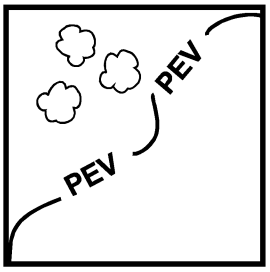
5. *Regional Standard Drawing D-40 - Rip Rap Energy Dissipater is also acceptable for velocity reduction.*

6. *Not all projects will have every waste identified. The applicant is responsible for identifying wastes that will- be on-site and applying the appropriate BMP. For example, if concrete will be used, BMP WM-8 must be selected.*

Preservation of Existing Vegetation

SS-2





Standard Symbol

BMP Objectives

- Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ● Non-Storm Water Management
- ○ Materials and Waste Management
- ○

Definition and Purpose

Preservation of existing vegetation is the identification and protection of desirable vegetation that provides erosion and sediment control benefits.

Appropriate Applications

- Preserve existing vegetation at areas on a site where no construction activity is planned or will occur at a later date. Specifications for preservation of existing vegetation can be found in Standard Specifications, Section 7-1.11.
- On a year-round basis, temporary fencing shall be provided prior to the commencement of clearing and grubbing operations or other soil-disturbing activities in areas.
- Clearing and grubbing operations should be staged to preserve existing vegetation.

Limitations

Protection of existing vegetation requires planning, and may limit the area available for construction activities.

Standards and Specifications

Timing

- Preservation of existing vegetation shall be provided prior to the commencement of clearing and grubbing operations or other soil-disturbing activities in areas identified on the plans to be preserved, especially on areas designated as Environmentally Sensitive Areas (ESAs).
- Preservation of existing vegetation shall conform to scheduling requirements set forth in the special provisions.

Design and Layout

- Mark areas to be preserved with temporary fencing made of orange polypropylene that is stabilized against ultraviolet light. The temporary fencing shall be at least 1 meter (3.2. ft) tall and shall have openings not larger than 50 mm by 50 mm (2 in by 2 in).

- Fence posts shall be either wood or metal, at the Contractor's discretion, as appropriate for the intended purpose. The post spacing and depth shall be adequate to completely support the fence in an upright position.

- Minimize the disturbed areas by locating temporary roadways to avoid stands of trees and shrubs and to follow existing contours to reduce cutting and filling.

- Consider the impact of grade changes to existing vegetation and the root zone.

Installation

- Construction materials, equipment storage, and parking areas shall be located where they will not cause root compaction.

- Keep equipment away from trees to prevent trunk and root damage.

- Maintain existing irrigation systems.

- Employees and subcontractors shall be instructed to honor protective devices. No heavy equipment, vehicular traffic, or storage piles of any construction materials shall be permitted within the drip line of any tree to be retained. Removed trees shall not be felled, pushed, or pulled into any retained trees. Fires shall not be permitted within 30 m (100 ft) of the drip line of any retained trees. Any fires shall be of limited size, and shall be kept under continual surveillance. No toxic or construction materials (including paint, acid, nails, gypsum board, chemicals, fuels, and lubricants) shall be stored within 15 m (50 ft) of the drip line of any retained trees, nor disposed of in any way which would injure vegetation.

Trenching and Tunneling

- Trenching shall be as far away from tree trunks as possible, usually outside of the tree drip line or canopy. Curve trenches around trees to avoid large roots or root concentrations. If roots are encountered, consider tunneling under them. When trenching and/or tunneling near or under trees to be retained, tunnels shall be at least 450 mm (18 in) below the ground surface, and not below the tree center to minimize impact on the roots.

- Tree roots shall not be left exposed to air; they shall be covered with soil as soon as possible, protected, and kept moistened with wet burlap or peat moss until the tunnel and/or trench can be completed.

- The ends of damaged or cut roots shall be cut off smoothly.

- Trenches and tunnels shall be filled as soon as possible. Careful filling and tamping will eliminate air spaces in the soil which can damage roots.

- Remove any trees intended for retention if those trees are damaged seriously enough to affect their survival. If replacement is desired or required, the new tree shall be of similar species, and at least 50 mm (2 in) caliper, unless

otherwise required by the contract documents.

- After all other work is complete, fences and barriers shall be removed last. This is because protected trees may be destroyed by carelessness during the final cleanup and landscaping.

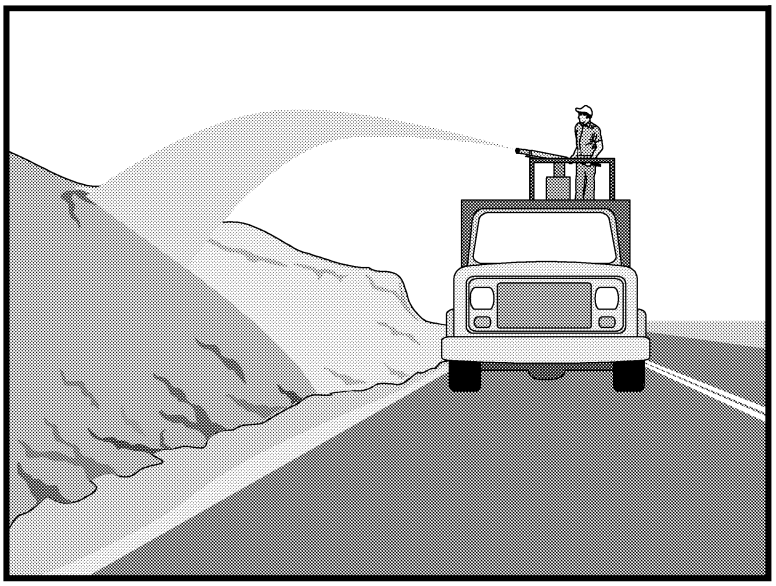
Maintenance and Inspection

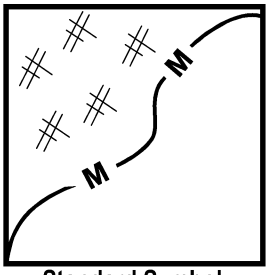
During construction, the limits of disturbance shall remain clearly marked at all times. Irrigation or maintenance of existing vegetation shall conform to the requirements in the landscaping plan. If damage to protected trees still occurs, maintenance guidelines described below shall be followed:

- Serious tree injuries shall be attended to by an arborist.
- During construction, District Environmental shall be contacted to ensure that ESAs are protected.

Hydraulic Mulch

SS-3





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ● Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Hydraulic mulch consists of applying a mixture of shredded wood fiber or a hydraulic matrix and a stabilizing emulsion or tackifier with hydroseeding equipment, which temporarily protects exposed soil from erosion by raindrop impact or wind. This is one of five temporary soil stabilization alternatives to consider.

Appropriate Applications

- Hydraulic mulch is applied to disturbed areas requiring temporary protection until permanent vegetation is established or disturbed areas that must re-disturbed following an extended period of inactivity.

Limitations

- Wood fiber hydraulic mulches are generally short-lived (only last a part of a growing season) and need 24 hours to dry before rainfall occurs to be effective.
- Paper mulches are not permitted.
- Avoid use in areas where the mulch would be incompatible with immediate future earthwork activities and would have to be removed.

Standards and Specifications

- Prior to application, roughen embankment and fill areas by rolling with a crimping or punching type roller or by track walking. Track walking shall only be used where other methods are impractical.
- Hydraulic matrices require 24 hours to dry before rainfall occurs to be effective unless approved by the Resident Engineer.
- Avoid mulch over-spray onto the traveled way, sidewalks, lined drainage channels, and existing vegetation.
- Selection of hydraulic mulches by the Contractor must be approved by the Resident Engineer (RE) or Construction Storm Water Coordinator.

- Materials for wood fiber based hydraulic mulches and hydraulic matrices shall conform to Standard Specifications Section 20-2.07.

- Hydraulic Mulch

- Wood fiber mulch is a component of hydraulic applications. It is typically applied at the rate of 2,250 to 4,500 kilograms per hectare (kg/ha) (2,000 to 4,000 lb/ac) with 0-5% by weight of a stabilizing emulsion or tackifier (e.g., guar, psyllium, acrylic copolymer) and applied as a slurry. This type of mulch is manufactured from wood or wood waste from lumber mills or from urban sources. Specifications for wood fiber mulch can be found in Standard Specifications Sections 20-2.07 and 20-2.08.

- Hydraulic matrix is a combination of wood fiber mulch and a tackifier applied as a slurry. It is typically applied at the rate of 2,250 to 4,500 kilograms per hectare (kg/Ha) with 5-10% by weight of a stabilizing emulsion or tackifier (e.g., guar, psyllium, acrylic copolymer).

- Hydraulic Matrix

- Hydraulic matrix is a combination of wood fiber mulch and tackifier applied as a slurry. It is typically applied at the rate of 2,250 to 4,500 kg/ha with 5-10% by weight of a stabilizing emulsion or tackifier (e.g., guar, psyllium, acrylic copolymer).

- Bonded Fiber Matrix

- Bonded fiber matrix (BFM) is a hydraulically-applied system of fibers and adhesives that upon drying forms an erosion-resistant blanket that promotes vegetation, and prevents soil erosion. BFMs are typically applied at rates from 3,400 kg/ha to 4,500 kg/ha based on the manufacturer's recommendation. The biodegradable BFM is composed of materials that are 100% biodegradable. The binder in the BFM should also be biodegradable and should not dissolve or disperse upon re-wetting. Typically, biodegradable BFMs should not be applied immediately before, during or immediately after rainfall if the soil is saturated. Depending on the product, BFMs require 12 to 24 hours to dry to become effective.

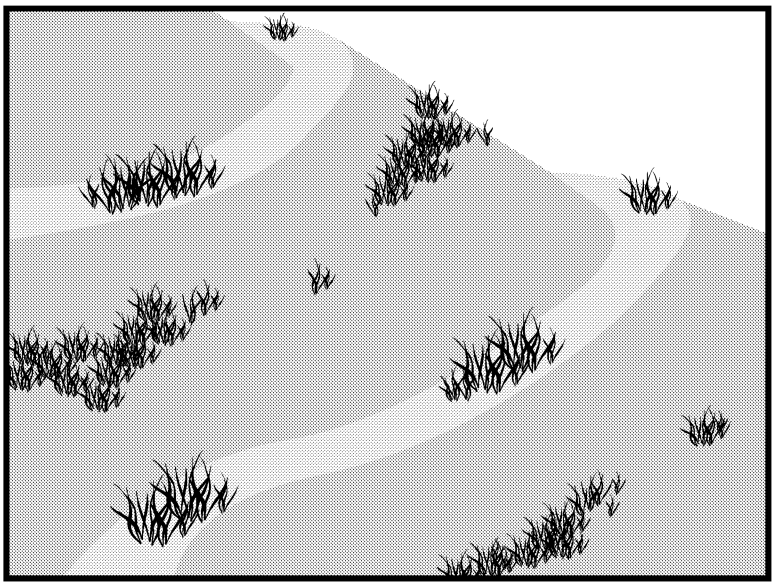
Maintenance and Inspections

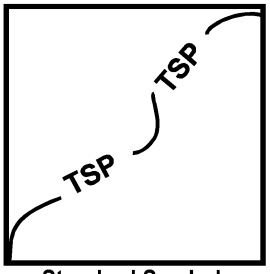
- Maintain an unbroken, temporary mulched ground cover throughout the period of construction when the soils are not being reworked. Inspect before expected rain storms and repair any damaged ground cover and re-mulch exposed areas of bare soil.

- After any rainfall event, the Contractor is responsible for maintaining all slopes to prevent erosion.

Hydroseeding

SS-4





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ● Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Hydroseeding typically consists of applying a mixture of wood fiber, seed, fertilizer, and stabilizing emulsion with hydro-mulch equipment, which temporarily protects exposed soils from erosion by water and wind. This is one of five temporary soil stabilization alternatives to consider.

Appropriate Applications

- Hydroseeding is applied on disturbed soil areas requiring temporary protection until permanent vegetation is established or disturbed soil areas that must be re-disturbed following an extended period of inactivity.

Limitations

- Hydroseeding may be used alone only when there is sufficient time in the season to ensure adequate vegetation establishment and erosion control. Otherwise, hydroseeding must be used in conjunction with a soil binder or mulching (i.e., straw mulch), refer to BMP SS-5, Table 1 for options.
- Steep slopes are difficult to protect with temporary seeding.
- Temporary seeding may not be appropriate in dry periods without supplemental irrigation.
- Temporary vegetation may have to be removed before permanent vegetation is applied.
- Temporary vegetation is not appropriate for short-term inactivity.

Standards and Specifications

To select appropriate hydroseeding mixtures, an evaluation of site conditions shall be performed with respect to:

- Soil conditions
- Site topography
- Season and climate
- Vegetation types
- Maintenance requirements
- Sensitive adjacent areas
- Water availability
- Plans for permanent vegetation

- Selection of hydroseeding mixtures shall be approved by the District Landscape Architect and the Construction Storm Water Coordinator.

The following steps shall be followed for implementation:

- Seed mix shall comply with the Standard Specifications Section 20-2.10, and the project's special provisions.

- Hydroseeding can be accomplished using a multiple-step or one-step process; refer to the special provisions for specified process. The multiple-step process ensures maximum direct contact of the seeds to soil. When the one-step process is used to apply the mixture of fiber, seed, etc., the seed rate shall be increased to compensate for all seeds not having direct contact with the soil.

- Prior to application, roughen the slope, fill area, or area to be seeded with the furrows trending along the contours. Rolling with a crimping or punching type roller or track walking is required on all slopes prior to hydroseeding. Track walking shall only be used where other methods are impractical.

- Apply a straw mulch to keep seeds in place and to moderate soil moisture and temperature until the seeds germinate and grow, refer to Standard Specifications Sections 20-2.06 and 20-3.03.

- All seeds shall be in conformance with the California State Seed Law of the Department of Agriculture. Each seed bag shall be delivered to the site sealed and clearly marked as to species, purity, percent germination, dealer's guarantee, and dates of test; provide the Resident Engineer (RE) with such documentation. The container shall be labeled to clearly reflect the amount of Pure Live Seed (PLS) contained. All legume seed shall be pellet-inoculated. Inoculant sources shall be species-specific and shall be applied at a rate of 2 kg of inoculant per 100 kg of seed (2-lb inoculant per 100-lb seed), refer to Standard Specifications Section 20-2.10.

- Commercial fertilizer shall conform to the requirements of the California Food and Agricultural Code. Fertilizer shall be pelleted or granular form.

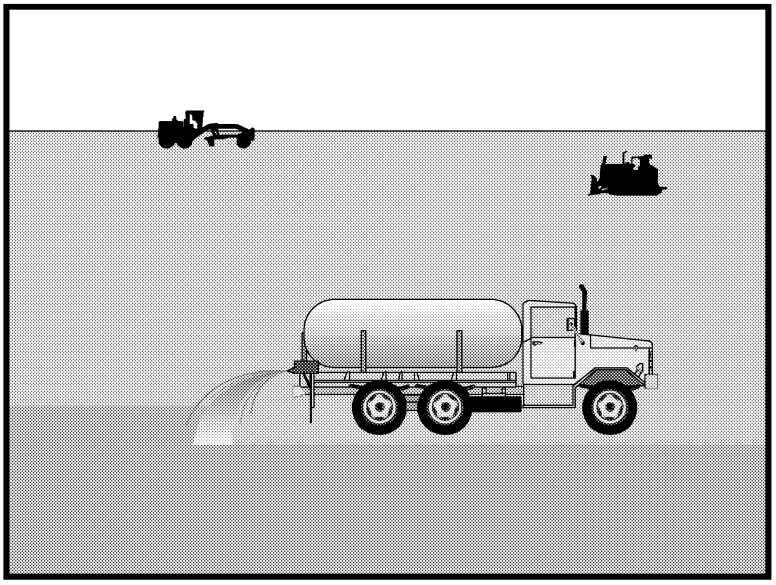
- Follow-up applications shall be made as needed to cover weak spots, and to maintain adequate soil protection.
- Avoid over-spray onto the traveled way, sidewalks, lined drainage channels, and existing vegetation.

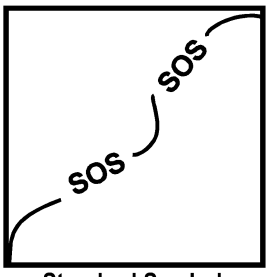
Maintenance and Inspection

- All seeded areas shall be inspected for failures and re-seeded, fertilized, and mulched within the planting season, using not less than half the original application rates. Any temporary revegetation efforts that do not provide adequate cover must be reapplied at a scheduled recommended by the Caltrans Landscape Architect or RE.
- After any rainfall event, the Contractor is responsible for maintaining all slopes to prevent erosion.

Soil Binders

SS-5





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ● Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Soil binders consist of applying and maintaining a soil stabilizer to exposed soil surfaces. Soil binders are materials applied to the soil surface to temporarily prevent water-induced erosion of exposed soils on construction sites. Soil binders also provide temporary dust, wind, and soil stabilization (erosion control) benefits. This is one of five temporary soil stabilization alternatives to consider.

Appropriate Applications

Soil binders are typically applied to disturbed areas requiring short-term temporary protection. Because soil binders can often be incorporated into the work, they may be a good choice for areas where grading activities will soon resume. Application on stockpiles to prevent water and wind erosion.

Limitations

- Soil binders are temporary in nature and may need reapplication.
- Soil binders require a minimum curing time until fully effective, as prescribed by the manufacturer, which may be 24 hours or longer. Soil binders may need reapplication after a storm event.
- Soil binders will generally experience spot failures during heavy rainfall events. If runoff penetrates the soil at the top of a slope treated with a soil binder, it is likely that the runoff will undercut the stabilized soil layer and discharge at a point further down slope.
- Soil binders do not hold up to pedestrian or vehicular traffic across treated areas.
- Soil binders may not penetrate soil surfaces made up primarily of silt and clay, particularly when compacted.
- Storm water quality runoff sampling is required for many soil binders. Soil binders that do not require sampling are identified in the Caltrans SWPPP/WPCP Preparation Manual, Pollutant Table, Attachment S.

- Some soil binders may not perform well with low relative humidity. Under rainy conditions, some agents may become slippery or leach out of the soil.
- May not cure if low temperatures occur within 24 hours of application.

Standards and Specifications

General Considerations

- Site-specific soil types will dictate appropriate soil binders to be used.
- A soil binder must be environmentally benign (non-toxic to plant and animal life), easy to apply, easy to maintain, economical, and shall not stain paved or painted surfaces, refer to Standard Specifications Section 20-2.11.
- Some soil binders are compatible with existing vegetation.
- Performance of soil binders depends on temperature, humidity, and traffic across treated areas.
- Avoid over-spray onto the traveled way, sidewalks, lined drainage channels, and existing vegetation.

Soil Binders Applications

After selecting an appropriate soil binder, the untreated soil surface must be prepared before applying the soil binder. The untreated soil surface must contain sufficient moisture to assist the agent in achieving uniform distribution. In general, the following steps shall be followed:

- Follow manufacturer's recommendations for application rates, pre-wetting of application area, and cleaning of equipment after use.
- Prior to application, roughen embankment and fill areas by rolling with a crimping or punching type roller or by track walking. Track walking shall only be used where rolling is impractical.
- Consider the drying time for the selected soil binder and apply with sufficient time before anticipated rainfall. Soil binders shall not be applied during or immediately before rainfall.
- Avoid over-spray onto the traveled way, sidewalks, lined drainage channels, sound walls, and existing vegetation.
- Soil binders shall not be applied to frozen soil, areas with standing water, under freezing or rainy conditions, or when the air temperature is below 4oC (40oF) during the curing period.
- More than one treatment is often necessary, although the second treatment may be diluted or have a lower application rate.
- Generally, soil binders require a minimum curing time of 24 hours before they are fully effective. Refer to manufacturer's instructions for specific cure times.

- For liquid agents:
  - Crown or slope ground to avoid ponding.
  - Uniformly pre-wet ground at 0.14 to 1.4 L/m^2 (0.03 to 0.3 gal/yd^2) or according to manufacturer's recommendations.
  - Apply solution under pressure. Overlap solution 150 to 300 mm (6 to 12 in).
  - Allow treated area to cure for the time recommended by the manufacturer; typically, at least 24 hours.
  - In low humidities, reactivate chemicals by re-wetting with water at 0.5 to 0.9 L/m^2 (0.1 to 0.2 gal/yd^2).

Selecting a Soil Binder

Properties of common soil binders used for erosion control are provided in Table 1 and Appendix B. Use Table 1 to select an appropriate soil binder.

Factors to consider when selecting a soil binder include the following:

- Suitability to situation - Consider where the soil binder will be applied; determine if it needs a high resistance to leaching or abrasion, and whether it needs to be compatible with any existing vegetation. Determine the length of time soil stabilization will be needed, and if the soil binder will be placed in an area where it will degrade rapidly. In general, slope steepness is not a discriminating factor for the listed soil binders.
- Soil types and surface materials - Fines and moisture content are key properties of surface materials. Consider a soil binder's ability to penetrate, likelihood of leaching, and ability to form a surface crust on the surface materials.
- Frequency of application - The frequency of application can be affected by subgrade conditions, surface type, climate, and maintenance schedule. Frequent applications could lead to high costs. Application frequency may be minimized if the soil binder has good penetration, low evaporation, and good longevity. Consider also that frequent application will require frequent equipment clean-up.

After considering the above factors, the soil binders in Table 1 will be generally appropriate as follows:

Plant-Material Based (Short Lived)

-*Guar:* Guar is a non-toxic, biodegradable, natural galactomannan-based hydrocolloid treated with dispersent agents for easy field mixing. It shall be diluted at the rate of 1.2 to 1.8 kg per 1,000 liters (1 to 5 lb per 100 gallons) of water, depending on application machine capacity. Recommended minimum application rates are as follows:

Application Rates for Guar Soil Stabilizer

Slope (V:H):	Flat	1:4	1:3	1:2	1:1
Kg/Ha:	45	50	56	67	78
lb/ac	40	45	50	60	70

-*Psyllium:* Psyllium is composed of the finely ground muciloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil. It dries to form a firm but rewettable membrane that binds soil particles together but permits germination and growth of seed. Psyllium requires 12 to 18 hours drying time. Psyllium shall be applied at a rate of 90 to 225 kg/ha (80 to 200 lb/ac), with enough water in solution to allow for a uniform slurry flow.

-*Starch:* Starch is non-ionic, cold-water soluble (pre-gelatinized) granular cornstarch. The material is mixed with water and applied at the rate of 170 kg/ha (150 lb/ac). Approximate drying time is 9 to 12 hours.

Plant-Material Based (Long Lived)

-*Pitch and Rosin Emulsion:* Generally, a non-ionic pitch and rosin emulsion has a minimum solids content of 48%. The rosin shall be a minimum of 26% of the total solids content. The soil stabilizer shall be non-corrosive, water-dilutable emulsion that upon application cures to a water insoluble binding and cementing agent. For soil erosion control applications, the emulsion is diluted and shall be applied as follows:

For clayey soil: 5 parts water to 1 part emulsion

For sandy soil: 10 parts water to 1 part emulsion

Application can be by water truck or hydraulic seeder with the emulsion/product mixture applied at the rate specified by the manufacturer. Approximate drying time is 19 to 24 hours.

Polymeric Emulsion Blends

-Acrylic Copolymers and Polymers: Polymeric soil stabilizers shall consist of a liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55% solids. The polymeric compound shall be handled and mixed in a manner that will not cause foaming or shall contain an anti-foaming agent. The polymeric emulsion shall not exceed its shelf life or expiration date; manufacturers shall provide the expiration date. Polymeric soil stabilizer shall be readily miscible in water, non-injurious to seed or animal life, non-flammable, shall provide surface soil stabilization for various soil types without totally inhibiting water infiltration, and shall not re-emulsify when cured. The applied compound shall air cure within a maximum of 36 to 48 hours. Liquid copolymer shall be diluted at a rate of 10 parts water to 1 part polymer and applied to soil at a rate of 11,000 liters/hectare (1,175 gal/ac).

-Liquid Polymers of Methacrylates and Acrylates: This material consists of a tackifier/sealer that is a liquid polymer of methacrylates and acrylates. It is an aqueous 100% acrylic emulsion blend of 40% solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants or silicates. For soil stabilization applications, it is diluted with water in accordance with manufacturer's recommendations, and applied with a hydraulic seeder at the rate of 190 L/ha (20 gal/ac). Drying time is 12 to 18 hours after application.

-Copolymers of Sodium Acrylates and Acrylamides: These materials are non-toxic, dry powders that are copolymers of sodium acrylate and acrylamide. They are mixed with water and applied to the soil surface for erosion control at rates that are determined by slope gradient:

Slope Gradient (V:H)	kg/ha (lb/ac)
Flat to 1:5	3.4 – 5.6 (3-5)
1:5 to 1:3	5.6 – 11.2 (5-10)
1:2 to 1:1	11.2 – 22.4 (10-20)

-Poly-Acrylamide and Copolymer of Acrylamide: Linear copolymer polyacrylamide is packaged as a dry-flowable solid. When used as a stand-alone stabilizer, it is diluted at a rate of 1.5 kg/1,000 liters (1 lb/100 gal) of water and applied at the rate of 5.6 kg/ha (5 lb/ac).

-Hydro-Colloid Polymers: Hydro-Colloid Polymers are various combinations of dry-flowable poly-acrylamides, copolymers and hydro-colloid polymers that are mixed with water and applied to the soil surface at rates of 60 to 70 kg/ha (53 to 62 lb/ac). Drying times are 0 to 4 hours.

Cementitious-Based Binders

-*Gypsum:* This is a formulated gypsum-based product that readily mixes with water and mulch to form a thin protective crust on the soil surface. It is composed of high purity gypsum that is ground, calcined and processed into calcium sulfate hemihydrate with a minimum purity of 86%. It is mixed in a hydraulic seeder and applied at rates 4,500 to 13,500 kg/ha (4,000 to 12,000 lb/ac). Drying time is 4 to 8 hours.

Maintenance and Inspection

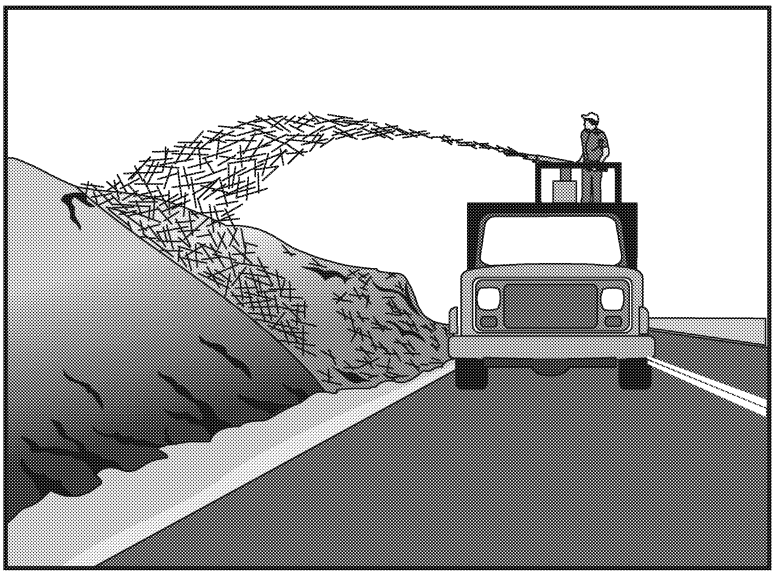
- Reapplying the selected soil binder may be needed for proper maintenance. High traffic areas shall be inspected daily, and lower traffic areas shall be inspected weekly.
- After any rainfall event, the Contractor is responsible for maintaining all slopes to prevent erosion.
- Maintain an unbroken, temporary stabilized area while DSAs are nonactive. Repair any damaged stabilized area and re-apply soil binder to exposed areas.

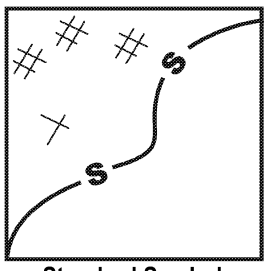
Table 1 Properties of Soil Binders for Erosion Control				
Chemicals	**Plant Material Based (Short Lived)**	**Plant Material Based (Long Lived)**	**Polymeric Emulsion Blends**	**Cementitious-Based Binders**
Relative Cost	Low	Low	Low	Low
Resistance to Leaching	High	High	Low to Moderate	Moderate
Resistance to Abrasion	Moderate	Low	Moderate to High	Moderate to High
Longevity	Short to Medium	Medium	Medium to Long	Medium
Minimum Curing Time before Rain	9 to 18 hours	19 to 24 hours	0 to 24 hours	4 to 8 hours
Compatibility with Existing Vegetation	Good	Poor	Poor	Poor
Mode of Degradation	Biodegradable	Biodegradable	Photodegradable/ Chemically Degradable	Photodegradable/ Chemically Degradable
Labor Intensive	No	No	No	No
Specialized Application Equipment	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher
Liquid/Powder	Powder	Liquid	Liquid/Powder	Powder
Surface Crusting	Yes, but dissolves on rewetting	Yes	Yes, but dissolves on rewetting	Yes
Clean-Up	Water	Water	Water	Water
Erosion Control Application Rate	Varies (1)	Varies (1)	Varies (1)	4,500 to 13,500 kg/ha

(1) Dependant on product, soil type, and slope inclination

Straw Mulch

SS-6





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ● Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Straw mulch consists of placing a uniform layer of straw and incorporating it into the soil with a studded roller or anchoring it with a stabilizing emulsion. This is one of five temporary soil stabilization alternatives to consider.

Appropriate Applications

- Straw mulch is typically used for soil stabilization as a temporary surface cover on disturbed areas until soils can be prepared for revegetation and permanent vegetation is established.
- Also typically used in combination with temporary and/or permanent seeding strategies to enhance plant establishment.

Limitations

- Availability of erosion control contractors and straw may be limited prior to the rainy season due to high demand.
- There is a potential for introduction of weed-seed and unwanted plant material.
- When straw blowers are used to apply straw mulch, the treatment areas must be within 45 m (150 ft) of a road or surface capable of supporting trucks.
- Straw mulch applied by hand is more time intensive and potentially costly.
- May have to be removed prior to permanent seeding or soil stabilization.
- "Punching" of straw does not work in sandy soils.

Standards and Specifications

- Straw shall be derived from wheat, rice, or barley.
- All materials shall conform to Standard Specifications Sections 20-2.06, 20-2.07 and 20-2.11.
- A tackifier is the preferred method for anchoring straw mulch to the soil on slopes.
- Crimping, punch roller-type rollers, or track-walking may also be used to incorporate straw mulch into the soil on slopes. Track walking shall only be used where other methods are impractical.
- Avoid placing straw onto the traveled way, sidewalks, lined drainage channels, sound walls, and existing vegetation.
- Straw mulch with tackifier shall not be applied during or immediately before rainfall.

Application Procedures

- Apply loose straw at a minimum rate of 3,570 kg/ha (4,000 lb/ac), or as indicated in the project's special provisions, either by machine or by hand distribution.
- If stabilizing emulsion will be used to anchor the straw mulch in lieu of incorporation, roughen embankment or fill areas by rolling with a crimping or punching-type roller or by track walking before placing the straw mulch. Track walking should only be used where rolling is impractical.
- The straw mulch must be evenly distributed on the soil surface.
- Anchor the mulch in place by using a tackifier or by "punching" it into the soil mechanically (incorporating).
- A tackifier acts to glue the straw fibers together and to the soil surface. The tackifier shall be selected based on longevity and ability to hold the fibers in place.
- A tackifier is typically applied at a rate of 140 kg/ha (125 lb/ac). In windy conditions, the rates are typically 200 kg/ha (178 lb/ac).
- Methods for holding the straw mulch in place depend upon the slope steepness, accessibility, soil conditions and longevity. If the selected method is incorporation of straw mulch into the soil, then do as follows:
  - Applying and incorporating straw shall follow the requirements in Standard Specifications Section 20-3.03.
  - On small areas, a spade or shovel can be used.

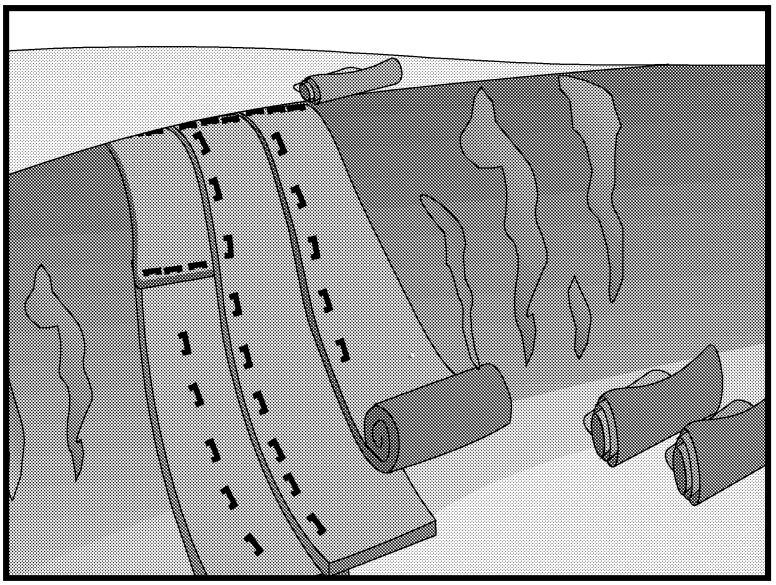
- On slopes with soils, which are stable enough and of sufficient gradient to safely support construction equipment without contributing to compaction and instability problems, straw can be "punched" into the ground using a knife-blade roller or a straight bladed coulter, known commercially as a "crimper."
- On small areas and/or steep slopes, straw can also be held in place using plastic netting or jute. The netting shall be held in place using 11 gauge wire staples, geotextile pins or wooden stakes. Refer to BMP SS-7, "Geotextiles, Plastic Covers and Erosion Control Blankets/Mats."

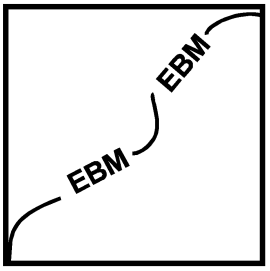
Maintenance and Inspections

- The key consideration in Maintenance and Inspection is that the straw needs to last long enough to achieve erosion control objectives.
- Maintain an unbroken, temporary mulched ground cover while DSAs are non-active. Repair any damaged ground cover and re-mulch exposed areas.
- Reapplication of straw mulch and tackifier may be required by the Resident Engineer (RE) to maintain effective soil stabilization over disturbed areas and slopes.
- After any rainfall event, the Contractor is responsible for maintaining all slopes to prevent erosion.

Geotextiles, Mats, Plastic Covers and Erosion Control Blankets

SS-7





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ● Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

This Best Management Practice (BMP) involves the placement of geotextiles, mats, plastic covers, or erosion control blankets to stabilize disturbed soil areas and protect soils from erosion by wind or water. This is one of five temporary soil stabilization alternatives to consider.

Appropriate Applications

These measures are used when disturbed soils may be particularly difficult to stabilize, including the following situations:

- Steep slopes, generally steeper than 1:3 (V:H).
- Slopes where the erosion potential is high.
- Slopes and disturbed soils where mulch must be anchored.
- Disturbed areas where plants are slow to develop.
- Channels with flows exceeding 1.0 m/s (3.3 ft/s).
- Channels to be vegetated.
- Stockpiles.
- Slopes adjacent to water bodies of Environmentally Sensitive Areas (ESAs).

Geotextiles, Mats, Plastic Covers and Erosion Control Blankets

SS-7

Limitations

- Blankets and mats are more expensive than other erosion control measures, due to labor and material costs. This usually limits their application to areas inaccessible to hydraulic equipment, or where other measures are not applicable, such as channels.
- Blankets and mats are generally not suitable for excessively rocky sites, or areas where the final vegetation will be mowed (since staples and netting can catch in mowers).
- Blankets and mats must be removed and disposed of prior to application of permanent soil stabilization measures.
- Plastic sheeting is easily vandalized, easily torn, photodegradable, and must be disposed of at a landfill.
- Plastic results in 100% runoff, which may cause serious erosion problems in the areas receiving the increased flow.
- The use of plastic shall be limited to covering stockpiles, or very small graded areas for short periods of time (such as through one imminent storm event), until alternative measures, such as seeding and mulching, may be installed.
- Geotextiles, mats, plastic covers, and erosion control covers have maximum flow rate limitations; consult the manufacturer for proper selection.

Standards and Specifications

Material Selection

There are many types of erosion control blankets and mats, and selection of the appropriate type shall be based on the specific type of application and site conditions. Selection(s) made by the Contractor must be approved by the Resident Engineer (RE); certification of compliance shall be in accordance with Standard Specifications Section 6-1.07.

Geotextiles

- Material shall be a woven polypropylene fabric with minimum thickness of 1.5 mm (0.06 inch), minimum width of 3.7 m (12 ft) and shall have minimum tensile strength of 0.67 kN (warp) 0.36 kN (fill) in conformance with the requirements in ASTM Designation: D 4632. The permittivity of the fabric shall be approximately 0.07 sec –1 in conformance with the requirements in ASTM Designation: D4491. The fabric shall have an ultraviolet (UV) stability of 70 percent in conformance with the requirements in ASTM designation: D4355. Geotextile blankets shall be secured in place with wire staples or sandbags and by keying into tops of slopes and edges to prevent infiltration of surface waters under Geotextile. Staples shall be made of 3.05-mm (0.12-inch) steel wire and shall be U-shaped with 200-mm (8-inch) legs and 50-mm (2-inch) crown.
- Geotextiles may be reused if, in the opinion of the RE, they are suitable for the use intended.

Plastic Covers

- Plastic sheeting shall have a minimum thickness of 6 mil, and shall be keyed in at the top of slope and firmly held in place with sandbags or other weights placed no more than 3 m (10 ft) apart. Seams are typically taped or weighted down their entire length, and there shall be at least a 300 mm to 600 mm (12 to 24 inches) overlap of all seams. Edges shall be embedded a minimum of 150 mm (6 inches) in soil.

- All sheeting shall be inspected periodically after installation and after significant rainstorms to check for erosion, undermining, and anchorage failure. Any failures shall be repaired immediately. If washout or breakages occurs, the material shall be re-installed after repairing the damage to the slope.

Erosion Control Blankets/Mats

- Biodegradable rolled erosion control products (RECPs) are typically composed of jute fibers, curled wood fibers, straw, coconut fiber, or a combination of these materials. For an RECP to be considered 100% biodegradable, the netting, sewing or adhesive system that holds the biodegradable mulch fibers together must also be biodegradable.

  - **Jute** is a natural fiber that is made into a yarn, which is loosely woven into a biodegradable mesh. It is designed to be used in conjunction with vegetation and has longevity of approximately one year. The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

  - **Excelsior (curled wood fiber)** blanket material shall consist of machine produced mats of curled wood excelsior with 80 percent of the fiber 150 mm (6 inches) or longer. The excelsior blanket shall be of consistent thickness. The wood fiber shall be evenly distributed over the entire area of the blanket. The top surface of the blanket shall be covered with a photodegradable extruded plastic mesh. The blanket shall be smolder resistant without the use of chemical additives and shall be non-toxic and non-injurious to plant and animal life. Excelsior blanket shall be furnished in rolled strips, a minimum of 1220 mm (48 inches) wide, and shall have an average weight of 0.5 kg/m^2 (12 lb/ft^2), ±10 percent, at the time of manufacture. Excelsior blankets shall be secured in place with wire staples. Staples shall be made of 3.05-mm (0.12 inch) steel wire and shall be U-shaped with 200-mm (8-inch) legs and 50-mm (2-inch) crown.

- **Straw blanket** shall be machine-produced mats of straw with a lightweight biodegradable netting top layer. The straw shall be attached to the netting with biodegradable thread or glue strips. The straw blanket shall be of consistent thickness. The straw shall be evenly distributed over the entire area of the blanket. Straw blanket shall be furnished in rolled strips a minimum of 2 m (6.5 ft) wide, a minimum of 25 m (80 ft) long and a minimum of 0.27 kg/m2 (6.4 lb/ft2). Straw blankets shall be secured in place with wire staples. Staples shall be made of 3.05-mm (0.12 inch) steel wire and shall be U-shaped with 200-mm (8-inch) legs and 50-mm (2-inch) crown.

- **Wood fiber blanket** is composed of biodegradable fiber mulch with extruded plastic netting held together with adhesives. The material is designed to enhance revegetation. The material is furnished in rolled strips, which shall be secured to the ground with U-shaped staples or stakes in accordance with manufacturers' recommendations.

- **Coconut fiber blanket** shall be machine-produced mats of 100% coconut fiber with biodegradable netting on the top and bottom. The coconut fiber shall be attached to the netting with biodegradable thread or glue strips. The coconut fiber blanket shall be of consistent thickness. The coconut fiber shall be evenly distributed over the entire area of the blanket. Coconut fiber blanket shall be furnished in rolled strips with a minimum of 2 m (6.5 ft) wide, a minimum of 25 m (80 ft) long and a minimum of 0.27-kg/m2 (6.4 lb/ft2). Coconut fiber blankets shall be secured in place with wire staples. Staples shall be made of 3.05-mm (0.12 inch) steel wire and shall be U-shaped with 200-mm (8-inch) legs and 50-mm (2-inch) crown.

- **Coconut fiber mesh** is a thin permeable membrane made from coconut or corn fiber that is spun into a yarn and woven into a biodegradable mat. It is designed to be used in conjunction with vegetation and typically has longevity of several years. The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

- **Straw coconut fiber blanket** shall be machine-produced mats of 70% straw and 30% coconut fiber with a biodegradable netting top layer and a biodegradable bottom net. The straw and coconut fiber shall be attached to the netting with biodegradable thread or glue strips. The straw coconut fiber blanket shall be of consistent thickness. The straw and coconut fiber shall be evenly distributed over the entire area of the blanket. Straw coconut fiber blanket shall be furnished in rolled strips a minimum of 2 m (6.5 ft) wide, a minimum of 25 m (80 ft) long and a minimum of 0.27 kg/m2 (6.4 lb/ft2). Straw coconut fiber blankets shall be secured in place with wire staples. Staples shall be made of 3.05-mm (0.12-inch) steel wire and shall be U-shaped with 200-mm (8-inch) legs and 50-mm (2-inch) crown.

- Non-biodegradable RECPs are typically composed of polypropylene, polyethylene, nylon or other synthetic fibers. In some cases, a combination of biodegradable and synthetic fibers is used to construct the RECP. Netting used to hold these fibers together is typically non-biodegradable as well.

  - **Plastic netting** is a lightweight biaxially-oriented netting designed for securing loose mulches like straw to soil surfaces to establish vegetation. The netting is photodegradable. The netting is supplied in rolled strips, which shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

  - **Plastic mesh** is an open-weave geotextile that is composed of an extruded synthetic fiber woven into a mesh with an opening size of less than 0.5 cm (0.2 inch). It is used with revegetation or may be used to secure loose fiber such as straw to the ground. The material is supplied in rolled strips, which shall be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

  - **Synthetic fiber with netting** is a mat that is composed of durable synthetic fibers treated to resist chemicals and ultraviolet light. The mat is a dense, three-dimensional mesh of synthetic (typically polyolefin) fibers stitched between two polypropylene nets. The mats are designed to be revegetated and provide a permanent composite system of soil, roots, and geomatrix. The material is furnished in rolled strips, which shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

  - **Bonded synthetic fibers** consist of a three-dimensional geomatrix nylon (or other synthetic) matting. Typically it has more than 90% open area, which facilitates root growth. Its tough root-reinforcing system anchors vegetation and protects against hydraulic lift and shear forces created by high volume discharges. It can be installed over prepared soil, followed by seeding into the mat. Once vegetated, it becomes an invisible composite system of soil, roots, and geomatrix. The material is furnished in rolled strips that shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

  - **Combination synthetic and biodegradable RECPs** consist of biodegradable fibers, such as wood fiber or coconut fiber, with a heavy polypropylene net stitched to the top and a high-strength continuous-filament geomatrix or net stitched to the bottom. The material is designed to enhance revegetation. The material is furnished in rolled strips, which shall be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Site Preparation

- Proper site preparation is essential to ensure complete contact of the blanket or matting with the soil.
- Grade and shape the area of installation.
- Remove all rocks, clods, vegetation or other obstructions so that the installed blankets or mats will have complete, direct contact with the soil.
- Prepare seedbed by loosening 50 mm (2 in) to 75 mm (3 in) of topsoil.

Seeding

Seed the area before blanket installation for erosion control and revegetation. Seeding after mat installation is often specified for turf reinforcement application. When seeding prior to blanket installation, all check slots and other areas disturbed during installation must be re-seeded. Where soil filling is specified, seed the matting and the entire disturbed area after installation and prior to filling the mat with soil.

Anchoring

- U-shaped wire staples, metal geotextile stake pins or triangular wooden stakes can be used to anchor mats and blankets to the ground surface.
- Staples shall be made of 3.05 mm (0.12 inch) steel wire and shall be U-shaped with 200-mm (8-inch) legs and 50-mm (2-inch) crown.
- Metal stake pins shall be 5 mm (0.188 in) diameter steel with a 40 mm (1.5 in) steel washer at the head of the pin.
- Wire staples and metal stakes shall be driven flush to the soil surface.
- All anchors shall be 150 mm (6 in) to 450 mm (18 in) long and have sufficient ground penetration to resist pullout. Longer anchors may be required for loose soils.

Installation on Slopes

Installation shall be in accordance with the manufacturer's recommendations. In general, these will be as follows:

- Begin at the top of the slope and anchor the blanket in a 150 mm (6 in) deep by 150 mm (6 in) wide trench. Backfill trench and tamp earth firmly.
- Unroll blanket downslope in the direction of water flow.

- Overlap the edges of adjacent parallel rolls 50 mm (2 in) to 75 mm (3 in) and staple every 1 m (3 ft).

- When blankets must be spliced, place blankets end over end (shingle style) with 150 mm (6 in) overlap. Staple through overlapped area, approximately 300 mm (12 in) apart.

- Lay blankets loosely and maintain direct contact with the soil. Do not stretch.

- Staple blankets sufficiently to anchor blanket and maintain contact with the soil. Staples shall be placed down the center and staggered with the staples placed along the edges. Steep slopes, 1:1 (V:H) to 1:2 (V:H), require a minimum of 2 staples/m2 (2 staples/yd2). Moderate slopes, 1:2 (V:H) to 1:3 (V:H), require a minimum of 1½ staples/m2 (1 ½ staples/yd2), placing 1 staple/m (1 staple/yd) on centers. Gentle slopes require a minimum of 1 staple/m2 (1 staple/yd2).

Installation in Channels

Installation shall be in accordance with the manufacturer's recommendations. In general, these will be as follows:

- Dig initial anchor trench 300 mm (12 in) deep and 150 mm (6 in) wide across the channel at the lower end of the project area.

- Excavate intermittent check slots, 150 mm (6 in) deep and 150 mm (6 in) wide across the channel at 8 m to 10 m (25 ft to 30 ft) intervals along the channels.

- Cut longitudinal channel anchor slots 100 mm (4 in) deep and 100 mm (4 in) wide along each side of the installation to bury edges of matting, whenever possible extend matting 50 mm (2 in) to 75 mm (3 in) above the crest of the channel side slopes.

- Beginning at the downstream end and in the center of the channel, place the initial end of the first roll in the anchor trench and secure with fastening devices at 300 mm (12 in) intervals. Note: matting will initially be upside down in anchor trench.

- In the same manner, position adjacent rolls in anchor trench, overlapping the preceding roll a minimum of 75 mm (3 in).

- Secure these initial ends of mats with anchors at 300 mm (12 in) intervals, backfill and compact soil.

- Unroll center strip of matting upstream. Stop at next check slot or terminal anchor trench. Unroll adjacent mats upstream in similar fashion, maintaining a 75 mm (3 in) overlap.

- Fold and secure all rolls of matting snugly into all transverse check slots. Lay mat in the bottom of the slot then fold back against itself. Anchor through both layers of mat at 300 mm (12 in) intervals, then backfill and compact soil. Continue rolling all mat widths upstream to the next check slot or terminal anchor trench.

