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Port of Oakland

2015 Post-Construction Stormwater Design Manual

prepared by

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Executive Summary

PURPOSE AND GOALS OF THE 2015 POST-CONSTRUCTION STORMWATER DESIGN MANUAL

In 2013 the California State Water Resources Control Board (State Water Board) adopted a National Pollutant Discharge Elimination System (NPDES) general permit (hereafter Phase II Permit), to regulate stormwater and non-stormwater discharges from Municipal Separate Storm Sewer System (MS4s) to waters of the United States. Under the Phase II Permit, the Port of Oakland (Port) is classified as a Non-Traditional Small MS4 and is required to develop post-construction standards to address stormwater discharges from new development and redevelopment projects.

This Manual provides guidance for planning, implementing, and maintaining effective control measures with the intention of improving water quality and mitigating potential water quality impacts from stormwater and non-stormwater discharges from land use development in the Port Area. Maps of the port jurisdictional area are included in **Appendix B**.

APPLICABILITY OF THE 2015 POST-CONSTRUCTION STORMWATER DESIGN MANUAL

Section 2 of the Manual details the types of projects subject to the post-construction stormwater requirements, including exempt and special conditions projects. The Manual applies to all projects in the Port Area, including development and redevelopment projects proposed by private property owners, tenants, and projects undertaken by the Port (hereinafter Port Area Developers).

The Phase II Permit specifies two types of projects that must implement post-construction stormwater measures:

- **Small Projects**[1] – These projects create and/or replace at least 2,500, but less than 5,000 square feet of impervious surface.
- **Regulated Projects**[2] – These projects create and/or replace 5,000 square feet or more of impervious surface.

The applicability of this Manual for Small and Regulated Projects is presented in a flow chart in **Figure ES-1**. A summary of the post-construction stormwater requirements that are applicable to a project are presented in **Table ES-1**.

Projects exempted from the Small and Regulated Requirements are described in **Section 2.2.2**. The Manual also describes special conditions for Redevelopment Projects (**Section 2.2.3**) and special conditions for Roads and Linear Overhead / Underground Utility Projects (**Section2.2.4**). These sections are critical to a good understanding of the Phase II Permit requirements for the Port Area since most of the projects at the Port are redevelopment projects as well as road projects (e.g., roadways, taxiways, and runaways).

[1] Defined in Provision F.5.g.1 of the Phase II Permit.

[2] Defined in Provision F.5.g.2 of the Phase II Permit

Table ES-1. Applicable Post-Construction Stormwater Requirements

Post-Construction Stormwater Requirement	Small Project, 2,500 – 5,000 ft^2	Regulated Project, ≥5,000 ft^2
Site Assessment (Section 3.1.1)	X	X
Source Control Measures (Section 3.1.2)	X	X
Site Design Measures (Section 3.1.3)	X	X
Treatment Measures (Section 3.2.6)		X
Operations & Maintenance (Section 4)		X
Preparation of Post Construction Stormwater Management Plan by credentialed professional	X	X