- Alternate method for non-critical installations: Place two rows of anchors on 150 mm (6 in) centers at 8 m (25 ft) to 10 m (30 ft) intervals in lieu of excavated check slots.

- Shingle-lap spliced ends by a minimum of 300 mm (12 in) apart on 300 mm (12 in) intervals.

- Place edges of outside mats in previously excavated longitudinal slots, anchor using prescribed staple pattern, backfill and compact soil.

- Anchor, fill and compact upstream end of mat in a 300 mm (12 in) by 150 mm (6 in) terminal trench.

- Secure mat to ground surface using U-shaped wire staples, geotextile pins, or wooden stakes.

- Seed and fill turf reinforcement matting with soil, if specified.

Soil Filling (if specified for turf reinforcement)

- Always consult the manufacturer's recommendations for installation.

- Do not drive tracked or heavy equipment over mat.

- Avoid any traffic over matting if loose or wet soil conditions exist.

- Use shovels, rakes or brooms for fine grading and touch up.

- Smooth out soil filling, just exposing top netting of mat.

Temporary Soil Stabilization Removal

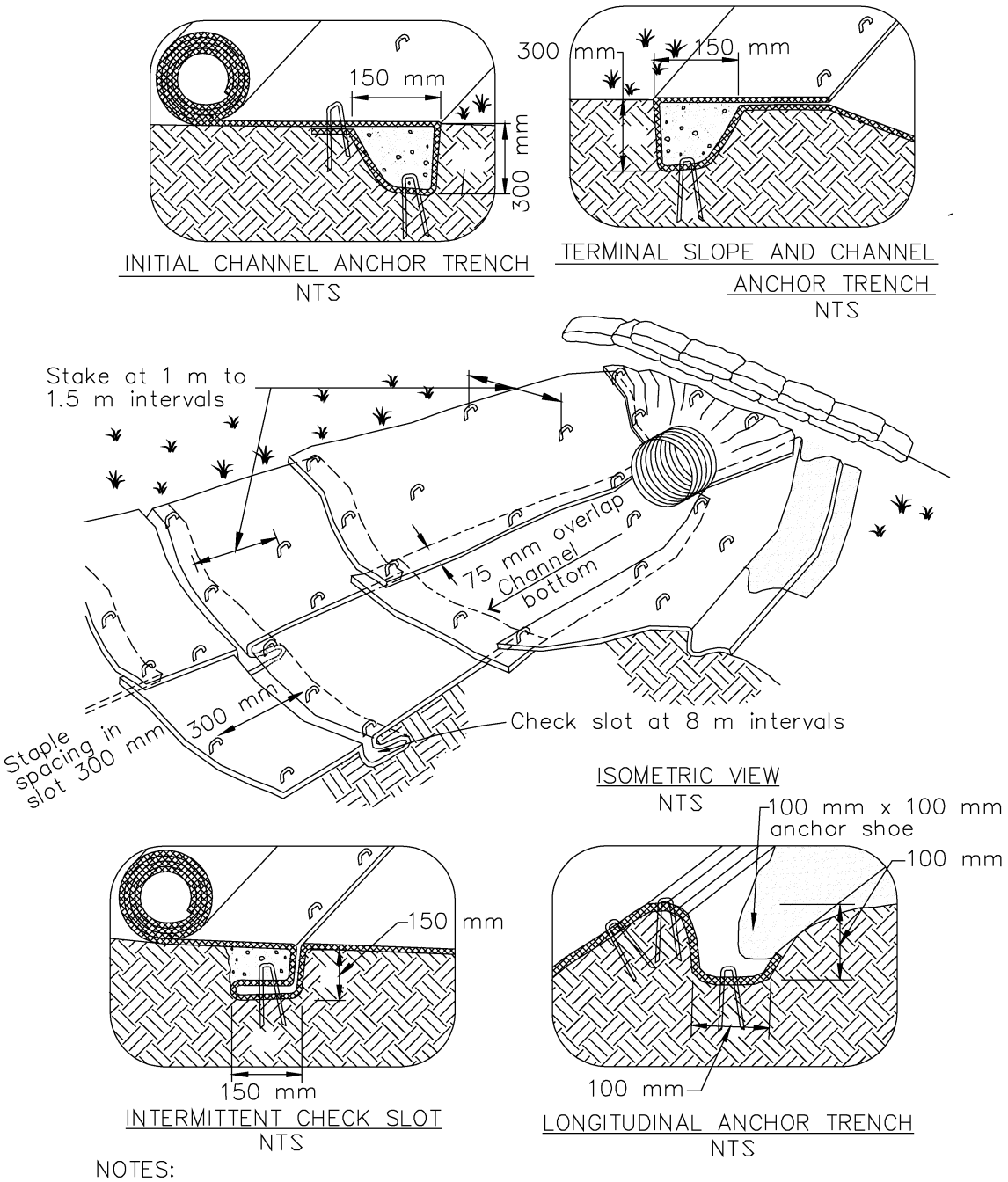
- When no longer required for the work, temporary soil stabilization shall become the property of the Contractor. Temporary soil stabilization removed from the site of the work shall be disposed of outside the highway right-of-way in conformance with the provisions in Standard Specifications Section 7-1.13. If approved by the RE, the contractor may leave the temporary soil stabilizer in place.

Maintenance and Inspection

Areas treated with temporary soil stabilization shall be inspected as specified in the special provisions. Areas treated with temporary soil stabilization shall be maintained to provide adequate erosion control. Temporary soil stabilization shall be reapplied or replaced on exposed soils when area becomes exposed or exhibits visible erosion.

- All blankets and mats shall be inspected periodically after installation.
- Installation shall be inspected after significant rain storms to check for erosion and undermining. Any failures shall be repaired immediately.
- If washout or breakage occurs, re-install the material after repairing the damage to the slope or channel.

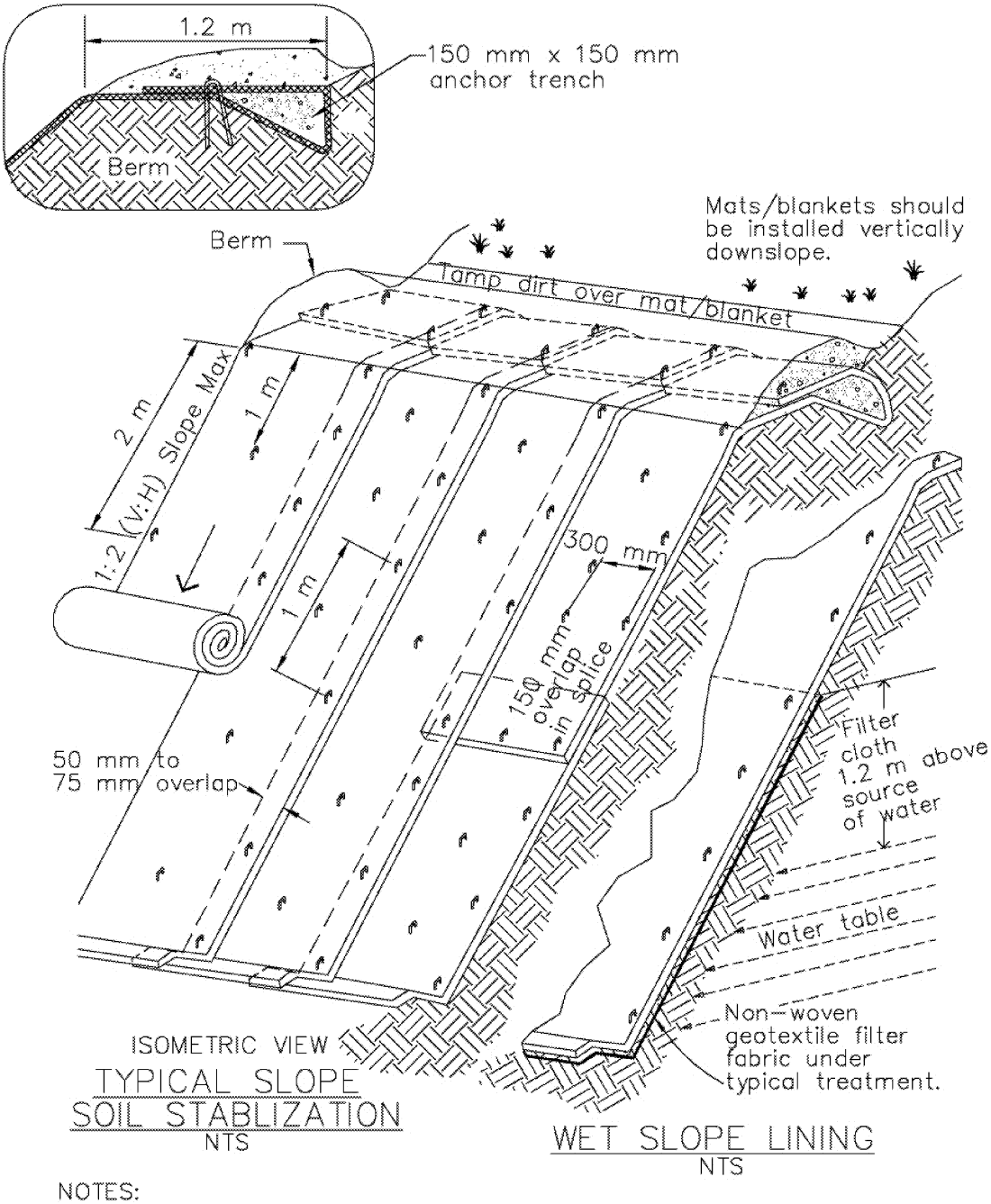
Typical Installation Detail



NOTES:

1. Check slots to be constructed per manufacturers specifications.
2. Staking or stapling layout per manufacturers specifications.
3. Install per manufacturer's recommendations

Typical Installation Detail

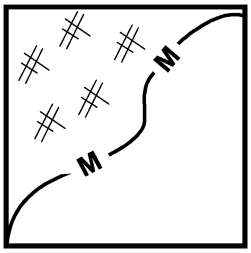


NOTES:

1. Slope surface shall be free of rocks, clods, sticks and grass. Mats/blankets shall have good soil contact.
2. Lay blankets loosely and stake or staple to maintain direct contact with the soil. Do not stretch.
3. Install per manufacturer's recommendations

Wood Mulching

SS-8



Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ● Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Wood mulching consist of applying a mixture of shredded wood mulch, bark or compost. Wood mulch is mostly applicable to landscape projects.

The primary function of wood mulching is to reduce erosion by protecting bare soil from rainfall impact, increasing infiltration, and reducing runoff.

Appropriate Applications

Wood mulching is considered a temporary soil stabilization (erosion control) alternative in the following situations:

- As a stand-alone temporary surface cover on disturbed areas until soils can be prepared for revegetation and permanent vegetative cover can be established.
- As short term, non-vegetative ground cover on slopes to reduce rainfall impact, decrease the velocity of sheet flow, settle out sediment and reduce wind erosion.

Limitations

- Wood mulch may introduce unwanted species.
- Shredded wood does not withstand concentrated flows and is prone to sheet erosion.
- Green material has the potential for the presence of unwanted weeds and other plant materials. Delivery system is primarily by manual labor, although pneumatic application equipment is available.

Standards and Specifications

Mulch Selection

There are many types of mulches, and selection of the appropriate type shall be based on the type of application and site conditions. Prior to use of wood mulches, there shall be concurrence with the District Landscape Architect since some mulch use on construction projects may not be compatible with planned or future projects. Selection of wood mulches by the Contractor shall comply with Standard Specifications Section 20-2.08, and must be approved by the Resident Engineer (RE).

Application Procedures

Prior to application, after existing vegetation has been removed, roughen embankment and fill areas by rolling with a punching-type roller or by track walking. The construction-application procedures for mulches vary significantly depending upon the type of mulching method specified. Two (2) methods are highlighted here:

- Green Material: This type of mulch is produced by recycling vegetation trimmings such as grass, shredded shrubs and trees. Methods of application are generally by hand, although pneumatic methods are available. Mulch shall be composted to kill weed seeds.
  - It can be used as a temporary ground cover with or without seeding.
  - The green material shall be evenly distributed on site to a depth of not more than 50 mm (2 in).
- Shredded Wood: Suitable for ground cover in ornamental or revegetated plantings.
  - Shredded wood/bark is conditionally suitable; see note under limitations.
  - Shall be distributed by hand (although pneumatic methods may be available).
  - The mulch shall be evenly distributed across the soil surface to a depth of 50 mm (2 in) to 75 mm (3 in).
- Avoid mulch placement onto the traveled way, sidewalks, lined drainage channels, sound walls, and existing vegetation.
- All material must be removed before re-starting work on the slopes.

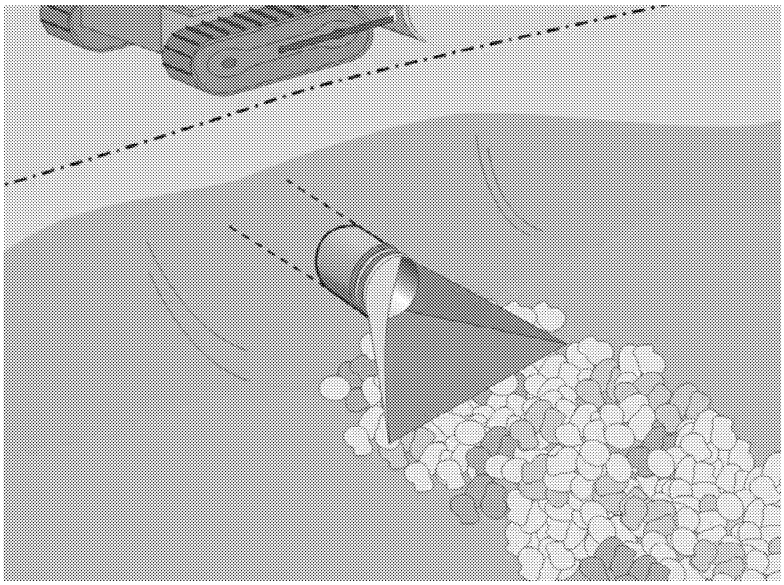
Maintenance and Inspection

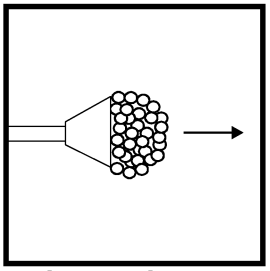
- Regardless of the mulching technique selected, the key consideration in Maintenance and Inspection is that the mulch needs to last long enough to achieve erosion-control objectives. If the mulch is applied as a stand-alone erosion control method over disturbed areas (without seed), it shall last the length of time the site will remain barren or until final re-grading and revegetation.

- Where vegetation is not the ultimate cover, such as ornamental and landscape applications of bark or wood chips, inspection and maintenance shall focus on longevity and integrity of the mulch.

Outlet Protection/Velocity Dissipation Devices

SS-10





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

These devices are placed at pipe outlets to prevent scour and reduce the velocity and/or energy of storm water flows.

Appropriate Applications

- These devices may be used at the following locations:
  - Outlets of pipes, drains, culverts, slope drains, diversion ditches, swales, conduits or channels.
  - Outlets located at the bottom of mild to steep slopes.
  - Discharge outlets that carry continuous flows of water.
  - Outlets subject to short, intense flows of water, such as flash floods.
  - Points where lined conveyances discharge to unlined conveyances.
- This BMP may be implemented on a project-by-project basis with other BMPs when determined necessary and feasible by the Resident Engineer (RE).

Limitations

- Loose rock may have stones washed away during high flows.
- Grouted riprap may break up in areas of freeze and thaw.
- If there is not adequate drainage, and water builds up behind grouted riprap, it may cause the grouted riprap to break up due to the resulting hydrostatic pressure.

Outlet Protection/Velocity Dissipation Devices

SS-10

Standards and Specifications

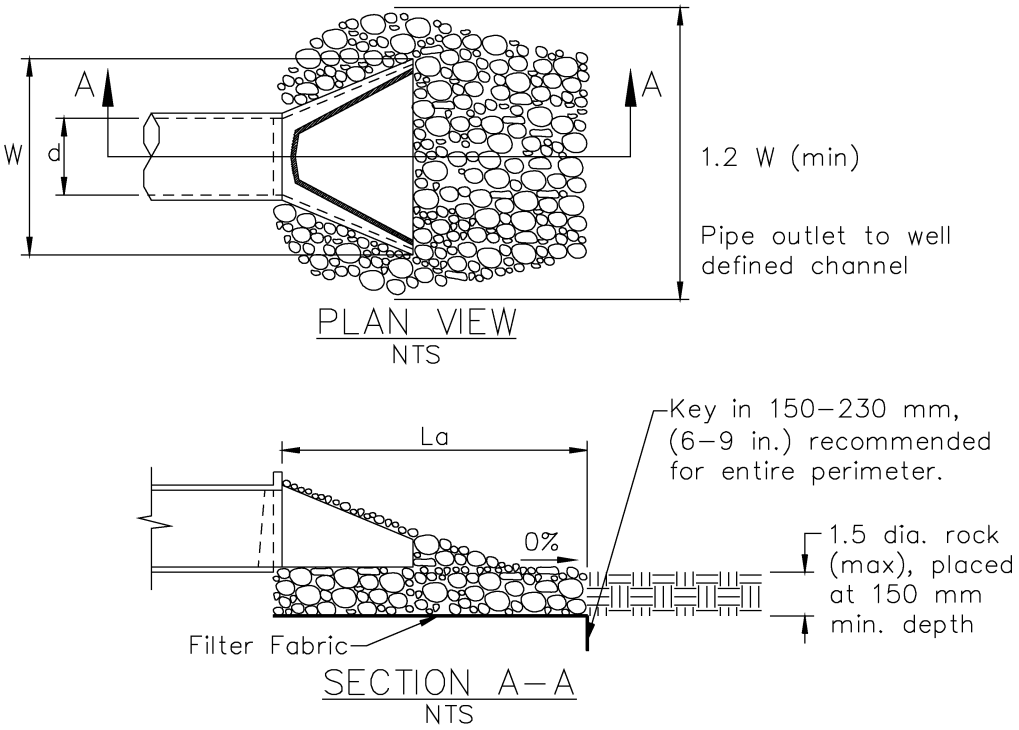
- There are many types of energy dissipaters, with rock being the one that is represented in the figure on Page 3. Please note that this is only one example and the RE may approve other types of devices proposed by the contractor.
- Install riprap, grouted riprap, or concrete apron at selected outlet. Riprap aprons are best suited for temporary use during construction.
- Carefully place riprap to avoid damaging the filter fabric.
- For proper operation of apron:
  - Align apron with receiving stream and keep straight throughout its length. If a curve is needed to fit site conditions, place it in upper section of apron.
  - If size of apron riprap is large, protect underlying filter fabric with a gravel blanket.
- Outlets on slopes steeper than 10% shall have additional protection.

Maintenance and Inspection

- Inspect temporary measures prior to the rainy season, after rainfall events, and regularly (approximately once per week) during the rainy season.
- Inspect apron for displacement of the riprap and/or damage to the underlying fabric. Repair fabric and replace riprap that has washed away.
- Inspect for scour beneath the riprap and around the outlet. Repair damage to slopes or underlying filter fabric immediately.
- Temporary devices shall be completely removed as soon as the surrounding drainage area has been stabilized, or at the completion of construction.

Outlet Protection/Velocity Dissipation Devices

SS-10

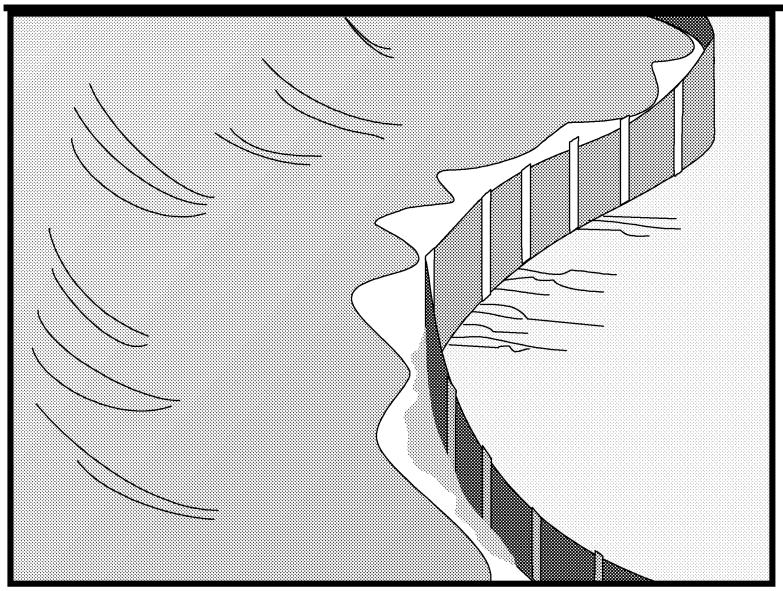


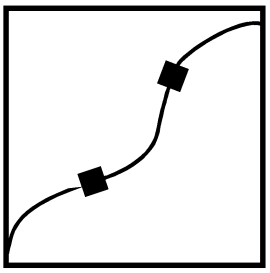
Pipe Diameter mm	Discharge m^3/s	Apron Length, La m	Rip Rap D_{50} Diameter Min mm
300	0.14	3	100
	0.28	4	150
450	0.28	3	150
	0.57	5	200
	0.85	7	300
	1.13	8	400
600	0.85	5	200
	1.13	8	200
	1.42	8	300
	1.70	9	400
For larger or higher flows, consult a Registered Civil Engineer			

Source: USDA – SCS

Silt Fence

SC-1





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

A silt fence is a temporary linear sediment barrier of permeable fabric designed to intercept and slow the flow of sediment-laden sheet flow runoff. Silt fences allow sediment to settle from runoff before water leaves the construction site.

Appropriate Applications

Silt fences are placed:

- Below the toe of exposed and erodible slopes.
- Down-slope of exposed soil areas.
- Around temporary stockpiles.
- Along streams and channels.
- Along the perimeter of a project.

Limitations

- Not effective unless trenched and keyed in.
- Not intended for use as mid-slope protection on slopes greater than 1:4 (V:H).
- Must be maintained.
- Must be removed and disposed of.
- Don't use below slopes subject to creep, slumping, or landslides.
- Don't use in streams, channels, drain inlets, or anywhere flow is concentrated.
- Don't use silt fences to divert flow.

Standards and Specifications

Design and Layout

- The maximum length of slope draining to any point along the silt fence shall be 61 m (200 ft) or less.
- Slope of area draining to silt fence shall be less than 1:1 (V:H).
- Limit to locations suitable for temporary ponding or deposition of sediment.
- Fabric life span generally limited to between five and eight months. Longer periods may require fabric replacement.
- Silt fences shall not be used in concentrated flow areas.
- Lay out in accordance with Pages 5 and 6 of this BMP.
- For slopes steeper than 1:2 (V:H) and that contain a high number of rocks or large dirt clods that tend to dislodge, it may be necessary to install additional protection immediately adjacent to the bottom of the slope, prior to installing silt fence. Additional protection may be a chain link fence or a cable fence.
- For slopes adjacent to water bodies or Environmentally Sensitive Areas (ESAs), additional temporary soil stabilization BMPs shall be used.

Materials

- Silt fence fabric shall be woven polypropylene with a minimum width of 900 mm (36 inches) and a minimum tensile strength of 0.45-kN. The fabric shall conform to the requirements in ASTM designation D4632 and shall have an integral reinforcement layer. The reinforcement layer shall be a polypropylene, or equivalent, net provided by the manufacturer. The permittivity of the fabric shall be between 0.1 sec^{-1} and 0.15 sec^{-1} in conformance with the requirements in ASTM designation D4491. Contractor must submit certificate of compliance in accordance with Standard Specifications Section 6-1.07.
- Wood stakes shall be commercial quality lumber of the size and shape shown on the plans. Each stake shall be free from decay, splits or cracks longer than the thickness of the stake or other defects that would weaken the stakes and cause the stakes to be structurally unsuitable.
- Bar reinforcement may be used, and its size shall be equal to a number four (4) or greater. End protection shall be provided for any exposed bar reinforcement.
- Staples used to fasten the fence fabric to the stakes shall be not less than 45 mm (1.75 inches) long and shall be fabricated from 1.57 mm (0.06 inch) or heavier wire. The wire used to fasten the tops of the stakes together when

joining two sections of fence shall be 3.05 mm (0.12 inch) or heavier wire. Galvanizing of the fastening wire is not required.

Installation

- Generally, silt fences shall be used in conjunction with soil stabilization source controls up slope to provide effective erosion and sediment control.
- Bottom of the silt fence shall be keyed-in a minimum of 150 mm (12 inches).
- Trenches shall not be excavated wider and deeper than necessary for proper installation of the temporary linear sediment barriers.
- Excavation of the trenches shall be performed immediately before installation of the temporary linear sediment barriers.
- Construct silt fences with a set-back of at least 1m (3 ft) from the toe of a slope. Where a silt fence is determined to be not practical due to specific site conditions, the silt fence may be constructed at the toe of the slope, but shall be constructed as far from the toe of the slope as practical.
- Construct the length of each reach so that the change in base elevation along the reach does not exceed 1/3 the height of the barrier; in no case shall the reach exceed 150 meters (490 ft).
- Cross barriers shall be a minimum of 1/3 and a maximum of 1/2 the height of the linear barrier.
- Install in accordance with Pages 5 and 6 of this BMP.

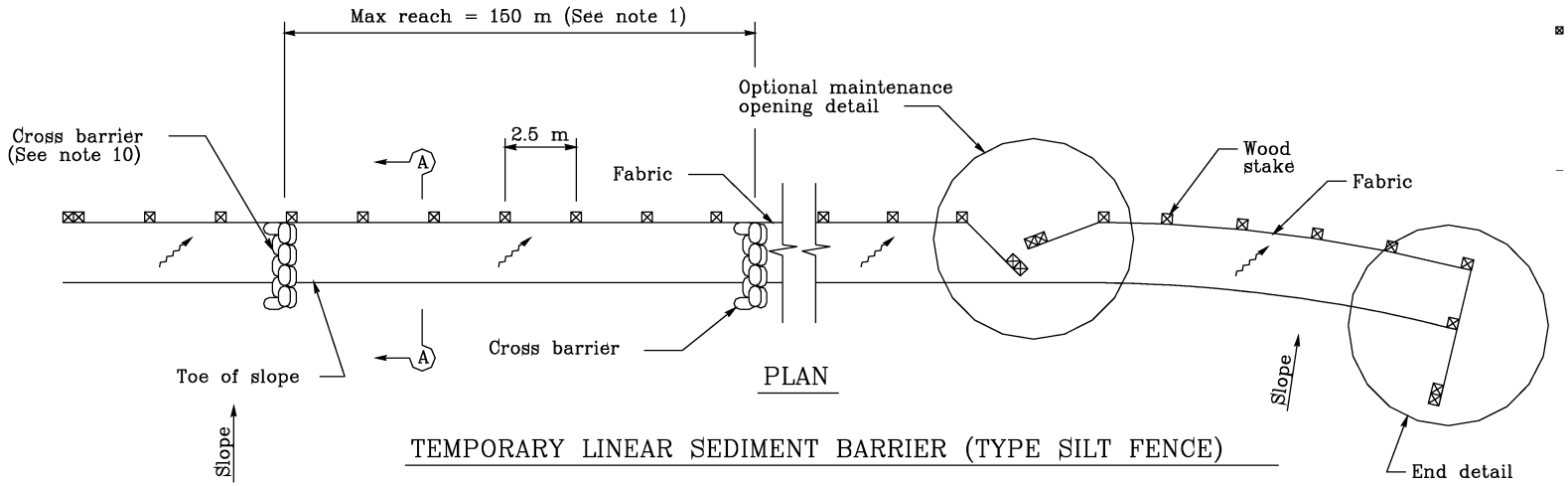
Maintenance and Inspection

- Repair undercut silt fences.
- Repair or replace split, torn, slumping, or weathered fabric.
- Inspect silt fence when rain is forecast. Perform necessary maintenance, or maintenance required by the Resident Engineer (RE).
- Inspect silt fence following rainfall events. Perform maintenance as necessary, or as required by the RE.
- Maintain silt fences to provide an adequate sediment holding capacity. Sediment shall be removed when the sediment accumulation reaches one-third (1/3) of the barrier height. Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the right-of-way in conformance with the Standard Specifications.
- Silt fences that are damaged and become unsuitable for the intended purpose, as determined by the RE, shall be removed from the site of work, disposed of outside the highway right-of-way in conformance with the Standard Specifications, and replaced with new silt fence barriers.

- Holes, depressions or other ground disturbance caused by the removal of the temporary silt fences shall be backfilled and repaired in conformance with the Standard Specifications.

- Remove silt fence when no longer needed or as required by the RE. Fill and compact post holes and anchorage trench, remove sediment accumulation, and grade fence alignment to blend with adjacent ground.

Silt Fence



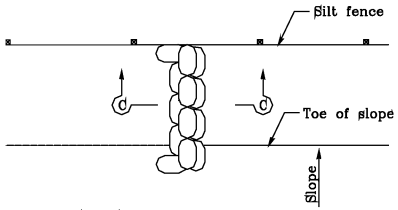
TEMPORARY LINEAR SEDIMENT BARRIER (TYPE SILT FENCE)

NOTES

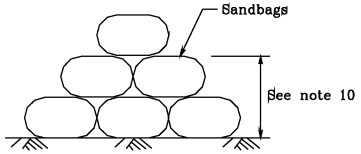
1. Construct the length of each reach so that the change in base elevation along the reach does not exceed 1/3 the height of the linear barrier, in no case shall the reach length exceed 150m.
2. The last 2.5 m of fence shall be turned up slope.
3. Stake dimensions are nominal.
4. Dimension may vary to fit field condition.
5. Stakes shall be spaced at 2.5 m maximum and shall be positioned on downstream side of fence.
6. Stakes to overlap and fence fabric to fold around each stake one full turn. Secure fabric to stake with 4 staples.
7. Stakes shall be driven tightly together to prevent potential flow-through of sediment at joint. The tops of the stakes shall be secured with wire.
8. For end stake, fence fabric shall be folded around two stakes one full turn and secured with 4 staples.
9. Minimum 4 staples per stake. Dimensions shown are typical.
10. Cross barriers shall be a minimum of 1/3 and a maximum of 1/2 the height of the linear barrier.
11. Maintenance openings shall be constructed in a manner to ensure sediment remains behind silt fence.
12. Joining sections shall not be placed at sump locations.
13. Sandbag rows and layers shall be offset to eliminate gaps.

LEGEND

- Tamped backfill
- Slope direction
- Direction of flow



CROSS BARRIER DETAIL



SECTION C-C

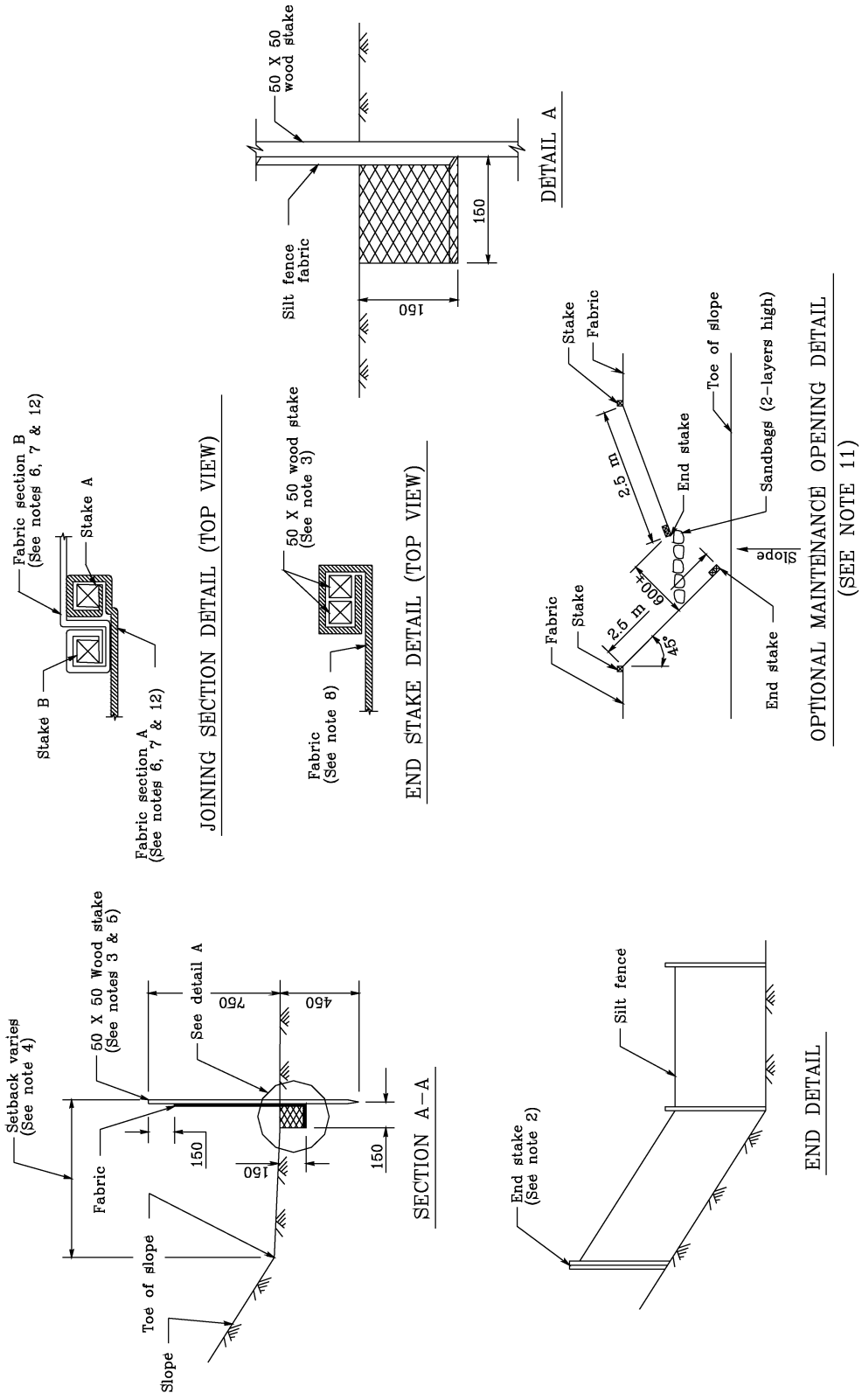
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

TEMPORARY LINEAR SEDIMENT BARRIER
(TYPE SILT FENCE)

NO SCALE

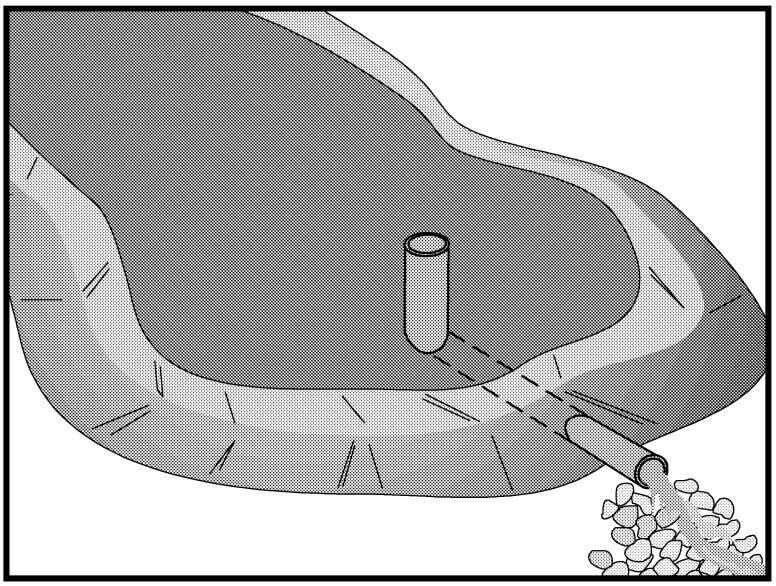
ALL DIMENSIONS ARE IN
MILLIMETERS UNLESS OTHERWISE SHOWN

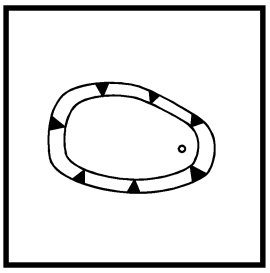
SC-1


50 X 50 wood stake
Silt fence fabric
150
150
DETAIL A
Fabric section B (See notes 6, 7 & 12)
Stake A
Stake B
Fabric section A (See notes 6, 7 & 12)
JOINING SECTION DETAIL (TOP VIEW)
50 X 50 wood stake (See note 3)
Fabric (See note 8)
END STAKE DETAIL (TOP VIEW)
Stake
Fabric
2.5 m
End stake
Toe of slope
Sandbags (2-layers high)
Slope
600
2.5 m
45°
Fabric
Stake
End stake
OPTIONAL MAINTENANCE OPENING DETAIL
(SEE NOTE 11)
Setback varies (See note 4)
50 X 50 Wood stake (See notes 3 & 5)
See detail A
750
460
150
150
150
Fabric
Toe of slope
Slope
SECTION A-A
Silt fence
End stake (See note 2)
END DETAIL

Sediment/Desilting Basin

SC-2





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

A sediment/desilting basin is a temporary basin formed by excavating and/or constructing an embankment so that sediment-laden runoff is temporarily detained under quiescent conditions, allowing sediment to settle out before the runoff is discharged (refer to Figures 1 and 2).

Appropriate Applications

Sediment basins shall be designed in accordance with Section A of the State of California NPDES General Permit for Storm Water Discharges Associated with Construction Activities (General Permit). If there is insufficient area to construct a sediment basin in accordance with the General Permit requirements, then the alternate desilting design standards specified herein may be used. This BMP may be implemented on a project-by-project basis with other BMPs when determined necessary and feasible by the RE.

Sediment/Desilting Basins shall be considered for use:

- On construction projects with disturbed areas during the rainy season.
- Where sediment-laden water may enter the drainage system or watercourses.
- At outlets of disturbed soil areas with areas between 2 ha and 4 ha (5 ac and 10 ac).

Limitations

- Alternative BMPs must be thoroughly investigated for erosion control before selecting temporary desilting basins.
- Requires large surface areas to permit settling of sediment.
- Not appropriate for drainage areas greater than 30 ha (75 ac).
- Not to be located in live streams

- For safety reasons, basins shall have protective fencing.
- Size may be limited by availability of right-of-way.

Standards and Specifications

- Limit the contributing area to the sediment/desilting basin to only the runoff from the disturbed soil areas. Use temporary concentrated flow conveyance controls to divert runoff from undisturbed areas away from the sediment/desilting basin.

Sediment Basin

- Sediment basins shall, at a minimum, be designed as follows:
  - Option 1: Pursuant to local ordinance for sediment basin design and maintenance, provided that the design efficiency is as protective or more protective of water quality than Option 3.

    OR

  - Option 2: Sediment basin(s), as measured from the bottom of the basin to the principal outlet, shall have at least a capacity equivalent to 102 cubic meters (3,600 cubic feet) of storage per 0.4 hectare (1 acre) draining into the sediment basin. The length of the basin shall be more than twice the width of the basin. The length is determined by measuring the distance between the inlet and the outlet; and the depth must not be less than 0.9 m (3 ft) nor greater than 1.5 m (5 ft) for safety reasons and for maximum efficiency.

    OR

  - Option 3: Sediment basin(s) shall be designed using the standard equation:

    $$As=1.2Q/Vs \qquad \text{(Eq. 1)}$$

    Where:

    As = Minimum surface area for trapping soil particles of a certain size

    Vs = Settling velocity of the design particle size chosen

    $Q = C\,I\,A$

    Where:

    Q = Discharge rate measured in cubic feet per second

    C = Runoff coefficient

    I = Precipitation intensity for the 10-year, 6-hour rain event

    A = Area draining into the sediment basin in acres

The design particle size shall be the smallest soil grain size determined by wet sieve analysis, or the fine silt sized (0.01mm) particle, and the *Vs* used shall be 100 percent of the calculated settling velocity.

The length is determined by measuring the distance between the inlet and the outlet; the length shall be more than twice the dimension as the width; the depth shall not be less than 0.9 m (3 ft) nor greater than 1.5 m (5 ft) for safety reasons and for maximum efficiency [0.6 m (2 ft) of sediment storage, 0.6 m (2 ft) of capacity). The basin(s) shall be located on the site where it can be maintained on a year-round basis and shall be maintained on a schedule to retain the 0.6 m (2 ft) of capacity.

OR

– Option 4: The use of an equivalent surface area design or equation, provided that the design efficiency is as protective or more protective of water quality than Option 3.

Desilting Basin

- Desilting basins shall be designed to have a capacity equivalent to 100 cubic meters of storage (as measured from the top of the basin to the principal outlet) per hectare of contributory area. This design is less than the required to capture the 0.01 mm particle size but larger than that required to capture particles 0.02 mm or larger.

- The length of the basin shall be more than twice the width of the basin; the length shall be determined by measuring the distance between the inlet and the outlet.

- The depth must be no less than one (1) meter nor greater than 1.5 m.

- Basins with an impounding levee greater than 1.5 m (5 ft) tall, measured from the lowest point to the impounding area to the highest point of the levee, and basins capable of impounding more than 1000 cubic meters (35,300 cubic feet), shall be designed by a professional Civil Engineer registered with the state of California. The design must be submitted to the Resident Engineer (RE) for approval at least 7 days prior to the basin construction. The design shall include maintenance requirements, including sediment and vegetation removal, to ensure continuous function of the basin outlet and bypass structures.

General Requirements

- Design and locate sediment/desilting basins so that they can be maintained. Construct desilting basins prior to the rainy season and construction activities.

- Sediment/desilting basins, regardless of size and storage volume, shall include features to accommodate overflow or bypass flows that exceed the design storm event. The calculated basin volume and proposed location shall be submitted to

the RE for approval at least 3 days prior to the basin construction.

- Construct an emergency spillway to accommodate flows not carried by the principal spillway. Spillway shall consist of an open channel (earthen or vegetated) over undisturbed material (not fill) or constructed of a non-erodible riprap.
- Spillway control section, which is a level portion of the spillway channel at the highest elevation in the channel, shall be a minimum of 6 m (20 ft) in length.
- A forebay, constructed upstream of the basin may be provided to remove debris and larger particles.
- Basin inlets shall be located to maximize travel distance to the basin outlet.
- Rock or vegetation shall be used to protect the basin inlet and slopes against erosion.
- The outflow from the basins shall be provided with outlet protection to prevent erosion and scouring of the embankment and channel. See BMP SS-10, "Outlet Protection/Velocity Dissipation Devices."
- Basin shall be located: (1) by excavating a suitable area or where a low embankment can be constructed across a swale, (2) where post-construction (permanent) detention basins will be constructed, (3) where failure would not cause loss of life or property damage, (4) where the basins can be maintained on a year-round basins to provide access for maintenance, including sediment removal and sediment stockpiling in a protected area, and to maintain the basin to provide the required capacity.
- Areas under embankments, structural works, and sediment/desilting basin must be cleared, stripped of vegetation in accordance with Standard Specifications Section 16 – "Clearing and Grubbing."
- Earthwork shall be in accordance with Standard Specifications Section 19 – "Earthwork". Contractor is specifically directed to Standard Specifications Sections 19-5, "Compaction," and 19-6, "Embankment Construction."
- Structure shall be placed on a firm, smooth foundation with the base securely anchored with concrete or other means to prevent floatation.
- Discharge from the basin shall be accomplished through a water quality outlet. An example is shown in Figure 3. The Principal outlet shall consist of a corrugated metal, high density polyethylene (HDPE), or reinforced concrete riser pipe with dewatering holes and an anti-vortex device and trash rack attached to the top of the riser, to prevent floating debris from flowing out of the basin or obstructing the system. This principal structure shall be designed

to accommodate the inflow design storm.

- A rock pile or rock-filled gabions can serve as alternatives to the debris screen, although the designer should be aware of the potential for extra maintenance involved should the pore spaces in the rock pile clog.

- Proper hydraulic design of the outlet is critical to achieving the desired performance of the basin. The water quality outlet should be designed to drain the basin within 24 to 72 hours (also referred to as "drawdown time"). (The 24-hour limit is specified to provide adequate settling time; the 72-hour limit is specified to mitigate vector control concerns.)

- The two most common outlet problems that occur are: (1) the capacity of the outlet is too great resulting in only partial filling of the basin and drawdown time less than designed for; and (2) the outlet clogs because it is not adequately protected against trash and debris. To avoid these problems, the following outlet types are recommended for use: (1) a single orifice outlet with or without the protection of a riser pipe, and (2) perforated riser. Design guidance for single orifice and perforated riser outlets are as follows:

  Flow Control Using a Single Orifice At The Bottom Of The Basin (Figure 1): The outlet control orifice should be sized using the following equation:

$$a = \frac{2A(H-Ho)^{0.5}}{3600CT(2g)^{0.5}} = \frac{(7x10^{-5})A(H-Ho)^{0.5}}{CT} \qquad \text{(Eq. 2)}$$

  where:

  a = area of orifice (ft^2) (1 ft^2 =0.0929m^2)
  A = surface area of the basin at mid elevation (ft^2)
  C = orifice coefficient
  T = drawdown time of full basin (hrs)
  G = gravity (32.2 ft/s^2)
  H = elevation when the basin is full (ft)
  Ho = final elevation when basin is empty (ft)

  With a drawdown time of 40 hours, the equation becomes:

$$a = \frac{(1.75x10^{-6})A(H-Ho)^{0.5}}{C} \qquad \text{(Eq. 3)}$$

  Flow Control Using Multiple Orifices (see Figure2):

$$a_t = \frac{2A(h_{\max})}{CT(2g[h_{\max} - h_{centroid\ of\ orifices}])^{0.5}} \qquad \text{(Eq. 4)}$$

With terms as described above except:

a_t = total area of orifices

h_{max} = maximum height from lowest orifice to the maximum water surface (ft)

$h_{centroid\ of\ orifices}$ = height from the lowest orifice to the centroid of the orifice configuration (ft)

Allocate the orifices evenly on two rows; separate the holes by 3x hole diameter vertically, and by 120 degrees horizontally (refer to Figure 3).

Because basins are not maintained for infiltration, water loss by infiltration should be disregarded when designing the hydraulic capacity of the outlet structure.

Care must be taken in the selection of "C"; 0.60 is most often recommended and used. However, based on actual tests, GKY (1989), "Outlet Hydraulics of Extended Detention Facilities for Northern Virginia Planning District Commission", recommends the following:

C = 0.66 for thin materials; where the thickness is equal to or less than the orifice diameter, or

C = 0.80 when the material is thicker than the orifice diameter

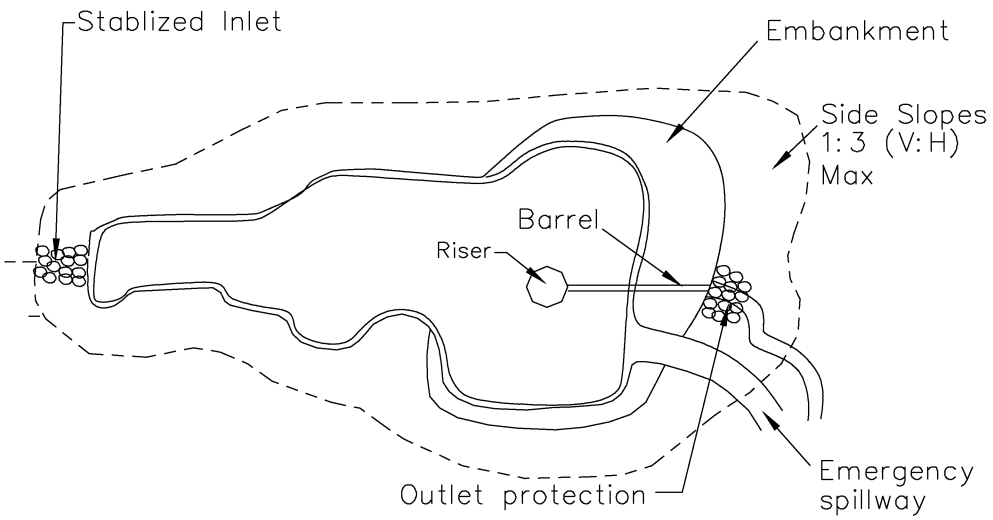
- The Contractor shall verify that the outlet is properly designed to handle the design and peak flows.
- Attach riser pipe (watertight connection) to a horizontal pipe (barrel), which extends through the embankment to toe of fill. Provide anti-seep collars on the barrel.
- Cleanout level shall be clearly marked on the riser pipe
- Avoid dewatering of groundwater to the sediment/desilting basin during the rainy season. Insignificant quantities of accumulated precipitation may be dewatered to the sediment/desilting basin unless precipitation is forecasted within 24 hours. Refer to NS-2 “Dewatering Operations.”
- Chain link fencing shall be provided around each sediment/desilting basin to prevent unauthorized entry to the basin or if safety is a concern. Fencing shall be in accordance with Standard Specifications Section 80 – “Fencing.”