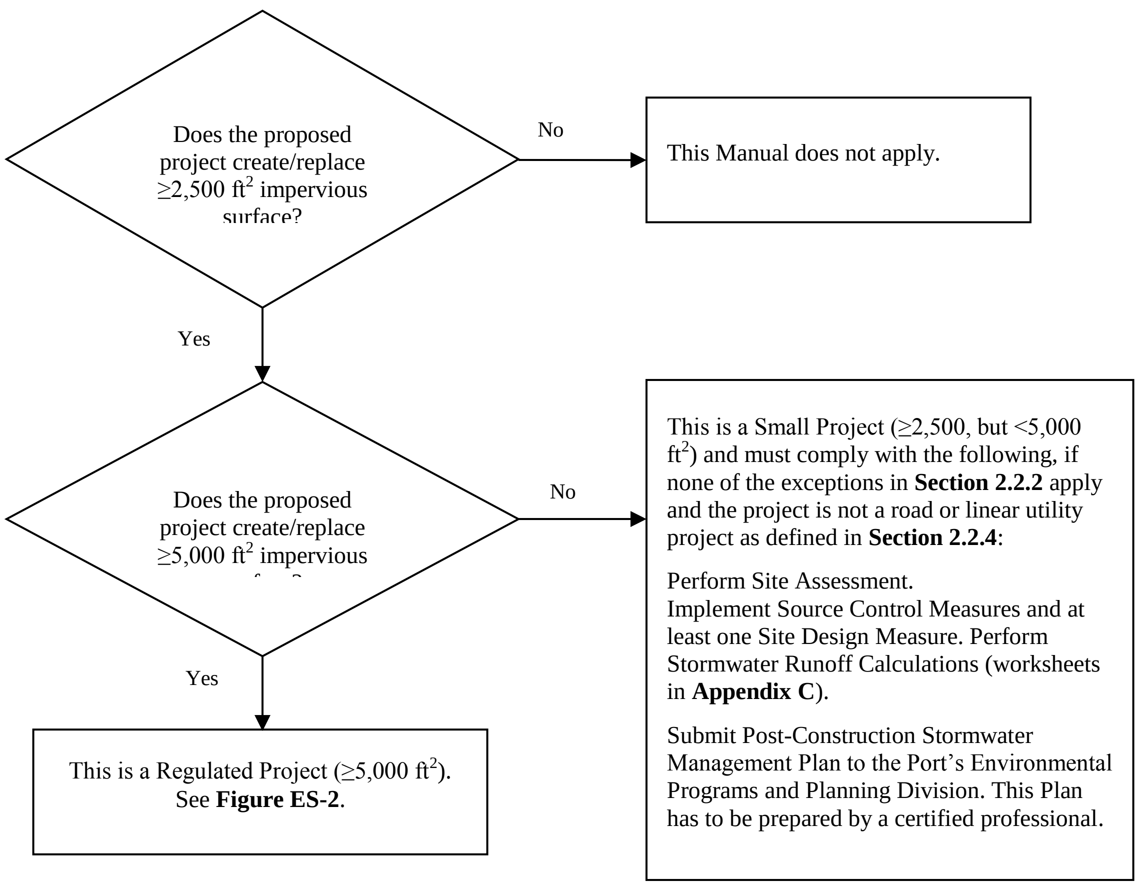


Figure ES-1. Applicability of 2015 Post-Construction Stormwater Design Manual

POST CONSTRUCTION STORMWATER MANAGEMENT REQUIREMENTS

Section 3 of the Manual details the requirements of the Post Construction Stormwater Management Plan (PCSM Plan). Project Area Developers submit this plan to the Port for review as part of the project development application. The PCSM Plan must provide a sufficient level of information depending on the type of project and be prepared and stamped by a certified engineering geologist, professional civil engineer, or professional geologist. Worksheets, which are included in **Appendix C**, must be submitted as part of the PCSM Plan.

Small Projects Requirements

Site Assessment

Site assessment (described in **Section 3.1.1**) is required for both Small and Regulated Projects. Such an assessment is important for identifying project site constraints that may limit or reduce the ability of a project site to mitigate stormwater runoff. The site assessment must include a Site Conditions Report prepared by or under the supervision of a competent, licensed professional. (see Section **3.1.1.1**) The Site Assessment also identifies pollutants of concern that may be present at the project site prior to, during, and following construction.

Source Control Measures

Source control measures (described in **Section 3.1.2**) are designed to prevent pollutants from contacting stormwater runoff or prevent discharge of contaminated stormwater runoff to the storm drain system and/or receiving water. Source control measures are required for both Small and Regulated Projects. At a minimum, all projects that include landscape irrigation must implement water efficient landscape irrigation design as a source control measure. The Port may require additional source control measures not included in this Manual for specific pollutants, activities, or land uses for a project.

Site Design Measures

The intention of site design measures (as detailed in **Section 3.1.3**) is to reduce pollution, stormwater runoff peak flows and volumes, and other impacts associated with development. Such measures include tree planting and preservation, rooftop and impervious area disconnection, green roofs, vegetated swales, porous pavement, rain barrels and cisterns, stream setbacks and San Francisco Bay buffers, and soil quality improvement and maintenance.

Small Projects do not have to meet specific numeric design criteria for the reduction of post project runoff but they still have to implement at least one site design measure. All projects, including Small Projects, must determine the stormwater runoff reduction due to site design measures using the State Water Board's Post-Construction Calculator. Instructions for using the Post-Construction Calculator are available online and **Appendix I**.