Maintenance and Inspection

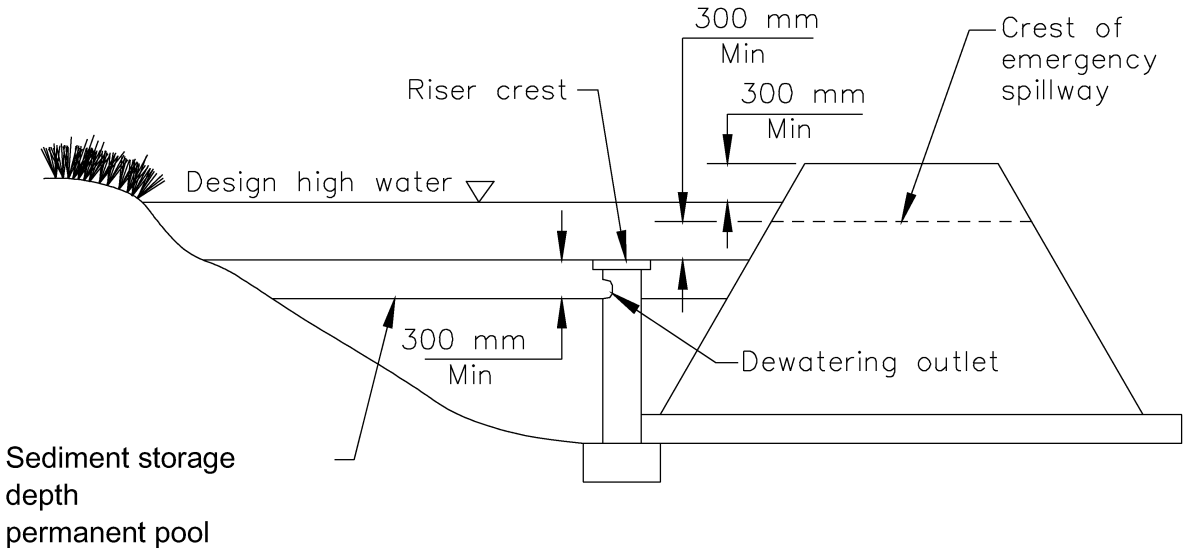
- Inspect sediment/desilting basins before and after rainfall events and weekly during the rest of the rainy season. During extended rainfall events, inspect at

least every 24 hours.

- Examine basin banks for seepage and structural soundness.
- Check inlet and outlet structures and spillway for any damage or obstructions. Repair damage and remove obstructions as needed, or as directed by the RE.
- Remove standing water from the basin within 72 hours after accumulation.
- Check inlet and outlet area for erosion and stabilize if required, or if directed by the RE.
- Remove accumulated sediment when its volume reaches one-third the volume of the sediment storage. Properly dispose of sediment and debris removed from the basin.
- Check fencing for damage and repair as needed or as directed by the RE.

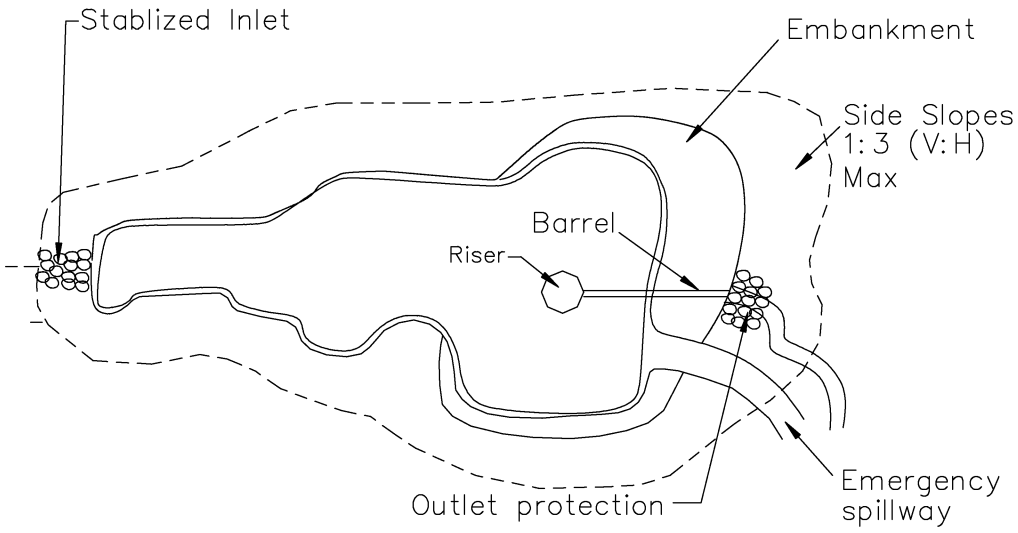


TOP VIEW



This outlet provides no drainage for permanent pool.

FIGURE 1: SINGLE ORIFICE DESIGN
NOT TO SCALE



TOP VIEW

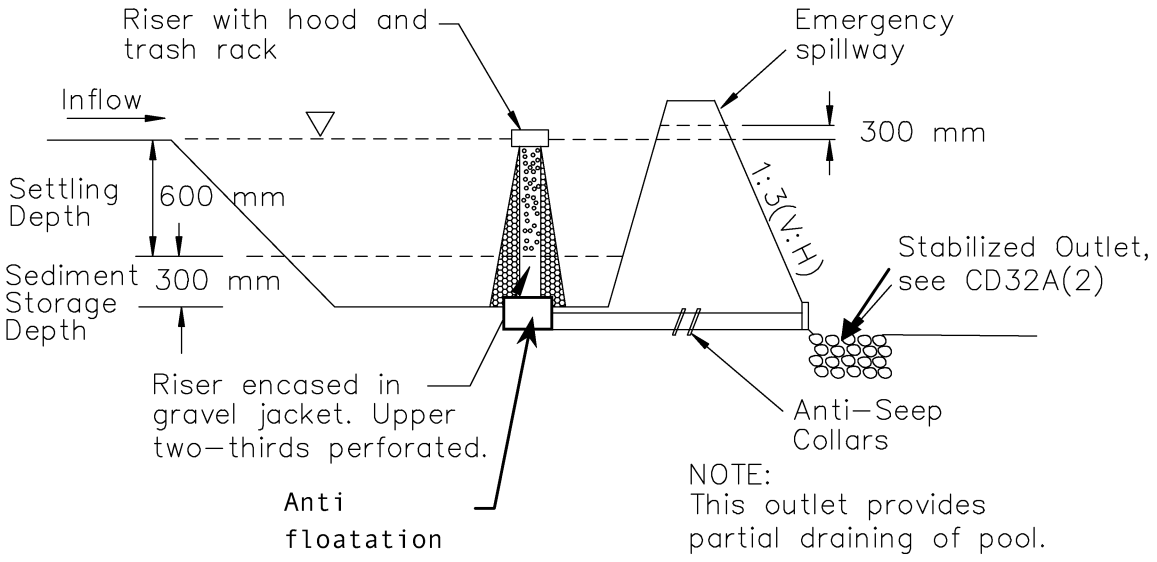
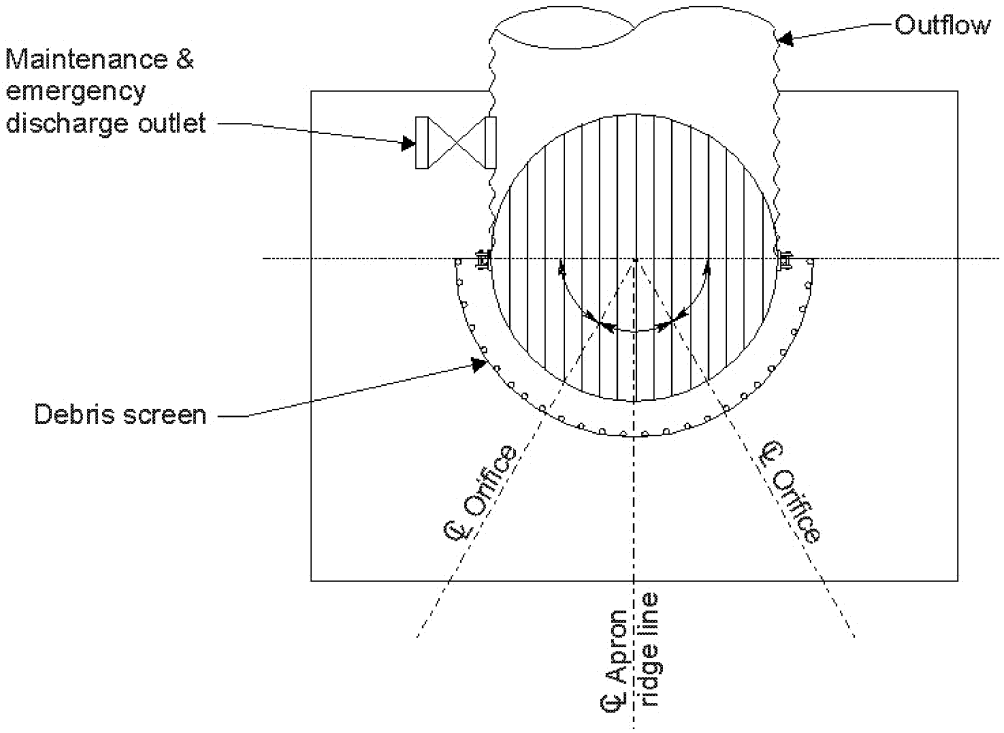


FIGURE 2: MULTIPLE ORIFICE DESIGN
NOT TO SCALE

Plan



Profile

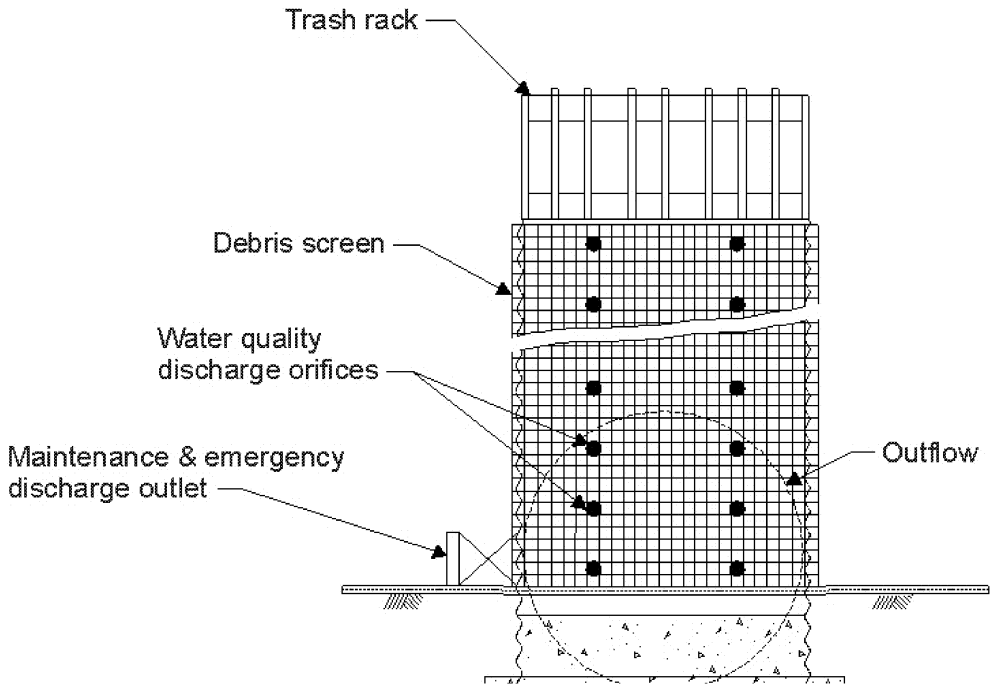
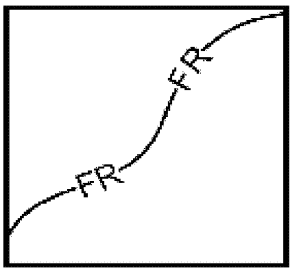


FIGURE 3: MULTIPLE ORIFICE OUTLET RISER
NOT TO SCALE

Fiber Rolls

SC-5



Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

A fiber roll consists of wood excelsior, rice or wheat straw, or coconut fibers that is rolled or bound into a tight tubular roll and placed on the toe and face of slopes to intercept runoff, reduce its flow velocity, release the runoff as sheet flow and provide removal of sediment from the runoff. Fiber rolls may also be used for inlet protection and as check dams under certain situations.

Appropriate Applications

- This BMP may be implemented on a project-by-project basis with other BMPs when determined necessary and feasible by the RE.
- Along the toe, top, face, and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
- Below the toe of exposed and erodible slopes.
- Fiber rolls may be used as check dams in unlined ditches if approved by the Resident Engineer (RE) or the District Construction Storm Water Coordinator (refer to SC-4 “Check Dams”).
- Fiber rolls may be used for drain inlet protection if approved by the RE or the District Construction Storm Water Coordinator (refer to SC-10 “Storm Drain Inlet Protection”).
- Down-slope of exposed soil areas.
- Around temporary stockpiles.
- Along the perimeter of a project.

Limitations

- Runoff and erosion may occur if fiber roll is not adequately trenched in.
- Fiber rolls at the toe of slopes greater than 1:5 may require the use of 500 mm (20" diameter) or installations achieving the same protection (i.e., stacked smaller diameter fiber rolls, etc.).
- Fiber rolls may be used for drainage inlet protection if they can be properly anchored.
- Difficult to move once saturated.
- Fiber rolls could be transported by high flows if not properly staked and trenched in.
- Fiber rolls have limited sediment capture zone.
- Do not use fiber rolls on slopes subject to creep, slumping, or landslide.

Standards and Specifications

Fiber Roll Materials

- Fiber rolls shall be either:

  (1) Prefabricated rolls.

  (2) Rolled tubes of erosion control blanket.

Assembly of Field Rolled Fiber Roll

- Roll length of erosion control blanket into a tube of minimum 200 mm (8 in) diameter.
- Bind roll at each end and every 1.2 m (4 ft) along length of roll with jute-type twine.

Installation

- Slope inclination of 1:4 or flatter: fiber rolls shall be placed on slopes 6.0 m apart.
- Slope inclination of 1:4 to 1:2: fiber rolls shall be placed on slopes 4.5 m apart.
- Slope inclination 1:2 or greater: fiber rolls shall be placed on slopes 3.0 m apart.
- Stake fiber rolls into a 50 to 100 mm (2 to 4 in) trench.

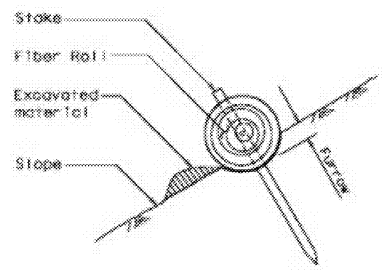
- Drive stakes at the end of each fiber roll and spaced 600 mm (2 ft) apart if Type 2 installation is used (refer to Page 4). Otherwise, space stakes 1.2 m (4 ft) maximum on center if installed as shown on Pages 5 and 6.
- Use wood stakes with a nominal classification of 19 by 19 mm (3/4 by 3/4 in), and minimum length of 600 mm (24 in).
- If more than one fiber roll is placed in a row, the rolls shall be overlapped; not abutted.

Removal

- Fiber rolls are typically left in place.
- If fiber rolls are removed, collect and dispose of sediment accumulation, and fill and compact holes, trenches, depressions or any other ground disturbance to blend with adjacent ground.

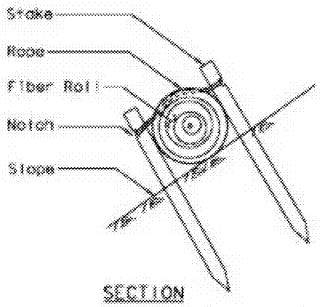
Maintenance and Inspection

- Repair or replace split, torn, unraveling, or slumping fiber rolls.
- Inspect fiber rolls when rain is forecast. Perform maintenance as needed or as required by the RE.
- Inspect fiber rolls following rainfall events and a least daily during prolonged rainfall. Perform maintenance as needed or as required by the RE.
- Maintain fiber rolls to provide an adequate sediment holding capacity. Sediment shall be removed when the sediment accumulation reaches three quarters (3/4) of the barrier height. Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the highway right-of-way in conformance with the Standard Specifications.

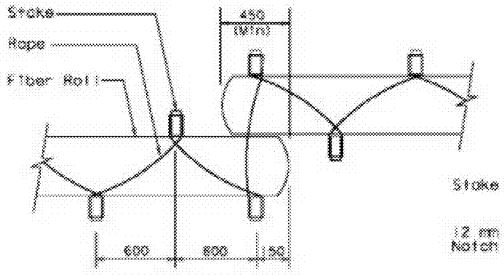


SECTION

TEMPORARY FIBER ROLL (TYPE 1)

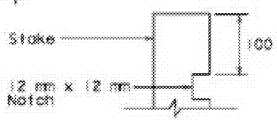


SECTION



PLAN

TEMPORARY FIBER ROLL (TYPE 2)

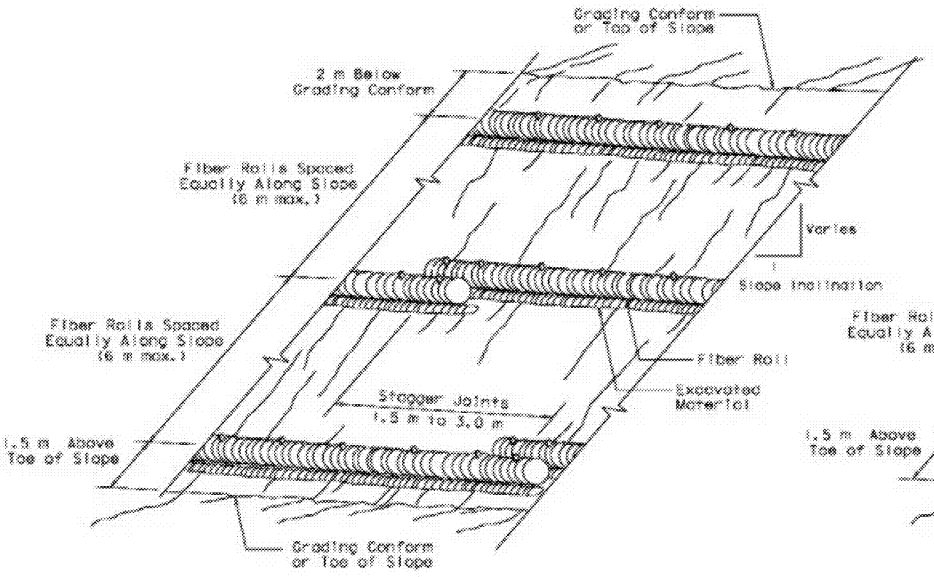


ELEVATION

NOTCH DETAIL

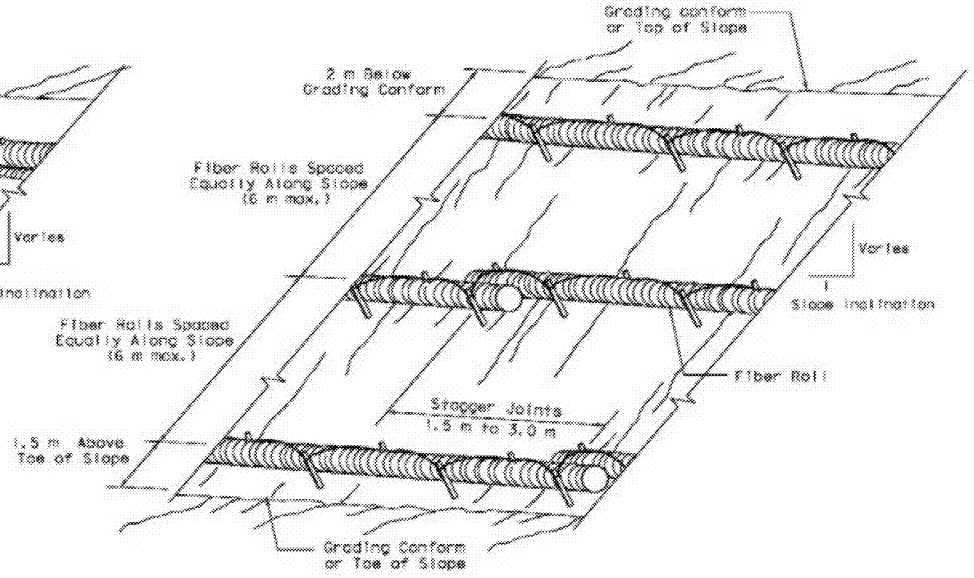
NOTE

1. Temporary fiber roll spacing varies depending upon slope inclination.



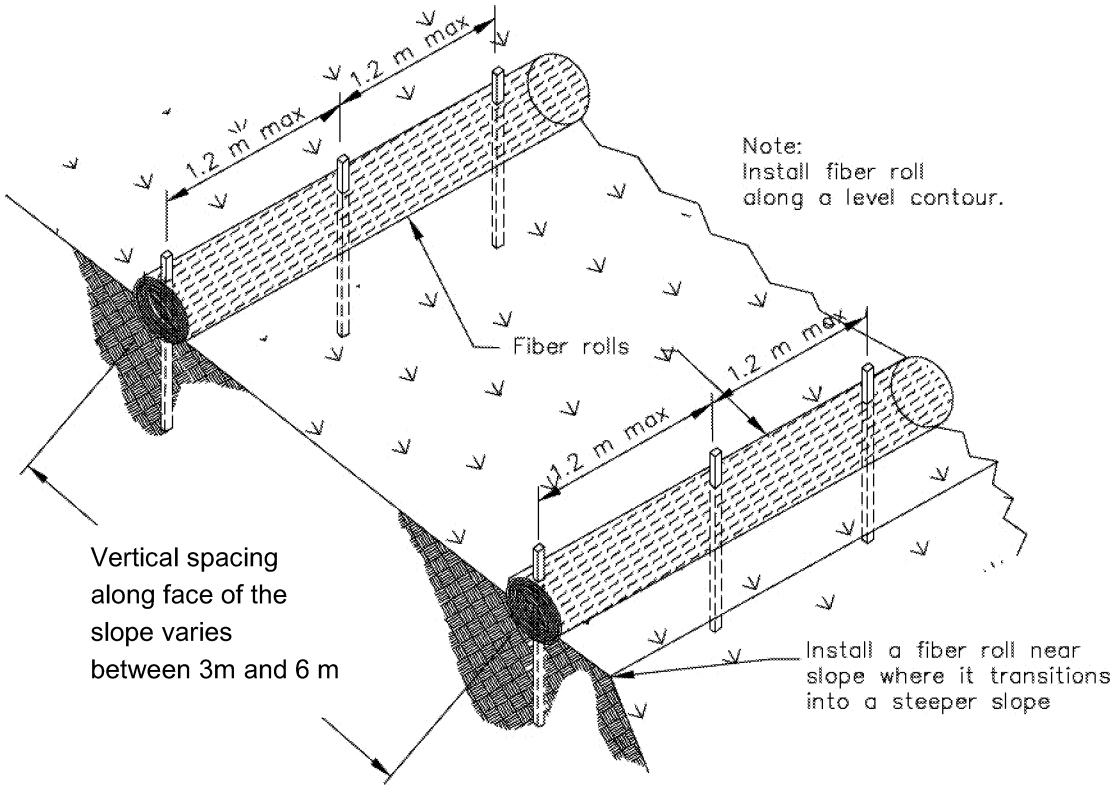
PERSPECTIVE

TEMPORARY FIBER ROLL (TYPE 1)



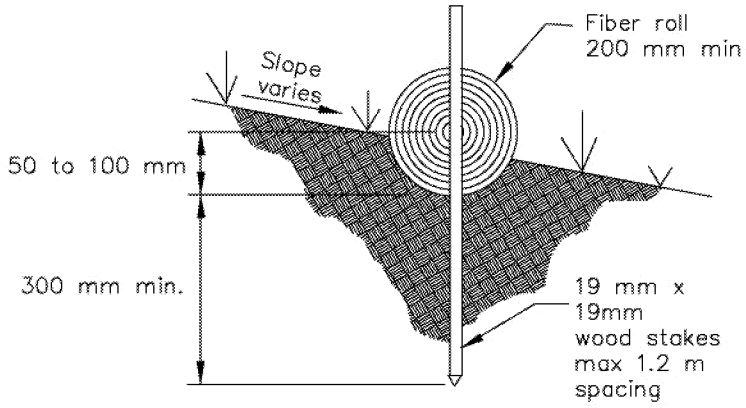
PERSPECTIVE

TEMPORARY FIBER ROLL (TYPE 2)



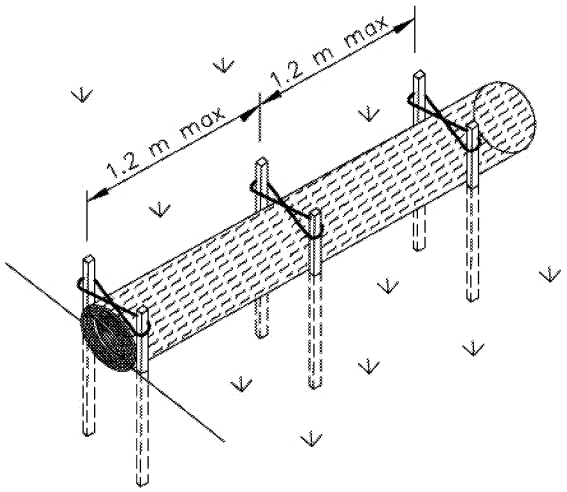
TYPICAL FIBER ROLL INSTALLATION

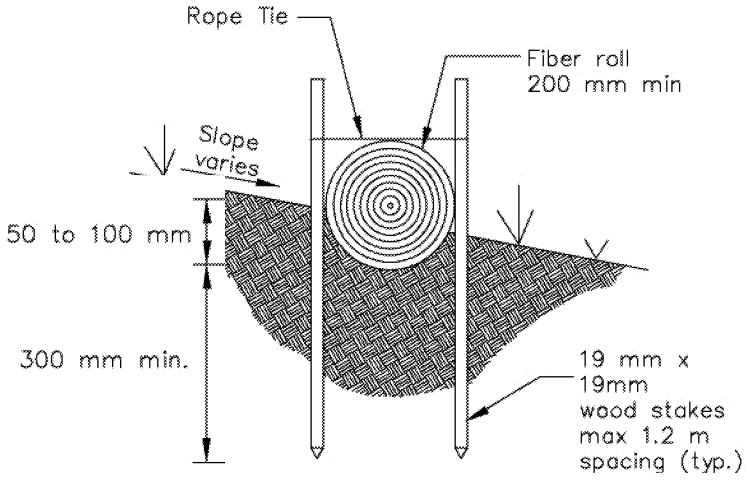
N.T.S.



ENTRENCHMENT DETAIL

N.T.S.



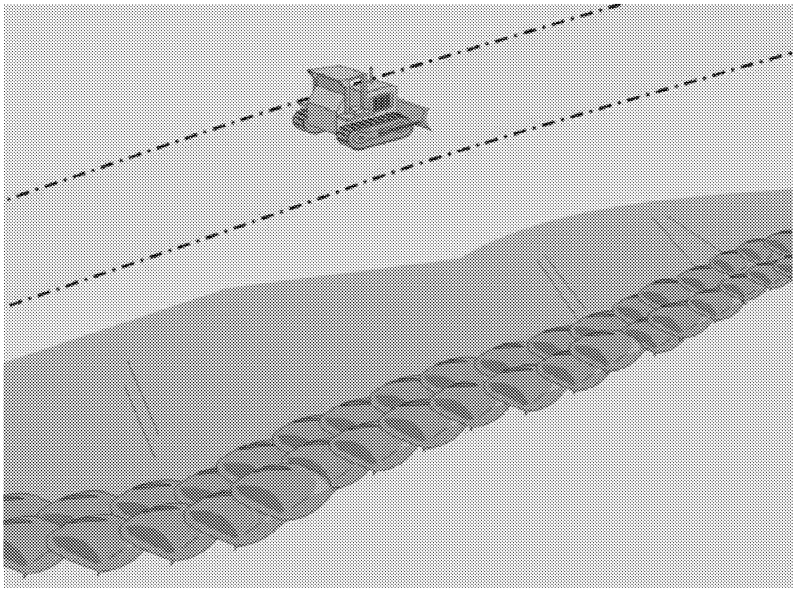


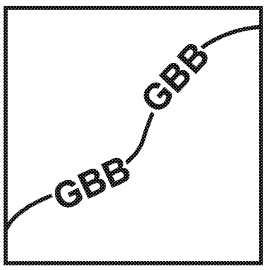
OPTIONAL ENTRENCHMENT DETAIL

N.T.S.

Gravel Bag Berm

SC-6





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

A gravel bag berm consists of a single row of gravel bags that are installed end to end to form a barrier across a slope to intercept runoff, reduce its flow velocity, release the runoff as sheet flow and provide some sediment removal. Gravel bags can be used where flows are moderately concentrated, such as ditches, swales, and storm drain inlets (see BMP SC-10, Storm Drain Inlet Protection) to divert and/or detain flows.

Appropriate Applications

- BMP may be implemented on a project-by-project basis with other BMPs when determined necessary and feasible by the RE.
- Along streams and channels.
- Below the toe of exposed and erodible slopes.
- Down slope of exposed soil areas.
- Around stockpiles.
- Across channels to serve as a barrier for utility trenches or provide a temporary channel crossing for construction equipment, to reduce stream impacts.
- Parallel to a roadway to keep sediment off paved areas.
- At the top of slopes to divert roadway runoff away from disturbed slopes.
- Along the perimeter of a site.
- To divert or direct flow or create a temporary sediment basin.
- During construction activities in stream beds when the contributing drainage

area is less than 2 ha (5 ac).

- When extended construction period limits the use of either silt fences or straw bale barriers.
- When site conditions or construction sequencing require adjustments or relocation of the barrier to meet changing field conditions and needs during construction.
- At grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.

Limitations

- Degraded gravel bags may rupture when removed, spilling contents.
- Installation can be labor intensive.
- Limited durability for long term projects.
- When used to detain concentrated flows, maintenance requirements increase.

Standards and Specifications

Materials

- Bag Material: Bags shall be woven polypropylene, polyethylene or polyamide fabric, minimum unit weight 135 g/m2 (four ounces per square yard), mullen burst strength exceeding 2,070 kPa (300 psi) in conformance with the requirements in ASTM designation D3786, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D4355.
- Bag Size: Each gravel-filled bag shall have a length of 450 mm (18 in), width of 300 mm (12 in), thickness of 75 mm (3 in), and mass of approximately 15 kg (33 lb). Bag dimensions are nominal, and may vary based on locally available materials. Alternative bag sizes shall be submitted to the RE for approval prior to deployment.
- Fill Material: Gravel shall be between 10 mm and 20 mm (0.4 and 0.8 inch) in diameter, and shall be clean and free from clay balls, organic matter, and other deleterious materials. The opening of gravel-filled bags shall be between 13 kg and 22 kg (28 and 48 lb) in mass. Fill material is subject to approval by the RE.

Installation

- When used as a linear control for sediment removal:
  - Install along a level contour.
  - Turn ends of gravel bag row up slope to prevent flow around the ends.
  - Generally, gravel bag barriers shall be used in conjunction with temporary soil stabilization controls up slope to provide effective erosion and sediment

control.

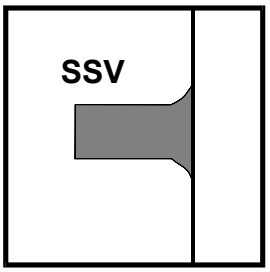
- When used for concentrated flows:
  - Stack gravel bags to required height using a pyramid approach.
  - Upper rows of gravel bags shall overlap joints in lower rows.
- Construct gravel bag barriers with a set-back of at least 1m from the toe of a slope. Where it is determined to be not practicable due to specific site conditions, the gravel bag barrier may be constructed at the toe of the slope, but shall be constructed as far from the toe of the slope as practicable.
- Requires Certificate of Compliance per Standard Specifications 6-1.07.

Maintenance and Inspection

- Inspect gravel bag berms before and after each rainfall event, and weekly throughout the rainy season.
- Reshape or replace gravel bags as needed, or as directed by the RE.
- Repair washouts or other damages as needed, or as directed by the RE.
- Inspect gravel bag berms for sediment accumulations and remove sediments when accumulation reaches one-third of the berm height. Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the highway right-of-way in conformance with the Standard Specifications.
- Remove gravel bag berms when no longer needed. Remove sediment accumulations and clean, re-grade, and stabilize the area.

Street Sweeping and Vacuuming

SC-7



Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ● Sediment Control
- ● Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Practices to remove tracked sediment to prevent the sediment from entering a storm drain or watercourse.

Appropriate Applications

These practices are implemented anywhere sediment is tracked from the project site onto public or private paved roads, typically at points of ingress/egress.

Limitations

Sweeping and vacuuming may not be effective when soil is wet or muddy.

Standards and Specifications

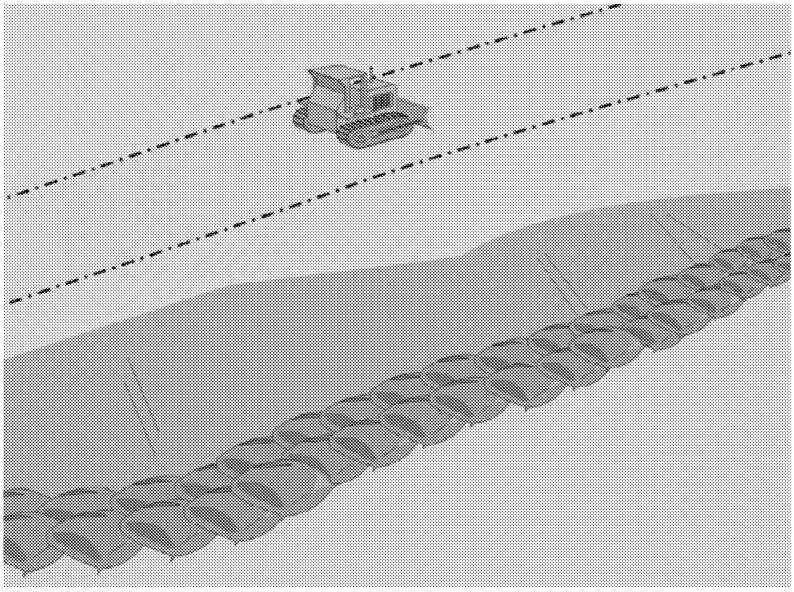
- ■ Kick brooms or sweeper attachments shall not be used.
- ■ Inspect potential sediment tracking locations daily.
- ■ Visible sediment tracking shall be swept and/or vacuumed daily.
- ■ If not mixed with debris or trash, consider incorporating the removed sediment back into the project.

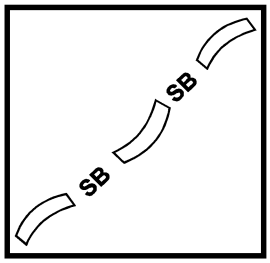
Maintenance and Inspection

- ■ Inspect ingress/egress access points daily and sweep tracked sediment as needed, or as required by the Resident Engineer (RE).
- ■ Be careful not to sweep up any unknown substance or any object that may be potentially hazardous.
- ■ Adjust brooms frequently; maximize efficiency of sweeping operations.
- ■ After sweeping is finished, properly dispose of sweeper wastes at an approved dumpsite in conformance with the provisions in Standard Specifications Section 7-1.13 .

Sandbag Barrier

SC-8





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

A sandbag barrier is a temporary linear sediment barrier consisting of stacked sandbags, designed to intercept and slow the flow of sediment-laden sheet flow runoff. Sandbag barriers allow sediment to settle from runoff before water leaves the construction site.

Appropriate Applications

- This BMP may be implemented on a project-by-project basis in addition to other BMPs when determined necessary and feasible by the Resident Engineer (RE).
- Along the perimeter of a site.
- Along streams and channels.
- Below the toe of exposed and erodible slopes.
- Down slope of exposed soil areas.
- Around stockpiles.
- Across channels to serve as a barrier for utility trenches or provide a temporary channel crossing for construction equipment, to reduce stream impacts.
- Parallel to a roadway to keep sediment off paved areas.
- At the top of slopes to divert roadway runoff away from disturbed slopes.
- To divert or direct flow or create a temporary sediment/desilting basin.
- During construction activities in stream beds when the contributing drainage area is less than 2 ha (5 ac).

- When extended construction period limits the use of either silt fences or straw bale barriers.
- Along the perimeter of vehicle and equipment fueling and maintenance areas or chemical storage areas.
- To capture and detain non-storm water flows until proper cleaning operations occur.
- When site conditions or construction sequencing require adjustments or relocation of the barrier to meet changing field conditions and needs during construction.
- To temporarily close or continue broken, damaged or incomplete curbs.

Limitations

- Limit the drainage area upstream of the barrier to 2 ha (5 ac).
- Degraded sandbags may rupture when removed, spilling sand.
- Installation can be labor intensive.
- Limited durability for long-term projects.
- When used to detain concentrated flows, maintenance requirements increase.

Standards and Specifications

Materials

- Sandbag Material: Sandbag shall be woven polypropylene, polyethylene or polyamide fabric, minimum unit weight 135 g/m2 (four ounces per square yard), mullen burst strength exceeding 2,070 kPa (300 psi) in conformance with the requirements in ASTM designation D3786, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D4355. Use of burlap is not acceptable.
- Sandbag Size: Each sand-filled bag shall have a length of 450 mm (18 in), width of 300 mm (12 in), thickness of 75 mm (3 in), and mass of approximately 15 kg (33 lb.). Bag dimensions are nominal, and may vary based on locally available materials. Alternative bag sizes shall be submitted to the RE for approval prior to deployment.
- Fill Material: All sandbag fill material shall be non-cohesive, Class 1 or Class 2 permeable material free from clay and deleterious material, conforming to the provisions in Standard Specifications Section 68-1.025 “Permeable Material”. The requirements for the Durability Index and Sand Equivalent do not apply. Fill material is subject to approval by the RE.

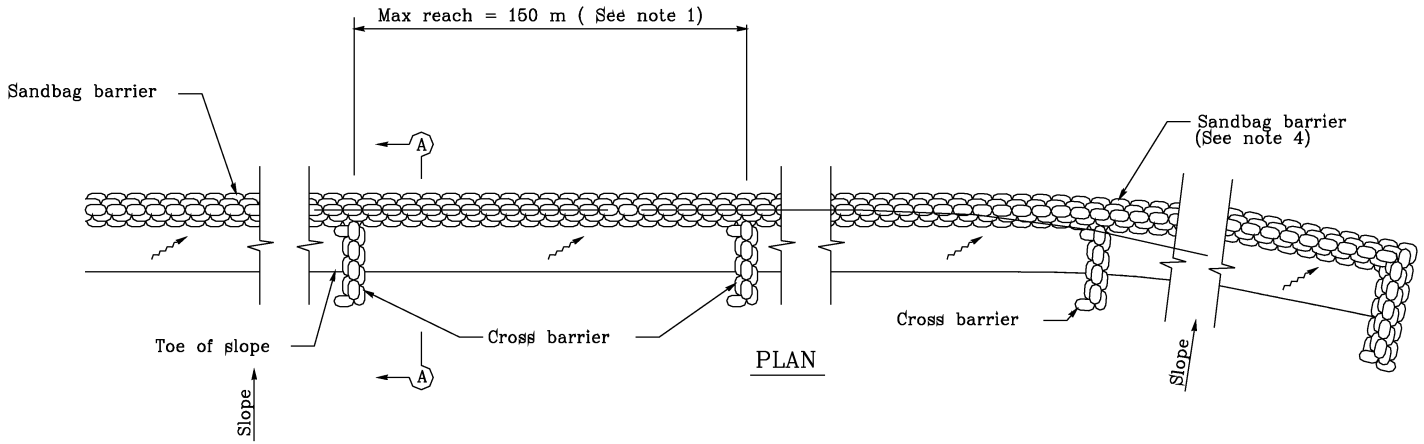
Installation

- When used as a linear sediment control:
  - Install along a level contour.
  - Turn ends of sandbag row up slope to prevent flow around the ends.
  - Generally, sandbag barriers shall be used in conjunction with temporary soil stabilization controls up slope to provide effective erosion and sediment control.
  - Install as shown in Pages 4 and 5 of this BMP.
- Construct sandbag barriers with a set-back of at least 1m (3 ft) from the toe of a slope. Where it is determined to be not practical due to specific site conditions, the sandbag barrier may be constructed at the toe of the slope, but shall be constructed as far from the toe of the slope as practicable.

Maintenance and Inspection

- Inspect sandbag barriers before and after each rainfall event, and weekly throughout the rainy season.
- Reshape or replace sandbags as needed, or as directed by the RE.
- Repair washouts or other damages as needed, or as directed by the RE.
- Inspect sandbag barriers for sediment accumulations and remove sediments when accumulation reaches one-third the barrier height. Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the highway right-of-way in conformance with the Standard Specifications.
- Remove sandbags when no longer needed. Remove sediment accumulation, and clean, re-grade, and stabilized the area.

Sandbag Barrier



TEMPORARY LINEAR SEDIMENT BARRIER (TYPE SANDBAG)

Caltrans Metric

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

TEMPORARY LINEAR SEDIMENT BARRIER (TYPE SANDBAG)

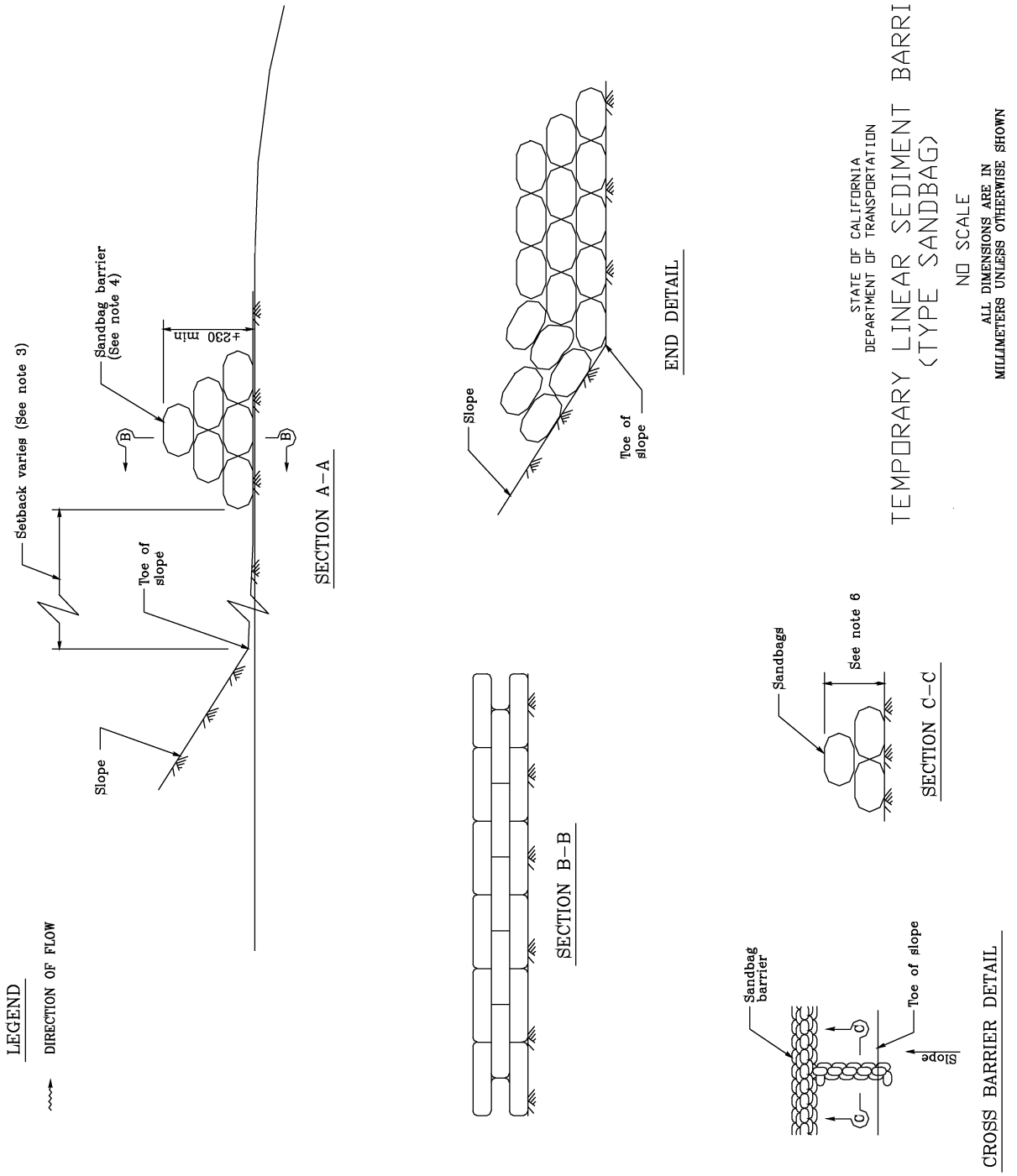
NO SCALE

ALL DIMENSIONS ARE IN
MILLIMETERS UNLESS OTHERWISE SHOWN

NOTES

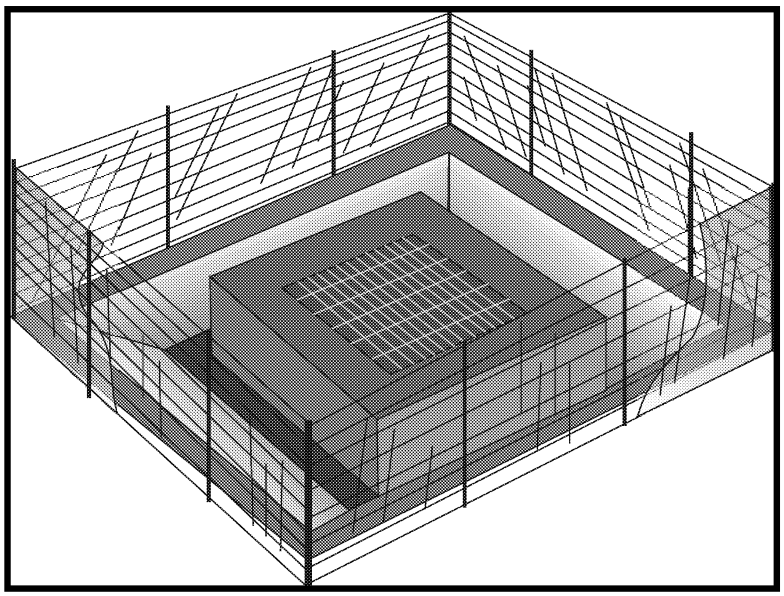
1. Construct the length of each reach so that the change in base elevation along the reach does not exceed 1/2 the height of the linear barrier. In no case shall the reach length exceed 150 m.
2. Place sandbags tightly.
3. Dimension may vary to fit field condition.
4. Sandbag barrier shall be a minimum of 3 bags high.
5. The end of the barrier shall be turned up slope.
6. Cross barriers shall be a min of 1/2 and a max of 2/3 the height of the linear barrier.
7. Sandbag rows and layers shall be staggered to eliminate gaps.

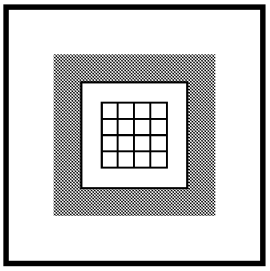
SC-8


LEGEND
DIRECTION OF FLOW
Setback varies (See note 3)
Sandbag barrier (See note 4)
+230 min
Toe of slope
Slope
B
B
SECTION A-A
Slope
Toe of slope
END DETAIL
SECTION B-B
Sandbags
See note 6
SECTION C-C
Sandbag barrier
Toe of slope
Slope
CROSS BARRIER DETAIL
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
TEMPORARY LINEAR SEDIMENT BARRIER
(TYPE SANDBAG)
NO SCALE
ALL DIMENSIONS ARE IN
MILLIMETERS UNLESS OTHERWISE SHOWN

Storm Drain Inlet Protection

SC-10





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Devices used at storm drain inlets that are subject to runoff from construction activities to detain and/or to filter sediment-laden runoff to allow sediment to settle and/or to filter sediment prior to discharge into storm drainage systems or watercourses.

Appropriate Applications

- Where ponding will not encroach into highway traffic.
- Where sediment laden surface runoff may enter an inlet.
- Where disturbed drainage areas have not yet been permanently stabilized.
- Where the drainage area is 0.4 ha (1 ac) or less.
- Appropriate during wet and snow-melt seasons.

Limitations

- Requires an adequate area for water to pond without encroaching upon traveled way and should not present itself to be an obstacle to oncoming traffic.
- May require other methods of temporary protection to prevent sediment-laden storm water and non-storm water discharges from entering the storm drain system.
- Sediment removal may be difficult in high flow conditions or if runoff is heavily sediment laden. If high flow conditions are expected, use other on-site sediment trapping techniques (e.g. check dams) in conjunction with inlet protection.
- Frequent maintenance is required.
- For drainage areas larger than 0.4 ha (1 ac), runoff shall be routed to a sediment trapping device designed for larger flows. See BMPs SC-2, "Sediment/Desilting Basin," and SC-3 "Sediment Trap."

- Filter fabric fence inlet protection is appropriate in open areas that are subject to sheet flow and for flows not exceeding 0.014 m3/s (0.5 cfs).
- Gravel bag barriers for inlet protection are applicable when sheet flows or concentrated flows exceed 0.014 m3/s (0.5 cfs), and it is necessary to allow for overtopping to prevent flooding.
- Fiber rolls and foam barriers are not appropriate for locations where they cannot be properly anchored to the surface.
- Excavated drop inlet sediment traps are appropriate where relatively heavy flows are expected and overflow capability is needed.

Standards and Specifications

Identify existing and/or planned storm drain inlets that have the potential to receive sediment-laden surface runoff. Determine if storm drain inlet protection is needed, and which method to use.

Methods and Installation

- ***DI Protection Type 1 - Filter Fabric Fence -*** The filter fabric fence (Type 1) protection is illustrated on Page 5. Similar to constructing a silt fence. See BMP SC-1, "Silt Fence." Do not place filter fabric underneath the inlet grate since the collected sediment may fall into the drain inlet when the fabric is removed or replaced.
- ***DI Protection Type 2 - Excavated Drop Inlet Sediment Trap -*** The excavated drop inlet sediment trap (Type 2) is illustrated in Page 6. Similar to constructing a temporary silt fence, See BMP SC-1, "Silt Fence." Size excavated trap to provide a minimum storage capacity calculated at the rate of 130 m3/ha (67 yd3/ac) of drainage area.
- ***DI Protection Type 3 – Gravel bag -*** The gravel bag barrier (Type 3) is illustrated in Page 7. Flow from a severe storm shall not overtop the curb. In areas of high clay and silts, use filter fabric and gravel as additional filter media. Construct gravel bags in accordance with BMP SC-6, "Gravel Bag Berm." Gravel bags shall be used due to their high permeability.
- ***DI Protection Type 4 – Foam Barriers and Fiber Rolls*** – Foam barrier or fiber roll (Type 4) is placed around the inlet and keyed and anchored to the surface. Foam barriers and fiber rolls are intended for use as inlet protection where the area around the inlet is unpaved and the foam barrier or fiber roll can be secured to the surface. RE or Construction Storm Water Coordinator approval is required.

Maintenance and Inspection

General

- Inspect all inlet protection devices before and after every rainfall event, and weekly during the rest of the rainy season. During extended rainfall events, inspect inlet protection devices at least once every 24 hours.

- Inspect the storm drain inlet after severe storms in the rainy season to check for bypassed material.
- Remove all inlet protection devices within thirty days after the site is stabilized, or when the inlet protection is no longer needed.
  - Bring the disturbed area to final grade and smooth and compact it. Appropriately stabilize all bare areas around the inlet.
  - Clean and re-grade area around the inlet and clean the inside of the storm drain inlet as it must be free of sediment and debris at the time of final inspection.

Requirements by Method

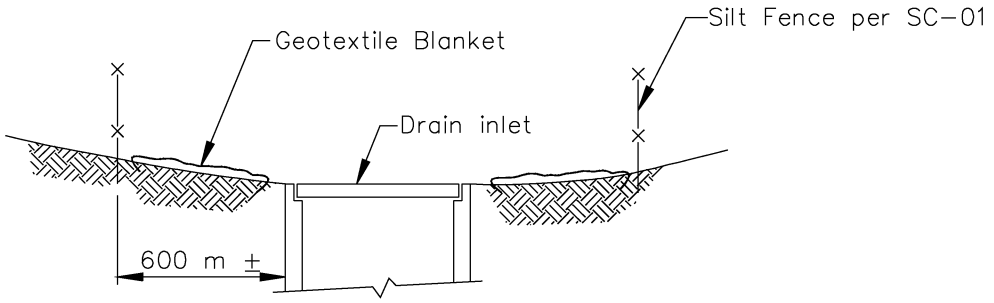
- ***Type 1 - Filter Fabric Fence***
  - This method shall be used for drain inlets requiring protection in areas where finished grade is established and erosion control seeding has been applied or is pending.
  - Make sure the stakes are securely driven in the ground and are structurally sound (i.e., not bent, cracked, or splintered, and are reasonably perpendicular to the ground). Replace damaged stakes.
  - Replace or clean the fabric when the fabric becomes clogged with sediment. Make sure the fabric does not have any holes or tears. Repair or replace fabric as needed or as directed by the RE.
  - At a minimum, remove the sediment behind the fabric fence when accumulation reaches one-third the height of the fence or barrier height. Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the highway right-of-way in conformance with the Standard Specifications Section 7-1.13.
- ***Type 2 – Excavated Drop Inlet Sediment Trap***
  - This method may be used for drain inlets requiring protection in areas that have been cleared and grubbed, and where exposed soil areas are subject to grading.
  - Remove sediment from basin when the volume of the basin has been reduced by one-half.
- ***Type 3 - Gravel Bag Barrier***
  - This method may be used for drain inlets surrounded by AC or paved surfaces.
  - Inspect bags for holes, gashes, and snags.

- Check gravel bags for proper arrangement and displacement. Remove the sediment behind the barrier when it reaches one-third the height of the barrier. Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the highway right-of-way in conformance with the Standard Specifications Section 7-1.13.

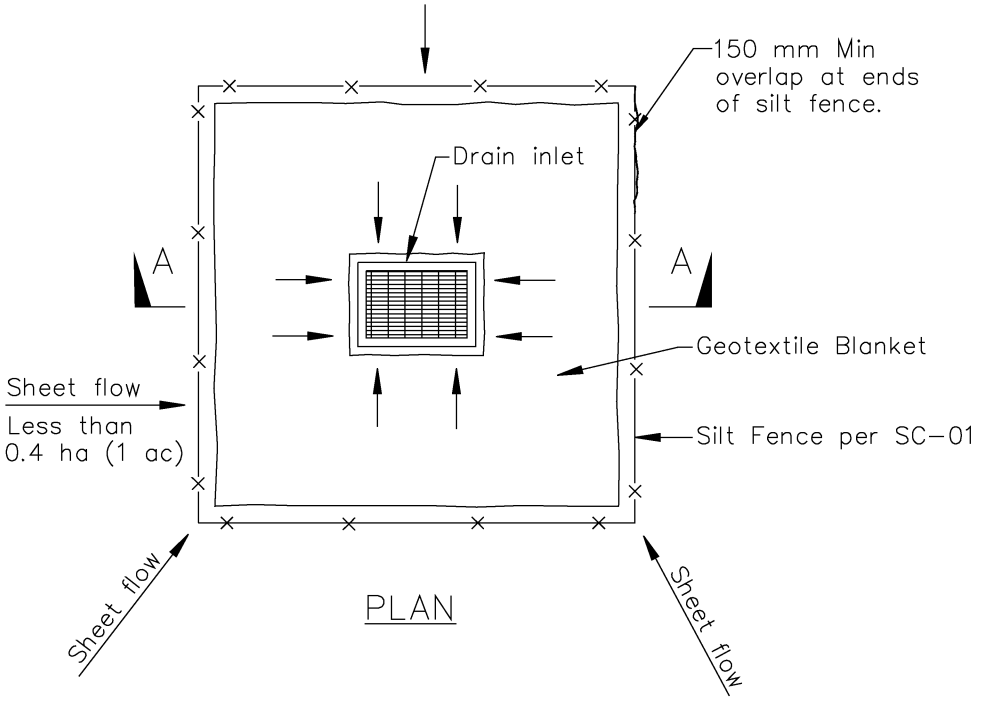
■ ***Type 4 Foam Barriers and Fiber Rolls***

- This method may be used for drain inlets requiring protection in areas that have been cleared and grubbed, and where exposed soil areas subject to grading. RE or Construction Storm Coordinator approval is required.

- Check foam barrier or fiber roll for proper arrangement and displacement. Remove the sediment behind the barrier when it reaches one-third the height of the barrier. Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the highway right-of-way in conformance with the Standard Specifications.



SECTION A–A

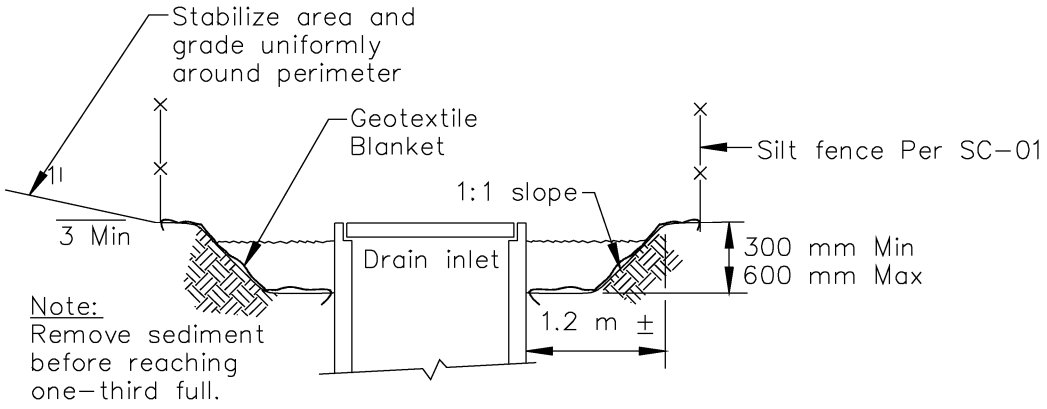


PLAN

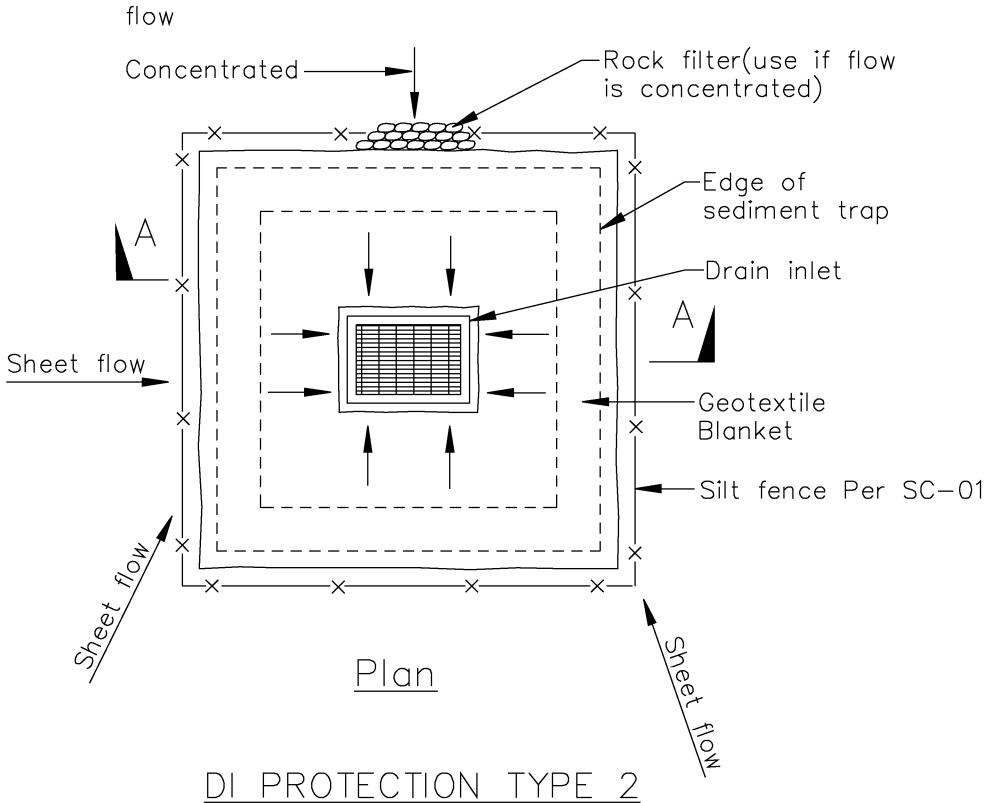
DI PROTECTION TYPE 1
NOT TO SCALE

NOTES:

1. For use in areas where grading has been completed and final soil stabilization and seeding are pending.
2. Not applicable in paved areas.
3. Not applicable with concentrated flows.



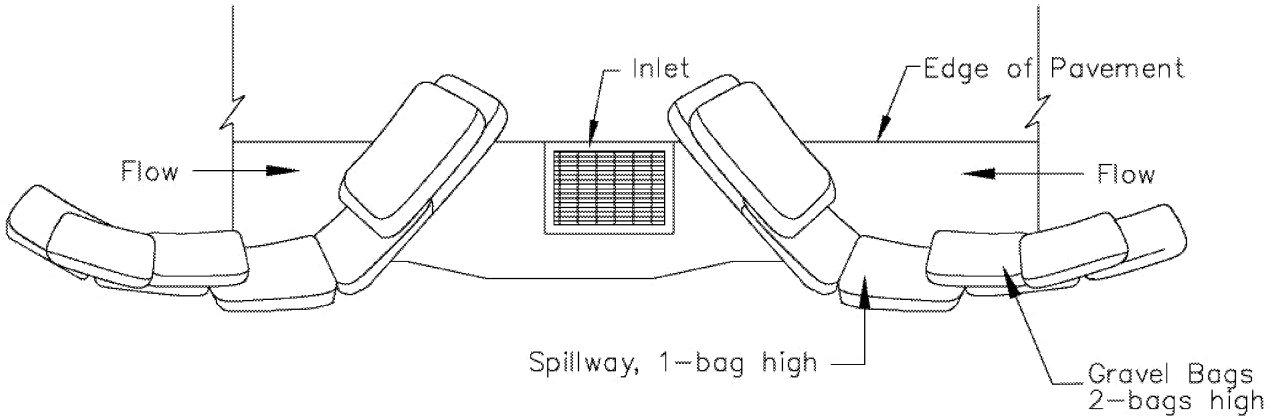
Section A–A



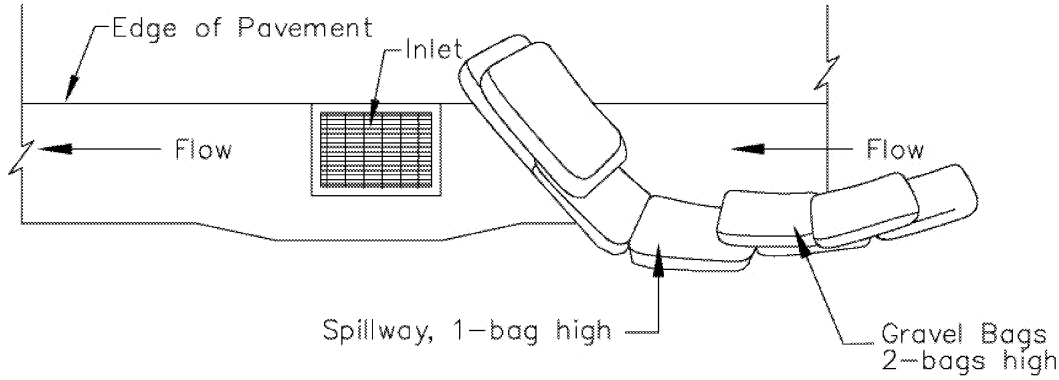
Plan

DI PROTECTION TYPE 2
NOT TO SCALE

Notes
1. For use in cleared and grubbed and in graded areas.
2. Shape basin so that longest inflow area faces longest length of trap.
3. For concentrated flows, shape basin in 2:1 ratio with length oriented towards direction of flow.



TYPICAL PROTECTION FOR INLET WITH OPOSING FLOW DIRECTIONS



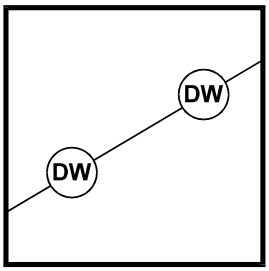
TYPICAL PROTECTION FOR INLET WITH SINGLE FLOW DIRECTION

NOTES:

1. Intended for short-term use.
2. Use to inhibit non-storm water flow.
3. Allow for proper maintenance and cleanup.
4. Bags must be removed after adjacent operation is completed
5. Not applicable in areas with high silts and clays without filter fabric.

Dewatering Operations

NS-2



Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ● Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Dewatering Operations are practices that manage the discharge of pollutants when non-storm water and accumulated precipitation (storm water) must be removed from a work location so that construction work may be accomplished.

Appropriate Applications

- These practices are implemented for discharges of non-storm water and storm water (accumulated rain water) from construction sites. Non-storm water includes, but is not limited to, groundwater, dewatering of piles, water from cofferdams, water diversions, and water used during construction activities that must be removed from a work area.
- Practices identified in this section are also appropriate for implementation when managing the removal of accumulated precipitation (storm water) from depressed areas at a construction site.
- Storm water mixed with non-storm water should be managed as non-storm water.

Limitations

- Dewatering operations for non-storm water will require, and must comply with, applicable local permits, project-specific permits, and regulations.
- Site conditions will dictate design and use of dewatering operations.
- A dewatering plan shall be submitted as part of the SWPPP/WPCP detailing the location of dewatering activities, equipment, and discharge point.
- The controls discussed in this best management practice (BMP) address sediment only. If the presence of polluted water with hazardous substances is identified in the contract, the contractor shall implement dewatering pollution controls as required by the contract documents. If the quality of water to be removed by dewatering is not identified as polluted in the contract documents, but is later determined by observation or testing to be polluted, the contractor shall notify the Resident Engineer (RE) and comply with Standard Specifications Section 5-1.116, "Differing Site Conditions."

- Avoid dewatering discharges where possible by using the water for dust control, by infiltration, etc.

Standards and Specifications

- Dewatering shall be conducted in accordance with the Field Guide to Construction Site Dewatering, October 2001, CTSW-RT-01-010.
- Dewatering for accumulated precipitation (storm water) shall follow this BMP and use treatment measures specified herein.
- The RWQCB may require a separate NPDES permit prior to the dewatering discharge of non-storm water. These permits will have specific testing, monitoring, and discharge requirements and can take significant time to obtain.
- Except in RWQCB Regions 1 and 2, the discharge of accumulated precipitation (storm water) to a water body or storm drain is subject to the requirements of Caltrans NPDES permit. Sediment control and other appropriate BMPs (e.g., outlet protection/energy dissipation) must be employed when this water is discharged.
- RWQCB Regions 1 and 2 require notification and approval prior to any discharge of water from construction sites.
- In RWQCB Regions 3, 5, 7, and 9 non-storm water dewatering for discharges meeting certain conditions are allowed under an RWQCB general dewatering NPDES Permit. Notification and approval from the RWQCB is required prior to conducting these operations. This includes storm water that is mixed with groundwater or other non-storm water sources. Once the discharge is allowed, appropriate BMPs must be implemented to ensure that the discharge complies with all permit requirements. Conditions for potential discharge under an RWQCB general dewatering NPDES Permit include:
  - Regions 3, 5, 7: Non-storm water discharges, free of pollutants other than sediment, <0.25 MGD, with a duration of 4 or fewer months.
  - Region 9: Groundwater, free of pollutants other than sediment, <0.10 MGD, to surface waters other than San Diego Bay.
- The flow chart shown on Page 4 shall be utilized to guide dewatering operations.
- The RE will coordinate monitoring and permit compliance.
- Discharges must comply with regional and watershed-specific discharge requirements.
- Additional permits or permissions from other agencies may be required for dewatering cofferdams or diversions.
- Dewatering discharges must not cause erosion at the discharge point.

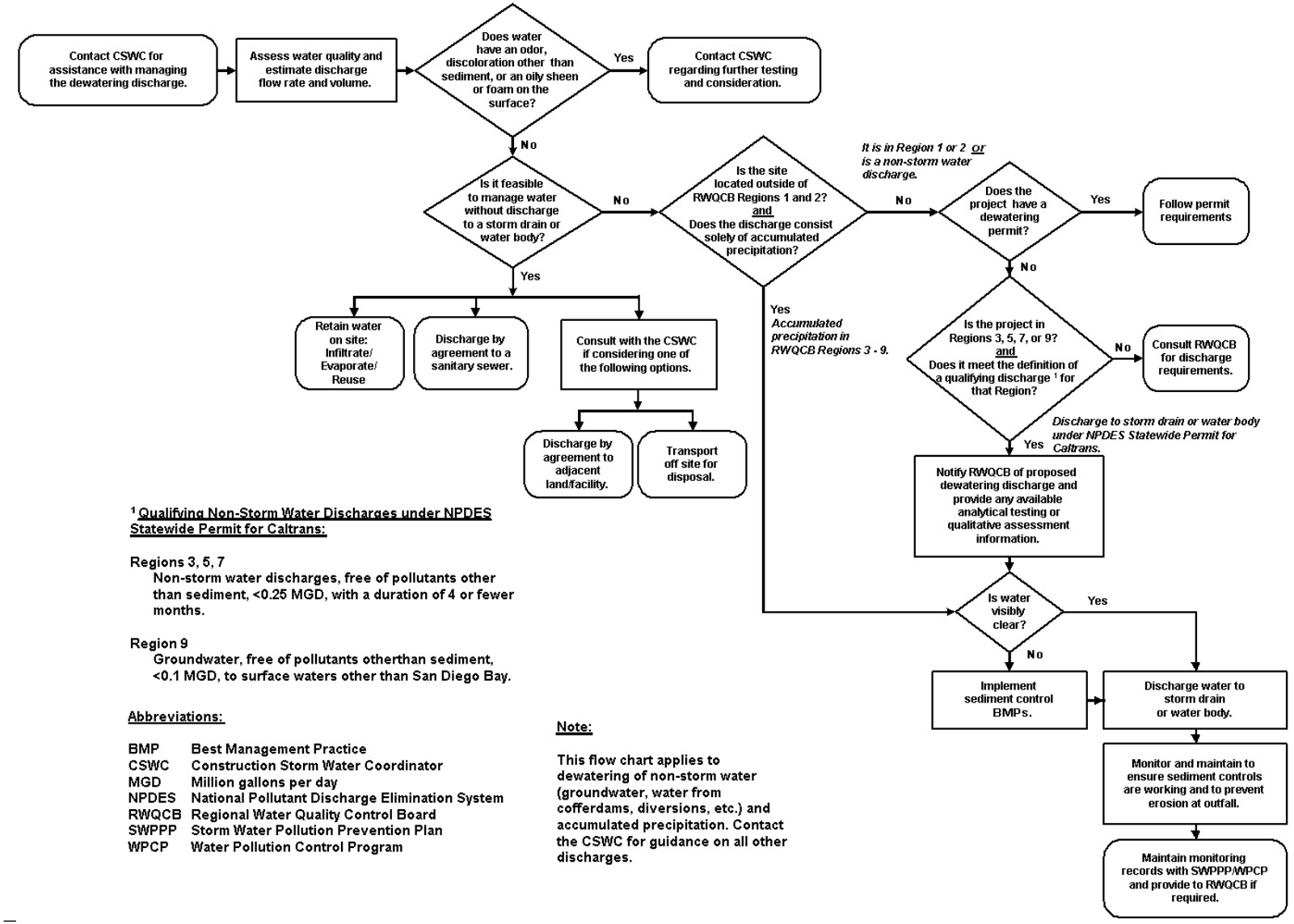
- Dewatering records shall be maintained for a period of 3 years.

Maintenance and Inspection

- Inspect all BMPs implemented to comply with permit requirements frequently and repair or replace to ensure the BMPs function as designed.
- Conduct water quality monitoring pursuant to the "Storm Water Dewatering Operations BMP Discharge Monitoring Forms".
- Accumulated sediment removed during the maintenance of a dewatering device may be incorporated in the project at locations designated by the RE or disposed of outside the right-of-way in conformance with the Standard Specifications.
- Accumulated sediment that is commingled with other pollutants must be disposed of in accordance with all applicable laws and regulations and as approved by the RE.

Dewatering Operations

NS-2



[1] Qualifying Non-Storm Water Discharges under NPDES Statewide Permit for Caltrans:

Regions 3, 5, 7
Non-storm water discharges, free of pollutants other than sediment, <0.25 MGD, with a duration of 4 or fewer months.

Region 9
Groundwater, free of pollutants otherthan sediment, <0.1 MGD, to surface waters other than San Diego Bay.

Abbreviations:

BMP	Best Management Practice
CSWC	Construction Storm Water Coordinator
MGD	Million gallons per day
NPDES	National Pollutant Discharge Elimination System
RWQCB	Regional Water Quality Control Board
SWPPP	Storm Water Pollution Prevention Plan
WPCP	Water Pollution Control Program

Note:

This flow chart applies to dewatering of non-storm water (groundwater, water from cofferdams, diversions, etc.) and accumulated precipitation. Contact the CSWC for guidance on all other discharges.

=

Sediment Treatment

A variety of methods can be used to treat water during dewatering operations from the construction site. Several devices are presented in this section that provide options to achieve sediment removal. The size of particles present in the sediment and Permit or receiving water limitations on sediment are key considerations for selecting sediment treatment option(s); in some cases, the use of multiple devices may be appropriate.

Category 1: Constructed Settling Technologies

The devices discussed in this category are to be used exclusively for dewatering operations only.

Sediment/Desilting Basin (SC-2)

Description:

A desilting basin is a temporary basin with a controlled release structure that is formed by excavation and/or construction of an embankment to detain sediment-laden runoff and allow sediment to settle out before discharging.

Appropriate Applications:

- Effective for the removal of trash, gravel, sand, and silt and some metals that settle out with the sediment.

Implementation:

- Excavation and construction of related facilities is required.
- Temporary desilting basins must be fenced if safety is a concern.
- Outlet protection is required to prevent erosion at the outfall location.

Maintenance:

- Maintenance is required for safety fencing, vegetation, embankment, inlet and outfall structures, as well as other features.
- Removal of sediment is required when the storage volume is reduced by one-third.

Sediment Trap (SC-3)

Description:

A sediment trap is a temporary basin formed by excavation and/or construction of an earthen embankment across a waterway or low drainage area to detain sediment-laden runoff and allow sediment to settle out before discharging.

Appropriate Applications:

- Effective for the removal of large and medium sized particles (sand and gravel) and some metals that settle out with the sediment.

Implementation:

- Excavation and construction of related facilities is required.
- Trap inlets shall be located to maximize the travel distance to the trap outlet.
- Use rock or vegetation to protect the trap outlets against erosion.

Maintenance:

- Maintenance is required for vegetation, embankment, inlet and outfall structures, as well as other features.
- Removal of sediment is required when the storage volume is reduced by one-third.

Category 2: Mobile Settling Technologies

The devices discussed in this category are typical of tanks that can be used for sediment treatment of dewatering operations. A variety of vendors are available who supply these tanks.

Weir Tank

Description:

A weir tank separates water and waste by using weirs. The configuration of the weirs (over and under weirs) maximizes the residence time in the tank and determines the waste to be removed from the water, such as oil, grease, and sediments.

Appropriate Applications:

- The tank removes trash, some settleable solids (gravel, sand, and silt), some visible oil and grease, and some metals (removed with sediment). To achieve high levels of flow, multiple tanks can be used in parallel. If additional treatment is desired, the tanks can be placed in series or as pre-treatment for other methods.

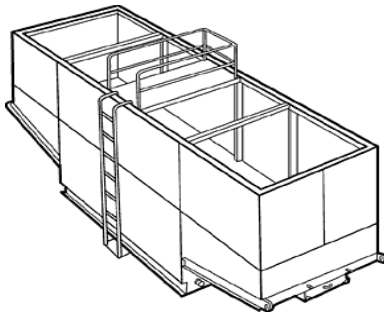
Implementation:

- Tanks are delivered to the site by the vendor, who can provide assistance with set-up and operation.
- Tank size will depend on flow volume, constituents of concern, and residency period required. Vendors shall be consulted to appropriately size tank.

Maintenance:

- Periodic cleaning is required based on visual inspection or reduced flow.
- Oil and grease disposal must be by licensed waste disposal company.

Schematic Diagrams:



Weir Tanks

Dewatering Tank

Description:

A dewatering tank removes debris and sediment. Flow enters the tank through the top, passes through a fabric filter, and is discharged through the bottom of the tank. The filter separates the solids from the liquids.

Appropriate Applications:

- The tank removes trash, gravel, sand, and silt, some visible oil and grease, and some metals (removed with sediment). To achieve high levels of flow, multiple tanks can be used in parallel. If additional treatment is desired, the tanks can be placed in series or as pre-treatment for other methods.

Implementation:

- Tanks are delivered to the site by the vendor, who can provide assistance with set-up and operation.
- Tank size will depend on flow volume, constituents of concern, and residency period required. Vendors shall be consulted to appropriately size tank.

Maintenance:

- Periodic cleaning is required based on visual inspection or reduced flow.
- Oil and grease disposal must be by licensed waste disposal company.

Schematic Diagrams:

Dewatering Tanks

Category 3: Basic Filtration Technologies

Gravity Bag Filter

Description:

A gravity bag filter, also referred to as a dewatering bag, is a square or rectangular bag made of non-woven geotextile fabric that collects sand, silt, and fines.

Appropriate Applications:

- Effective for the removal of sediments (gravel, sand, and silt). Some metals are removed with the sediment.

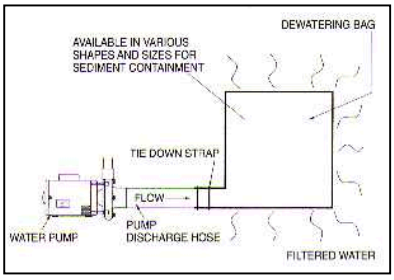
Implementation:

- Water is pumped into one side of the bag and seeps through the bottom and sides of the bag.
- A secondary barrier, such as a rock filter bed or straw/hay bale barrier, is placed beneath and beyond the edges of the bag to capture sediments that escape the bag.

Maintenance:

- Inspection of the flow conditions, bag condition, bag capacity, and the secondary barrier is required.
- Replace the bag when it no longer filters sediment or passes water at a reasonable rate.
- The bag is disposed off-site, or on-site as directed by the RE.

Schematic Diagrams:



Gravity Bag Filter

Category 4: Advanced Filtration Technologies

Sand Media Particulate Filter

Description:

Water is treated by passing it through canisters filled with sand media. Generally, sand filters provide a final level of treatment. They are often used as a secondary or higher level of treatment after a significant amount of sediment and other pollutants have been removed.

Appropriate Applications:

- Effective for the removal of trash, gravel, sand, and silt and some metals, as well as the reduction of biochemical oxygen demand (BOD) and turbidity.
- Sand filters can be used for standalone treatment or in conjunction with bag and cartridge filtration if further treatment is required.
- Sand filters can also be used to provide additional treatment to water treated via settling or basic filtration.

Implementation:

- The filters require delivery to the site and initial set up. The vendor can provide assistance with installation and operation.

Maintenance:

- The filters require monthly service to monitor and maintain the sand media.

Schematic Diagrams:

Sand Media Particulate Filters

Pressurized Bag Filter

Description:

A pressurized bag filter is a unit composed of single filter bags made from polyester felt material. The water filters through the unit and is discharged through a header, allowing for the discharge of flow in series to an additional treatment unit. Vendors provide pressurized bag filters in a variety of configurations. Some units include a combination of bag filters and cartridge filters for enhanced contaminant removal.

Appropriate Applications:

- Effective for the removal of sediment (sand and silt) and some metals, as well as the reduction of BOD, turbidity, and hydrocarbons. Oil absorbent bags are available for hydrocarbon removal.
- Filters can be used to provide secondary treatment to water treated via settling or basic filtration.

Implementation:

- The filters require delivery to the site and initial set up. The vendor can provide assistance with installation and operation.

Maintenance:

- The filter bags require replacement when the pressure differential exceeds the manufacturer's recommendation.

Schematic Diagrams:

Pressurized Bag Filter

Cartridge Filter

Description:

Cartridge filters provide a high degree of pollutant removal by utilizing a number of individual cartridges as part of a larger filtering unit. They are often used as a secondary or higher (polishing) level of treatment after a significant amount of sediment and other pollutants are removed. Units come with various cartridge configurations (for use in series with pressurized bag filters) or with a larger single cartridge filtration unit (with multiple filters within).

Appropriate Applications:

- Effective for the removal of sediment (sand, silt, and some clays) and metals, as well as the reduction of BOD, turbidity, and hydrocarbons. Hydrocarbons can effectively be removed with special resin cartridges.
- Filters can be used to provide secondary treatment to water treated via settling or basic filtration.

Implementation:

- The filters require delivery to the site and initial set up. The vendor can provide assistance.

Maintenance:

- The cartridges require replacement when the pressure differential exceeds the manufacturer's recommendation.

Schematic Designs:

Cartridge Filter

STORM WATER DEWATERING OPERATIONS BMP DISCHARGE MONITORING FORM [a]

Central Coast Region (RWQCB 3)
For Inland Surface Waters [b]

GENERAL INFORMATION	
Project Name	
Contract No	
Contractor	
Sampler's Name	
Sampler's Signature	
Date Discharge Began	
Date of Sampling	

WATER SAMPLE LOG [c, d, e]

Constituents	Units	Results		
		Effluent	Receiving Water [f]	
			Upstream (R-1)	Downstream (R-2)
Dissolved Oxygen	mg/L			
pH	unitless			
Turbidity	JTUs			

DISCHARGE LIMITATIONS [g, h, i]

Constituent	Units	EFFLUENT	RECEIVING WATER
		Daily Maximum	Daily Maximum
Dissolved Oxygen	mg/L	--	5.0 [j]
pH	unitless	--	Between 7.0 - 8.5 [j]
Turbidity	JTUs	--	20% (Where Ambient is 0 - 50 JTUs)
			10 (Where Ambient is 50 - 100 JTUs)
			10% (Where Ambient is > 100 JTUs)

NOTES:

Ambient - Upstream sample result (i.e.. R-1)
BMP - Best Management Practice
JTUs - Jackson turbidity units
mg/L - Milligrams per liter
RWQCB - Regional Water Quality Control Board
SAR - Sodium absorption ratio
-- - Not required
> - Greater Than

a This form shall be used only for dewatering of storm water/accumulated precipitation. Dewatering non-storm water shall monitor constituents required in the applicable NPDE permit or Waste Discharge Requirements.

b All inland surface waters, enclosed bays, and estuaries. **Based on the 1994 RWQCB 3 Basin Plan.** [http://www.swrcb.ca.gov/rwqcb3/BasinPlan/Index.htm]

c Collect monthly samples. The first sample shall be collected at the start of the discharge and the last sample shall be collected at the completion of the discharge. Use the same sample collection criteria for discharges less than one month in duration for a total of two samples per discharge event.

d Each constituent will be analyzed in the effluent and the two receiving water samples.

e Dissolved oxygen, pH, and turbidity are required to be analyzed throughout the basin.
The following constituents shall be sampled if suspected to present in the discharge: ammonia for toxicity, MBAS, PCBs, phenols, and phthalate esters are required to be analyzed throughout the basin, however, bacteria, boron, chemical color, temperature, and total dissolved solids shall be analyzed if the project lies in an area designated for a specific beneficial use, as noted in the Basin Plan.

f R-1 shall be collected 100 feet upstream from the closest point of discharge. R-2 shall be collected 100 feet downstream from the closest point of discharge.

g If the results from receiving water sample exceed any of the discharge limits then discontinue dewatering activities to surface waters.

h All discharge limitations are listed in the Water Quality Objectives Section of the Basin Plan.

i Water shall not contain concentrations that cause nuisance or adversely affect beneficial uses of the following: Biostimulatory substances, floating material, oil and grease, pesticides, sediment, settleable materials, suspended materials, and tastes and odors.

j In addition, dissolved oxygen and pH have specific beneficial uses discharge limitations. See basin plan for specific limitations.

STORM WATER DEWATERING OPERATIONS BMP DISCHARGE MONITORING FORM [a]

Los Angeles Region (RWQCB 4)
Los Angeles and Ventura Counties
For Inland Surface Waters [b]

GENERAL INFORMATION	
Project Name	
Contract No	
Contractor	
Sampler's Name	
Sampler's Signature	
Date Discharge Began	
Date of Sampling	

WATER SAMPLE LOG [c, d, e]

Constituents	Units	Results		
		Effluent	Receiving Water [f]	
			Upstream (R-1)	Downstream (R-2)
pH	unitless			
Turbidity	NTUs			
TDS [j]	mg/L			

DISCHARGE LIMITATIONS [g, h, k, i]

Constituent	Units	EFFLUENT	RECEIVING WATER
		Daily Maximum	Daily Maximum
pH	unitless	--	Between 6.5 - 8.5 [j]
Turbidity	NTUs	--	20% (Where Ambient is 0 - 50 NTUs)
			10% (Where Ambient is > 50 NTUs)
TDS	mg/L	--	See Table 3-8 in Basin Plan

NOTES:

Ambient - Upstream sample result (ie. R-1)
BMP - Best Management Practice
mg/L - Milligrams per liter
NTUs - Nephelometric turbidity units
RWQCB - Regional Water Quality Control Board
-- - Not required
> - Greater Than

a This form shall be used only for dewatering of storm water/accumulated precipitation. Dewatering non-storm water shall monitor constituents required in the applicable NPDES permit or Waste Discharge Requirements.

b All inland surface waters, enclosed bays, and estuaries, including wetlands. **Based on the 1995 RWQCB 4 Basin Plan.** [http://www.swrcb.ca.gov/rwqcb4/html/meetings/tmdl/Basin_plan/basin_plan_doc.html]

c Collect monthly samples. The first sample shall be collected at the start of the discharge and the last sample shall be collected at the completion of the discharge. Use the same sample collection criteria for discharges less than one month in duration for a total of two samples per discharge event.

d Each constituent will be analyzed in the effluent and the two receiving water samples.

e pH, and turbidity are required to be analyzed throughout the basin, however, ammonia, bacteria/coliform, boron, chemical constituents, chloride, dissolved oxygen, methylene blue activated substances, nitrogen, pesticides, polychlorinated biphenyls, radioactive substances, sodium absorption ratio, sulfate, temperature, and total dissolved solids shall be analyzed if the project lies in an area designated for a specific beneficial use, as noted in the Basin Plan.

f R-1 shall be collected 100 feet upstream from the closest point of discharge. R-2 shall be collected 100 feet downstream from the closest point of discharge.

g If the results from receiving water sample exceed any of the discharge limits then discontinue dewatering activities to surface waters

h All discharge limitations are listed in the Water Quality Objectives Section of the Basin Plan.

i Water shall not contain concentrations that cause nuisance or adversely affect beneficial uses of the following: Bioaccumulation, biochemical oxygen demand, biostimulatory substances, color, exotic vegetation, floating material, oil and grease, solid/suspended/settleable materials, tastes and odors, and toxicity.

j In addition, ambient pH levels shall not be changed more than 0.2 units for inland surface waters, and 0.5 for bays or estuaries from natural conditions.

k See Table 3-8 in Basin Plan for applicable watershed

STORM WATER DEWATERING OPERATIONS BMP DISCHARGE MONITORING FORM [a]

Central Valley Region (RWQCB 5)
Sacramento River Basin and The San Joaquin River Basin
For Inland Surface Waters [b]

GENERAL INFORMATION	
Project Name	
Contract No.	
Contractor	
Sampler's Name	
Sampler's Signature	
Date Discharge Began	
Date of Sampling	

WATER SAMPLE LOG [c, d, e]				
		Results		
		Effluent	Receiving Water [f]	
Constituents	Units		Upstream (R-1)	Downstream (R-2)
pH	unitless			
Turbidity	NTUs			

DISCHARGE LIMITATIONS [g, h, i]			
		EFFLUENT	RECEIVING WATER
Constituent	Units	Daily Maximum	Daily Maximum
pH	unitless	--	Between 6.5 - 8.5
Turbidity	NTUs	--	1 NTU increase (Where Ambient is 0 - 5 NTUs)
			20% increase (Where Ambient is 5 - 50 NTUs)
			10 NTU increase (Where Ambient is 50 - 100 NTUs)
			10% increase (Where Ambient is > 100 NTUs)

NOTES:

Ambient - Upstream sample result (i.e.. R-1)
BMP - Best Management Practice
NTUs - Nephelometric turbidity units
RWQCB - Regional Water Quality Control Board
-- - Not required
> - Greater Than

a This form shall be used only for dewatering of storm water/accumulated precipitation. Dewatering non-storm water shall monitor constituents required in the applicable NPDES permit or Waste Discharge Requirements.

b All surface waters in the Sacramento and San Joaquin River Basins, including the Delta.**Based on the 1998 RWQCB 5a/5b Basin Plan.** [http://www.swrcb.ca.gov/rwqcb5/available_documents/index.html#anchor616381]

c Collect monthly samples. The first sample shall be collected at the start of the discharge and the last sample shall be collected at the completion of the discharge. Use the same sample collection criteria for discharges less than one month in duration for a total of two samples per discharge event.

d Each constituent will be analyzed in the effluent and the two receiving water samples.

e Turbidity and pH are required to be analyzed throughout the basin, however, bacteria, chemical constituents, dissolved oxygen, pesticides, radioactivity, salinity, and temperature shall be analyzed if the project lies in an area designated for a specific beneficial use or along a specific waterbody, as noted in the Basin Plan.

f R-1 shall be collected 100 feet upstream from the closest point of discharge. R-2 shall be collected 100 feet downstream from the closest point of discharge.

g If the results from receiving water sample exceed any of the discharge limits then discontinue dewatering activities to surface water

h All discharge limitations are listed in the Water Quality Objectives Section of the Basin Plar

i Water shall not contain concentrations that cause nuisance or adversely affect beneficial uses of the following: Biostimulatory substances, color, floating material, oil and grease, sediment, settleable material, suspended material, tastes and odors, and toxicity.

STORM WATER DEWATERING OPERATIONS BMP DISCHARGE MONITORING FORM[a]

Central Valley Region (RWQCB 5)
Tulare Lake Basin
For Inland Surface Waters [b]

GENERAL INFORMATION	
Project Name	
Contract No	
Contractor	
Sampler's Name	
Sampler's Signature	
Date Discharge Began	
Date of Sampling	

WATER SAMPLE LOG [c, d, e]

Constituents	Units	Results		
		Effluent	Receiving Water [f]	
			Upstream (R-1)	Downstream (R-2)
pH	unitless			
Turbidity	NTUs			
Dissolved Oxygen	mg/L			
Electrical Conductivity	umho/cm			

DISCHARGE LIMITATIONS [g, h, i]

Constituent	Units	EFFLUENT	RECEIVING WATER
		Daily Maximum	Daily Maximum
pH	unitless	--	Between 6.5 - 8.3 0.3 unit change for background
Turbidity	NTUs	--	1 (Where Ambient is 0 - 5 NTUs) 20% (Where Ambient is 5 - 50 NTUs) 10 (Where Ambient is 50 - 100 NTUs) 10% (Where Ambient is > 100 NTUs)
Dissolved Oxygen	mg/L		See Table III-1 in Basin Plan
Electrical Conductivity	umho/cm		See Table III-2 in Basin Plan

NOTES:

Ambient - Upstream sample result (i.e.. R-1)
BMP - Best Management Practice
cm - Centimeter
mg/L - Milligrams per liter
NTUs - Nephelometric turbidity units
RWQCB - Regional Water Quality Control Board
-- - Not required
> - Greater Than

a This form shall be used only for dewatering of storm water/accumulated precipitation. Dewatering non-storm water shall monitor constituents required in the applicable NPDES permit or Waste Discharge Requirements.

b **Based on the 1995 RWQCB 5c Basin Plan.** [http://www.swrcb.ca.gov/rwqcb5/available_documents/index.html#anchor616381]

c Collect monthly samples. The first sample shall be collected at the start of the discharge and the last sample shall be collected at the completion of the discharge. Use the same sample collection criteria for discharges less than one month in duration for a total of two samples per discharge event.

d Each constituent will be analyzed in the effluent and the two receiving water samples.

e Bacteria, chemical constituents, pesticides, radioactivity, salinity, and temperature shall be analyzed for a specific beneficial use as noted in the Basin Plan. Ammonia is suspected at elevated levels.

f R-1 shall be collected 100 feet upstream from the closest point of discharge. R-2 shall be collected 100 feet downstream from the closest point of discharge.

g If the results from receiving water sample exceed any of the discharge limits then discontinue dewatering activities to surface water

h All discharge limitations are listed in the Water Quality Objectives Section of the Basin Plan

i Water shall not contain concentrations that cause nuisance or adversely affect beneficial uses of the following: Biostimulatory substances, color, floating material, oil and grease, sediment, settleable material, suspended material, tastes and odors, and toxicity.