Regulated Projects Requirements

Project applicants for Regulated Projects must submit a comprehensive, technical discussion describing compliance with the requirements of this Manual. Similar to requirements for Small Projects, Regulated Projects must include a Site Assessment, Source Control Measures, and Site Design Measures previously described. However, unlike Small Projects, Regulated Projects must implement site design measures to the extent technically feasible to meet the numeric sizing criteria, i.e., the stormwater design volume or stormwater design flow (SDV/SDF, see **Section 3.2.5**).

If site design measures do not manage the entire SDV/SDF, the excess runoff must be directed to Stormwater Treatment Measures (see **Section 3.2.6**). The Phase II Permit (Provision F.5.g.2.d) requires the use of bioretention as the preferred Stormwater Treatment Measure unless (1) an alternative treatment measure that is equivalent to bioretention is proposed and demonstrated (see **Section 3.3**), or (2) a specific exception applies (see **Section 3.4**).

Flow charts of the design process for managing stormwater runoff for proposed Regulated Projects are presented in Figure ES-2.

To ensure continued effectiveness of stormwater control measures, Regulated Projects are required to develop an Operations and Maintenance Plan as detailed in **Section 4**. Port Area Developers are responsible for the ongoing operation and maintenance of their stormwater control measure(s). On the Port's leased properties, maintenance requirements for stormwater control measure(s) will be included in the tenant lease agreement. In situations where the stormwater control measure(s) will be owned or maintained by the Port, the tenant lease agreement will allow Port staff access to the property to maintain the stormwater control measure(s).