STORM WATER DEWATERING OPERATIONS BMP DISCHARGE MONITORING FORM [a]

Lahontan Region (RWQCB 6)
For Surface Waters [b]

GENERAL INFORMATION	
Project Name	
Contract No	
Contractor	
Sampler's Name	
Sampler's Signature	
Date Discharge Began	
Date of Sampling	

WATER SAMPLE LOG [c, d, e]

Constituents	Units	Results		
		Effluent	Receiving Water [f]	
			Upstream (R-1)	Downstream (R-2)
pH	unitless			
Turbidity	NTUs			

DISCHARGE LIMITATIONS [g, h, i]

Constituent	Units	EFFLUENT	RECEIVING WATER
		Daily Maximum	Daily Maximum
pH	unitless	--	Between 6.5 - 8.5 [j]
Turbidity	NTUs	--	10% of Ambient [j]

NOTES:

Ambient - Upstream sample result (i.e.. R-1)
BMP - Best Management Practice
NTUs - Nephelometric turbidity units
mg/L - Milligrams per liter
RWQCB - Regional Water Quality Control Board
-- - Not required
> - Greater Than

a This form shall be used only for dewatering of storm water/accumulated precipitation. Dewatering non-storm water shall monitor constituents required in the applicable NPDES permit or Waste Discharge Requirements.

b All surface waters including wetlands. **Based on the 1994 RWQCB 6 Basin Plan.** [http://www.swrcb.ca.gov/rwqcb6/BPlan/BPlan_Index.htm]

c Collect monthly samples. The first sample shall be collected at the start of the discharge and the last sample shall be collected at the completion of the discharge. Use the same sample collection criteria for discharges less than one month in duration for a total of two samples per discharge event.

d Each constituent will be analyzed in the effluent and the two receiving water samples.

e pH and turbidity are required to be analyzed throughout the basin, however, adjusted sodium adsorption ration, algal growth potential, biological indicators, biostimulatory substances, boron, chemical constituents, chlorophyll-a, clarity, color, dissolved inorganic nitrogen, dissolved orthophosphate, dissolved oxygen, electrical conductivity, fluoride, iron, nitrogen as nitrate, pesticides, plankton counts, radioactivity, sodium adsorption ratio, soluble reactive iron, soluble reactive phosphorous, species composition, sulfate, suspended sediment, tastes & odors, temperatures, total dissolved solids, total alkalinity as carbonate, total kjeldahl nitrogen, total nitrogen, total phosphorous, total reactive iron, toxicity, transparency, un-ionized ammonia shall be analyzed if the project lies in an area designated for a specific beneficial use, as noted in the Basin Plan. Bacteria/Coliform if high levels are suspected. Residual chlorine if suspected to be present.

f R-1 shall be collected 100 feet upstream from the closest point of discharge. R-2 shall be collected 100 feet downstream from the closest point of discharge.

g If the results from receiving water sample exceed any of the discharge limits then discontinue dewatering activities to surface waters

h All discharge limitations are listed in the Water Quality Objectives Section of the Basin Plan.

i Water shall not contain concentrations that cause nuisance or adversely affect beneficial uses of the following: Floating material, nondegradation of aquatic communities and populations, oil and grease, sediment, settleable materials, and suspended materials.

j In addition, bacteria/coliform, pH, total residual chlorine, and turbidity have specific beneficial uses and/or location specific discharge limitations. See basin plan for specific limitations.

STORM WATER DEWATERING OPERATIONS BMP DISCHARGE MONITORING FORM[a]

Colorado River Basin Region (RWQCB 7)
For Surface Waters [b]

GENERAL INFORMATION	
Project Name	
Contract No.	
Contractor	
Sampler's Name	
Sampler's Signature	
Date Discharge Began	
Date of Sampling	

WATER SAMPLE LOG [c, d, e]				
		Results		
		Effluent	Receiving Water [f]	
Constituents	Units		Upstream (R-1)	Downstream (R-2)
pH	unitless			
TDS [f]	mg/L			

DISCHARGE LIMITATIONS [g, h, i]			
		EFFLUENT	RECEIVING WATER
Constituent	Units	Daily Maximum	Daily Maximum
pH	unitless	--	Between 6.0 - 9.0
TDS [g]	mg/L	--	See Basin Plan

NOTES:

BMP - Best Management Practice

RWQCB - Regional Water Quality Control Board

-- - Not required

> - Greater Than

a This form shall be used only for dewatering of storm water/accumulated precipitation. Dewatering non-storm water shall monitor constituents required in the applicable NPDES permit or Waste Discharge Requirements.

b **Based on the 2002 RWQCB 7 Water Quality Plan.**
[http://www.swrcb.ca.gov/rwqcb7/documents/RB7Plan.pdf]

c Collect monthly samples. The first sample shall be collected at the start of the discharge and the last sample shall be collected at the completion of the discharge. Use the same sample collection criteria for discharges less than one month in duration for a total of two samples per discharge event.

d Each constituent will be analyzed in the effluent and the two receiving water samples.

e Bacteria, biochemical oxygen demand, chemical constituents, chemical oxygen demand, dissolved oxygen, radioactivity, and selenium shall be analyzed for specific beneficial uses as noted in the Basin Plan.

f R-1 shall be collected 100 feet upstream from the closest point of discharge. R-2 shall be collected 100 feet downstream from the closest point of discharge.

g Total Dissolved Solids (TDS) has specific location discharge limitations. See basin plan for specific limitations.

h If the results from receiving water sample exceed any of the discharge limits then discontinue dewatering activities to surface waters

i All discharge limitations are listed in the Water Quality Objectives Section of the Basin Plan.

j Water shall not contain concentrations that cause nuisance or adversely affect beneficial uses of the following: Biostimulatory substances, color, floating material, herbicides, oil and grease, pesticides, sediment, settleable and suspended solids, tainting substances, tastes and odors, temperature, toxicity, and turbidity.

STORM WATER DEWATERING OPERATIONS BMP DISCHARGE MONITORING FORM [a]

Santa Ana Region (RWQCB 8)
For Inland Surface Waters [b]

GENERAL INFORMATION	
Project Name	
Contract No	
Contractor	
Sampler's Name	
Sampler's Signature	
Date Discharge Began	
Date of Sampling	

WATER SAMPLE LOG [c, d, e]				
		Results		
		Effluent	Receiving Water [f]	
Constituents	Units		Upstream (R-1)	Downstream (R-2)
pH	unitless			
Turbidity	NTUs			
TDS	mg/L			

DISCHARGE LIMITATIONS [g, h, i, j]			
		EFFLUENT	RECEIVING WATER
Constituent	Units	Daily Maximum	Daily Maximum
pH	unitless	--	Between 7.0 - 8.6 (bays and estuaries)
		--	Between 6.5 - 8.5 (inland surface waters)
Turbidity	NTUs	--	20% (Where Ambient is 0 - 50 NTUs)
			10 NTUs (Where Ambient is 50 - 100 NTUs)
			10% (Where Ambient is > 100 NTUs)
TDS	mg/L	--	See Table 4-1 in Basin Plan

NOTES:

Ambient - Upstream sample result (i.e.. R-1)
BMP - Best Management Practice
NTUs - Nephelometric turbidity units
mg/L - Milligrams per liter
RWQCB - Regional Water Quality Control Board
-- - Not required
> - Greater Than

a This form shall be used only for dewatering of storm water/accumulated precipitation. Dewatering non-storm water shall monitor constituents required in the applicable NPDE permit or Waste Discharge Requirements.

b All inland surface waters including streams, rivers, lakes, and wetlands. **Based on the 1995 RWQCB 8 Basin Plan.** [http://www.swrcb.ca.gov/rwqcb8/pdf/R8BPlan.pdf]

c Collect monthly samples. The first sample shall be collected at the start of the discharge and the last sample shall be collected at the completion of the discharge. Use the same sample collection criteria for discharges less than one month in duration for a total of two samples per discharge event.

d Each constituent will be analyzed in the effluent and the two receiving water samples.

e Bacteria/coliform, dissolved oxygen, fluoride, methylene blue-activated substances (MBAS), metals, nitrate, radioactivity, temperature, and un-ionized ammonia shall be analyzed for a specific beneficial use, as noted in the Basin Plan. Boron, Residual Chlorine, Hardness, sodium, chloride, total inorganic nitrogen, sulfate, and chemical oxygen demand if present at elevated levels.

f R-1 shall be collected 100 feet upstream from the closest point of discharge. R-2 shall be collected 100 feet downstream from the closest point of discharge.

g If the results from receiving water sample exceed any of the discharge limits then discontinue dewatering activities to surface waters.

h All discharge limitations are listed in the Water Quality Objectives Section of the Basin Plan.

i Water shall not contain concentrations that cause nuisance or adversely affect beneficial uses of the following: Algae, color, floatables, oil and grease, suspended & settleable solids, sulfides, sulfides, surfactants, tastes and odors, and toxic substances.

j Total dissolved solids (TDS), hardness, sodium (Na), chloride (Cl), total inorganic nitrogen (TIN), sulfate (SO_4) and chemical oxygen demand (COD) shall be analyzed for specific waterbodies as identified in the Basin Plan.

STORM WATER DEWATERING OPERATIONS BMP DISCHARGE MONITORING FORM [a]

San Diego Region (RWQCB 9)
For Inland Surface Waters [b]

GENERAL INFORMATION	
Project Name	
Contract No	
Contractor	
Sampler's Name	
Sampler's Signature	
Date Discharge Began	
Date of Sampling	

WATER SAMPLE LOG [c, d, e]

Constituents	Units	Results		
		Effluent	Receiving Water [f]	
			Upstream (R-1)	Downstream (R-2)
pH	unitless			
Turbidity	NTUs			
TDS	mg/L			
Dissolved Oxygen	mg/L			
Color				

DISCHARGE LIMITATIONS [g, h, i]

Constituent	Units	EFFLUENT Daily Maximum	RECEIVING WATER Daily Maximum
pH	unitless	--	Between 6.5 - 8.5
Turbidity	NTUs	--	20% (Where Ambient is 0 - 50 NTUs) 10 NTUs (Where Ambient is 50 - 100 NTUs) 10% (Where Ambient is > 100 NTUs) 0.2 NTUs (ocean waters)
TDS	mg/L		See Table 3-2 in Basin Plan
Dissolved Oxygen	mg/L		5.0 mg/l in inland surface waters 6.0 mg/l in waters with designated COLD beneficial uses
Color		--	See Table 3-2 in Basin Plan

NOTES:

Ambient - Upstream sample result (i.e.. R-1)
BMP - Best Management Practice
NTUs - Nephelometric turbidity units
mg/L - Milligrams per liter
RWQCB - Regional Water Quality Control Board
-- - Not required
> - Greater Than

a This form shall be used only for dewatering of storm water/accumulated precipitation. Dewatering non-storm water shall monitor constituents required in the applicable NPDES permit or Waste Discharge Requirements.

b All inland surface waters, enclosed bays, and estuaries and coastal lagoons. **Based on the 1994 RWQCB 9 Basin Plan.** [http://www.swrcb.ca.gov/rwqcb9/programs/basinplan.html]

c Collect monthly samples. The first sample shall be collected at the start of the discharge and the last sample shall be collected at the completion of the discharge. Use the same sample collection criteria for discharges less than one month in duration for a total of two samples per discharge event.

d Each constituent will be analyzed in the effluent and the two receiving water samples.

e Bacteria, E. Coli & enterococci, biostimulatory substances, dissolved oxygen, inorganic chemicals, organic chemicals, pesticides, phenolic compounds, radioactivity, tastes & odors, temperatures, and trihalomethanes shall be analyzed for specific beneficial use, as noted in the Basin Plan.
Un-ionized Ammonia, chloride, sulfate, sodium, iron, manganese, MBAS, boron, and fluoride if suspected at elevated levels.

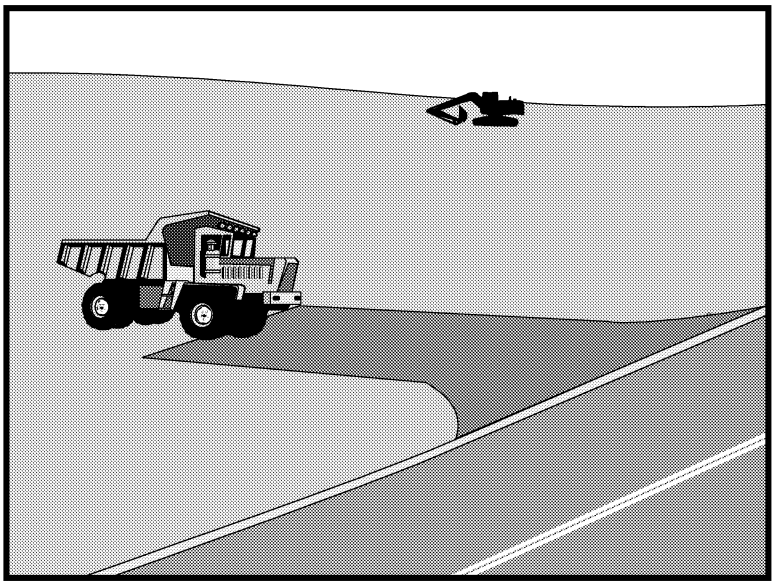
f R-1 shall be collected 100 feet upstream from the closest point of discharge. R-2 shall be collected 100 feet downstream from the closest point of discharge.

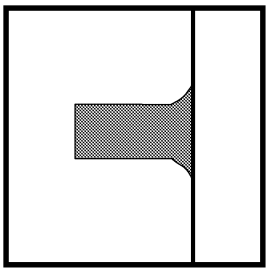
g If the results from receiving water sample exceed any of the discharge limits then discontinue dewatering activities to surface waters.

h All discharge limitations are listed in the Water Quality Objectives Section of the Basin Plan.

i Water shall not contain concentrations that cause nuisance or adversely affect beneficial uses as required in the Basin Plan.

Stabilized Construction Entrance/Exit TC-1





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ○ Sediment Control
- ● Tracking Control
- ● Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

A stabilized construction access is defined by a point of entrance/exit to a construction site that is stabilized to reduce the tracking of mud and dirt onto public roads by construction vehicles.

Appropriate Applications

- Use at construction sites:
  - Where dirt or mud can be tracked onto public roads.
  - Adjacent to water bodies.
  - Where poor soils are encountered.
  - Where dust is a problem during dry weather conditions.
- This BMP may be implemented on a project-by-project basis in addition to other BMPs when determined necessary and feasible by the Resident Engineer (RE).

Limitations

- Site conditions will dictate design and need.

Standards and Specifications

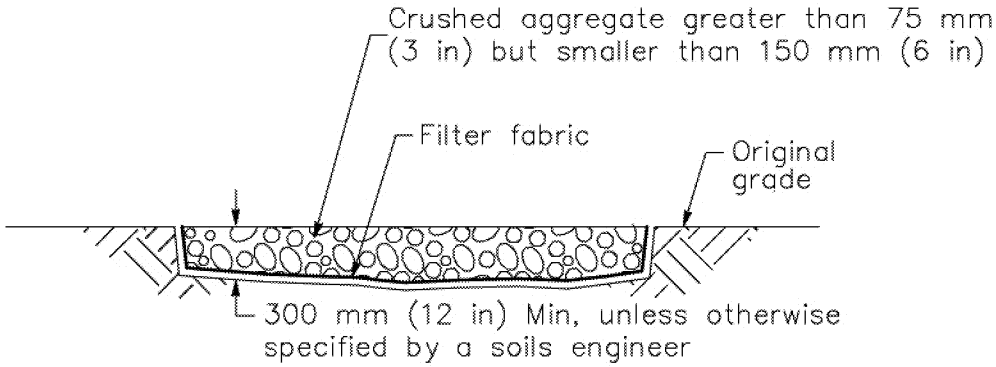
- Limit the points of entrance/exit to the construction site.
- Limit speed of vehicles to control dust.
- Properly grade each construction entrance/exit to prevent runoff from leaving the construction site.
- Route runoff from stabilized entrances/exits through a sediment-trapping device before discharge.
- Design stabilized entrance/exit to support the heaviest vehicles and equipment that will use it.

- Select construction access stabilization (aggregate, asphaltic concrete, concrete) based on longevity, required performance, and site conditions. The use of asphalt concrete (AC) grindings for stabilized construction access/roadway is not allowed.
- Use of constructed/manufactured steel plates with ribs for entrance/exit access is allowed with written approval from the RE.
- If aggregate is selected, place crushed aggregate over geotextile fabric to at least 300 mm (12 in) depth, or place aggregate to a depth recommended by the RE. Crushed aggregate greater than 75 mm (3 inches) and smaller than 150 mm (6 inches) shall be used.
- Designate combination or single purpose entrances and exits to the construction site.
- Implement BMP SC-7, "Street Sweeping and Vacuuming" as needed and as required.
- Require all employees, subcontractors, and suppliers to utilize the stabilized construction access.
- All exit locations intended to be used continuously and for a period of time shall have stabilized construction entrance/exit BMPs (TC-1 "Stabilized Construction Entrance/Exit" or TC-3 "Entrance/Outlet Tire Wash").

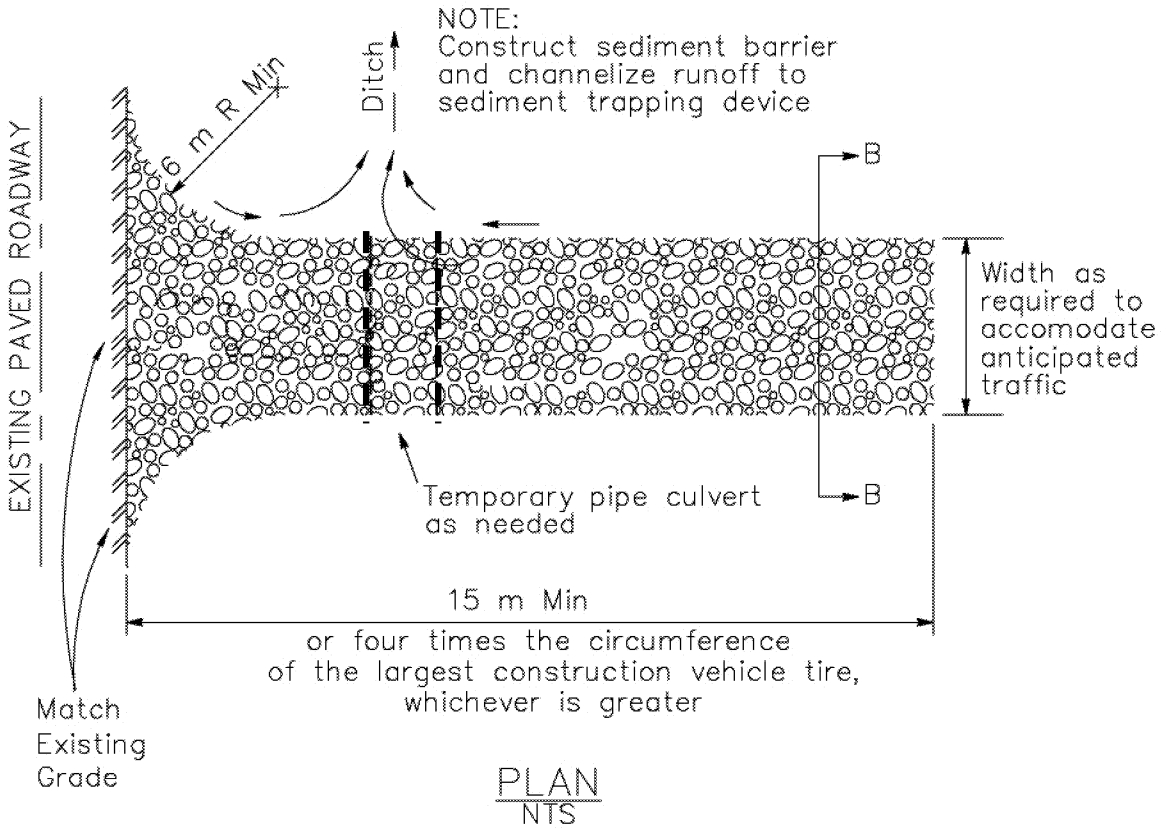
Maintenance and Inspection

- Inspect routinely for damage and assess effectiveness of the BMP. Remove aggregate, separate and dispose of sediment if construction entrance/exit is clogged with sediment or as directed by the RE.
- Keep all temporary roadway ditches clear.
- Inspect for damage and repair as needed.

Stabilized Construction Entrance/Exit TC-1



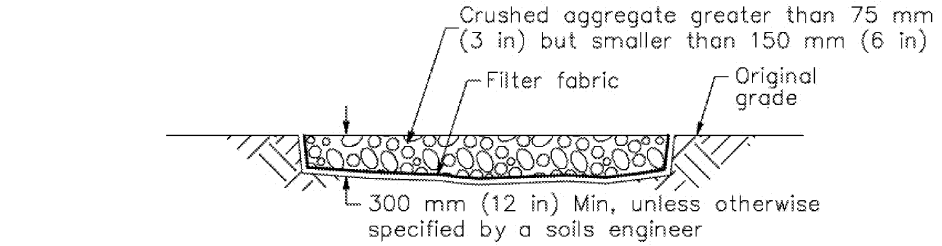
SECTION B–B
NTS



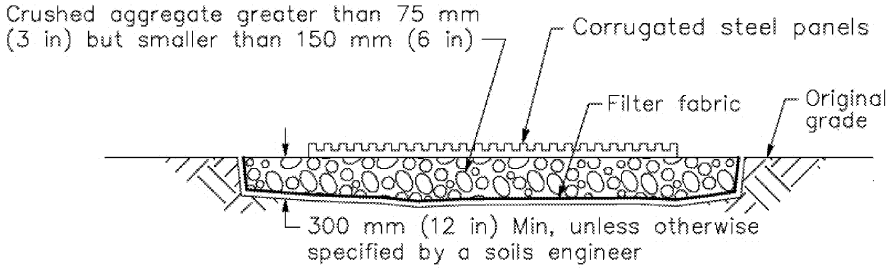
PLAN
NTS

Stabilized Contraction Entrance/Exit (Type 1)

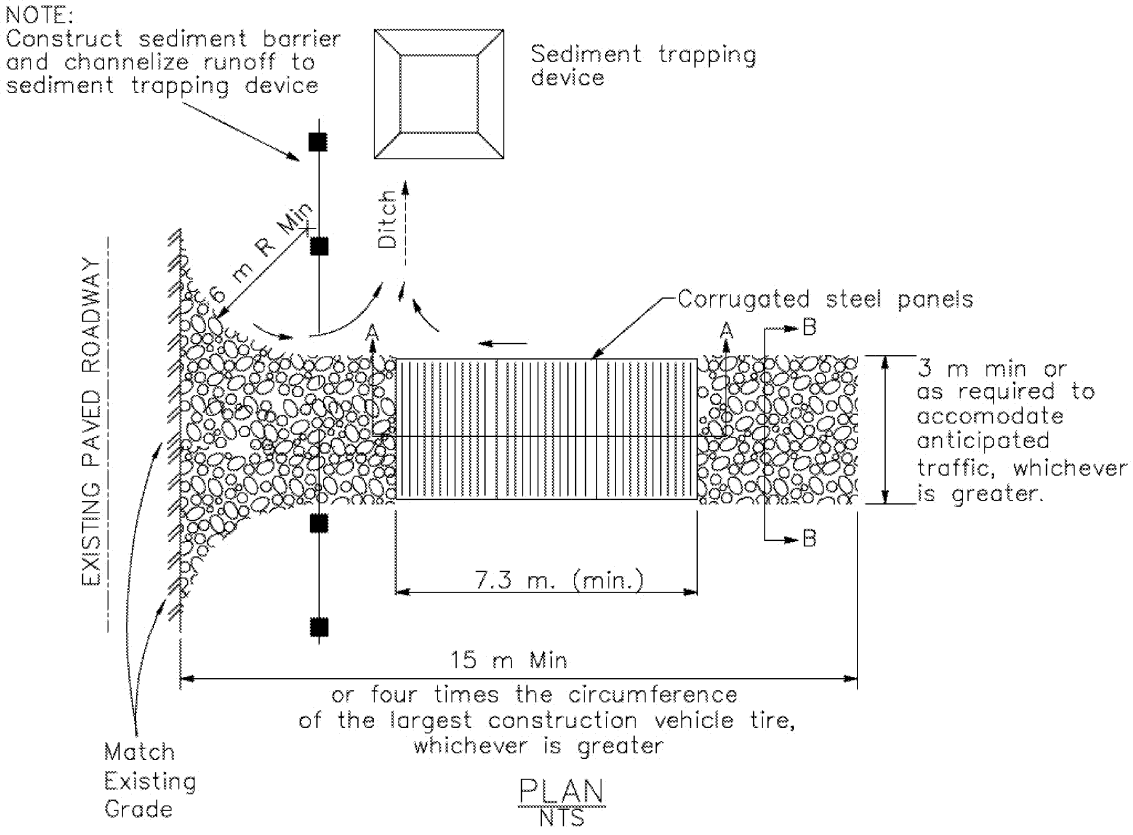
Stabilized Construction Entrance/Exit TC-1



SECTION B–B
NTS



SECTION A–A
NOT TO SCALE

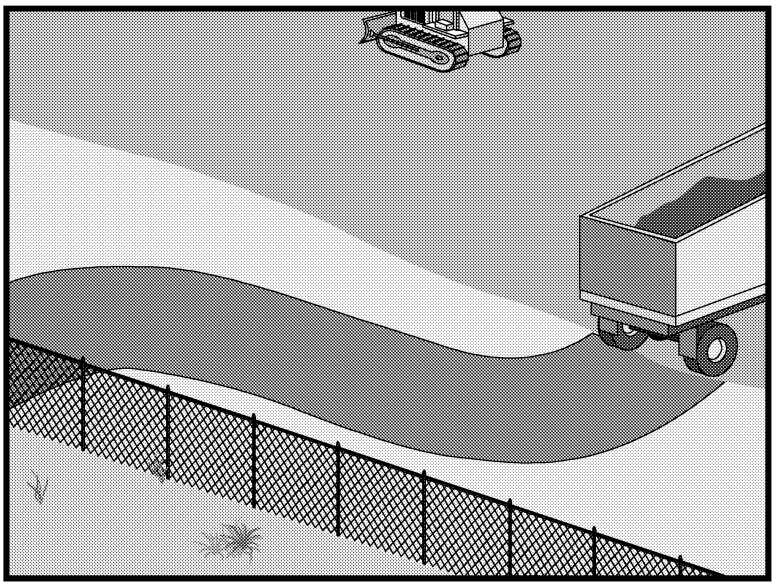


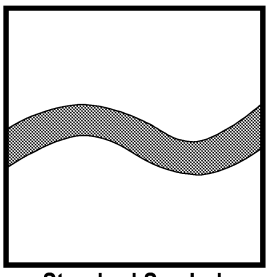
PLAN
NTS

Stabilized Construction Entrance/Exit (Type 2)

Stabilized Construction Roadway

TC-2





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ○ Sediment Control
- ● Tracking Control
- ● Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

A stabilized construction roadway is a temporary access road. It is designed for the control of dust and erosion created by vehicular tracking.

Appropriate Applications

- Construction roadways and short-term detour roads:
  - Where mud tracking is a problem during wet weather.
  - Where dust is a problem during dry weather.
  - Adjacent to water bodies.
  - Where poor soils are encountered.
  - Where there are steep grades and additional traction is needed.
- This BMP may be implemented on a project-by-project basis with other BMPs when determined necessary and feasible by the Resident Engineer (RE).

Limitations

- Materials will likely need to be removed prior to final project grading and stabilization.
- Site conditions will dictate design and need.
- May not be applicable to very short duration projects.
- Limit speed of vehicles to control dust.

Stabilized Construction Roadway

TC-2

Standards and Specifications

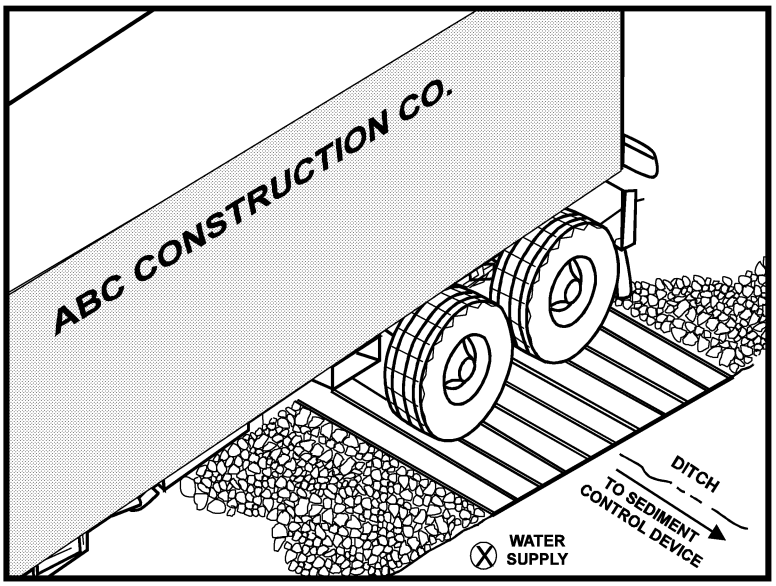
- Properly grade roadway to prevent runoff from leaving the construction site.
- Design stabilized access to support the heaviest vehicles and equipment that will use it.
- Stabilize roadway using aggregate, asphalt concrete, or concrete based on longevity, required performance, and site conditions. The use of cold mix asphalt or asphalt concrete (AC) grindings for stabilized construction roadway is not allowed.
- Coordinate materials with those used for stabilized construction entrance/exit points.
- If aggregate is selected, place crushed aggregate over geotextile fabric to at least 300 mm (12 in) depth, or place aggregate to a depth recommended by the RE or Construction Storm Water Coordinator. Crushed aggregate greater than 75 mm (3 inches) and smaller than 150 mm (6 inches) shall be used.

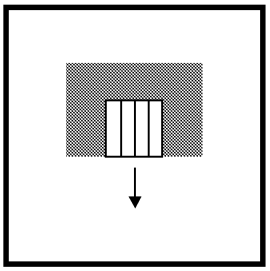
Maintenance and Inspection

- Inspect routinely for damage and repair as needed, or as directed by the RE.
- Keep all temporary roadway ditches clear.
- When no longer required, remove stabilized construction roadway and re-grade and repair slopes.

Entrance/Outlet Tire Wash

TC-3





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ● Sediment Control
- ● Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

A tire wash is an area located at stabilized construction access points to remove sediment from tires and undercarriages, and to prevent sediment from being transported onto public roadways.

Appropriate Applications

- Tire washes may be used on construction sites where dirt and mud tracking onto public roads by construction vehicles may occur.
- This BMP may be implemented on a project-by-project basis with other BMPs when determined necessary and feasible by the Resident Engineer (RE).

Limitations

- Requires a supply of wash water.
- Requires a turnout or doublewide exit to avoid having entering vehicles drive through the wash area.

Standards and Specifications

- Incorporate with a stabilized construction entrance/exit. See BMP TC-1, "Stabilized Construction Entrance/Exit."
- Construct on level ground when possible, on a pad of coarse aggregate, greater than 75 mm (3 inches) and smaller than 150 mm (6 inches). A geotextile fabric shall be placed below the aggregate.
- Wash rack shall be designed and constructed/manufactured for anticipated traffic loads.
- Provide a drainage ditch that will convey the runoff from the wash area to a sediment trapping device. The drainage ditch shall be of sufficient grade, width, and depth to carry the wash runoff.

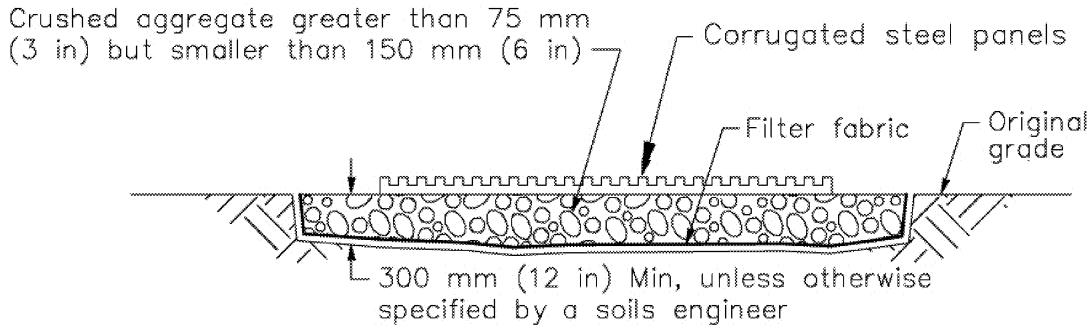
- Require all employees, subcontractors, and others that leave the site with mud-caked tires and/or undercarriages to use the wash facility.
- Implement BMP SC-7, "Street Sweeping and Vacuuming" as needed.
- Use of constructed or prefabricated steel plate with ribs for entrance/exit access is allowed with written approval of RE.

Maintenance and Inspection

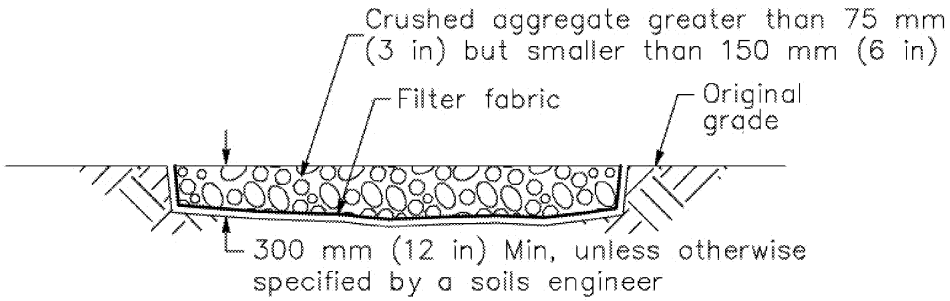
- Remove accumulated sediment in wash rack and/or sediment trap to maintain system performance.
- Inspect routinely for damage and repair as needed.

Entrance/Outlet Tire Wash

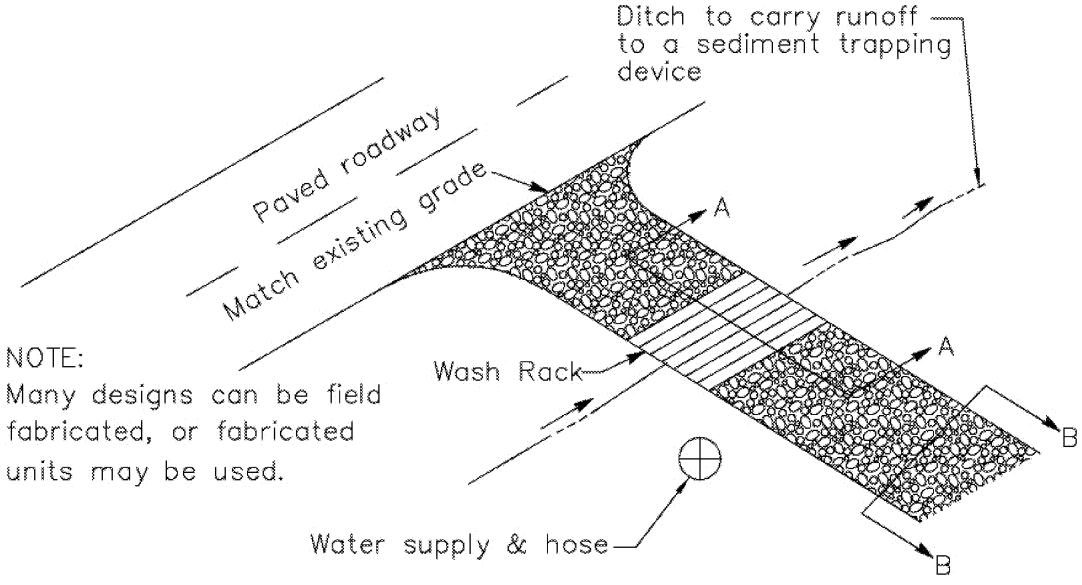
TC-3



SECTION A–A
NOT TO SCALE



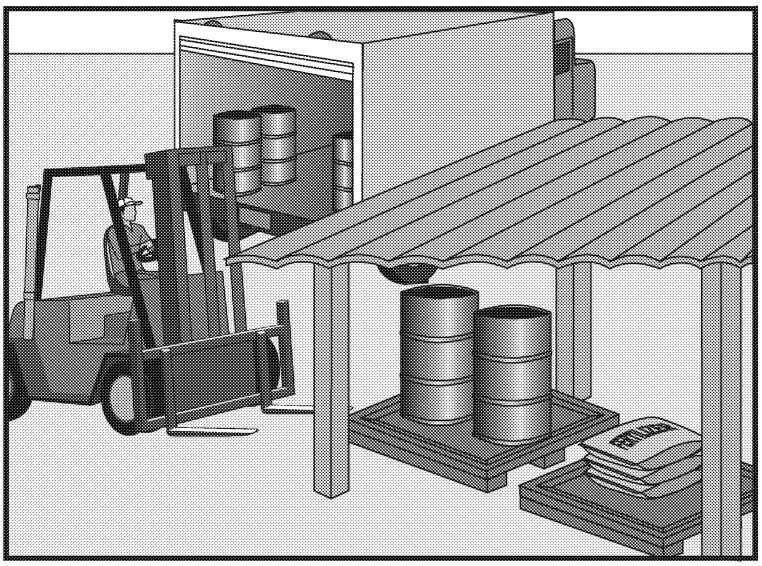
SECTION B–B
NTS

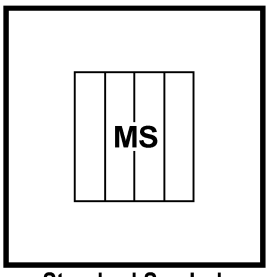


TYPICAL TIRE WASH
NOT TO SCALE

Material Delivery and Storage

WM-1





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ● Non-Storm Water Management
- ● Materials and Waste Management

Definition and Purpose

Procedures and practices for the proper handling and storage of materials in a manner that minimizes or eliminates the discharge of these materials to the storm drain system or to watercourses.

Appropriate Applications

These procedures are implemented at all construction sites with delivery and storage of the following:

- Hazardous chemicals such as:
  - Acids,
  - lime,
  - glues,
  - adhesives,
  - paints,
  - solvents, and
  - curing compounds.
- Soil stabilizers and binders.
- Fertilizers.
- Detergents.
- Plaster.
- Petroleum products such as fuel, oil, and grease.
- Asphalt and concrete components.
- Pesticides and herbicides.

- Other materials that may be detrimental if released to the environment.

Limitations

- Space limitation may preclude indoor storage.
- Storage sheds must meet building & fire code requirements.

Standards and Specifications

General

- Train employees and subcontractors on the proper material delivery and storage practices.
- Temporary storage area shall be located away from vehicular traffic.
- Material Safety Data Sheets (MSDS) shall be supplied to the Resident Engineer (RE) for all materials stored.

Material Storage Areas and Practices

- Liquids, petroleum products, and substances listed in 40 CFR Parts 110, 117, or 302 shall be stored in approved containers and drums and shall be placed in temporary containment facilities for storage.
- Throughout the rainy season, each temporary containment facility shall have a permanent cover and side wind protection or be covered during non-working days and prior to and during rain events.
- A temporary containment facility shall provide for a spill containment volume able to contain precipitation from a 24-hour, 25-year storm event, plus the greater of 10% of the aggregate volume of all containers or 100% of the capacity of the largest container within its boundary, whichever is greater.
- A temporary containment facility shall be impervious to the materials stored therein for a minimum contact time of 72 hours.
- A temporary containment facility shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, accumulated rainwater and spills shall be collected and placed into drums. These liquids shall be handled as a hazardous waste unless testing determines them to be non-hazardous. All collected liquids or non-hazardous liquids shall be sent to an approved disposal site.
- Sufficient separation shall be provided between stored containers to allow for spill cleanup and emergency response access.
- Incompatible materials, such as chlorine and ammonia, shall not be stored in the same temporary containment facility.
- Materials shall be stored in their original containers and the original product labels shall be maintained in place in a legible condition. Damaged or otherwise illegible labels shall be replaced immediately.

-
- Bagged and boxed materials shall be stored on pallets and shall not be allowed to accumulate on the ground. To provide protection from wind and rain, throughout the rainy season, bagged and boxed materials shall be covered during non-working days and prior to rain events.
- Stockpiles shall be protected in accordance with BMP WM-3, "Stockpile Management."
- Minimize the material inventory stored on-site (e.g., only a few days supply).
- Have proper storage instructions posted at all times in an open and conspicuous location.
- Do not store hazardous chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and when possible, under cover in secondary containment.
- Keep hazardous chemicals well labeled and in their original containers.
- Keep ample supply of appropriate spill clean up material near storage areas.
- Also see BMP WM-6, "Hazardous Waste Management", for storing of hazardous materials.

Material Delivery Practices

- Keep an accurate, up-to-date inventory of material delivered and stored on-site.
- Employees trained in emergency spill clean-up procedures shall be present when dangerous materials or liquid chemicals are unloaded.

Spill Clean-up

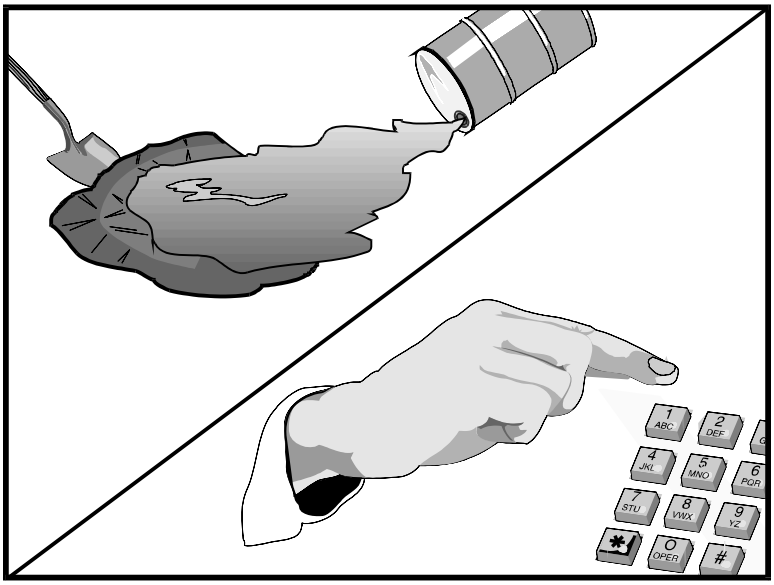
- Contain and clean up any spill immediately.
- If significant residual materials remain on the ground after construction is complete, properly remove and dispose any hazardous materials or contaminated soil.
- See BMP WM-4, "Spill Prevention and Control", for spills of chemicals and/or hazardous materials.

Maintenance and Inspection

- Storage areas shall be kept clean, well organized, and equipped with ample clean-up supplies as appropriate for the materials being stored.
- Perimeter controls, containment structures, covers, and liners shall be repaired or replaced as needed to maintain proper function.
- Inspect storage areas before and after rainfall events, and at least weekly during other times. Collect and place into drums any spills or accumulated rainwater.

Spill Prevention and Control

WM-4



Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ● Non-Storm Water Management
- ● Materials and Waste Management

Definition and Purpose

These procedures and practices are implemented to prevent and control spills in a manner that minimizes or prevents the discharge of spilled material to the drainage system or watercourses.

Appropriate Application

This best management practice (BMP) applies to all construction projects. Spill control procedures are implemented anytime chemicals and/or hazardous substances are stored. Substances may include, but are not limited to:

- Soil stabilizers/binders.
- Dust Palliatives.
- Herbicides.
- Growth inhibitors.
- Fertilizers.
- Deicing/anti-icing chemicals.
- Fuels.
- Lubricants.
- Other petroleum distillates.

To the extent that the work can be accomplished safely, spills of oil, petroleum products, substances listed under 40 CFR parts 110, 117, and 302, and sanitary and septic wastes shall be contained and cleaned up immediately.

Limitations

- This BMP only applies to spills caused by the contractor.
- Procedures and practices presented in this BMP are general. Contractor shall identify appropriate practices for the specific materials used or stored on-site.

Standards and Specifications

- To the extent that it doesn't compromise clean up activities, spills shall be covered and protected from storm water run-on during rainfall.
- Spills shall not be buried or washed with water.
- Used clean up materials, contaminated materials, and recovered spill material that is no longer suitable for the intended purpose shall be stored and disposed of in conformance with the special provisions.
- Water used for cleaning and decontamination shall not be allowed to enter storm drains or watercourses and shall be collected and disposed of in accordance with BMP WM-10, "Liquid Waste Management."
- Water overflow or minor water spillage shall be contained and shall not be allowed to discharge into drainage facilities or watercourses.
- Proper storage, clean-up and spill reporting instruction for hazardous materials stored or used on the project site shall be posted at all times in an open, conspicuous and accessible location.
- Waste storage areas shall be kept clean, well organized and equipped with ample clean-up supplies as appropriate for the materials being stored. Perimeter controls, containment structures, covers and liners shall be repaired or replaced as needed to maintain proper function.

Education

- Educate employees and subcontractors on what a "significant spill" is for each material they use, and what is the appropriate response for "significant" and "insignificant" spills.
- Educate employees and subcontractors on potential dangers to humans and the environment from spills and leaks.
- Hold regular meetings to discuss and reinforce appropriate disposal procedures (incorporate into regular safety meetings).
- Establish a continuing education program to indoctrinate new employees.
- The Contractor's Water Pollution Control Manager (WPCM) shall oversee and enforce proper spill prevention and control measures.

Cleanup and Storage Procedures

- Minor Spills
  - Minor spills typically involve small quantities of oil, gasoline, paint, etc., which can be controlled by the first responder at the discovery of the spill.
  - Use absorbent materials on small spills rather than hosing down or burying the spill.
  - Remove the absorbent materials promptly and dispose of properly.
  - The practice commonly followed for a minor spill is:
    - Contain the spread of the spill.
    - Recover spilled materials.
    - Clean the contaminated area and/or properly dispose of contaminated materials.
- Semi-Significant Spills
  - Semi-significant spills still can be controlled by the first responder along with the aid of other personnel such as laborers and the foreman, etc. This response may require the cessation of all other activities.
  - Clean up spills immediately:
    - Notify the project foreman immediately. The foreman shall notify the Resident Engineer (RE).
    - Contain spread of the spill.
    - If the spill occurs on paved or impermeable surfaces, clean up using "dry" methods (absorbent materials, cat litter and/or rags). Contain the spill by encircling with absorbent materials and do not let the spill spread widely.
    - If the spill occurs in dirt areas, immediately contain the spill by constructing an earthen dike. Dig up and properly dispose of contaminated soil.
    - If the spill occurs during rain, cover spill with tarps or other material to prevent contaminating runoff.

- Significant/Hazardous Spills
  - For significant or hazardous spills that cannot be controlled by personnel in the immediate vicinity, the following steps shall be taken:
    - Notify the RE immediately and follow up with a written report.
    - Notify the local emergency response by dialing 911. In addition to 911, the contractor will notify the proper county officials. It is the contractor's responsibility to have all emergency phone numbers at the construction site.
    - Notify the Governor's Office of Emergency Services Warning Center, (805) 852-7550.
    - For spills of federal reportable quantities, in conformance with the requirements in 40 CFR parts 110,119, and 302, the contractor shall notify the National Response Center at (800) 424-8802.
    - Notification shall first be made by telephone and followed up with a written report.
    - The services of a spills contractor or a Haz-Mat team shall be obtained immediately. Construction personnel shall not attempt to clean up the spill until the appropriate and qualified staff have arrived at the job site.
    - Other agencies which may need to be consulted include, but are not limited to, the Fire Department, the Public Works Department, the Coast Guard, the Highway Patrol, the City/County Police Department, Department of Toxic Substances, California Division of Oil and Gas, Cal/OSHA, RWQCB, etc.

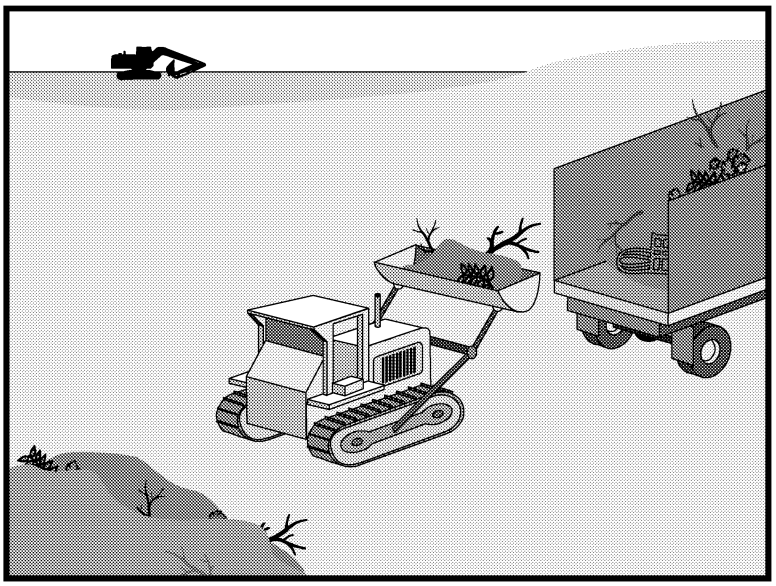
Maintenance and Inspection

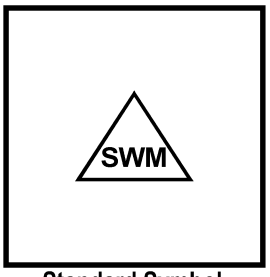
- Verify weekly that spill control clean up materials are located near material storage, unloading, and use areas.
- Update spill prevention and control plans and stock appropriate clean-up materials whenever changes occur in the types of chemicals used or stored onsite.

`

Solid Waste Management

WM-5





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ● Non-Storm Water Management
- ● Materials and Waste Management

Definition and Purpose

Solid waste management procedures and practices are designed to minimize or eliminate the discharge of pollutants to the drainage system or to watercourses as a result of the creation, stockpiling, or removal of construction site wastes.

Appropriate Applications

Solid waste management procedures and practices are implemented on all construction projects that generate solid wastes.

Solid wastes include but are not limited to:

- Construction wastes including brick, mortar, timber, steel and metal scraps, sawdust, pipe and electrical cuttings, non-hazardous equipment parts, styrofoam and other materials used to transport and package construction materials.
- Highway planting wastes, including vegetative material, plant containers, and packaging materials.
- Litter, including food containers, beverage cans, coffee cups, paper bags, plastic wrappers, and smoking materials, including litter generated by the public.

Limitations

- Temporary stockpiling of certain construction wastes may not necessitate stringent drainage related controls during the non-rainy season or in desert areas with low rainfall.

Standards and Specifications

Education

- The Contractor's Water Pollution Control Manager (WPCM) shall oversee and enforce proper solid waste procedures and practices.
- Instruct employees and subcontractors on identification of solid waste and hazardous waste.
- Educate employees and subcontractors on solid waste storage and disposal procedures.
- Hold regular meetings to discuss and reinforce disposal procedures (incorporate into regular safety meetings).
- Require that employees and subcontractors follow solid waste handling and storage procedures.
- Prohibit littering by employees, subcontractors, and visitors.
- Wherever possible, minimize production of solid waste materials.

Collection, Storage, and Disposal

- Dumpsters of sufficient size and number shall be provided to contain the solid waste generated by the project and properly serviced.
- Littering on the project site shall be prohibited.
- To prevent clogging of the storm drainage system litter and debris removal from drainage grates, trash racks, and ditch lines shall be a priority.
- Trash receptacles shall be provided in the Contractor's yard, field trailer areas, and at locations where workers congregate for lunch and break periods.
- Construction debris and litter from work areas within the construction limits of the project site shall be collected and placed in watertight dumpsters at least weekly regardless of whether the litter was generated by the Contractor, the public, or others. Collected litter and debris shall not be placed in or next to drain inlets, storm water drainage systems or watercourses.
- Full dumpsters shall be removed from the project site and the contents shall be disposed of outside the highway right-of-way in conformance with the provisions in the Standard Specifications Section 7-1.13.
- Litter stored in collection areas and containers shall be handled and disposed of by trash hauling contractors.
- Construction debris and waste shall be removed from the site every two weeks or as directed by the RE.

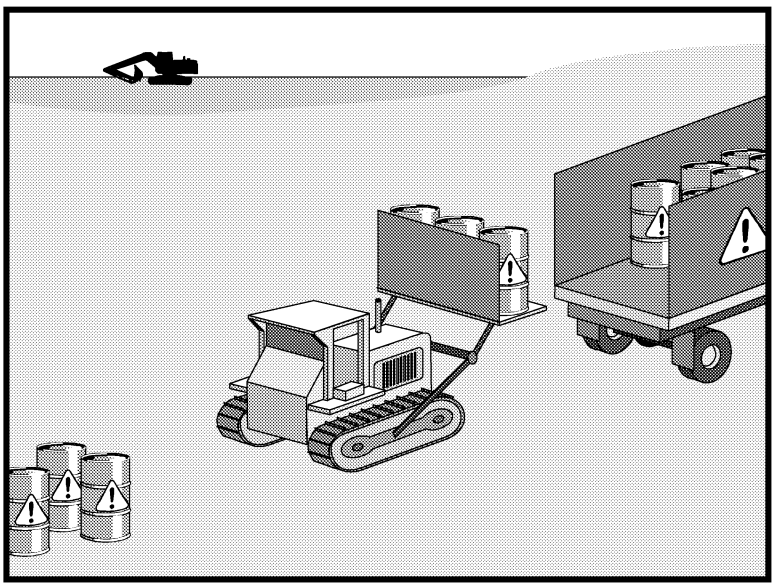
- Construction material visible to the public shall be stored or stacked in an orderly manner to the satisfaction of the RE.
- Storm water run-on shall be prevented from contacting stored solid waste through the use of berms, dikes, or other temporary diversion structures or through the use of measures to elevate waste from site surfaces.
- Solid waste storage areas shall be located at least 15 m (50 ft) from drainage facilities and watercourses and shall not be located in areas prone to flooding or ponding.
- Except during fair weather, construction and highway planting waste not stored in watertight dumpsters shall be securely covered from wind and rain by covering the waste with tarps or plastic sheeting or protected in conformance with the applicable Disturbed Soil Area protection section.
- Dumpster washout on the project site is not allowed.
- Notify trash hauling contractors that only watertight dumpsters are acceptable for use on-site.
- Plan for additional containers during the demolition phase of construction.
- Plan for more frequent pickup during the demolition phase of construction.
- Construction waste shall be stored in a designated area approved by the RE.
- Segregate potentially hazardous waste from non-hazardous construction site waste.
- Keep the site clean of litter debris.
- Make sure that toxic liquid wastes (e.g., used oils, solvents, and paints) and chemicals (e.g., acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.
- Dispose of non-hazardous waste in accordance with Standard Specification 7-1.13, Disposal of Material Outside the Highway Right of Way.
- For disposal of hazardous waste, see BMP WM-6, "Hazardous Waste Management." Have hazardous waste hauled to an appropriate disposal and/or recycling facility.
- Salvage or recycle useful vegetation debris, packaging and/or surplus building materials when practical. For example, trees and shrubs from land clearing can be converted into wood chips, then used as mulch on graded areas. Wood pallets, cardboard boxes, and construction scraps can also be recycled.

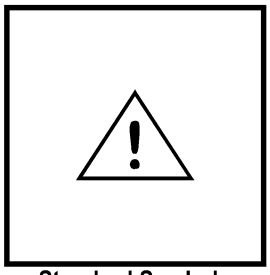
Maintenance and Inspection

- The WPCM shall monitor onsite solid waste storage and disposal procedures.
- Police site for litter and debris.

Hazardous Waste Management

WM-6





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ● Non-Storm Water Management
- ● Materials and Waste Management

Definition and Purpose

These are procedures and practices to minimize or eliminate the discharge of pollutants from construction site hazardous waste to the storm drain systems or to watercourses.

Appropriate Applications

- This best management practice (BMP) applies to all construction projects.
- Hazardous waste management practices are implemented on construction projects that generate waste from the use of:
  - Petroleum Products,
  - Asphalt Products,
  - Concrete Curing Compounds,
  - Pesticides,
  - Acids,
  - Paints,
  - Stains,
  - Solvents,
  - Wood Preservatives,
  - Roofing Tar, or
  - Any materials deemed a hazardous waste in California, Title 22 Division 4.5, or listed in 40 CFR Parts 110, 117, 261, or 302.

Limitations

- Nothing in this BMP relieves the Contractor from responsibility for compliance with federal, state, and local laws regarding storage, handling, transportation, and disposal of hazardous wastes.
- This BMP does not cover aerially deposited lead (ADL) soils. For ADL soils refer to BMP WM-7, "Contaminated Soil Management," and the project special provisions.

Standards and Specifications

Education

- Educate employees and subcontractors on hazardous waste storage and disposal procedures.
- Educate employees and subcontractors on potential dangers to humans and the environment from hazardous wastes.
- Instruct employees and subcontractors on safety procedures for common construction site hazardous wastes.
- Instruct employees and subcontractors in identification of hazardous and solid waste.
- Hold regular meetings to discuss and reinforce hazardous waste management procedures (incorporate into regular safety meetings).
- The Contractor's Water Pollution Control Manager (WPCM) shall oversee and enforce proper hazardous waste management procedures and practices.
- Make sure that hazardous waste is collected, removed, and disposed of only at authorized disposal areas.

Storage Procedures

- Wastes shall be stored in sealed containers constructed of a suitable material and shall be labeled as required by Title 22 CCR, Division 4.5 and 49 CFR Parts 172,173, 178, and 179.
- All hazardous waste shall be stored, transported, and disposed as required in Title 22 CCR, Division 4.5 and 49 CFR 261-263.
- Waste containers shall be stored in temporary containment facilities that shall comply with the following requirements:
  - Temporary containment facility shall provide for a spill containment volume able to contain precipitation from a 24-hour, 25 year storm event, plus the greater of 10% of the aggregate volume of all containers or 100% of the capacity of the largest tank within its boundary, whichever is greater.

- Temporary containment facility shall be impervious to the materials stored there for a minimum contact time of 72 hours.

- Temporary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks accumulated rainwater and spills shall be placed into drums after each rainfall. These liquids shall be handled as a hazardous waste unless testing determines them to be non-hazardous. Non-hazardous liquids shall be sent to an approved disposal site.

- Sufficient separation shall be provided between stored containers to allow for spill cleanup and emergency response access.

- Incompatible materials, such as chlorine and ammonia, shall not be stored in the same temporary containment facility.

- Throughout the rainy season, temporary containment facilities shall be covered during non-working days, and prior to rain events. Covered facilities may include use of plastic tarps for small facilities or constructed roofs with overhangs. A storage facility having a solid cover and sides is preferred to a temporary tarp. Storage facilities shall be equipped with adequate ventilation.

- Drums shall not be overfilled and wastes shall not be mixed.

- Unless watertight, containers of dry waste shall be stored on pallets.

- Paint brushes and equipment for water and oil based paints shall be cleaned within a contained area and shall not be allowed to contaminate site soils, watercourses or drainage systems. Waste paints, thinners, solvents, residues, and sludges that cannot be recycled or reused shall be disposed of as hazardous waste. When thoroughly dry, latex paint and paint cans, used brushes, rags, absorbent materials, and drop cloths shall be disposed of as solid waste.

- Ensure that adequate hazardous waste storage volume is available.

- Ensure that hazardous waste collection containers are conveniently located.

- Designate hazardous waste storage areas on site away from storm drains or watercourses and away from moving vehicles and equipment to prevent accidental spills.

- Minimize production or generation of hazardous materials and hazardous waste on the job site.

- Use containment berms in fueling and maintenance areas and where the potential for spills is high.

- Segregate potentially hazardous waste from non-hazardous construction site debris.
- Keep liquid or semi-liquid hazardous waste in appropriate containers (closed drums or similar) and under cover.
- Clearly label all hazardous waste containers with the waste being stored and the date of accumulation.
- Place hazardous waste containers in secondary containment.
- Do not allow potentially hazardous waste materials to accumulate on the ground.
- Do not mix wastes.

Disposal Procedures

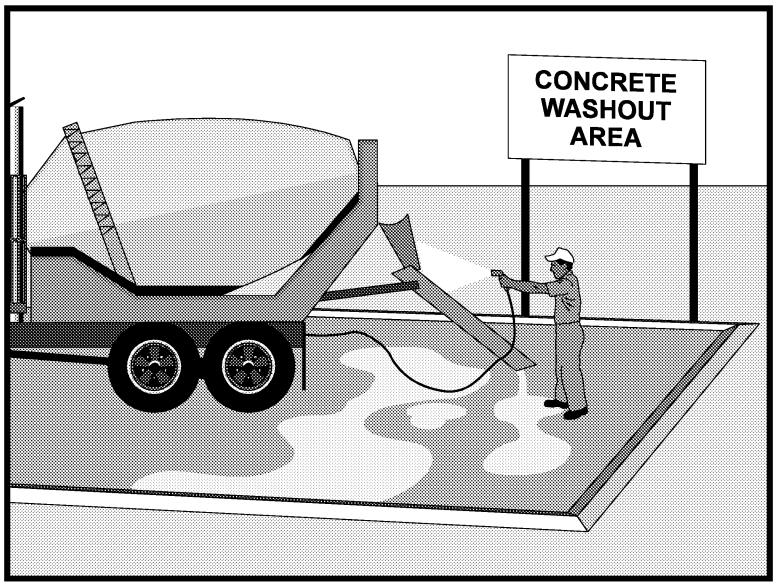
- Waste shall be disposed of outside the highway right-of-way within 90 days of being generated, or as directed by the Resident Engineer (RE). In no case shall hazardous waste storage exceed requirements in Title 22 CCR, Section 66262.34.
- Waste shall be disposed of by a licensed hazardous waste transporter at an authorized and licensed disposal facility or recycling facility utilizing properly completed Uniform Hazardous Waste Manifest forms.
- A Department of Health Services (DHS) certified laboratory shall sample waste and classify it to determine the appropriate disposal facility.
- Make sure that toxic liquid wastes (e.g., used oils, solvents, and paints) and chemicals (e.g., acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for solid waste construction debris.
- Properly dispose of rainwater in secondary containment that may have mixed with hazardous waste.
- Recycle any useful material such as used oil or water-based paint when practical.
- Attention is directed to "Hazardous Material", "Contaminated Material", and "Aerially Deposited Lead" of the contract documents regarding the handling and disposal of hazardous materials.

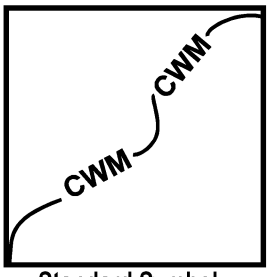
Maintenance and Inspection

- A foreman and/or construction supervisor shall monitor on-site hazardous waste storage and disposal procedures.
- Waste storage areas shall be kept clean, well organized, and equipped with ample clean-up supplies as appropriate for the materials being stored.
- Storage areas shall be inspected in conformance with the provisions in the contract documents.
- Perimeter controls, containment structures, covers, and liners shall be repaired or replaced as needed to maintain proper function.
- Hazardous spills shall be cleaned up and reported in conformance with the applicable Material Safety Data Sheet (MSDS) and the instructions posted at the project site.
- The National Response Center, at (800) 424-8802, shall be notified of spills of Federal reportable quantities in conformance with the requirements in 40 CFR parts 110, 117, and 302.
- Copy of the hazardous waste manifests shall be provided to the RE.

Concrete Waste Management

WM-8





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ● Non-Storm Water Management
- ● Materials and Waste Management

Definition and Purpose

These are procedures and practices that are designed to minimize or eliminate the discharge of concrete waste materials to the storm drain systems or watercourses.

Appropriate Applications

- Concrete waste management procedures and practices are implemented on construction projects where concrete is used as a construction material or where concrete dust and debris result from demolition activities.
- Where slurries containing portland cement concrete (PCC) or asphalt concrete (AC) are generated, such as from sawcutting, coring, grinding, grooving, and hydro-concrete demolition.
- Where concrete trucks and other concrete-coated equipment are washed on site, when approved by the Resident Engineer (RE). See also NS-8, “Vehicle and Equipment Cleaning."
- Where mortar-mixing stations exist.

Limitations

- None identified.

Standards and Specifications

Education

- Educate employees, subcontractors, and suppliers on the concrete waste management techniques described herein.
- The Contractor’s Water Pollution Control Manager (WPCM) shall oversee and enforce concrete waste management procedures.

Concrete Demolition Wastes

- Stockpile concrete demolition wastes in accordance with BMP WM-3, “Stockpile Management.”
- Disposal of hardened PCC and AC waste shall be in conformance with

Standard Specifications Section 7-1.13 or 15-3.02.

Concrete Slurry Waste Management and Disposal

- PCC and AC waste shall not be allowed to enter storm drainage systems or watercourses.
- A sign shall be installed adjacent to each temporary concrete washout facility to inform concrete equipment operators to utilize the proper facilities as shown on Page 7.
- A foreman and/or construction supervisor shall monitor onsite concrete working tasks, such as saw cutting, coring, grinding and grooving to ensure proper methods are implemented.
- Residue from saw cutting, coring and grinding operations shall be picked up by means of a vacuum device. Residue shall not be allowed to flow across the pavement and shall not be left on the surface of the pavement. See also BMP NS-3, "Paving and Grinding Operations."
- Vacuumed slurry residue shall be disposed in accordance with BMP WM-5, "Solid Waste Management" and Standard Specifications Section 7-1.13. Slurry residue shall be temporarily stored in a facility as described in "Onsite Temporary Concrete Washout Facility, Concrete Transit Truck Washout Procedures" below), or within an impermeable containment vessel or bin approved by the Engineer.
- Collect and dispose of all residues from grooving and grinding operations in accordance with Standard Specifications Section 7-1.13, 42-1.02 and 42-2.02.

Onsite Temporary Concrete Washout Facility, Concrete Transit Truck Washout Procedures

- Temporary concrete washout facilities shall be located a minimum of 15 m (50 ft) from storm drain inlets, open drainage facilities, and watercourses, unless determined infeasible by the RE. Each facility shall be located away from construction traffic or access areas to prevent disturbance or tracking.
- A sign shall be installed adjacent to each washout facility to inform concrete equipment operators to utilize the proper facilities. The sign shall be installed as shown on the plans and in conformance with the provisions in Standard Specifications Section 56-2, Roadside Signs.
- Temporary concrete washout facilities shall be constructed above grade or below grade at the option of the Contractor. Temporary concrete washout facilities shall be constructed and maintained in sufficient quantity and size to contain all liquid and concrete waste generated by washout operations.
- Temporary washout facilities shall have a temporary pit or bermed areas of sufficient volume to completely contain all liquid and waste concrete

materials generated during washout procedures.

- Perform washout of concrete mixers, delivery trucks, and other delivery systems in designated areas only.
- Wash concrete only from mixer chutes into approved concrete washout facility. Washout may be collected in an impermeable bag or other impermeable containment devices for disposal.
- Pump excess concrete in concrete pump bin back into concrete mixer truck.
- Concrete washout from concrete pumper bins can be washed into concrete pumper trucks and discharged into designated washout area or properly disposed offsite.
- Once concrete wastes are washed into the designated area and allowed to harden, the concrete shall be broken up, removed, and disposed of in conformance with the provisions in Standard Specifications Section 7-1.13 or 15-3.02.

Temporary Concrete Washout Facility Type "Above Grade"

- Temporary concrete washout facility Type "Above Grade" shall be constructed as shown on Page 6 or 7, with a recommended minimum length and minimum width of 3 m (10 ft), but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations. The length and width of a facility may be increased, at the Contractor's expense, upon approval from the RE.
- Straw bales, wood stakes, and sandbag materials shall conform to the provisions in BMP SC-9, "Straw Bale Barrier."
- Plastic lining material shall be a minimum of 10-mil polyethylene sheeting and shall be free of holes, tears or other defects that compromise the impermeability of the material. Liner seams shall be installed in accordance with manufacturers' recommendations.
- Portable delineators shall conform to the provisions in Standard Specifications Section 12-3.04, "Portable Delineators." The delineator bases shall be cemented to the pavement in the same manner as provided for cementing pavement markers to pavement in Standard Specifications Section 85-1.06, "Placement." Portable delineators shall be applied only to a clean, dry surface.

Temporary Concrete Washout Facility (Type Below Grade)

- Temporary concrete washout facility Type "Below Grade" shall be constructed as shown on page 6, with a recommended minimum length and minimum width of 3m (10 ft). The quantity and volume shall be sufficient to contain all liquid and concrete waste generated by washout operations. The length and width of a facility may be increased, at the Contractor's expense,

upon approval of the RE. Lath and flagging shall be commercial type.

- Plastic lining material shall be a minimum of 10-mil polyethylene sheeting and shall be free of holes, tears or other defects that compromise the impermeability of the material. Liner seams shall be installed in accordance with manufacturers' recommendations.

- The soil base shall be prepared free of rocks or other debris that may cause tears or holes in the plastic lining material.

Removal of Temporary Concrete Washout Facilities

- When temporary concrete washout facilities are no longer required for the work, as determined by the RE, the hardened concrete shall be removed and disposed of in conformance with the provisions in Standard Specifications Section 7-1.13 or 15-3.02. Disposal of PCC dried residues, slurries or liquid waste shall be disposed of outside the highway right-of-way in conformance with provisions of Standard Specifications Section 7-1-13. Materials used to construct temporary concrete washout facilities shall become the property of the Contractor, shall be removed from the site of the work, and shall be disposed of outside the highway right-of-way in conformance with the provisions of the Standard Specifications, Section 7-1.13.

- Holes, depressions or other ground disturbance caused by the removal of the temporary concrete washout facilities shall be backfilled and repaired in conformance with the provisions in Standard Specifications Section 15-1.02, "Preservation of Property."

Maintenance and Inspection

- The Contractor's Water Pollution Control Manager (WPCM) shall monitor on site concrete waste storage and disposal procedures at least weekly or as directed by the RE.

- The WPCM shall monitor concrete working tasks, such as saw cutting, coring, grinding and grooving daily to ensure proper methods are employed or as directed by the RE.

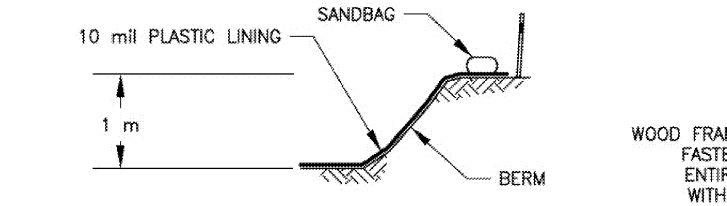
- Temporary concrete washout facilities shall be maintained to provide adequate holding capacity with a minimum freeboard of 100 mm (4 inches) for above grade facilities and 300 mm (12 inches) for below grade facilities. Maintaining temporary concrete washout facilities shall include removing and disposing of hardened concrete and returning the facilities to a functional condition. Hardened concrete materials shall be removed and disposed of in conformance with the provisions in Standard Specifications Section 7-1.13 or 15-3.02.

- Existing facilities must be cleaned, or new facilities must be constructed and ready for use once the washout is 75% full.

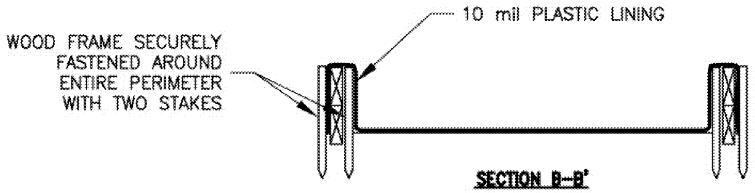
- Temporary concrete washout facilities shall be inspected for damage (i.e.

tears in polyethylene liner, missing sandbags, etc.). Damaged facilities shall be repaired.

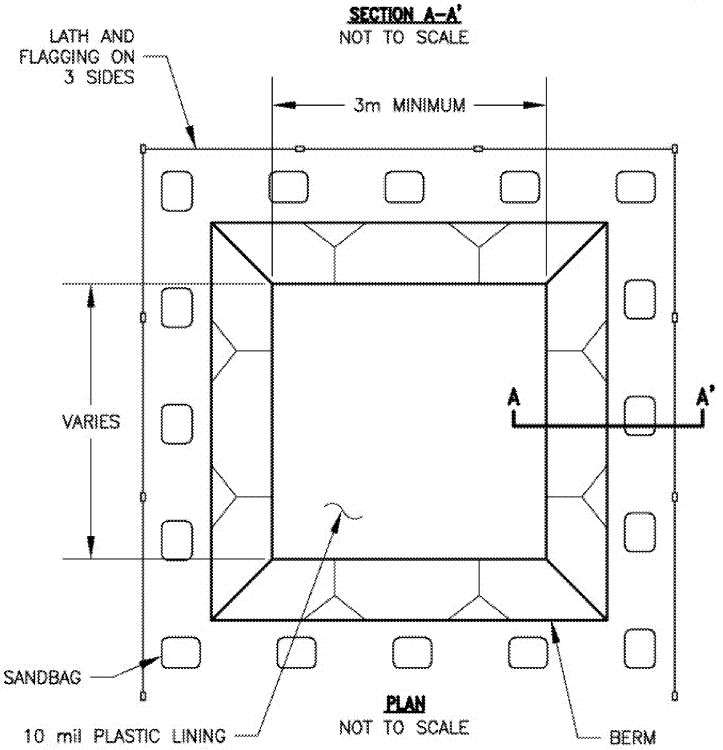
Concrete Waste Management



SECTION A–A'
NOT TO SCALE

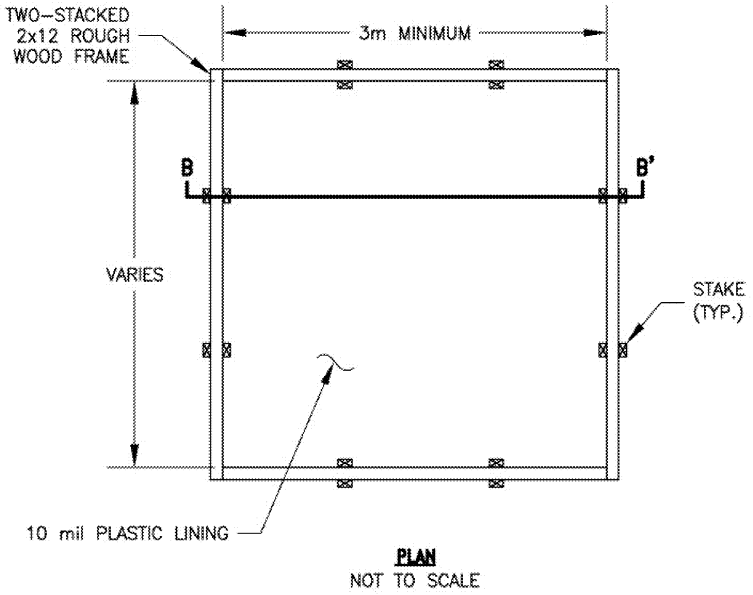


SECTION B–B'
NOT TO SCALE



PLAN
NOT TO SCALE

TYPE "BELOW GRADE"

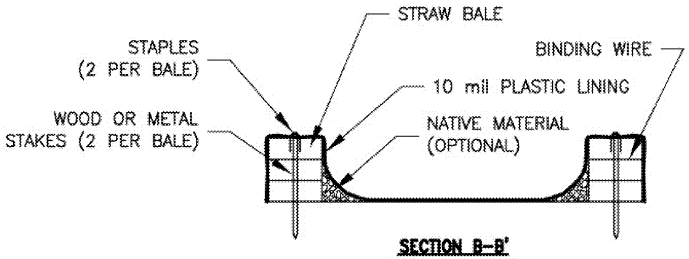


PLAN
NOT TO SCALE

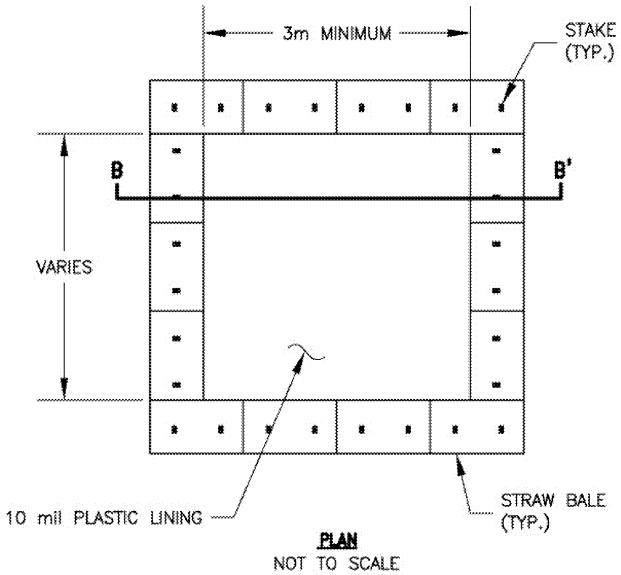
TYPE "ABOVE GRADE" WITH WOOD PLANKS

NOTES:

1. ACTUAL LAYOUT DETERMINED IN THE FIELD.
2. THE CONCRETE WASHOUT SIGN (SEE PAGE 6) SHALL BE INSTALLED WITHIN 10 m OF THE TEMPORARY CONCRETE WASHOUT FACILITY.

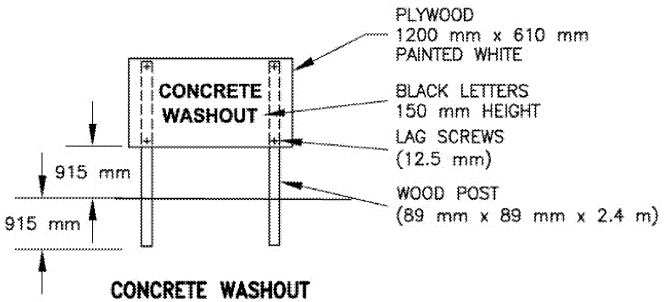


SECTION B–B'
NOT TO SCALE

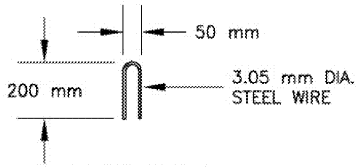


PLAN
NOT TO SCALE

TYPE "ABOVE GRADE" WITH STRAW BALES



CONCRETE WASHOUT SIGN DETAIL (OR EQUIVALENT)



STAPLE DETAIL

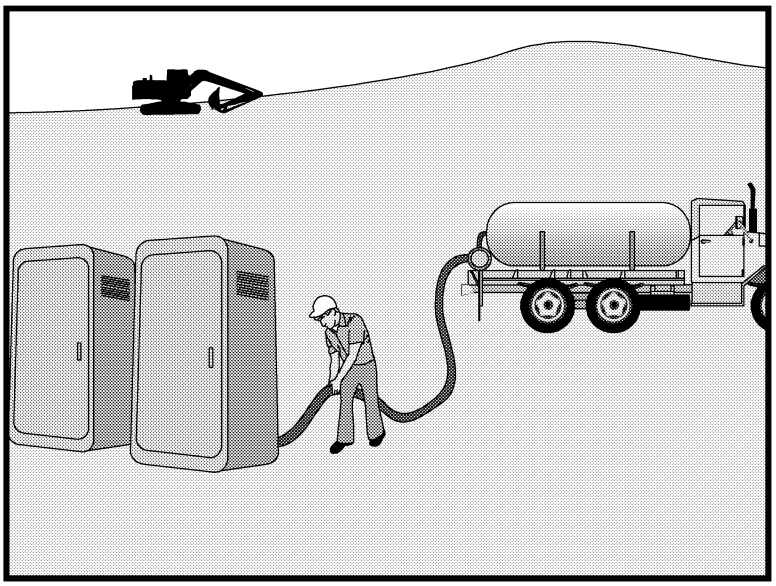
NOTES:

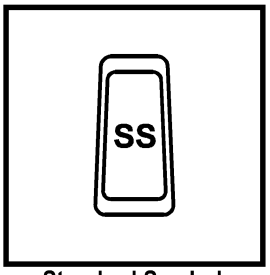
1. ACTUAL LAYOUT DETERMINED IN THE FIELD.
2. THE CONCRETE WASHOUT SIGN (SEE FIG. 4–15) SHALL BE INSTALLED WITHIN 10 m OF THE TEMPORARY CONCRETE WASHOUT FACILITIY.

CALTRANS/FIG4–14.DWG SAC 8–14–02

Sanitary/Septic Waste Management

WM-9





Standard Symbol

BMP Objectives

- ○ Soil Stabilization
- ○ Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ● Non-Storm Water Management
- ● Materials and Waste Management

Definition and Purpose

Procedures and practices to minimize or eliminate the discharge of construction site sanitary/septic waste materials to the storm drain system or to watercourses.

Appropriate Applications

Sanitary/septic waste management practices are implemented on all construction sites that use temporary or portable sanitary/septic waste systems.

Limitations

- None identified.

Standards and Specifications

Education

- Educate employees, subcontractors, and suppliers on sanitary/septic waste storage and disposal procedures.
- Educate employees, subcontractors, and suppliers of potential dangers to humans and the environment from sanitary/septic wastes.
- Instruct employees, subcontractors, and suppliers in identification of sanitary/septic waste.
- Hold regular meetings to discuss and reinforce disposal procedures (incorporate into regular safety meetings).
- Establish a continuing education program to indoctrinate new employees.

Storage and Disposal Procedures

- Temporary sanitary facilities shall be located away from drainage facilities, watercourses, and from traffic circulation. When subjected to high winds or risk.

- Wastewater shall not be discharged or buried within the highway right-of-way.
- Sanitary and septic systems that discharge directly into sanitary sewer systems, where permissible, shall comply with the local health agency, city, county, and sewer district requirements.
- If using an on site disposal system, such as a septic system, comply with local health agency requirements.
- Properly connect temporary sanitary facilities that discharge to the sanitary sewer system to avoid illicit discharges.
- Ensure that sanitary/septic facilities are maintained in good working order by a licensed service.
- Use only reputable, licensed sanitary/septic waste haulers.

Maintenance and Inspection

- The Contractor's Water Pollution Control Manager (WPCM) shall monitor onsite sanitary/septic waste storage and disposal procedures at least weekly.

Flat areas that have a slope no greater than 3% may be configured as described below to provide a desilting function, thus eliminating the need for other protection. The following requirements control the use of this option:

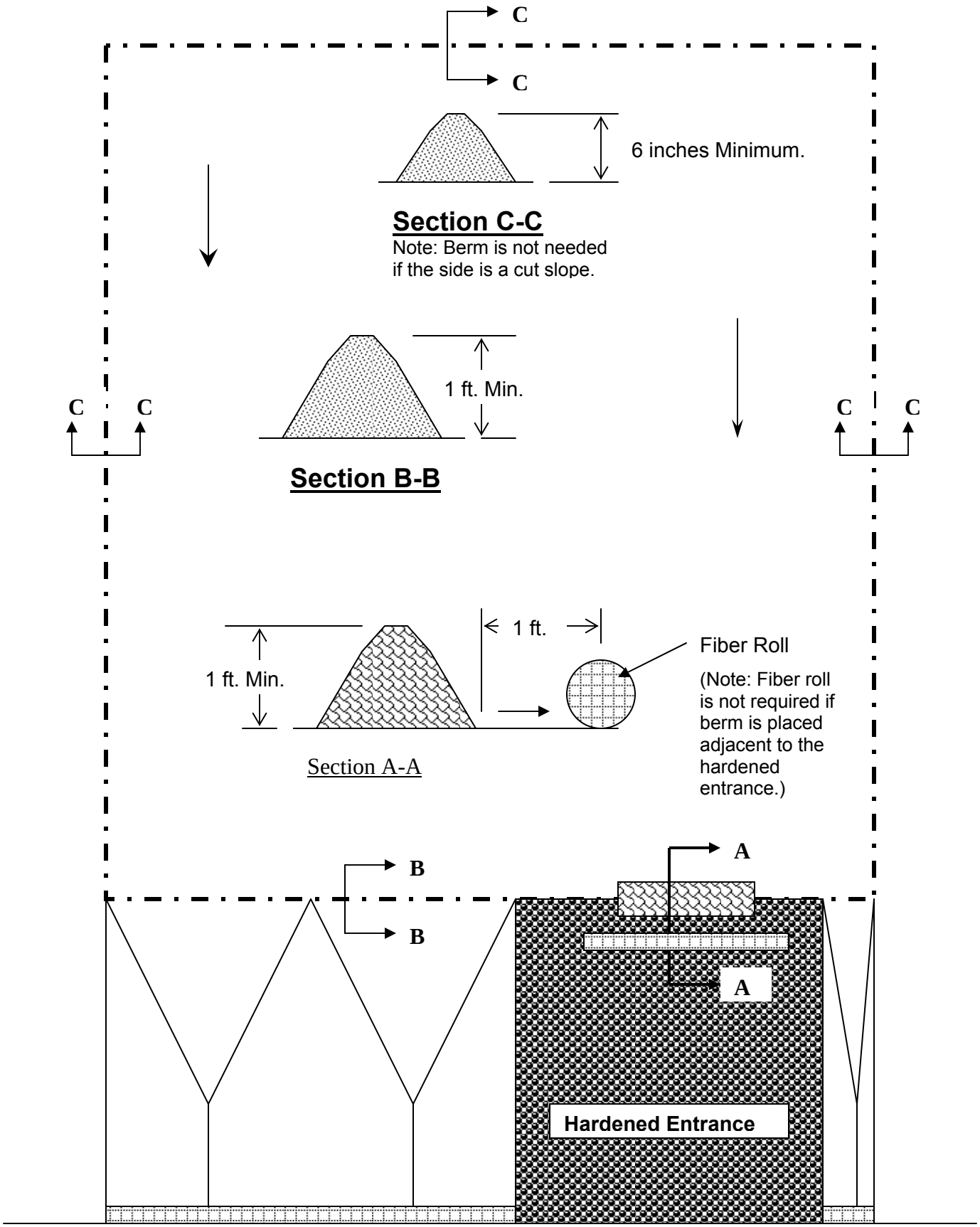
- Maximum holding time is 72 hours.
- Maximum size for using Lot Perimeter Protection is 1 acre of disturbed area.
- Basin shall be sized for the entire pad. Each pad shall be treated separately.
- A berm with a minimum height of 1 foot, shall be placed and compacted along the outlet side. A berm, with a minimum height of 6 inches, shall be installed and compacted around the remaining perimeter of the pad.
- A rock filter shall be placed at the outlet location to slowly release the captured flows. For basins sized between 1 to 0.75 acre the rock filter shall be 6 feet in length. For basins that are sized less than 0.75 acre but greater than 0.10 acre the rock filter shall be 4 feet in length. For basins that are less than or equal to 0.10 acre the rock filter shall be 2 feet in length.
- The rock filter shall have a minimum width of 1 foot.
- The minimum height of the rock filter shall be 1 foot.
- The rock size shall be between 1 to 3 inches in diameter.
- Fiber roll with the equivalent length of the rock filter shall be properly placed 1 foot downstream of the rock filter.
- Access to the pad shall be restricted to prevent tracking off of the pad or appropriate tracking control installed.
- A sketch of this option is on the back of this form.

Maintenance and Inspection of all Desiltation Basins

- Inspect all basins before and after rainfall events and weekly during the rest of the rainy season. During extended rainfall events, inspect at least every 24 hours. Examine basin banks for seepage and structural soundness. Repair banks as needed.
- Check outlet structure and spillway for any damage or obstructions. Repair damages and remove obstructions as needed. Check outlet area for erosion and stabilize, if required.
- Remove accumulated sediment when the depth has reached one-third the original basin depth.

5201 RUFFIN ROAD, SUITE B, SAN DIEGO, CA 92123 • (858) 565-5920 • (888) 336-7553
HTTP://WWW.SDCDPLU.ORG

Standard Lot Perimeter Protection Detail



Soil

Rock, 1 to 3 inch in diameter

Class 2 Min.

Fiber Roll

County of San Diego, Department of Planning and Land Use

COUNTY STANDARD DESILTING BASIN FOR DISTURBED AREAS OF 1 ACRE OR LESS

BUILDING DIVISION

Standard Basin Design & Limitations

The below described standard design may only be used for drainage areas less than one acre. The use of a basin requires regular maintenance to remove silt deposits and may require protective fencing, and both should be identified on grading plans. Basins are not to be located in live streams. Sediment basin should be constructed prior to the rainy season and prior to any other construction activities.

- Basin shall be located: (1) where a low embankment can be constructed across a swale or excavation, (2) where failure would not cause loss of life or property damage, and (3) in areas accessible for maintenance work, including sediment removal and sediment stockpiling in a protected area.
- Minimum dimensions are specified in the table on the drawing on page 2 of this form.
- Basin inlets shall be located to maximize travel distance to the basin outlet. Rock, vegetation or plastic sheeting shall be used to protect the basin inlet and slopes against erosion. An emergency spillway shall be constructed using plastic sheeting or rock lining over undisturbed material.
- Outlet shall consist of a 4" perforated drainpipe riser and an inlet grate attached to the top of the riser. Attach riser to a 4" HDPE horizontal pipe (barrel) with a 90^{o} elbow. The horizontal pipe shall extend through the embankment to toe of fill. Place outlet structure on firm, smooth foundation with base securely anchored with gravel jacket or other means to prevent floatation. Compact fill over outlet pipe. Use outlet protection (1" size rock/gravel minimum) at the pipe outlet.
- Safety fencing is recommended on all applications, but if basin is within 300 feet of an existing residence or is visible from an existing residence, safety fence must be provided to prevent unauthorized entry to the basin unless a perimeter fence already protects site.

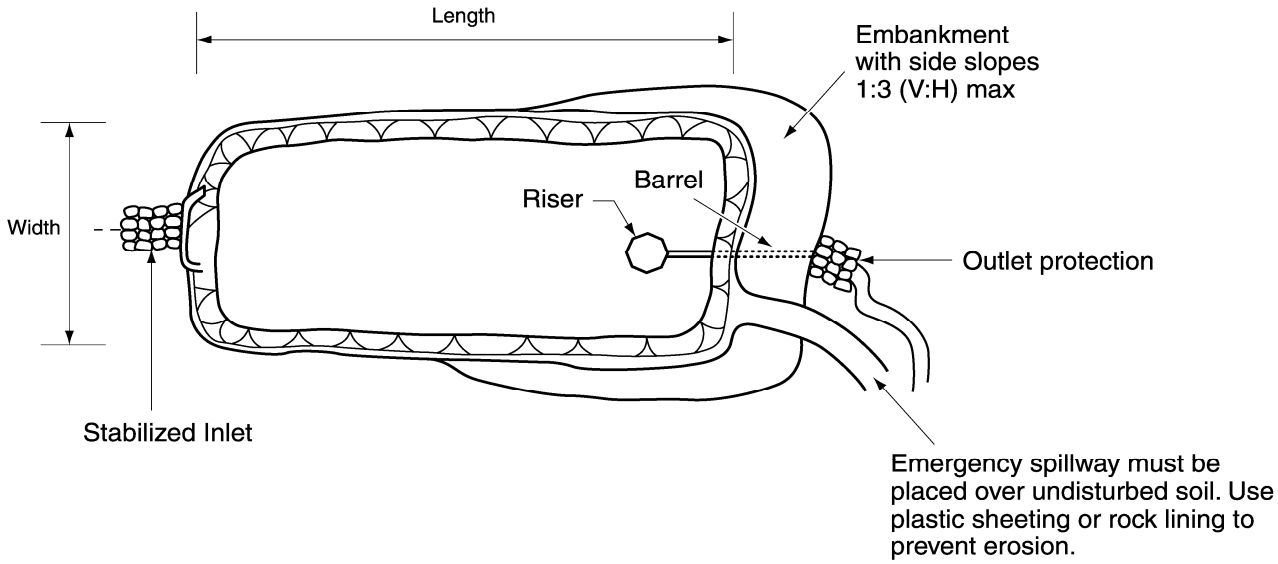
Maintenance and Inspection of all Desiltation Basins

- Inspect all basins before and after rainfall events and weekly during the rest of the rainy season. During extended rainfall events, inspect at least every 24 hours. Examine basin banks for seepage and structural soundness. Repair banks as needed.
- Check outlet structure and spillway for any damage or obstructions. Repair damages and remove obstructions as needed. Check outlet area for erosion and stabilize, if required.
- Remove accumulated sediment when the depth has reached one-third the original basin depth.

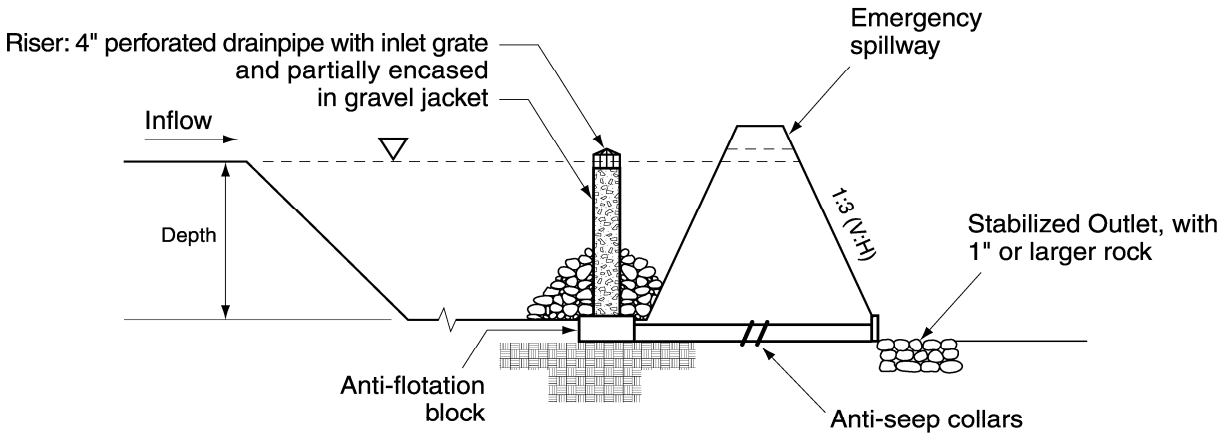
5201 RUFFIN ROAD, SUITE B, SAN DIEGO, CA 92123 • (858) 565-5920 • (888) 336-7553
HTTP://WWW.SDCDPLU.ORG

COUNTY STANDARD DESILTING BASIN
FOR DISTURBED AREAS OF 1 ACRE OR LESS

TOP VIEW



SECTION VIEW



NOTE: This outlet provides complete draining of basin

Basin Dimensions (Feet)	1 Acre Lot	½ Acre Lot	¼ Acre Lot
Length	40	30	25
Width	20	15	12
Depth	5	4	3

Site Design & Landscape Planning SD-10

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Each project site possesses unique topographic, hydrologic, and vegetative features, some of which are more suitable for development than others. Integrating and incorporating appropriate landscape planning methodologies into the project design is the most effective action that can be done to minimize surface and groundwater contamination from stormwater.

Approach

Landscape planning should couple consideration of land suitability for urban uses with consideration of community goals and projected growth. Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for site design and landscapes planning should conform to applicable standards and specifications of agencies with jurisdiction and be consistent with applicable General Plan and Local Area Plan policies.

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

Designing New Installations

Begin the development of a plan for the landscape unit with attention to the following general principles:

- Formulate the plan on the basis of clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.
- Map and assess land suitability for urban uses. Include the following landscape features in the assessment: wooded land, open unwooded land, steep slopes, erosion-prone soils, foundation suitability, soil suitability for waste disposal, aquifers, aquifer recharge areas, wetlands, floodplains, surface waters, agricultural lands, and various categories of urban land use. When appropriate, the assessment can highlight outstanding local or regional resources that the community determines should be protected (e.g., a scenic area, recreational area, threatened species habitat, farmland, fish run). Mapping and assessment should recognize not only these resources but also additional areas needed for their sustenance.

Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Conserve Natural Areas during Landscape Planning

If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Cluster development on least-sensitive portions of a site while leaving the remaining land in a natural undisturbed condition.
- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.
- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.
- Promote natural vegetation by using parking lot islands and other landscaped areas.
- Preserve riparian areas and wetlands.

Maximize Natural Water Storage and Infiltration Opportunities Within the Landscape Unit

- Promote the conservation of forest cover. Building on land that is already deforested affects basin hydrology to a lesser extent than converting forested land. Loss of forest cover reduces interception storage, detention in the organic forest floor layer, and water losses by evapotranspiration, resulting in large peak runoff increases and either their negative effects or the expense of countering them with structural solutions.
- Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Develop and implement policies and

regulations to discourage the clearing, filling, and channelization of these features. Utilize them in drainage networks in preference to pipes, culverts, and engineered ditches.

- Evaluating infiltration opportunities by referring to the stormwater management manual for the jurisdiction and pay particular attention to the selection criteria for avoiding groundwater contamination, poor soils, and hydrogeological conditions that cause these facilities to fail. If necessary, locate developments with large amounts of impervious surfaces or a potential to produce relatively contaminated runoff away from groundwater recharge areas.