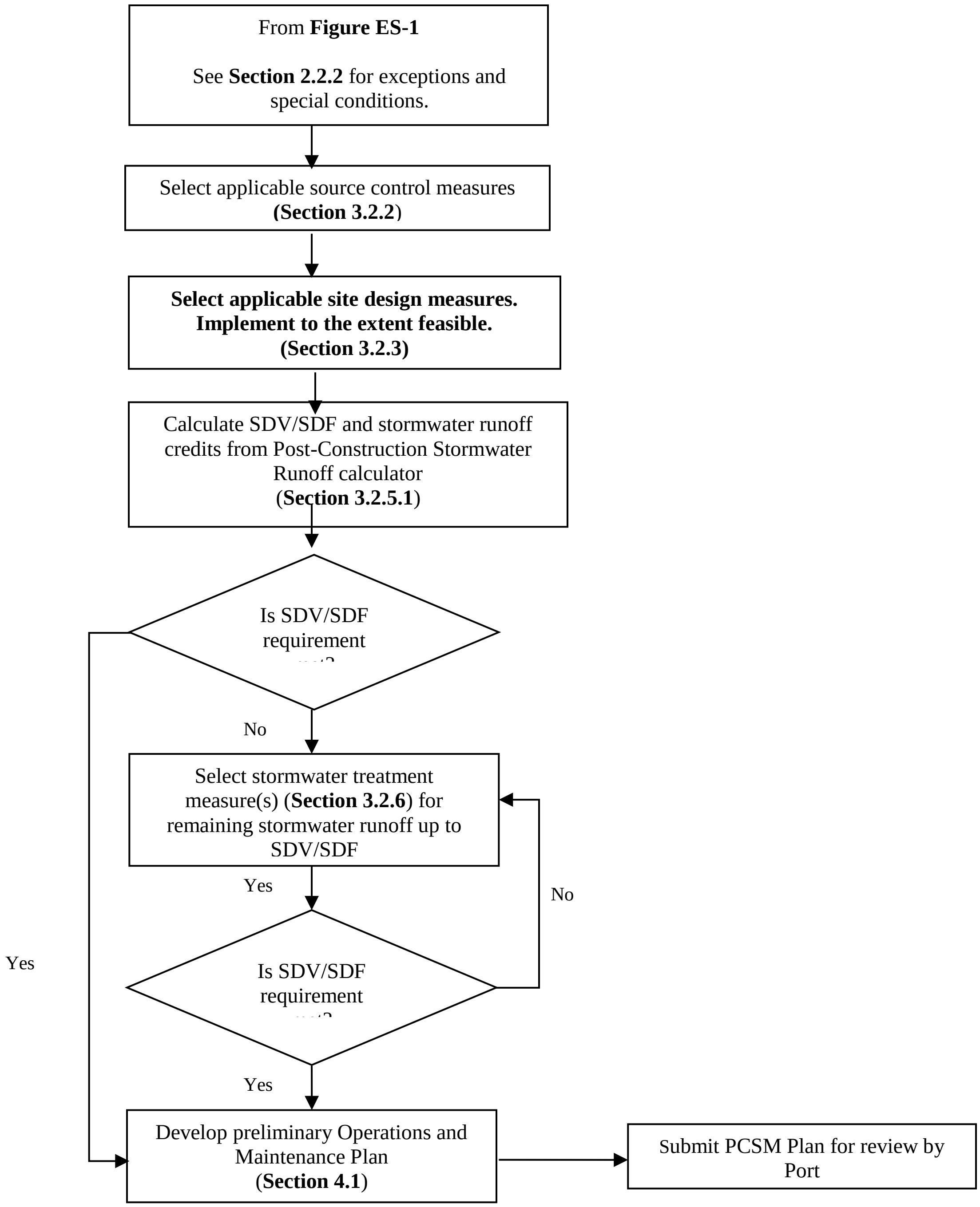


Figure ES-2. Design Process for Meeting Stormwater Requirements for Regulated Projects

1 Introduction

1.1 PURPOSE AND GOALS

The Port of Oakland (Port) is classified as a Non-Traditional Phase II Small Municipal Separate Storm Sewer System (MS4). In 2013 the California State Water Resources Control Board (State Water Board) adopted a National Pollutant Discharge Elimination System (NPDES) general permit[3] (hereafter Phase II Permit), to regulate stormwater and non-stormwater discharges from MS4s to waters of the United States. As part of the Phase II Permit, the Port is required to develop post-construction standards to address stormwater discharges from new development and redevelopment projects (Phase II Permit, Provision F.5.g).

The Port prepared this *2015 Post-Construction Stormwater Standards Manual* (Manual) to assist the development community in complying with the requirements of Provision F.5.g. of the Phase II Permit and Port Ordinance No. 4311[4], (hereafter Stormwater Ordinance or Ordinance).

This Manual provides guidance for planning, implementing, and maintaining effective control measures with the intention of improving water quality and mitigating potential water quality impacts from stormwater and non-stormwater discharges. This Manual provides tools to address the following objectives:

- Guide Port staff, Port tenants, and private property owners in the Port Area (Port Area Developers);
- Develop strategies to address large expanses of paved areas at a seaport and an airport;
- Establish the methodology to consider the effects of stormwater runoff from a new development or redevelopment project during the project planning phase;
- Minimize contiguously-connected impervious surfaces in areas of new development and redevelopment, and where feasible, maximize on-site infiltration of stormwater runoff;
- Implement site design measures to preserve, create, or restore areas that provide important water quality benefits and maintain and protect underlying soil quality;
- Provide source control measures to minimize the transport of and/or eliminate potential sources of pollution to stormwater runoff or run-on into the MS4 and receiving waters;
- Implement Low Impact Development (LID) control measures to reduce and/or eliminate the volume of stormwater and non-stormwater runoff and pollutants leaving the project site; and
- Develop tools for effectively operating, managing, and maintaining stormwater control measures.

[3] State Water Board Order 2013-0001-DWQ, NPDES Permit No. CAS000004.

[4] Adopted on January 15, 2015

1.2 PORT SETTING

The Port is under the management and control of the Board of Port Commissioners of the City of Oakland (Port Board). The Port was established by Section 701 of the Charter of the City of Oakland. The Charter grants land use jurisdiction to the Port for land within the Port Area. The Port Board serves as steward of public and private lands along and within San Francisco Bay and the Oakland Estuary. The Port Area includes the Oakland International Airport, the Oakland Airport Business Park, the seaport, and maritime operations and private properties located west of Clay Street and highway I-880. The Port Area is mostly developed and covered with impervious surfaces; although it does include Middle Harbor Shoreline Park and the Martin Luther King, Jr. Regional Shoreline Park.

Under the Charter, the Port has jurisdiction to regulate land use development in the Port Area. Maps of the port jurisdictional area are included in **Appendix B**.