Protection of Slopes and Channels during Landscape Design

- Convey runoff safely from the tops of slopes.
- Avoid disturbing steep or unstable slopes.
- Avoid disturbing natural channels.
- Stabilize disturbed slopes as quickly as possible.
- Vegetate slopes with native or drought tolerant vegetation.
- Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems.
- Stabilize temporary and permanent channel crossings as quickly as possible, and ensure that increases in run-off velocity and frequency caused by the project do not erode the channel.
- Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion. Energy dissipaters shall be installed in such a way as to minimize impacts to receiving waters.
- Line on-site conveyance channels where appropriate, to reduce erosion caused by increased flow velocity due to increases in tributary impervious area. The first choice for linings should be grass or some other vegetative surface, since these materials not only reduce runoff velocities, but also provide water quality benefits from filtration and infiltration. If velocities in the channel are high enough to erode grass or other vegetative linings, riprap, concrete, soil cement, or geo-grid stabilization are other alternatives.
- Consider other design principles that are comparable and equally effective.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Redevelopment may present significant opportunity to add features which had not previously been implemented. Examples include incorporation of depressions, areas of permeable soils, and swales in newly redeveloped areas. While some site constraints may exist due to the status of already existing infrastructure, opportunities should not be missed to maximize infiltration, slow runoff, reduce impervious areas, disconnect directly connected impervious areas.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Stormwater Management Manual for Western Washington, Washington State Department of Ecology, August 2001.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Roof Runoff Controls SD-11

Rain Garden

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

Description

Various roof runoff controls are available to address stormwater that drains off rooftops. The objective is to reduce the total volume and rate of runoff from individual lots, and retain the pollutants on site that may be picked up from roofing materials and atmospheric deposition. Roof runoff controls consist of directing the roof runoff away from paved areas and mitigating flow to the storm drain system through one of several general approaches: cisterns or rain barrels; dry wells or infiltration trenches; pop-up emitters, and foundation planting. The first three approaches require the roof runoff to be contained in a gutter and downspout system. Foundation planting provides a vegetated strip under the drip line of the roof.

Approach

Design of individual lots for single-family homes as well as lots for higher density residential and commercial structures should consider site design provisions for containing and infiltrating roof runoff or directing roof runoff to vegetative swales or buffer areas. Retained water can be reused for watering gardens, lawns, and trees. Benefits to the environment include reduced demand for potable water used for irrigation, improved stormwater quality, increased groundwater recharge, decreased runoff volume and peak flows, and decreased flooding potential.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Designing New Installations

Cisterns or Rain Barrels

One method of addressing roof runoff is to direct roof downspouts to cisterns or rain barrels. A cistern is an above ground storage vessel with either a manually operated valve or a permanently open outlet. Roof runoff is temporarily stored and then released for irrigation or infiltration between storms. The number of rain

barrels needed is a function of the rooftop area. Some low impact developers recommend that every house have at least 2 rain barrels, with a minimum storage capacity of 1000 liters. Roof barrels serve several purposes including mitigating the first flush from the roof which has a high volume, amount of contaminants, and thermal load. Several types of rain barrels are commercially available. Consideration must be given to selecting rain barrels that are vector proof and childproof. In addition, some barrels are designed with a bypass valve that filters out grit and other contaminants and routes overflow to a soak-away pit or rain garden.

If the cistern has an operable valve, the valve can be closed to store stormwater for irrigation or infiltration between storms. This system requires continual monitoring by the resident or grounds crews, but provides greater flexibility in water storage and metering. If a cistern is provided with an operable valve and water is stored inside for long periods, the cistern must be covered to prevent mosquitoes from breeding.

A cistern system with a permanently open outlet can also provide for metering stormwater runoff. If the cistern outlet is significantly smaller than the size of the downspout inlet (say ¼ to ½ inch diameter), runoff will build up inside the cistern during storms, and will empty out slowly after peak intensities subside. This is a feasible way to mitigate the peak flow increases caused by rooftop impervious land coverage, especially for the frequent, small storms.

Dry wells and Infiltration Trenches

Roof downspouts can be directed to dry wells or infiltration trenches. A dry well is constructed by excavating a hole in the ground and filling it with an open graded aggregate, and allowing the water to fill the dry well and infiltrate after the storm event. An underground connection from the downspout conveys water into the dry well, allowing it to be stored in the voids. To minimize sedimentation from lateral soil movement, the sides and top of the stone storage matrix can be wrapped in a permeable filter fabric, though the bottom may remain open. A perforated observation pipe can be inserted vertically into the dry well to allow for inspection and maintenance.

In practice, dry wells receiving runoff from single roof downspouts have been successful over long periods because they contain very little sediment. They must be sized according to the amount of rooftop runoff received, but are typically 4 to 5 feet square, and 2 to 3 feet deep, with a minimum of 1-foot soil cover over the top (maximum depth of 10 feet).

To protect the foundation, dry wells must be set away from the building at least 10 feet. They must be installed in solids that accommodate infiltration. In poorly drained soils, dry wells have very limited feasibility.

Infiltration trenches function in a similar manner and would be particularly effective for larger roof areas. An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. These are described under Treatment Controls.

Pop-up Drainage Emitter

Roof downspouts can be directed to an underground pipe that daylights some distance from the building foundation, releasing the roof runoff through a pop-up emitter. Similar to a pop-up irrigation head, the emitter only opens when there is flow from the roof. The emitter remains flush to the ground during dry periods, for ease of lawn or landscape maintenance.

Foundation Planting

Landscape planting can be provided around the base to allow increased opportunities for stormwater infiltration and protect the soil from erosion caused by concentrated sheet flow coming off the roof. Foundation plantings can reduce the physical impact of water on the soil and provide a subsurface matrix of roots that encourage infiltration. These plantings must be sturdy enough to tolerate the heavy runoff sheet flows, and periodic soil saturation.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Supplemental Information

Examples

- City of Ottawa's Water Links Surface –Water Quality Protection Program
- City of Toronto Downspout Disconnection Program
- City of Boston, MA, Rain Barrel Demonstration Program

Other Resources

Hager, Marty Catherine, Stormwater, "Low-Impact Development", January/February 2003. www.stormh2o.com

Low Impact Urban Design Tools, Low Impact Development Design Center, Beltsville, MD. www.lid-stormwater.net

Start at the Source, Bay Area Stormwater Management Agencies Association, 1999 Edition

Efficient Irrigation SD-12

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Irrigation water provided to landscaped areas may result in excess irrigation water being conveyed into stormwater drainage systems.

Approach

Project plan designs for development and redevelopment should include application methods of irrigation water that minimize runoff of excess irrigation water into the stormwater conveyance system.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

Design Considerations

Designing New Installations

The following methods to reduce excessive irrigation runoff should be considered, and incorporated and implemented where determined applicable and feasible by the Permittee:

- Employ rain-triggered shutoff devices to prevent irrigation after precipitation.
- Design irrigation systems to each landscape area's specific water requirements.
- Include design featuring flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.
- Implement landscape plans consistent with County or City water conservation resolutions, which may include provision of water sensors, programmable irrigation times (for short cycles), etc.

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

- Design timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the storm water drainage system.
- Group plants with similar water requirements in order to reduce excess irrigation runoff and promote surface filtration. Choose plants with low irrigation requirements (for example, native or drought tolerant species). Consider design features such as:
  - Using mulches (such as wood chips or bar) in planter areas without ground cover to minimize sediment in runoff
  - Installing appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant materials where possible and/or as recommended by the landscape architect
  - Leaving a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible
  - Choosing plants that minimize or eliminate the use of fertilizer or pesticides to sustain growth
- Employ other comparable, equally effective methods to reduce irrigation water runoff.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Storm Drain Signage SD-13

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- ☑ Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Waste materials dumped into storm drain inlets can have severe impacts on receiving and ground waters. Posting notices regarding discharge prohibitions at storm drain inlets can prevent waste dumping. Storm drain signs and stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets.

Approach

The stencil or affixed sign contains a brief statement that prohibits dumping of improper materials into the urban runoff conveyance system. Storm drain messages have become a popular method of alerting the public about the effects of and the prohibitions against waste disposal.

Suitable Applications

Stencils and signs alert the public to the destination of pollutants discharged to the storm drain. Signs are appropriate in residential, commercial, and industrial areas, as well as any other area where contributions or dumping to storm drains is likely.

Design Considerations

Storm drain message markers or placards are recommended at all storm drain inlets within the boundary of a development project. The marker should be placed in clear sight facing toward anyone approaching the inlet from either side. All storm drain inlet locations should be identified on the development site map.

Designing New Installations

The following methods should be considered for inclusion in the project design and show on project plans:

- Provide stenciling or labeling of all storm drain inlets and catch basins, constructed or modified, within the project area with prohibitive language. Examples include "NO DUMPING

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

– DRAINS TO OCEAN" and/or other graphical icons to discourage illegal dumping.

- Post signs with prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points along channels and creeks within the project area.

Note - Some local agencies have approved specific signage and/or storm drain message placards for use. Consult local agency stormwater staff to determine specific requirements for placard types and methods of application.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. If the project meets the definition of "redevelopment", then the requirements stated under " designing new installations" above should be included in all project design plans.

Additional Information

Maintenance Considerations

- Legibility of markers and signs should be maintained. If required by the agency with jurisdiction over the project, the owner/operator or homeowner's association should enter into a maintenance agreement with the agency or record a deed restriction upon the property title to maintain the legibility of placards or signs.

Placement

- Signage on top of curbs tends to weather and fade.

- Signage on face of curbs tends to be worn by contact with vehicle tires and sweeper brooms.

Supplemental Information

Examples

- Most MS4 programs have storm drain signage programs. Some MS4 programs will provide stencils, or arrange for volunteers to stencil storm drains as part of their outreach program.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Pervious Pavements SD-20

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Pervious paving is used for light vehicle loading in parking areas. The term describes a system comprising a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface can itself be porous such that water infiltrates across the entire surface of the material (e.g., grass and gravel surfaces, porous concrete and porous asphalt), or can be built up of impermeable blocks separated by spaces and joints, through which the water can drain. This latter system is termed 'permeable' paving. Advantages of pervious pavements is that they reduce runoff volume while providing treatment, and are unobtrusive resulting in a high level of acceptability.

Approach

Attenuation of flow is provided by the storage within the underlying structure or sub base, together with appropriate flow controls. An underlying geotextile may permit groundwater recharge, thus contributing to the restoration of the natural water cycle. Alternatively, where infiltration is inappropriate (e.g., if the groundwater vulnerability is high, or the soil type is unsuitable), the surface can be constructed above an impermeable membrane. The system offers a valuable solution for drainage of spatially constrained urban areas.

Significant attenuation and improvement in water quality can be achieved by permeable pavements, whichever method is used. The surface and subsurface infrastructure can remove both the soluble and fine particulate pollutants that occur within urban runoff. Roof water can be piped into the storage area directly, adding areas from which the flow can be attenuated. Also, within lined systems, there is the opportunity for stored runoff to be piped out for reuse.

Suitable Applications

Residential, commercial and industrial applications are possible. The use of permeable pavement may be restricted in cold regions, arid regions or regions with high wind erosion. There are some specific disadvantages associated with permeable pavement, which are as follows:

- Permeable pavement can become clogged if improperly installed or maintained. However, this is countered by the ease with which small areas of paving can be cleaned or replaced when blocked or damaged.
- Their application should be limited to highways with low traffic volumes, axle loads and speeds (less than 30 mph limit), car parking areas and other lightly trafficked or non-trafficked areas. Permeable surfaces are currently not considered suitable for adoptable roads due to the risks associated with failure on high speed roads, the safety implications of ponding, and disruption arising from reconstruction.
- When using un-lined, infiltration systems, there is some risk of contaminating groundwater, depending on soil conditions and aquifer susceptibility. However, this risk is likely to be small because the areas drained tend to have inherently low pollutant loadings.
- The use of permeable pavement is restricted to gentle slopes.
- Porous block paving has a higher risk of abrasion and damage than solid blocks.

Design Considerations

Designing New Installations

If the grades, subsoils, drainage characteristics, and groundwater conditions are suitable, permeable paving may be substituted for conventional pavement on parking areas, cul de sacs and other areas with light traffic. Slopes should be flat or very gentle. Scottish experience has shown that permeable paving systems can be installed in a wide range of ground conditions, and the flow attenuation performance is excellent even when the systems are lined.

The suitability of a pervious system at a particular pavement site will, however, depend on the loading criteria required of the pavement.

Where the system is to be used for infiltrating drainage waters into the ground, the vulnerability of local groundwater sources to pollution from the site should be low, and the seasonal high water table should be at least 4 feet below the surface.

Ideally, the pervious surface should be horizontal in order to intercept local rainfall at source. On sloping sites, pervious surfaces may be terraced to accommodate differences in levels.

Design Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and their required operational life. To provide satisfactory performance, the following criteria should be considered:

- The subgrade should be able to sustain traffic loading without excessive deformation.
- The granular capping and sub-base layers should give sufficient load-bearing to provide an adequate construction platform and base for the overlying pavement layers.
- The pavement materials should not crack of suffer excessive rutting under the influence of traffic. This is controlled by the horizontal tensile stress at the base of these layers.

There is no current structural design method specifically for pervious pavements. Allowances should be considered the following factors in the design and specification of materials:

- Pervious pavements use materials with high permeability and void space. All the current UK pavement design methods are based on the use of conventional materials that are dense and relatively impermeable. The stiffness of the materials must therefore be assessed.
- Water is present within the construction and can soften and weaken materials, and this must be allowed for.
- Existing design methods assume full friction between layers. Any geotextiles or geomembranes must be carefully specified to minimize loss of friction between layers.
- Porous asphalt loses adhesion and becomes brittle as air passes through the voids. Its durability is therefore lower than conventional materials.

The single sized grading of materials used means that care should be taken to ensure that loss of finer particles between unbound layers does not occur.

Positioning a geotextile near the surface of the pervious construction should enable pollutants to be trapped and retained close to the surface of the construction. This has both advantages and disadvantages. The main disadvantage is that the filtering of sediments and their associated pollutants at this level may hamper percolation of waters and can eventually lead to surface ponding. One advantage is that even if eventual maintenance is required to reinstate infiltration, only a limited amount of the construction needs to be disturbed, since the sub-base below the geotextile is protected. In addition, the pollutant concentration at a high level in the structure allows for its release over time. It is slowly transported in the stormwater to lower levels where chemical and biological processes may be operating to retain or degrade pollutants.

The design should ensure that sufficient void space exists for the storage of sediments to limit the period between remedial works.

- Pervious pavements require a single size grading to give open voids. The choice of materials is therefore a compromise between stiffness, permeability and storage capacity.
- Because the sub-base and capping will be in contact with water for a large part of the time, the strength and durability of the aggregate particles when saturated and subjected to wetting and drying should be assessed.
- A uniformly graded single size material cannot be compacted and is liable to move when construction traffic passes over it. This effect can be reduced by the use of angular crushed rock material with a high surface friction.

In pollution control terms, these layers represent the site of long term chemical and biological pollutant retention and degradation processes. The construction materials should be selected, in addition to their structural strength properties, for their ability to sustain such processes. In general, this means that materials should create neutral or slightly alkaline conditions and they should provide favorable sites for colonization by microbial populations.

Construction/Inspection Considerations

- Permeable surfaces can be laid without cross-falls or longitudinal gradients.
- The blocks should be lain level
- They should not be used for storage of site materials, unless the surface is well protected from deposition of silt and other spillages.
- The pavement should be constructed in a single operation, as one of the last items to be built, on a development site. Landscape development should be completed before pavement construction to avoid contamination by silt or soil from this source.
- Surfaces draining to the pavement should be stabilized before construction of the pavement.
- Inappropriate construction equipment should be kept away from the pavement to prevent damage to the surface, sub-base or sub-grade.

Maintenance Requirements

The maintenance requirements of a pervious surface should be reviewed at the time of design and should be clearly specified. Maintenance is required to prevent clogging of the pervious surface. The factors to be considered when defining maintenance requirements must include:

- Type of use
- Ownership
- Level of trafficking
- The local environment and any contributing catchments

Studies in the UK have shown satisfactory operation of porous pavement systems without maintenance for over 10 years and recent work by Imbe et al. at 9th ICUD, Portland, 2002 describes systems operating for over 20 years without maintenance. However, performance under such regimes could not be guaranteed, Table 1 shows typical recommended maintenance regimes:

Table 1 Typical Recommended Maintenance Regimes	
Activity	**Schedule**
■ Minimize use of salt or grit for de-icing ■ Keep landscaped areas well maintained ■ Prevent soil being washed onto pavement	Ongoing
■ Vacuum clean surface using commercially available sweeping machines at the following times: - End of winter (April) - Mid-summer (July / August) - After Autumn leaf-fall (November)	2/3 x per year
■ Inspect outlets	Annual
■ If routine cleaning does not restore infiltration rates, then reconstruction of part of the whole of a pervious surface may be required. ■ The surface area affected by hydraulic failure should be lifted for inspection of the internal materials to identify the location and extent of the blockage. ■ Surface materials should be lifted and replaced after brush cleaning. Geotextiles may need complete replacement. ■ Sub-surface layers may need cleaning and replacing. ■ Removed silts may need to be disposed of as controlled waste.	As needed (infrequent) Maximum 15-20 years

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 1 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Cost Considerations

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 2 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Table 2 Engineer's Estimate for Porous Pavement

Porous Pavement													
Item	Units	Price	Cycles/ Year	Quant. 1 Acre WS	Total	Quant. 2 Acre WS	Total	Quant. 3 Acre WS	Total	Quant. 4 Acre WS	Total	Quant. 5 Acre WS	Total
Grading	SY	$2.00		604	$1,208	1209	$2,418	1812	$3,624	2419	$4,838	3020	$6,040
Paving	SY	$19.00		212	$4,028	424	$8,056	636	$12,084	848	$16,112	1060	$20,140
Excavation	CY	$3.60		201	$724	403	$1,451	604	$2,174	806	$2,902	1008	$3,629
Filter Fabric	SY	$1.15		700	$805	1400	$1,610	2000	$2,300	2800	$3,220	3600	$4,140
Stone Fill	CY	$16.00		201	$3,216	403	$6,448	604	$9,664	806	$12,896	1008	$16,128
Sand	CY	$7.00		100	$700	200	$1,400	300	$2,100	400	$2,800	500	$3,500
Sight Well	EA	$300.00		2	$600	3	$900	4	$1,200	7	$2,100	7	$2,100
Seeding	LF	$0.05		644	$32	1288	$64	1932	$97	2576	$129	3220	$161
Check Dam	CY	$35.00		0	$0	0	$0	0	$0	0	$0	0	$0
Total Construction Costs					**$10,105**		**$19,929**		**$29,619**		**$40,158**		**$49,798**
Construction Costs Amortized for 20 Years					**$505**		**$996**		**$1,481**		**$2,008**		**$2,490**
Annual Maintenance Expense													
Item	Units	Price	Cycles/ Year	Quant. 1 Acre WS	Total	Quant. 2 Acre WS	Total	Quant. 3 Acre WS	Total	Quant. 4 Acre WS	Total	Quant. 5 Acre WS	Total
Sweeping	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Washing	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Inspection	MH	$20.00	5	5	$100	5	$100	5	$100	5	$100	5	$100
Deep Clean	AC	$450.00	0.5	1	$225	2	$450	3	$675	3.9	$878	5	$1,125
Total Annual Maintenance Expense					**$3,960**		**$7,792**		**$11,651**		**$15,483**		**$19,370**

Other Resources

Abbott C.L. and Comino-Mateos L. 2001. *In situ performance monitoring of an infiltration drainage system and field testing of current design procedures*. Journal CIWEM, 15(3), pp.198-202.

Construction Industry Research and Information Association (CIRIA). 2002. *Source Control using Constructed Pervious Surfaces C582*, London, SW1P 3AU.

Construction Industry Research and Information Association (CIRIA). 2000. *Sustainable urban drainage systems - design manual for Scotland and Northern Ireland Report C521*, London, SW1P 3AU.

Construction Industry Research and Information Association (CIRIA). 2000 C522 *Sustainable urban drainage systems - design manual for England and Wales*, London, SW1P 3AU.

Construction Industry Research and Information Association (CIRIA). *RP448 Manual of good practice for the design, construction and maintenance of infiltration drainage systems for stormwater runoff control and disposal*, London, SW1P 3AU.

Dierkes C., Kuhlmann L., Kandasamy J. & Angelis G. Pollution Retention Capability and Maintenance of Permeable Pavements. *Proc 9th International Conference on Urban Drainage, Portland Oregon, September 2002*.

Hart P (2002) Permeable Paving as a Stormwater Source Control System. *Paper presented at Scottish Hydraulics Study Group 14th* Annual seminar, SUDS. 22 March 2002, Glasgow.

Kobayashi M., 1999. Stormwater runoff control in Nagoya City. Proc. 8 th Int. Conf. on

Urban Storm Drainage, Sydney, Australia, pp.825-833.

Landphair, H., McFalls, J., Thompson, D., 2000, Design Methods, Selection, and Cost Effectiveness of Stormwater Quality Structures, Texas Transportation Institute Research Report 1837-1, College Station, Texas.

Legret M, Colandini V, Effects of a porous pavement with reservior strucutre on runoff water:water quality and the fate of heavy metals. Laboratoire Central Des Ponts et Chaussesss

Macdonald K. & Jefferies C. Performance Comparison of Porous Paved and Traditional Car Parks. *Proc. First National Conference on Sustainable Drainage Systems, Coventry June 2001*.

Niemczynowicz J, Hogland W, 1987: Test of porous pavements performed in Lund, Sweden, in Topics in Drainage Hydraulics and Hydrology. BC. Yen (Ed.), pub. Int. Assoc. For Hydraulic Research, pp 19-80.

Pratt C.J. SUSTAINABLE URBAN DRAINAGE – A Review of published material on the performance of various SUDS devices prepared for the UK Environment Agency. Coventry University, UK December 2001.

Pratt C.J., 1995. Infiltration drainage – case studies of UK practice. Project Report

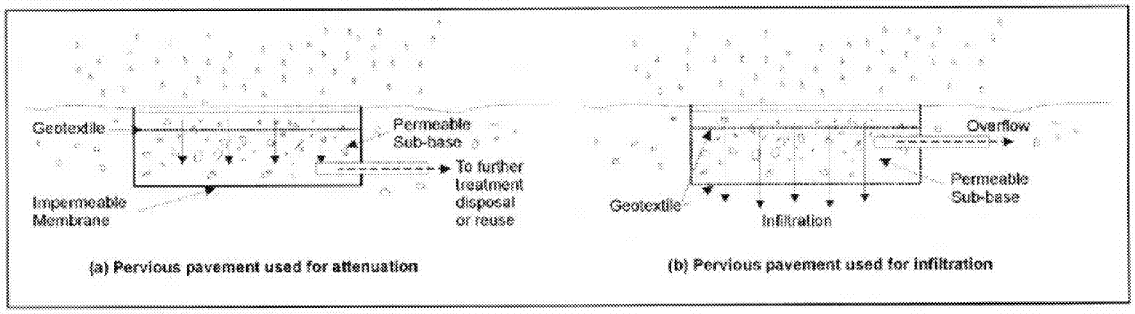
22,Construction Industry Research and Information Association, London, SW1P 3AU; also known as National Rivers Authority R & D Note 485

Pratt. C. J., 1990. Permeable Pavements for Stormwater Quality Enhancement. In: Urban Stormwater Quality Enhancement - Source Control, retrofitting and combined sewer technology, Ed. H.C. Torno, ASCE, ISBN 087262 7594, pp. 131-155

Raimbault G., 1997 French Developments in Reservoir Structures Sustainable water resources I the 21st century. Malmo Sweden

Schlüter W. & Jefferies C. Monitoring the outflow from a *Porous Car Park Proc. First National Conference on Sustainable Drainage Systems, Coventry June 2001.*

Wild, T.C., Jefferies, C., and D'Arcy, B.J. SUDS in Scotland – the Scottish SUDS database Report No SR(02)09 *Scotland and Northern Ireland Forum for Environmental Research, Edinburgh.* In preparation August 2002.



Schematics of a Pervious Pavement System

Trash Storage Areas SD-32

Description

Trash storage areas are areas where a trash receptacle (s) are located for use as a repository for solid wastes. Stormwater runoff from areas where trash is stored or disposed of can be polluted. In addition, loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or creeks. Waste handling operations that may be sources of stormwater pollution include dumpsters, litter control, and waste piles.

Approach

This fact sheet contains details on the specific measures required to prevent or reduce pollutants in stormwater runoff associated with trash storage and handling. Preventative measures including enclosures, containment structures, and impervious pavements to mitigate spills, should be used to reduce the likelihood of contamination.

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

Design Considerations

Design requirements for waste handling areas are governed by Building and Fire Codes, and by current local agency ordinances and zoning requirements. The design criteria described in this fact sheet are meant to enhance and be consistent with these code and ordinance requirements. Hazardous waste should be handled in accordance with legal requirements established in Title 22, California Code of Regulation.

Wastes from commercial and industrial sites are typically hauled by either public or commercial carriers that may have design or access requirements for waste storage areas. The design criteria in this fact sheet are recommendations and are not intended to be in conflict with requirements established by the waste hauler. The waste hauler should be contacted prior to the design of your site trash collection areas. Conflicts or issues should be discussed with the local agency.

Designing New Installations

Trash storage areas should be designed to consider the following structural or treatment control BMPs:

- Design trash container areas so that drainage from adjoining roofs and pavement is diverted around the area(s) to avoid run-on. This might include berming or grading the waste handling area to prevent run-on of stormwater.
- Make sure trash container areas are screened or walled to prevent off-site transport of trash.

- Use lined bins or dumpsters to reduce leaking of liquid waste.
- Provide roofs, awnings, or attached lids on all trash containers to minimize direct precipitation and prevent rainfall from entering containers.
- Pave trash storage areas with an impervious surface to mitigate spills.
- Do not locate storm drains in immediate vicinity of the trash storage area.
- Post signs on all dumpsters informing users that hazardous materials are not to be disposed of therein.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Maintenance Considerations

The integrity of structural elements that are subject to damage (i.e., screens, covers, and signs) must be maintained by the owner/operator. Maintenance agreements between the local agency and the owner/operator may be required. Some agencies will require maintenance deed restrictions to be recorded of the property title. If required by the local agency, maintenance agreements or deed restrictions must be executed by the owner/operator before improvement plans are approved.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Outdoor Material Storage Areas SD-34

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutant
- Collect and Convey

Description

Proper design of outdoor storage areas for materials reduces opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the stormwater conveyance system. Materials may be in the form of raw products, by-products, finished products, and waste products. The type of pollutants associated with the materials will vary depending on the type of commercial or industrial activity.

Approach

Outdoor storage areas require a drainage approach different from the typical infiltration/detention strategy. In outdoor storage areas, infiltration is discouraged. Containment is encouraged. Preventative measures include enclosures, secondary containment structures and impervious surfaces.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Some materials are more of a concern than others. Toxic and hazardous materials must be prevented from coming in contact with stormwater. Non-toxic or non-hazardous materials do not have to be prevented from stormwater contact. However, these materials may have toxic effects on receiving waters if allowed to be discharged with stormwater in significant quantities. Accumulated material on an impervious surface could result in significant impact on the rivers or streams that receive the runoff.

Material may be stored in a variety of ways, including bulk piles, containers, shelving, stacking, and tanks. Stormwater contamination may be prevented by eliminating the possibility of stormwater contact with the material storage areas either through diversion, cover, or capture of the stormwater. Control measures may also include minimizing the storage area. Design

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

requirements for material storage areas are governed by Building and Fire Codes, and by current City or County ordinances and zoning requirements. Control measures are site specific, and must meet local agency requirements.

Designing New Installations

Where proposed project plans include outdoor areas for storage of materials that may contribute pollutants to the stormwater conveyance system, the following structural or treatment BMPS should be considered:

- Materials with the potential to contaminate stormwater should be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the stormwater conveyance system, or (2) protected by secondary containment structures such as berms, dikes, or curbs.
- The storage area should be paved and sufficiently impervious to contain leaks and spills.
- The storage area should slope towards a dead-end sump to contain spills and direct runoff from downspouts/roofs should be directed away from storage areas.
- The storage area should have a roof or awning that extends beyond the storage area to minimize collection of stormwater within the secondary containment area. A manufactured storage shed may be used for small containers.

Note that the location(s) of installations of where these preventative measures will be employed must be included on the map or plans identifying BMPs.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permits.

Other Resources

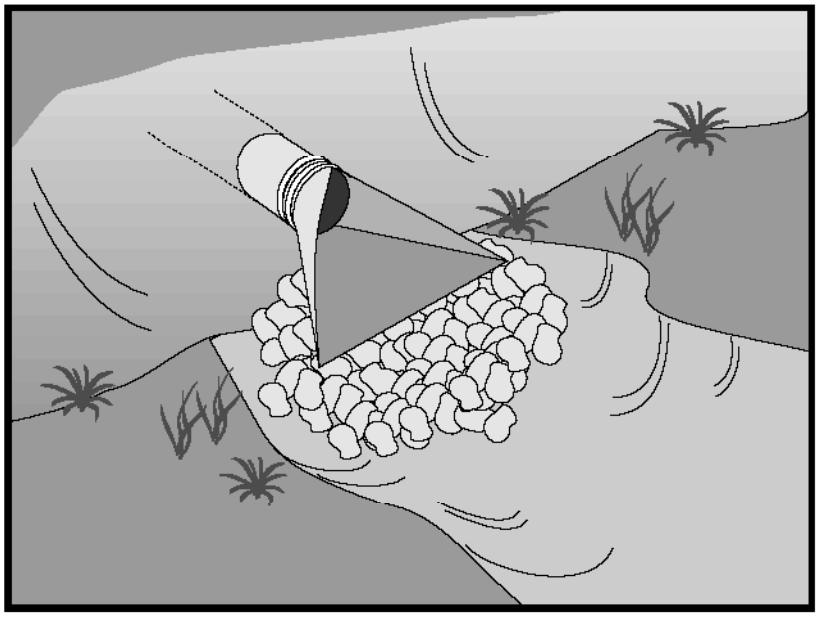
A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Velocity Dissipation Devices EC-10



Objectives

EC	Erosion Control	☑
SE	Sediment Control	
TR	Tracking Control	
WE	Wind Erosion Control	
NS	Non-Stormwater Management Control	
WM	Waste Management and Materials Pollution Control	

Legend:

☑ **Primary Objective**

☒ **Secondary Objective**

Targeted Constituents

Sediment	☑
Nutrients	
Trash	
Metals	
Bacteria	
Oil and Grease	
Organics	

Potential Alternatives

None

Description and Purpose

Outlet protection is a physical device composed of rock, grouted riprap, or concrete rubble, which is placed at the outlet of a pipe or channel to prevent scour of the soil caused by concentrated, high velocity flows.

Suitable Applications

Whenever discharge velocities and energies at the outlets of culverts, conduits, or channels are sufficient to erode the next downstream reach. This includes temporary diversion structures to divert runon during construction.

- These devices may be used at the following locations:
  - Outlets of pipes, drains, culverts, slope drains, diversion ditches, swales, conduits, or channels.
  - Outlets located at the bottom of mild to steep slopes.
  - Discharge outlets that carry continuous flows of water.
  - Outlets subject to short, intense flows of water, such as flash floods.
  - Points where lined conveyances discharge to unlined conveyances

Limitations

- Large storms or high flows can wash away the rock outlet protection and leave the area susceptible to erosion.

- Sediment captured by the rock outlet protection may be difficult to remove without removing the rock.
- Outlet protection may negatively impact the channel habitat.
- Grouted riprap may break up in areas of freeze and thaw.
- If there is not adequate drainage, and water builds up behind grouted riprap, it may cause the grouted riprap to break up due to the resulting hydrostatic pressure.

Implementation

General

Outlet protection is needed where discharge velocities and energies at the outlets of culverts, conduits or channels are sufficient to erode the immediate downstream reach. This practice protects the outlet from developing small eroded pools (plange pools), and protects against gully erosion resulting from scouring at a culvert mouth.

Design and Layout

As with most channel design projects, depth of flow, roughness, gradient, side slopes, discharge rate, and velocity should be considered in the outlet design. Compliance to local and state regulations should also be considered while working in environmentally sensitive streambeds. General recommendations for rock size and length of outlet protection mat are shown in the rock outlet protection figure in this BMP and should be considered minimums. The apron length and rock size gradation are determined using a combination of the discharge pipe diameter and estimate discharge rate: Select the longest apron length and largest rock size suggested by the pipe size and discharge rate. Where flows are conveyed in open channels such as ditches and swales, use the estimated discharge rate for selecting the apron length and rock size. Flows should be same as the culvert or channel design flow but never the less than the peak 5 year flow for temporary structures planned for one rainy season, or the 10 year peak flow for temporary structures planned for two or three rainy seasons.

- There are many types of energy dissipaters, with rock being the one that is represented in the attached figure.
- Best results are obtained when sound, durable, and angular rock is used.
- Install riprap, grouted riprap, or concrete apron at selected outlet. Riprap aprons are best suited for temporary use during construction. Grouted or wired tied rock riprap can minimize maintenance requirements.
- Rock outlet protection is usually less expensive and easier to install than concrete aprons or energy dissipaters. It also serves to trap sediment and reduce flow velocities.
- Carefully place riprap to avoid damaging the filter fabric.
  - Stone 4 in. to 6 in. may be carefully dumped onto filter fabric from a height not to exceed 12 in.
  - Stone 8 in. to 12 in. must be hand placed onto filter fabric, or the filter fabric may be covered with 4 in. of gravel and the 8 in. to 12 in. rock may be dumped from a height not to exceed 16 in.

- Stone greater than 12 in. shall only be dumped onto filter fabric protected with a layer of gravel with a thickness equal to one half the D_{50} rock size, and the dump height limited to twice the depth of the gravel protection layer thickness.

- For proper operation of apron: Align apron with receiving stream and keep straight throughout its length. If a curve is needed to fit site conditions, place it in upper section of apron.

- Outlets on slopes steeper than 10 percent should have additional protection.

Costs

Costs are low if material is readily available. If material is imported, costs will be higher. Average installed cost is $150 per device.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.

- Inspect BMPs subjected to non-stormwater discharges daily while non-stormwater discharges occur.

- Inspect apron for displacement of the riprap and damage to the underlying fabric. Repair fabric and replace riprap that has washed away. If riprap continues to wash away, consider using larger material.

- Inspect for scour beneath the riprap and around the outlet. Repair damage to slopes or underlying filter fabric immediately.

- Temporary devices should be completely removed as soon as the surrounding drainage area has been stabilized or at the completion of construction.

References

County of Sacramento Improvement Standards, Sacramento County, May 1989.

Erosion and Sediment Control Handbook, S.J. Goldman, K. Jackson, T.A. Bursztynsky, P.E., McGraw Hill Book Company, 1986.

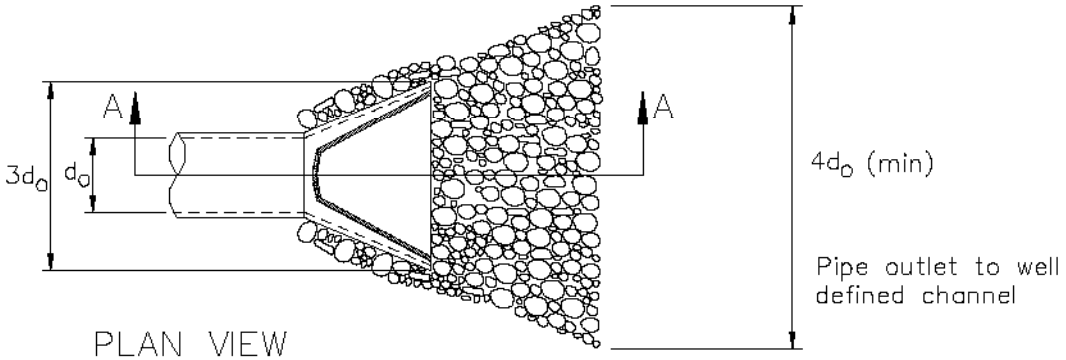
Handbook of Steel Drainage & Highway Construction, American Iron and Steel Institute, 1983.

Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, May 1995.

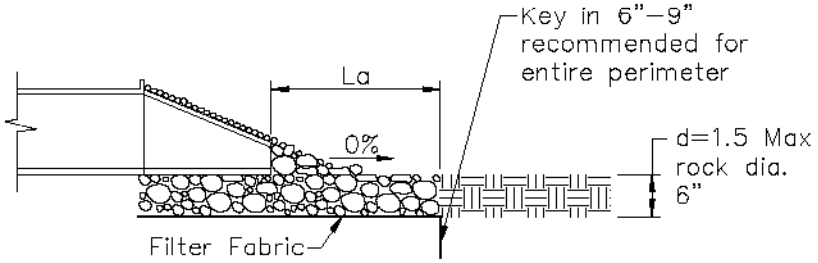
Stormwater Quality Handbooks Construction Site Best Management Practices (BMPs) Manual, state of California Department of Transportation (Caltrans), November 2000.

Stormwater Management of the Puget Sound Basin, Technical Manual, Publication #91-75, Washington State Department of Ecology, February 1992.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency, November 1988.



PLAN VIEW



SECTION A–A

Pipe Diameter inches	Discharge ft^3/s	Apron Length, La ft	Rip Rap D_{50} Diameter Min inches
12	5	10	4
	10	13	6
18	10	10	6
	20	16	8
	30	23	12
	40	26	16
24	30	16	8
	40	26	8
	50	26	12
	60	30	16

For larger or higher flows consult a Registered Civil Engineer
Source: USDA - SCS

Infiltration Trench TC-10

Design Considerations

- Accumulation of Metals
- Clogged Soil Outlet Structures
- Vegetation/Landscape Maintenance

Description

An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment entering the trench which can clog and render the trench ineffective.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend *(Removal Effectiveness)*

- ● Low
- ▲ Medium
- ■ High

California Experience

Caltrans constructed two infiltration trenches at highway maintenance stations in Southern California. Of these, one failed to operate to the design standard because of average soil infiltration rates lower than that measured in the single infiltration test. This highlights the critical need for appropriate evaluation of the site. Once in operation, little maintenance was required at either site.

Advantages

- Provides 100% reduction in the load discharged to surface waters.
- An important benefit of infiltration trenches is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated rather than flushed directly to creeks.
- If the water quality volume is adequately sized, infiltration trenches can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

- As an underground BMP, trenches are unobtrusive and have little impact of site aesthetics.

Limitations

- Have a high failure rate if soil and subsurface conditions are not suitable.
- May not be appropriate for industrial sites or locations where spills may occur.
- The maximum contributing area to an individual infiltration practice should generally be less than 5 acres.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration trenches once clogged.

Design and Sizing Guidelines

- Provide pretreatment for infiltration trenches in order to reduce the sediment load. Pretreatment refers to design features that provide settling of large particles before runoff reaches a management practice, easing the long-term maintenance burden. Pretreatment is important for all structural stormwater management practices, but it is particularly important for infiltration practices. To ensure that pretreatment mechanisms are effective, designers should incorporate practices such as grassed swales, vegetated filter strips, detention, or a plunge pool in series.
- Specify locally available trench rock that is 1.5 to 2.5 inches in diameter.
- Determine the trench volume by assuming the WQV will fill the void space based on the computed porosity of the rock matrix (normally about 35%).
- Determine the bottom surface area needed to drain the trench within 72 hr by dividing the WQV by the infiltration rate.

$$d = \frac{WQV + RFV}{SA}$$

- Calculate trench depth using the following equation:

where:

D = Trench depth

WQV	=	Water quality volume
RFV	=	Rock fill volume
SA	=	Surface area of the trench bottom

- The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).
- Provide observation well to allow observation of drain time.
- May include a horizontal layer of filter fabric just below the surface of the trench to retain sediment and reduce the potential for clogging.

Construction/Inspection Considerations

Stabilize the entire area draining to the facility before construction begins. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction. Stabilize the entire contributing drainage area before allowing any runoff to enter once construction is complete.

Performance

Infiltration trenches eliminate the discharge of the water quality volume to surface receiving waters and consequently can be considered to have 100% removal of all pollutants within this volume. Transport of some of these constituents to groundwater is likely, although the attenuation in the soil and subsurface layers will be substantial for many constituents.

Infiltration trenches can be expected to remove up to 90 percent of sediments, metals, coliform bacteria and organic matter, and up to 60 percent of phosphorus and nitrogen in the infiltrated runoff (Schueler, 1992). Biochemical oxygen demand (BOD) removal is estimated to be between 70 to 80 percent. Lower removal rates for nitrate, chlorides and soluble metals should be expected, especially in sandy soils (Schueler, 1992). Pollutant removal efficiencies may be improved by using washed aggregate and adding organic matter and loam to the subsoil. The stone aggregate should be washed to remove dirt and fines before placement in the trench. The addition of organic material and loam to the trench subsoil may enhance metals removal through adsorption.

Siting Criteria

The use of infiltration trenches may be limited by a number of factors, including type of native soils, climate, and location of groundwater table. Site characteristics, such as excessive slope of the drainage area, fine-grained soil types, and proximate location of the water table and bedrock, may preclude the use of infiltration trenches. Generally, infiltration trenches are not suitable for areas with relatively impermeable soils containing clay and silt or in areas with fill.

As with any infiltration BMP, the potential for groundwater contamination must be carefully considered, especially if the groundwater is used for human consumption or agricultural purposes. The infiltration trench is not suitable for sites that use or store chemicals or hazardous materials unless hazardous and toxic materials are prevented from entering the trench. In these areas, other BMPs that do not allow interaction with the groundwater should be considered.

The potential for spills can be minimized by aggressive pollution prevention measures. Many municipalities and industries have developed comprehensive spill prevention control and countermeasure (SPCC) plans. These plans should be modified to include the infiltration trench and the contributing drainage area. For example, diversion structures can be used to prevent spills from entering the infiltration trench. Because of the potential to contaminate groundwater, extensive site investigation must be undertaken early in the site planning process to establish site suitability for the installation of an infiltration trench.

Longevity can be increased by careful geotechnical evaluation prior to construction and by designing and implementing an inspection and maintenance plan. Soil infiltration rates and the water table depth should be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration trench. Pretreatment structures, such as a vegetated buffer strip or water quality inlet, can increase longevity by removing sediments, hydrocarbons, and other materials that may clog the trench. Regular maintenance, including the replacement of clogged aggregate, will also increase the effectiveness and life of the trench.

Evaluation of the viability of a particular site is the same as for infiltration basins and includes:

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30 percent clay or more than 40 percent of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15 percent should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.
- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Maintenance

Infiltration trenches required the least maintenance of any of the BMPs evaluated in the Caltrans study, with approximately 17 field hours spent on the operation and maintenance of each site. Inspection of the infiltration trench was the largest field activity, requiring approximately 8 hr/yr.

In addition to reduced water quality performance, clogged infiltration trenches with surface standing water can become a nuisance due to mosquito breeding. If the trench takes more than 72 hours to drain, then the rock fill should be removed and all dimensions of the trench should be increased by 2 inches to provide a fresh surface for infiltration.

Cost

Construction Cost

Infiltration trenches are somewhat expensive, when compared to other stormwater practices, in terms of cost per area treated. Typical construction costs, including contingency and design costs, are about \$5 per ft^3 of stormwater treated (SWRPC, 1991; Brown and Schueler, 1997). Actual construction costs may be much higher. The average construction cost of two infiltration trenches installed by Caltrans in southern California was about \$50/ft^3; however, these were constructed as retrofit installations.

Infiltration trenches typically consume about 2 to 3 percent of the site draining to them, which is relatively small. In addition, infiltration trenches can fit into thin, linear areas. Thus, they can generally fit into relatively unusable portions of a site.

Maintenance Cost

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly sited or maintained, infiltration trenches have a high failure rate. In general, maintenance costs for infiltration trenches are estimated at between 5 percent and 20 percent of the construction cost. More realistic values are probably closer to the 20-percent range, to ensure long-term functionality of the practice.

References and Sources of Additional Information

Caltrans, 2002, BMP Retrofit Pilot Program Proposed Final Report, Rpt. CTSW-RT-01-050, California Dept. of Transportation, Sacramento, CA.

Brown, W., and T. Schueler. 1997. *The Economics of Stormwater BMPs in the Mid-Atlantic Region.* Prepared for the Chesapeake Research Consortium, Edgewater, MD, by the Center for Watershed Protection, Ellicott City, MD.

Galli, J. 1992. *Analysis of Urban BMP Performance and Longevity in Prince George's County, Maryland.* Metropolitan Washington Council of Governments, Washington, DC.

Maryland Department of the Environment (MDE). 2000. *Maryland Stormwater Design Manual*. http://www.mde.state.md.us/environment/wma/stormwatermanual. Accessed May 22, 2001.

Metzger, M. E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer. 2002. The Dark Side Of Stormwater Runoff Management: Disease Vectors Associated With Structural BMPs. Stormwater 3(2): 24-39.

Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Metropolitan Washington Council of Governments, Washington, DC.

Southeastern Wisconsin Regional Planning Commission (SWRPC). 1991. *Costs of Urban Nonpoint Source Water Pollution Control Measures*. Southeastern Wisconsin Regional Planning Commission, Waukesha, WI.

Watershed Management Institute (WMI). 1997. *Operation, Maintenance, and Management of Stormwater Management Systems*. Prepared for U.S. Environmental Protection Agency, Office of Water, Washington, DC.

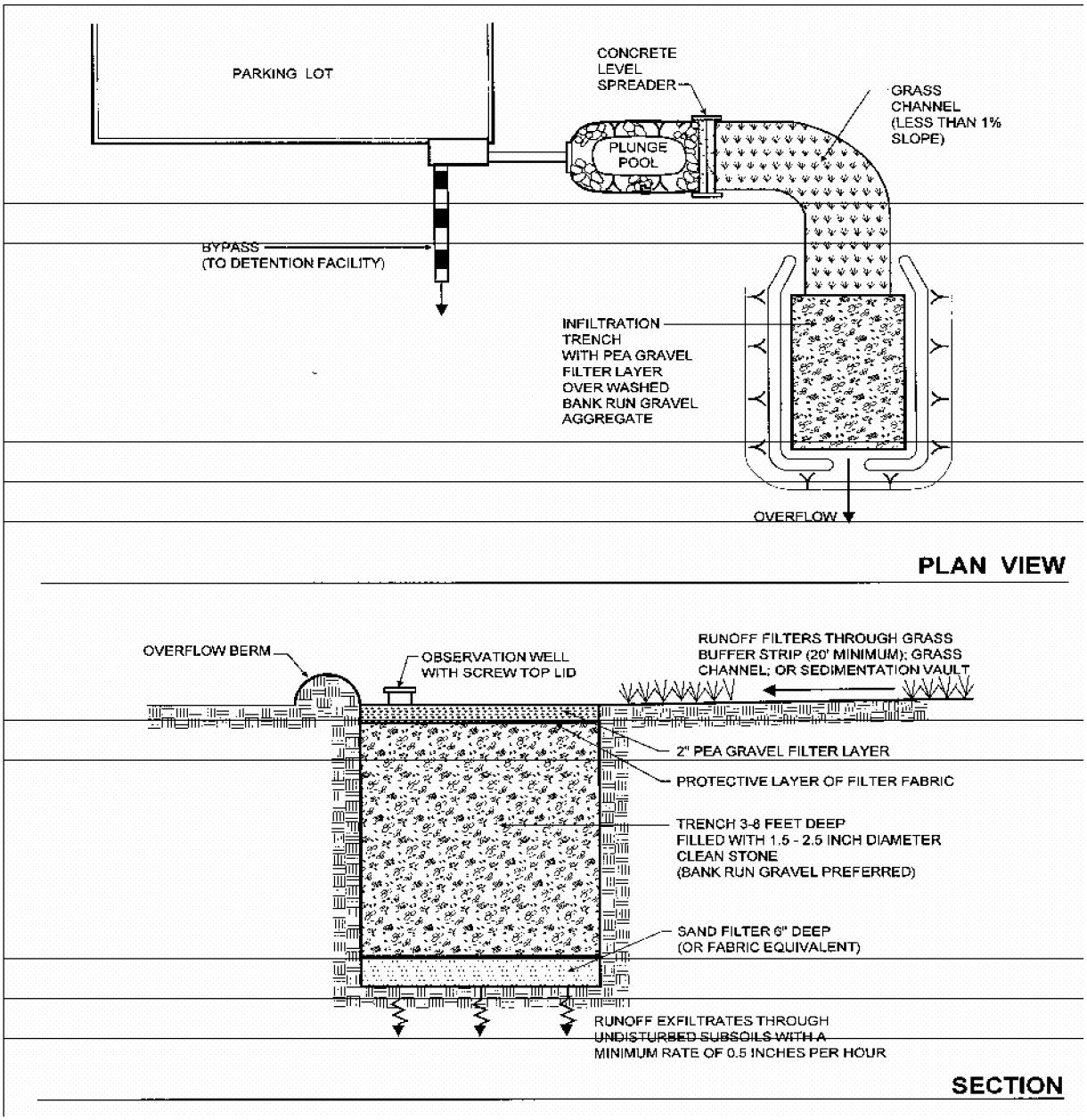
Information Resources

Center for Watershed Protection (CWP). 1997. *Stormwater BMP Design Supplement for Cold Climates*. Prepared for the U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, DC, by the Center for Watershed Protection, Ellicott City, MD.