1.3 REGULATORY PROGRAM BACKGROUND

In 1972, the Federal Water Pollution Control Act (Clean Water Act [CWA]) was amended to require NPDES permits for discharge of pollutants to waters of the United States from any point source, including stormwater sources. In 1987, the CWA was amended to add section 402(p), which required that municipal, industrial, and construction stormwater discharges be regulated under the NPDES permit program. In 1990, the United States Environmental Protection Agency (USEPA) promulgated rules that established the Phase I NPDES program to regulate stormwater from medium and large MS4s, which were defined as those serving populations of 100,000 or greater. In 1999, USEPA promulgated rules that established the Phase II NPDES program to regulate stormwater from small MS4s. Small MS4s includes systems similar to separate storm sewer systems in municipalities, such as systems at military bases, large hospital or prison complexes, and ports. These latter subsets of small MS4s are referred to as “Non-Traditional Small MS4s”.

1.3.1 Phase II General Permit

> The Port of Oakland is a Non-Traditional Small MS4

On April 30, 2003, the State Water Board adopted the first general NPDES permit (CAS000004) under Order No. 2003-0005-DWQ for small MS4s that required compliance with section 402(p) of the CWA and defined the minimum acceptable elements of stormwater management programs for small MS4s. On February 5, 2013, the State Water Board adopted Order No. 2013-0001-DWQ, which replaced Order No. 2003-0005-DWQ.

Provision F.5.g of the Phase II Permit requires that the Port regulate development through the following program elements:

- Site design measures (Phase II Permit, Provision F.5.g.1)
- Low impact development design standards (Phase II Permit, Provision F.5.g.2)
- Alternative Post-Construction Storm Water Management Program (Phase II Permit, Provision F.5.g.3)
- Operation and Maintenance of Post Construction Storm Water Management Measures (Phase II Permit, Provision F.5.g.4)

1.3.2 Other State of California Regulations

Projects in the Port Area are not subject to CGP Post-Construction Requirements

In addition to the Phase II Permit requirements, proposed projects may be subject to the State Water Board's Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities (Industrial General Permit, Order No. 2014-0057 -DWQ) and/or the General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities (Construction General Permit or CGP, Order No. 2009-0006-DWQ, as amended).

1.3.3 Port Ordinances and Standards

The Port adopted Ordinance No. 4311 known as the Stormwater Ordinance on January 15, 2015, to provide legal authority to control discharges to its storm drainage system. The purpose of the Ordinance is to protect and enhance the water quality of water bodies of San Francisco Bay and its tributaries by reducing pollutants in stormwater discharges to the maximum extent practicable and eliminating unauthorized non-stormwater discharges to the Port storm drains.

2 Applicability

2.1 EFFECTIVE DATE OF STANDARDS

The post-construction stormwater standards become effective June 30, 2015. Projects submitted for development on or after July 1, 2015, must incorporate these post-construction stormwater standards into project designs.

Project applicants who have submitted a Port Development Permit Application and received approval before July 1, 2015, are not subject to the requirements of this Manual. However, these projects must comply with the post-construction and drainage standards in effect at the time the development application were approved.

Broad planning documents (e.g., land use master plans, conceptual master plans, or broad-based California Environmental Quality Act [CEQA] or National Environmental Policy Act [NEPA]) approved or adopted by the Port prior to July 1, 2015, do not exempt a project applicant from the requirements of this Manual unless the project also received approval for the proposed development.

2.2 APPLICABILITY OF THE 2015 POST-CONSTRUCTION STORMWATER DESIGN MANUAL

2.2.1 Small and Regulated Projects

The requirements of this Manual apply to all projects in the Port Area, including development and redevelopment projects proposed by private property owners, tenants, and projects undertaken by the Port (hereinafter Port Area Developers). Projects that occur on Port property that are not within the planning jurisdiction of the Port are subject to the planning jurisdiction of the City of Oakland and need to comply with the City's post-construction standards.

The Phase II Permit specifies two types of projects that must implement post-construction stormwater measures, to varying degrees, as discussed below:

- **Small Projects**[5] – These projects create and/or replace at least 2,500, but less than 5,000 square feet of impervious surface.
- **Regulated Projects**[6] – These projects create and/or replace 5,000 square feet or more of impervious surface.

Impervious surfaces are the hardscapes installed during development that prevent the land's ability to absorb and infiltrate rain.

The applicability of this Manual for Small and Regulated Projects is presented in a flow chart in **Figure 1**. A summary of the post-construction stormwater requirements that are applicable to a project are presented in **Table 1**.

[5] Defined in Provision F.5.g.1 of the Phase II Permit.

[6] Defined in Provision F.5.g.2 of the Phase II Permit

Table 1. Applicable Post-Construction Stormwater Requirements

Post-Construction Stormwater Requirement	Small Project, 2,500 – 5,000 ft^2	Regulated Project, ≥5,000 ft^2
Site Assessment (Section 3.1.1)	X	X
Source Control Measures (Section 3.1.2)	X	X
Site Design Measures (Section 3.1.3)	X	X
Treatment Measures (Section 3.2.6)		X
Operations & Maintenance (Section 4)		X
Preparation of Post Construction Stormwater Management Plan by credentialed professional	X	X

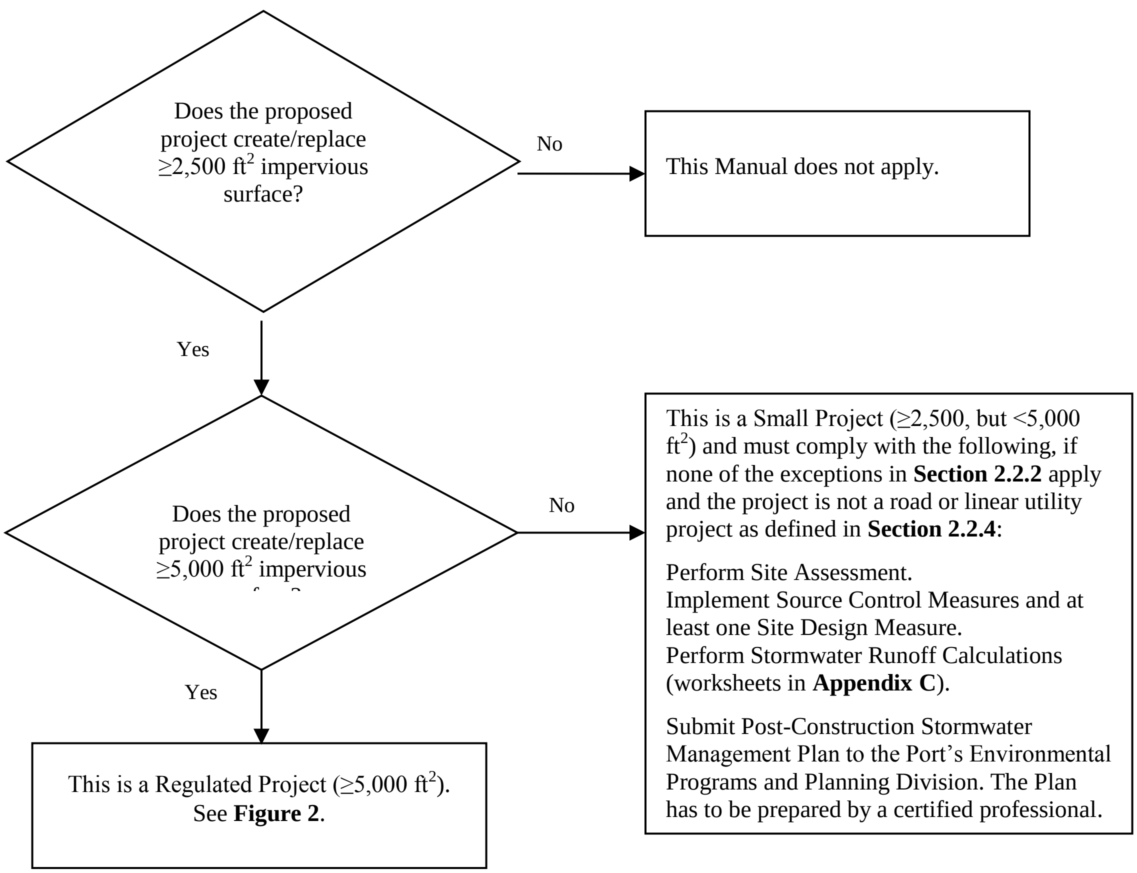


Figure 1. Applicability of 2015 Post-Construction Stormwater Design Manual

2.2.2 Exceptions for Specific Project Types

Certain types of projects that would otherwise be considered Regulated or Small Projects are exempt from the post-construction stormwater requirements. They are discussed below:

Think you qualify for an exception?
Discuss it with the Port staff before submitting a Development Permit Application