Ferguson, B.K. 1994. *Stormwater Infiltration*. CRC Press, Ann Arbor, MI.

Minnesota Pollution Control Agency. 1989. *Protecting Water Quality in Urban Areas: Best Management Practices*. Minnesota Pollution Control Agency, Minneapolis, MN.

USEPA. 1993. *Guidance to Specify Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. EPA-840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.


PARKING LOT
CONCRETE LEVEL SPREADER
GRASS CHANNEL (LESS THAN 1% SLOPE)
PLUNGE POOL
BYPASS (TO DETENTION FACILITY)
INFILTRATION TRENCH WITH PEA GRAVEL FILTER LAYER OVER WASHED BANK RUN GRAVEL AGGREGATE
OVERFLOW
PLAN VIEW
OVERFLOW BERM
OBSERVATION WELL WITH SCREW TOP LID
RUNOFF FILTERS THROUGH GRASS BUFFER STRIP (20' MINIMUM); GRASS CHANNEL; OR SEDIMENTATION VAULT
2" PEA GRAVEL FILTER LAYER
PROTECTIVE LAYER OF FILTER FABRIC
TRENCH 3-8 FEET DEEP FILLED WITH 1.5 - 2.5 INCH DIAMETER CLEAN STONE (BANK RUN GRAVEL PREFERRED)
SAND FILTER 6" DEEP (OR FABRIC EQUIVALENT)
RUNOFF EXFILTRATES THROUGH UNDISTURBED SUBSOILS WITH A MINIMUM RATE OF 0.5 INCHES PER HOUR
SECTION

Vegetated Swale TC-30

Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	●
☑	Metals	▲
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.
- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data							
	Removal Efficiencies (% Removal)						
Study	TSS	TP	TN	NO_3	Metals	Bacteria	Type
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately $0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately $0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd³	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd²	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]	Yd²	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd²	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	–	--	–	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	–	--	–	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right) \times$ swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	$0.85 / 1,000 ft^2 / mowing	$0.14 / linear foot	$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	$9.00 / 1,000 ft^2 / year	$0.18 / linear foot	$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	$0.10 / linear foot / year	$0.10 / linear foot	$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	$0.30 / yd^2	$0.01 / linear foot	$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	$0.15 / linear foot / year, plus $25 / inspection	$0.15 / linear foot	$0.15 / linear foot	Inspect four times per year
Total	--	$0.58 / linear foot	$ 0.75 / linear foot	--

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

References and Sources of Additional Information

Barrett, Michael E., Walsh, Patrick M., Malina, Joseph F., Jr., Charbeneau, Randall J, 1998, "Performance of vegetative controls for treating highway runoff," *ASCE Journal of Environmental Engineering*, Vol. 124, No. 11, pp. 1121-1128.

Brown, W., and T. Schueler. 1997. *The Economics of Stormwater BMPs in the Mid-Atlantic Region.* Prepared for the Chesapeake Research Consortium, Edgewater, MD, by the Center for Watershed Protection, Ellicott City, MD.

Center for Watershed Protection (CWP). 1996. *Design of Stormwater Filtering Systems.* Prepared for the Chesapeake Research Consortium, Solomons, MD, and USEPA Region V, Chicago, IL, by the Center for Watershed Protection, Ellicott City, MD.

Colwell, Shanti R., Horner, Richard R., and Booth, Derek B., 2000. *Characterization of Performance Predictors and Evaluation of Mowing Practices in Biofiltration Swales.* Report to King County Land And Water Resources Division and others by Center for Urban Water Resources Management, Department of Civil and Environmental Engineering, University of Washington, Seattle, WA

Dorman, M.E., J. Hartigan, R.F. Steg, and T. Quasebarth. 1989. *Retention, Detention and Overland Flow for Pollutant Removal From Highway Stormwater Runoff. Vol. 1.* FHWA/RD 89/202. Federal Highway Administration, Washington, DC.

Goldberg. 1993. *Dayton Avenue Swale Biofiltration Study.* Seattle Engineering Department, Seattle, WA.

Harper, H. 1988. *Effects of Stormwater Management Systems on Groundwater Quality.* Prepared for Florida Department of Environmental Regulation, Tallahassee, FL, by Environmental Research and Design, Inc., Orlando, FL.

Kercher, W.C., J.C. Landon, and R. Massarelli. 1983. Grassy swales prove cost-effective for water pollution control. *Public Works*, 16: 53–55.

Koon, J. 1995. *Evaluation of Water Quality Ponds and Swales in the Issaquah/East Lake Sammamish Basins.* King County Surface Water Management, Seattle, WA, and Washington Department of Ecology, Olympia, WA.

Metzger, M. E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer. 2002. The Dark Side Of Stormwater Runoff Management: Disease Vectors Associated With Structural BMPs. Stormwater 3(2): 24-39.Oakland, P.H. 1983. An evaluation of stormwater pollutant removal

through grassed swale treatment. In *Proceedings of the International Symposium of Urban Hydrology, Hydraulics and Sediment Control, Lexington, KY*. pp. 173–182.

Occoquan Watershed Monitoring Laboratory. 1983. Final Report: *Metropolitan Washington Urban Runoff Project*. Prepared for the Metropolitan Washington Council of Governments, Washington, DC, by the Occoquan Watershed Monitoring Laboratory, Manassas, VA.

Pitt, R., and J. McLean. 1986. *Toronto Area Watershed Management Strategy Study: Humber River Pilot Watershed Project*. Ontario Ministry of Environment, Toronto, ON.

Schueler, T. 1997. Comparative Pollutant Removal Capability of Urban BMPs: A reanalysis. *Watershed Protection Techniques* 2(2):379–383.

Seattle Metro and Washington Department of Ecology. 1992. *Biofiltration Swale Performance: Recommendations and Design Considerations*. Publication No. 657. Water Pollution Control Department, Seattle, WA.

Southeastern Wisconsin Regional Planning Commission (SWRPC). 1991. *Costs of Urban Nonpoint Source Water Pollution Control Measures*. Technical report no. 31. Southeastern Wisconsin Regional Planning Commission, Waukesha, WI.

U.S. EPA, 1999, Stormwater Fact Sheet: Vegetated Swales, Report # 832-F-99-006 http://www.epa.gov/owm/mtb/vegswale.pdf, Office of Water, Washington DC.

Wang, T., D. Spyridakis, B. Mar, and R. Horner. 1981. *Transport, Deposition and Control of Heavy Metals in Highway Runoff*. FHWA-WA-RD-39-10. University of Washington, Department of Civil Engineering, Seattle, WA.

Washington State Department of Transportation, 1995, *Highway Runoff Manual*, Washington State Department of Transportation, Olympia, Washington.

Welborn, C., and J. Veenhuis. 1987. *Effects of Runoff Controls on the Quantity and Quality of Urban Runoff in Two Locations in Austin, TX*. USGS Water Resources Investigations Report No. 87-4004. U.S. Geological Survey, Reston, VA.

Yousef, Y., M. Wanielista, H. Harper, D. Pearce, and R. Tolbert. 1985. *Best Management Practices: Removal of Highway Contaminants By Roadside Swales*. University of Central Florida and Florida Department of Transportation, Orlando, FL.

Yu, S., S. Barnes, and V. Gerde. 1993. *Testing of Best Management Practices for Controlling Highway Runoff*. FHWA/VA-93-R16. Virginia Transportation Research Council, Charlottesville, VA.

Information Resources

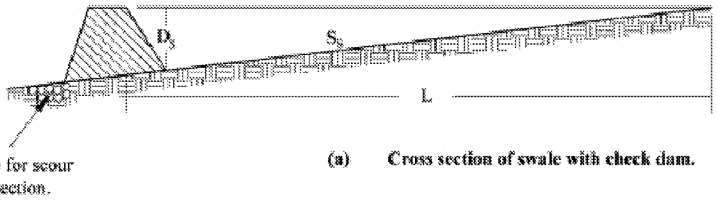
Maryland Department of the Environment (MDE). 2000. *Maryland Stormwater Design Manual*. www.mde.state.md.us/environment/wma/stormwatermanual. Accessed May 22, 2001.

Reeves, E. 1994. Performance and Condition of Biofilters in the Pacific Northwest. *Watershed Protection Techniques* 1(3):117–119.

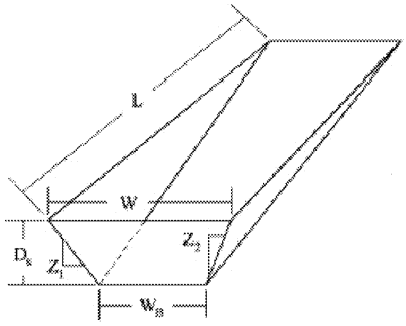
Seattle Metro and Washington Department of Ecology. 1992. *Biofiltration Swale Performance.* Recommendations and Design Considerations. Publication No. 657. Seattle Metro and Washington Department of Ecology, Olympia, WA.

USEPA 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. EPA-840-B-92-002. U.S. Environmental Protection Agency, Office of Water. Washington, DC.

Watershed Management Institute (WMI). 1997. *Operation, Maintenance, and Management of Stormwater Management Systems.* Prepared for U.S. Environmental Protection Agency, Office of Water. Washington, DC, by the Watershed Management Institute, Ingleside, MD.



(a) Cross section of swale with check dam.



(b) Dimensional view of swale impoundment area.

Notation:
L = Length of swale impoundment area per check dam (ft)
D_S = Depth of check dam (ft)
S_S = Bottom slpe of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
$Z_{1\&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Vegetated Buffer Strip TC-31

Design Considerations

- Tributary Area
- Slope
- Water Availability
- Aesthetics

Description

Grassed buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure. Consequently, there is little resistance to their use.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	●
☑	Trash	▲
☑	Metals	■
☑	Bacteria	●
☑	Oil and Grease	■
☑	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored three vegetated buffer strips in southern California and is currently evaluating their performance at eight additional sites statewide. These strips were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the southern California sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- Buffers require minimal maintenance activity (generally just erosion prevention and mowing).
- If properly designed, vegetated, and operated, buffer strips can provide reliable water quality benefits in conjunction with high aesthetic appeal.

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

- Flow characteristics and vegetation type and density can be closely controlled to maximize BMP effectiveness.
- Roadside shoulders act as effective buffer strips when slope and length meet criteria described below.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Buffer strips cannot treat a very large drainage area.
- A thick vegetative cover is needed for these practices to function properly.
- Buffer or vegetative filter length must be adequate and flow characteristics acceptable or water quality performance can be severely limited.
- Vegetative buffers may not provide treatment for dissolved constituents except to the extent that flows across the vegetated surface are infiltrated into the soil profile.
- This technology does not provide significant attenuation of the increased volume and flow rate of runoff during intense rain events.

Design and Sizing Guidelines

- Maximum length (in the direction of flow towards the buffer) of the tributary area should be 60 feet.
- Slopes should not exceed 15%.
- Minimum length (in direction of flow) is 15 feet.
- Width should be the same as the tributary area.
- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install strips at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be required.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

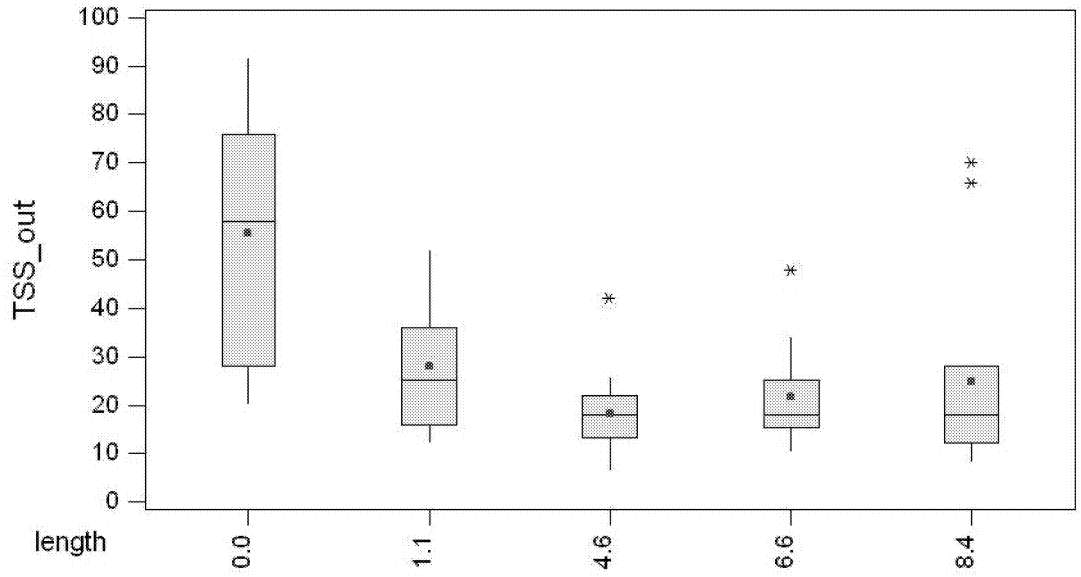
Vegetated buffer strips tend to provide somewhat better treatment of stormwater runoff than swales and have fewer tendencies for channelization or erosion. Table 1 documents the pollutant removal observed in a recent study by Caltrans (2002) based on three sites in southern California. The column labeled "Significance" is the probability that the mean influent and effluent EMCs are not significantly different based on an analysis of variance.

The removal of sediment and dissolved metals was comparable to that observed in much more complex controls. Reduction in nitrogen was not significant and all of the sites exported phosphorus for the entire study period. This may have been the result of using salt grass, a warm weather species that is dormant during the wet season, and which leaches phosphorus when dormant.

Another Caltrans study (unpublished) of vegetated highway shoulders as buffer strips also found substantial reductions often within a very short distance of the edge of pavement. Figure 1 presents a box and whisker plot of the concentrations of TSS in highway runoff after traveling various distances (shown in meters) through a vegetated filter strip with a slope of about 10%. One can see that the TSS median concentration reaches an irreducible minimum concentration of about 20 mg/L within 5 meters of the pavement edge.

Table 1 Pollutant Reduction in a Vegetated Buffer Strip

Constituent	Mean EMC		Removal %	Significance
	Influent (mg/L)	Effluent (mg/L)		P
TSS	119	31	74	<0.000
NO_3-N	0.67	0.58	13	0.367
TKN-N	2.50	2.10	16	0.542
Total N[a]	3.17	2.68	15	-
Dissolved P	0.15	0.46	-206	0.047
Total P	0.42	0.62	-52	0.035
Total Cu	0.058	0.009	84	<0.000
Total Pb	0.046	0.006	88	<0.000
Total Zn	0.245	0.055	78	<0.000
Dissolved Cu	0.029	0.007	77	0.004
Dissolved Pb	0.004	0.002	66	0.006
Dissolved Zn	0.099	0.035	65	<0.000



Filter strips also exhibit good removal of litter and other floatables because the water depth in these systems is well below the vegetation height and consequently these materials are not easily transported through them. Unfortunately little attenuation of peak runoff rates and volumes (particularly for larger events) is normally observed, depending on the soil properties. Therefore it may be prudent to follow the strips with another practice than can reduce flooding and channel erosion downstream.

Siting Criteria

The use of buffer strips is limited to gently sloping areas where the vegetative cover is robust and diffuse, and where shallow flow characteristics are possible. The practical water quality benefits can be effectively eliminated with the occurrence of significant erosion or when flow concentration occurs across the vegetated surface. Slopes should not exceed 15 percent or be less than 1 percent. The vegetative surface should extend across the full width of the area being drained. The upstream boundary of the filter should be located contiguous to the developed area. Use of a level spreading device (vegetated berm, sawtooth concrete border, rock trench, etc) to facilitate overland sheet flow is not normally recommended because of maintenance considerations and the potential for standing water.

Filter strips are applicable in most regions, but are restricted in some situations because they consume a large amount of space relative to other practices. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer or as pretreatment to a structural practice. In arid areas, however, the cost of irrigating the grass on the practice will most likely outweigh its water quality benefits, although aesthetic considerations may be sufficient to overcome this constraint. Filter strips are generally impractical in ultra-urban areas where little pervious surface exists.

Some cold water species, such as trout, are sensitive to changes in temperature. While some treatment practices, such as wet ponds, can warm stormwater substantially, filter strips do not

are not expected to increase stormwater temperatures. Thus, these practices are good for protection of cold-water streams.

Filter strips should be separated from the ground water by between 2 and 4 ft to prevent contamination and to ensure that the filter strip does not remain wet between storms.

Additional Design Guidelines

Filter strips appear to be a minimal design practice because they are basically no more than a grassed slope. In general the slope of the strip should not exceed 15fc% and the strip should be at least 15 feet long to provide water quality treatment. Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion. The top of the strip should be installed 2-5 inches below the adjacent pavement, so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering.

A major question that remains unresolved is how large the drainage area to a strip can be. Research has conclusively demonstrated that these are effective on roadside shoulders, where the contributing area is about twice the buffer area. They have also been installed on the perimeter of large parking lots where they performed fairly effectively; however much lower slopes may be needed to provide adequate water quality treatment.

The filter area should be densely vegetated with a mix of erosion-resistant plant species that effectively bind the soil. Native or adapted grasses, shrubs, and trees are preferred because they generally require less fertilizer and are more drought resistant than exotic plants. Runoff flow velocities should not exceed about 1 fps across the vegetated surface.

For engineered vegetative strips, the facility surface should be graded flat prior to placement of vegetation. Initial establishment of vegetation requires attentive care including appropriate watering, fertilization, and prevention of excessive flow across the facility until vegetation completely covers the area and is well established. Use of a permanent irrigation system may help provide maximal water quality performance.

In cold climates, filter strips provide a convenient area for snow storage and treatment. If used for this purpose, vegetation in the filter strip should be salt-tolerant (e.g., creeping bentgrass), and a maintenance schedule should include the removal of sand built up at the bottom of the slope. In arid or semi-arid climates, designers should specify drought-tolerant grasses to minimize irrigation requirements.

Maintenance

Filter strips require mainly vegetation management; therefore little special training is needed for maintenance crews. Typical maintenance activities and frequencies include:

- Inspect strips at least twice annually for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall run-off to be sure the strip is ready for winter. However, additional inspection after periods of heavy run-off is most desirable. The strip should be checked for debris and litter and areas of sediment accumulation.

- Recent research on biofiltration swales, but likely applicable to strips (Colwell et al., 2000), indicates that grass height and mowing frequency have little impact on pollutant removal;

consequently, mowing may only be necessary once or twice a year for safety and aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in strip areas, particularly along highways. The need for litter removal should be determined through periodic inspection but litter should always be removed prior to mowing.

- Regularly inspect vegetated buffer strips for pools of standing water. Vegetated buffer strips can become a nuisance due to mosquito breeding in level spreaders (unless designed to dewater completely in 48-72 hours), in pools of standing water if obstructions develop (e.g. debris accumulation, invasive vegetation), and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available on the actual construction costs of filter strips. One rough estimate can be the cost of seed or sod, which is approximately 30¢ per ft^2 for seed or 70¢ per ft^2 for sod. This amounts to between $13,000 and $30,000 per acre of filter strip. This cost is relatively high compared with other treatment practices. However, the grassed area used as a filter strip may have been seeded or sodded even if it were not used for treatment. In these cases, the only additional cost is the design. Typical maintenance costs are about $350/acre/year (adapted from SWRPC, 1991). This cost is relatively inexpensive and, again, might overlap with regular landscape maintenance costs.

The true cost of filter strips is the land they consume. In some situations this land is available as wasted space beyond back yards or adjacent to roadsides, but this practice is cost-prohibitive when land prices are high and land could be used for other purposes.

Maintenance Cost

Maintenance of vegetated buffer strips consists mainly of vegetation management (mowing, irrigation if needed, weeding) and litter removal. Consequently the costs are quite variable depending on the frequency of these activities and the local labor rate.

References and Sources of Additional Information

Caltrans, 2002, BMP Retrofit Pilot Program Proposed Final Report, Rpt. CTSW-RT-01-050, California Dept. of Transportation, Sacramento, CA.

Center for Watershed Protection (CWP). 1996. *Design of Stormwater Filtering Systems*. Prepared for Chesapeake Research Consortium, Solomons, MD, and EPA Region V, Chicago, IL.

Desbonette, A., P. Pogue, V. Lee, and N. Wolff. 1994. *Vegetated Buffers in the Coastal Zone: A Summary Review and Bibliography*. Coastal Resources Center. University of Rhode Island, Kingston, RI.

Magette, W., R. Brinsfield, R. Palmer and J. Wood. 1989. Nutrient and Sediment Removal by Vegetated Filter Strips. *Transactions of the American Society of Agricultural Engineers* 32(2): 663–667.

Metzger, M. E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer. 2002. The Dark Side Of Stormwater Runoff Management: Disease Vectors Associated With Structural BMPs. Stormwater 3(2): 24-39.

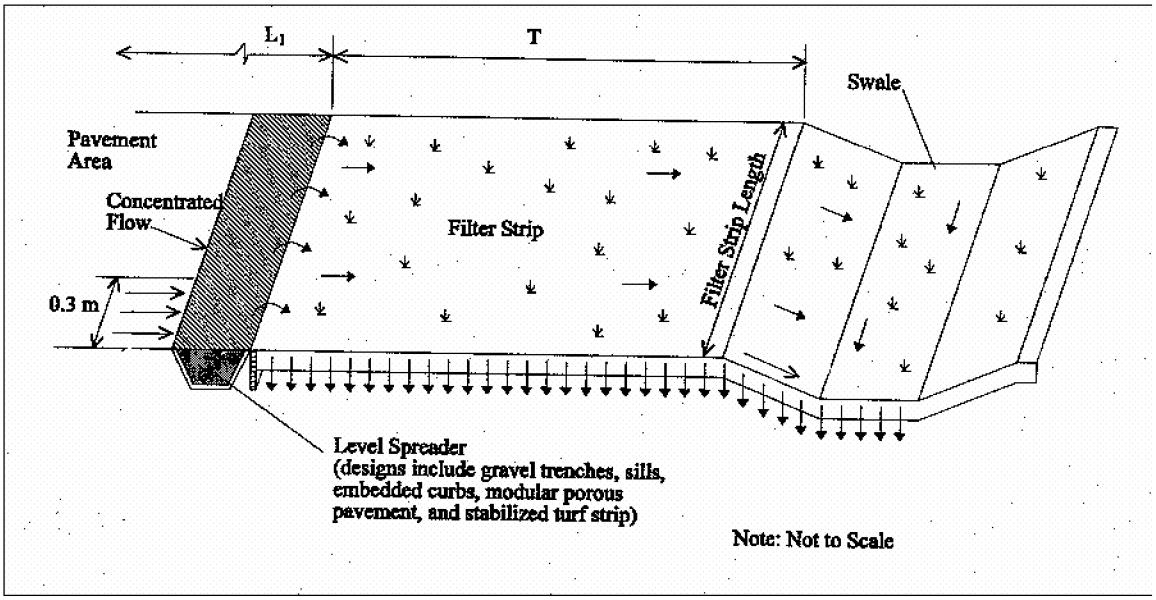
Southeastern Wisconsin Regional Planning Commission (SWRPC). 1991. *Costs of Urban Nonpoint Source Water Pollution Control Measures*. Technical report no. 31. Southeastern Wisconsin Regional Planning Commission, Waukesha, WI.

Yu, S., S. Barnes and V. Gerde. 1993. *Testing of Best Management Practices for Controlling Highway Runoff*. FHWA/VA 93-R16. Virginia Transportation Research Council, Charlottesville, VA.

Information Resources

Center for Watershed Protection (CWP). 1997. *Stormwater BMP Design Supplement for Cold Climates*. Prepared for U.S. Environmental Protection Agency Office of Wetlands, Oceans and Watersheds. Washington, DC.

Maryland Department of the Environment (MDE). 2000. *Maryland Stormwater Design Manual*. http://www.mde.state.md.us/environment/wma/stormwatermanual. Accessed May 22, 2001.


L1
T
Swale
Pavement Area
Concentrated Flow
Filter Strip
Filter Strip Length
0.3 m
Level Spreader
(designs include gravel trenches, sills, embedded curbs, modular porous pavement, and stabilized turf strip)
Note: Not to Scale

Bioretention TC-32

Design Considerations

- Soil for Infiltration
- Tributary Area
- Slope
- Aesthetics
- Environmental Side-effects

Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend *(Removal Effectiveness)*

● Low ■ High ▲ Medium

California Experience

None documented. Bioretention has been used as a stormwater BMP since 1992. In addition to Prince George's County, MD and Alexandria, VA, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

Advantages

- Bioretention provides stormwater treatment that enhances the quality of downstream water bodies by temporarily storing runoff in the BMP and releasing it over a period of four days to the receiving water (EPA, 1999).
- The vegetation provides shade and wind breaks, absorbs noise, and improves an area's landscape.

Limitations

- The bioretention BMP is not recommended for areas with slopes greater than 20% or where mature tree removal would

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

be required since clogging may result, particularly if the BMP receives runoff with high sediment loads (EPA, 1999).

- Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
- By design, bioretention BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water.
- In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Design and Sizing Guidelines

- The bioretention area should be sized to capture the design storm runoff.
- In areas where the native soil permeability is less than 0.5 in/hr an underdrain should be provided.
- Recommended minimum dimensions are 15 feet by 40 feet, although the preferred width is 25 feet. Excavated depth should be 4 feet.
- Area should drain completely within 72 hours.
- Approximately 1 tree or shrub per 50 ft^2 of bioretention area should be included.
- Cover area with about 3 inches of mulch.

Construction/Inspection Considerations

Bioretention area should not be established until contributing watershed is stabilized.

Performance

Bioretention removes stormwater pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (EPA, 1999). Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Thus, the infiltration rate of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover, and planting soil.

Common particulates removed from stormwater include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately

aerated. Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic stormwater runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals and nutrients are shown in Table 1.

Table 1 Laboratory and Estimated Bioretention Davis et al. (1998); PGDER (1993)

Pollutant	Removal Rate
Total Phosphorus	70-83%
Metals (Cu, Zn, Pb)	93-98%
TKN	68-80%
Total Suspended Solids	90%
Organics	90%
Bacteria	90%

Results for both the laboratory and field experiments were similar for each of the pollutants analyzed. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants concentrations (Davis et al, 1998).

The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

Siting Criteria

Bioretention BMPs are generally used to treat stormwater from impervious surfaces at commercial, residential, and industrial areas (EPA, 1999). Implementation of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales. Moreover, the runoff in these areas can be designed to either divert directly into the bioretention area or convey into the bioretention area by a curb and gutter collection system.

The best location for bioretention areas is upland from inlets that receive sheet flow from graded areas and at areas that will be excavated (EPA, 1999). In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized drainage areas.

Additional Design Guidelines

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered (EPA, 1999). Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil.

The use of bioretention may not be feasible given an unstable surrounding soil stratum, soils with clay content greater than 25 percent, a site with slopes greater than 20 percent, and/or a site with mature trees that would be removed during construction of the BMP.

Bioretention can be designed to be off-line or on-line of the existing drainage system (EPA, 1999). The drainage area for a bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Larger drainage areas may require multiple bioretention areas. Furthermore, the maximum drainage area for a bioretention area is determined by the expected rainfall intensity and runoff rate. Stabilized areas may erode when velocities are greater than 5 feet per second (1.5 meter per second). The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area, which is a function of the drainage area and the runoff generated from the area is sized to capture the water quality volume.

The recommended minimum dimensions of the bioretention area are 15 feet (4.6 meters) wide by 40 feet (12.2 meters) long, where the minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established. Thus replicating a natural forest and creating a microclimate, thereby enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet (7.6 meters), with a length of twice the width. Essentially, any facilities wider than 20 feet (6.1 meters) should be twice as long as they are wide, which promotes the distribution of flow and decreases the chances of concentrated flow.

In order to provide adequate storage and prevent water from standing for excessive periods of time the ponding depth of the bioretention area should not exceed 6 inches (15 centimeters). Water should not be left to stand for more than 72 hours. A restriction on the type of plants that can be used may be necessary due to some plants' water intolerance. Furthermore, if water is left standing for longer than 72 hours mosquitoes and other insects may start to breed.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.

Generally the soil should have infiltration rates greater than 0.5 inches (1.25 centimeters) per hour, which is typical of sandy loams, loamy sands, or loams. The pH of the soil should range between 5.5 and 6.5, where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. Additional requirements for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.

Soil tests should be performed for every 500 cubic yards (382 cubic meters) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area (EPA, 1999). Planting soil should be 4 inches (10.1 centimeters) deeper than the bottom of the largest root ball and 4 feet (1.2 meters) altogether. This depth will provide adequate soil for the plants' root systems to become established, prevent plant damage due to severe wind, and provide adequate moisture capacity. Most sites will require excavation in order to obtain the recommended depth.

Planting soil depths of greater than 4 feet (1.2 meters) may require additional construction practices such as shoring measures (EPA, 1999). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For instance, a 15 foot (4.6 meter) by 40 foot (12.2 meter) bioretention area (600 square feet or 55.75 square meters) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1.

Trees and shrubs should be planted when conditions are favorable. Vegetation should be watered at the end of each day for fourteen days following its planting. Plant species tolerant of pollutant loads and varying wet and dry conditions should be used in the bioretention area.

The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures, such as providing a soil breach to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities. The designers should evaluate the best placement of vegetation within the bioretention area. Plants should be placed at irregular intervals to replicate a natural forest. Trees should be placed on the perimeter of the area to provide shade and shelter from the wind. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. In cold climates, species that are more tolerant to cold winds, such as evergreens, should be placed in windier areas of the site.

Following placement of the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted at the beginning of the growing season. Mulch should be placed immediately after trees and shrubs are planted. Two to 3 inches (5 to 7.6 cm) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion.

Maintenance

The primary maintenance requirement for bioretention areas is that of inspection and repair or replacement of the treatment area's components. Generally, this involves nothing more than the routine periodic maintenance that is required of any landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell. Appropriately selected plants will aide in reducing fertilizer, pesticide, water, and overall maintenance requirements. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural

soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated as needed using preventative and low-toxic measures to the extent possible. BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water. Routine inspections for areas of standing water within the BMP and corrective measures to restore proper infiltration rates are necessary to prevent creating mosquito and other vector habitat. In addition, bioretention BMPs are susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained.

In order to maintain the treatment area's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.

New Jersey's Department of Environmental Protection states in their bioretention systems standards that accumulated sediment and debris removal (especially at the inflow point) will normally be the primary maintenance function. Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. There is also the possibility that the cation exchange capacity of the soils in the cell will be significantly reduced over time. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction (LID, 2000).

Cost

Construction Cost

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development (EPA, 1999). A general rule of thumb (Coffman, 1999) is that residential bioretention areas average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains and underdrains.

Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site in Maryland, Kettering Development, with 15 bioretention areas were estimated at $111,600.

In any bioretention area design, the cost of plants varies substantially and can account for a significant portion of the expenditures. While these cost estimates are slightly greater than those of typical landscaping treatment (due to the increased number of plantings, additional soil excavation, backfill material, use of underdrains etc.), those landscaping expenses that would be required regardless of the bioretention installation should be subtracted when determining the net cost.

Perhaps of most importance, however, the cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention areas quite attractive financially. For example, the use of bioretention can decrease the cost required for constructing stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the amount of storm drain pipe that was needed from 800 to 230 feet - a cost savings of $24,000 (PGDER, 1993). And a new residential development spent a total of approximately $100,000 using bioretention cells on each lot instead of nearly $400,000 for the traditional stormwater ponds that were originally planned (Rappahanock,). Also, in residential areas, stormwater management controls become a part of each property owner's landscape, reducing the public burden to maintain large centralized facilities.

Maintenance Cost

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

References and Sources of Additional Information

Coffman, L.S., R. Goo and R. Frederick, 1999: Low impact development: an innovative alternative approach to stormwater management. Proceedings of the 26th Annual Water Resources Planning and Management Conference ASCE, June 6-9, Tempe, Arizona.

Davis, A.P., Shokouhian, M., Sharma, H. and Minami, C., "Laboratory Study of Biological Retention (Bioretention) for Urban Stormwater Management," *Water Environ. Res.*, 73(1), 5-14 (2001).

Davis, A.P., Shokouhian, M., Sharma, H., Minami, C., and Winogradoff, D. "Water Quality Improvement through Bioretention: Lead, Copper, and Zinc," *Water Environ. Res.*, accepted for publication, August 2002.

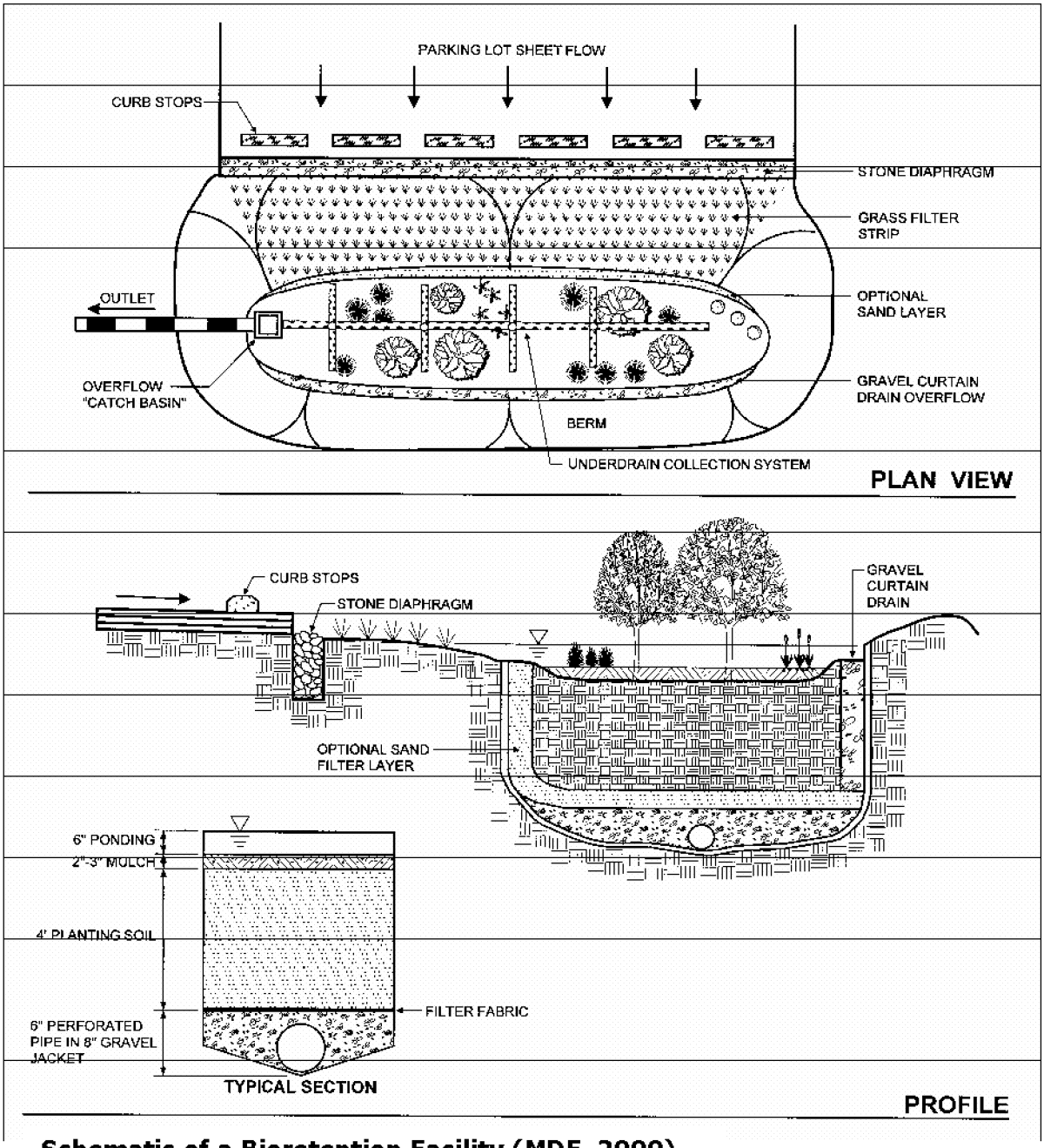
Kim, H., Seagren, E.A., and Davis, A.P., "Engineered Bioretention for Removal of Nitrate from Stormwater Runoff," *WEFTEC 2000 Conference Proceedings on CDROM Research Symposium, Nitrogen Removal*, Session 19, Anaheim CA, October 2000.

Hsieh, C.-h. and Davis, A.P. "Engineering Bioretention for Treatment of Urban Stormwater Runoff," *Watersheds 2002, Proceedings on CDROM Research Symposium*, Session 15, Ft. Lauderdale, FL, Feb. 2002.

Prince George's County Department of Environmental Resources (PGDER), 1993. Design Manual for Use of *Bioretention in Stormwater Management*. Division of Environmental Management, Watershed Protection Branch. Landover, MD.

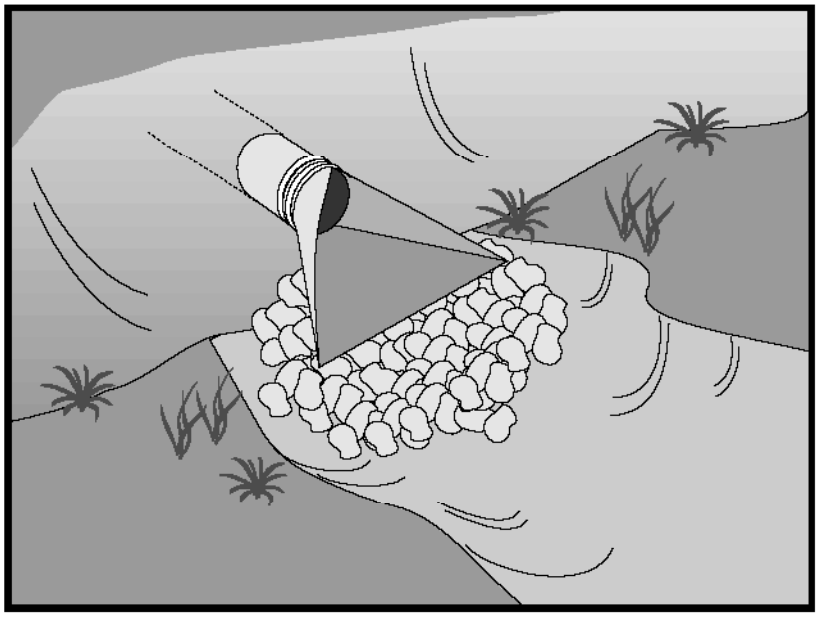
U.S. EPA Office of Water, 1999. Stormwater Technology Fact Sheet: Bioretention. EPA 832-F-99-012.

Weinstein, N. Davis, A.P. and Veeramachaneni, R. "Low Impact Development (LID) Stormwater Management Approach for the Control of Diffuse Pollution from Urban Roadways," *5th International Conference Diffuse/Nonpoint Pollution and Watershed Management Proceedings*, C.S. Melching and Emre Alp, Eds. 2001 International Water Association



Schematic of a Bioretention Facility (MDE, 2000)

Velocity Dissipation Devices EC-10



Objectives

EC	Erosion Control	☑
SE	Sediment Control	
TR	Tracking Control	
WE	Wind Erosion Control	
NS	Non-Stormwater Management Control	
WM	Waste Management and Materials Pollution Control	

Legend:

☑ **Primary Objective**

☒ **Secondary Objective**

Targeted Constituents

Sediment	☑
Nutrients	
Trash	
Metals	
Bacteria	
Oil and Grease	
Organics	

Potential Alternatives

None

Description and Purpose

Outlet protection is a physical device composed of rock, grouted riprap, or concrete rubble, which is placed at the outlet of a pipe or channel to prevent scour of the soil caused by concentrated, high velocity flows.

Suitable Applications

Whenever discharge velocities and energies at the outlets of culverts, conduits, or channels are sufficient to erode the next downstream reach. This includes temporary diversion structures to divert runon during construction.

- These devices may be used at the following locations:
  - Outlets of pipes, drains, culverts, slope drains, diversion ditches, swales, conduits, or channels.
  - Outlets located at the bottom of mild to steep slopes.
  - Discharge outlets that carry continuous flows of water.
  - Outlets subject to short, intense flows of water, such as flash floods.
  - Points where lined conveyances discharge to unlined conveyances

Limitations

- Large storms or high flows can wash away the rock outlet protection and leave the area susceptible to erosion.

- Sediment captured by the rock outlet protection may be difficult to remove without removing the rock.
- Outlet protection may negatively impact the channel habitat.
- Grouted riprap may break up in areas of freeze and thaw.
- If there is not adequate drainage, and water builds up behind grouted riprap, it may cause the grouted riprap to break up due to the resulting hydrostatic pressure.

Implementation

General

Outlet protection is needed where discharge velocities and energies at the outlets of culverts, conduits or channels are sufficient to erode the immediate downstream reach. This practice protects the outlet from developing small eroded pools (plange pools), and protects against gully erosion resulting from scouring at a culvert mouth.

Design and Layout

As with most channel design projects, depth of flow, roughness, gradient, side slopes, discharge rate, and velocity should be considered in the outlet design. Compliance to local and state regulations should also be considered while working in environmentally sensitive streambeds. General recommendations for rock size and length of outlet protection mat are shown in the rock outlet protection figure in this BMP and should be considered minimums. The apron length and rock size gradation are determined using a combination of the discharge pipe diameter and estimate discharge rate: Select the longest apron length and largest rock size suggested by the pipe size and discharge rate. Where flows are conveyed in open channels such as ditches and swales, use the estimated discharge rate for selecting the apron length and rock size. Flows should be same as the culvert or channel design flow but never the less than the peak 5 year flow for temporary structures planned for one rainy season, or the 10 year peak flow for temporary structures planned for two or three rainy seasons.

- There are many types of energy dissipaters, with rock being the one that is represented in the attached figure.
- Best results are obtained when sound, durable, and angular rock is used.
- Install riprap, grouted riprap, or concrete apron at selected outlet. Riprap aprons are best suited for temporary use during construction. Grouted or wired tied rock riprap can minimize maintenance requirements.
- Rock outlet protection is usually less expensive and easier to install than concrete aprons or energy dissipaters. It also serves to trap sediment and reduce flow velocities.
- Carefully place riprap to avoid damaging the filter fabric.
  - Stone 4 in. to 6 in. may be carefully dumped onto filter fabric from a height not to exceed 12 in.
  - Stone 8 in. to 12 in. must be hand placed onto filter fabric, or the filter fabric may be covered with 4 in. of gravel and the 8 in. to 12 in. rock may be dumped from a height not to exceed 16 in.

- Stone greater than 12 in. shall only be dumped onto filter fabric protected with a layer of gravel with a thickness equal to one half the D_{50} rock size, and the dump height limited to twice the depth of the gravel protection layer thickness.

- For proper operation of apron: Align apron with receiving stream and keep straight throughout its length. If a curve is needed to fit site conditions, place it in upper section of apron.

- Outlets on slopes steeper than 10 percent should have additional protection.

Costs

Costs are low if material is readily available. If material is imported, costs will be higher. Average installed cost is $150 per device.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.

- Inspect BMPs subjected to non-stormwater discharges daily while non-stormwater discharges occur.

- Inspect apron for displacement of the riprap and damage to the underlying fabric. Repair fabric and replace riprap that has washed away. If riprap continues to wash away, consider using larger material.

- Inspect for scour beneath the riprap and around the outlet. Repair damage to slopes or underlying filter fabric immediately.

- Temporary devices should be completely removed as soon as the surrounding drainage area has been stabilized or at the completion of construction.

References

County of Sacramento Improvement Standards, Sacramento County, May 1989.

Erosion and Sediment Control Handbook, S.J. Goldman, K. Jackson, T.A. Bursztynsky, P.E., McGraw Hill Book Company, 1986.

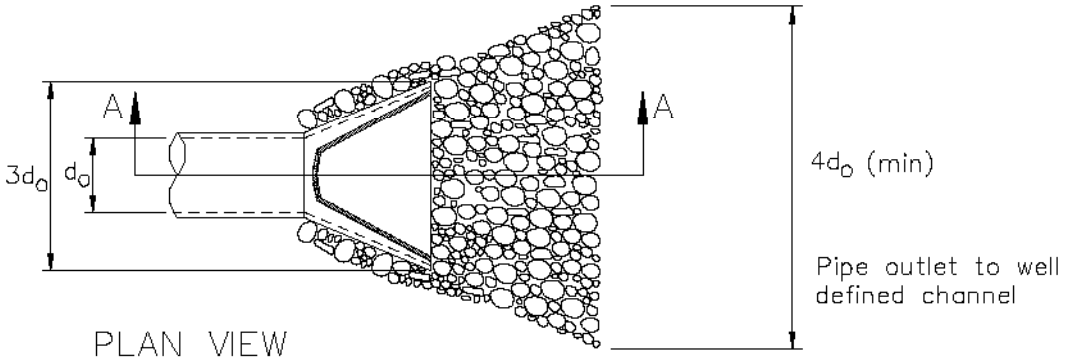
Handbook of Steel Drainage & Highway Construction, American Iron and Steel Institute, 1983.

Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, May 1995.

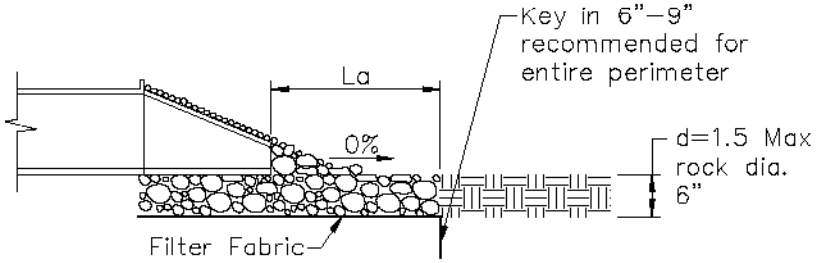
Stormwater Quality Handbooks Construction Site Best Management Practices (BMPs) Manual, state of California Department of Transportation (Caltrans), November 2000.

Stormwater Management of the Puget Sound Basin, Technical Manual, Publication #91-75, Washington State Department of Ecology, February 1992.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency, November 1988.



PLAN VIEW



SECTION A–A

Pipe Diameter inches	Discharge ft^3/s	Apron Length, La ft	Rip Rap D_{50} Diameter Min inches
12	5	10	4
	10	13	6
18	10	10	6
	20	16	8
	30	23	12
	40	26	16
24	30	16	8
	40	26	8
	50	26	12
	60	30	16

For larger or higher flows consult a Registered Civil Engineer
Source: USDA - SCS