- Interior remodels and demolition projects that do not modify the existing footprint;
- Routine maintenance and repair projects that maintain the original purpose and footprint of the facility, such as:
    - Exterior wall surface replacement;
    - Pavement and tarmac resurfacing[7] within an existing footprint;
    - Routine replacement[8] of damaged pavement, such as pothole repair, or short non-contiguous sections of roadway, tarmac, or seaport area pavement that are less than 5,000 square feet;
    - Re-roofing regardless of whether it is a full roof replacement or an overlay;
- Excavation, trenching, and resurfacing associated with linear utility projects;
- Pavement grinding and resurfacing of existing roadways and parking lots;
- Wharves and developments/redevelopments constructed on wharves over water that drain runoff directly into the bay;
- Construction of new sidewalks, pedestrian ramps, or bicycle lanes on existing roadways;
- Sidewalks and bicycle lanes built as part of new streets or roads when they are graded to runoff to adjacent vegetated areas;
- Sidewalks, bicycle lanes, and trails when constructed with permeable surfaces; and
- Impervious trails when they are graded to runoff to adjacent vegetated areas or other non-erodible permeable areas.

2.2.3 Special Conditions for Redevelopment Projects

Redevelopment is defined as any land-disturbing activity that results in the creation, addition, or replacement of exterior impervious surface area at a site on which some past development has occurred.

Most projects at the Port are redevelopment projects.

[7] Pavement resurfacing (also known as an overlay, asphalt overlay, or pavement overlay) is the process of installing a new layer of pavement over the existing pavement.

[8] Pavement replacement (also known as reconstruction) is the process of installing both the asphalt layer as well as the top pavement overlay after penetration through the base rock to the subgrade. The subgrade consists of native material and does not include engineered fill.

The amount of stormwater runoff that needs to be treated will depend on the amount of impervious surface added or replaced by the project. The following thresholds are used to determine the level of post-construction stormwater standards for a redevelopment project:

- If a redevelopment project results in an increase of 50 percent or more of the impervious surface area of the existing development, then the stormwater runoff from the entire project, consisting of all existing, new, and/or replaced impervious surfaces, for the stormwater design volume or flow must be managed under these standards to the extent feasible.
- If a redevelopment project results in an increase of less than 50 percent of the impervious surface of the existing development, then only the stormwater runoff from the new and/ or replaced impervious surfaces must be managed under these standards.

Depending on the size of the impervious surfaces added or replaced, the redevelopment project may be considered a Small or Regulated Project.

2.2.4 Special Conditions for Roads and Linear Underground/ Overhead Utility Projects

Road and linear underground / overhead utility projects (LUPs) listed in **Table 2** are considered special projects. These special projects are not required to implement Small Project requirements even if creating over 2,500 square feet of impervious surface. Special projects that create 5,000 square feet or more of newly constructed contiguous impervious surface are classified as Regulated Projects and must comply with the post-construction stormwater requirements in this Manual. However, when the stormwater runoff from the design storm event cannot be infiltrated on-site, stormwater runoff must be managed through the use of practices identified in USEPA's *Managing Wet Weather with Green Infrastructure Municipal Handbook Green Streets* (EPA 833-F-08-009, December 2008) to the extent feasible.

Table 2. Special Projects: Roads and Linear Utility Projects

Special Regulated Project	Description
New roads	Construction of new roads, including sidewalks and bicycle lanes built as part of the new roads
Widening of existing roads	This includes existing roads, taxiways, and runways. ○ If the project results in an alteration[9] of 50 percent or more of the impervious surface of the existing road, then the stormwater runoff from the entire project, consisting of all existing, new, and/or replaced impervious surfaces, must be managed; or ○ If the projects results in an alteration of less than 50 percent of the impervious surface of the existing road, then only the stormwater runoff from the new and/or replaced impervious surfaces must be managed;
Linear Underground / Overhead Utility Projects (LUPs)	Construction of LUPs in previously pervious areas

[9] Alterations do not include exceptions described in Section 2.2.2.

3 Post Construction Stormwater Management Requirements

The project applicant must submit a Post Construction Stormwater Management Plan (PCSM Plan) to the Port for review as part of its development application. The PCSM Plan must provide a sufficient level of information depending on the type of project and be prepared and stamped by a certified engineering geologist, professional civil engineer, or professional geologist. Worksheets, which are included in **Appendix C**, must be submitted as part of the PCSM Plan. Note that other overall project plan approvals are necessary before construction of the proposed project may begin.

3.1 SMALL PROJECTS REQUIREMENTS

Small Projects create and/or replace between 2,500 ft^2 and 5,000 ft^2 of impervious surfaces.

The PCSM Plan for Small Projects must provide the following information:

- Basic Project Information Worksheet (**Appendix C** Section 1);
- Site Assessment Worksheet (**Appendix C** Section 2) along with findings from a site assessment (see **Section 3.1.1**) that includes a Site Conditions Report summarizing relevant findings from geotechnical investigations (see **Section 3.1.1.1**) and identifies pollutants of concern for the stormwater at the site (see **Section 3.1.1.3**);
- Site Design Measures Worksheet, including results from the Post-Construction Stormwater Runoff Calculator showing the change in pre-project and post-project stormwater runoff (**Appendix C** Section 2); and
- Project site plan showing:
    - Project boundaries;
    - Hydrologic features and significant vegetation (if any);
    - Locations and footprints of existing impervious areas;
    - Proposed locations and footprints of improvements creating new, or replaced impervious surfaces;
    - Existing and proposed site drainage system and connections to off-site drainage; and
    - Proposed locations and footprints of stormwater Site Design Measures.

3.1.1 Site Assessment

This section generally applies to Small and Regulated Projects alike, with the exception of references to treatment measures, which only pertain to Regulated Projects. While Small Projects are welcome to implement treatment measures, they are only required to implement source control and site design measures, without having to meet specific numeric sizing criteria.

Site assessment in the planning and design process is important for identifying project site constraints that may limit or reduce the ability of a project site to mitigate stormwater runoff.

Conducting this step early in the planning process reduces the possibility of having to re-design the project site if the proposed site design and/or stormwater treatment measures cannot meet the applicable requirements, especially for Regulated Projects.

Assessing the applicable site design or stormwater treatment measures to implement at a project site requires the review of existing information and collection of site-specific data. In assessing the project site, a Port Area Developer must identify the following:

- Project location and description;
- Project area size (acreage), including pre-and post-construction impervious surface area;
- Location of point(s) of stormwater runoff discharge from the project site (e.g., storm drain system, receiving water);
- Geotechnical conditions[10];
- Other site considerations and constraints; and
- Potential pollutants of concern for stormwater at the project site.

The project area size and point(s) of discharge of stormwater runoff are important factors for sizing and determining the placement of stormwater runoff conveyance and/or stormwater design measures. Information on activities expected to be conducted on-site before, during, and after construction is used to identify potential pollutants of concern that may be present in stormwater runoff. Determining geotechnical conditions and other potential site conditions and constraints is critical in identifying potential impacts to site layout and feasibility, selection, sizing, and placement of site design or stormwater treatment measures.

3.1.1.1 Site Conditions Report

A Site Conditions Report is required and must be prepared by or under the supervision of a competent, licensed professional and submitted as part of the PCSM Plan. If a geotechnical report is otherwise required for the project, it may be included as part of the Site Conditions Report.

The Site Conditions Report addresses the following conditions, as appropriate, based on the stormwater management measures being considered:

- Soil type and geology;
- Groundwater;
- Existing soil and groundwater contamination;
- Other geotechnical issues; and
- Topography.

Available geologic or geotechnical reports on local geology can be used to aid the investigation of the geotechnical conditions at the project site. These reports may identify relevant features such as depth to bedrock, rock type, lithology, faults, hydrostratigraphic or confining units,

[10] Geotechnical information is only needed if stormwater mitigation devices that rely on infiltration are being considered.

historic groundwater levels, areas of shallow groundwater, and past soil and groundwater issues (e.g., contamination).

Soil Type and Geology

The soil type and geologic conditions of the project site must be investigated to evaluate the potential for infiltration and identify suitable and unsuitable locations at the project site for infiltration-based stormwater treatment measures. The most prevalent soil types present in the Port Area are Types C and D. For the purposes of this Manual soil types are classified and defined according to Table 3.

Table 3. Typical Soil Types and Infiltration Rates

Type	Description	Typical Infiltration Rate (in/hr) (1)
A	Sands, gravels	>1.0
B	Sandy loams with moderately fine to moderately coarse textures	0.5-1.0
C	Silty-loams or soils with moderately fine to fine texture	0.17-0.27
D	Clays	0.02-0.10

(1) Infiltration rates presented are adapted from multiple sources (National Resource Conservation Service, American Society of Civil Engineers, etc.).

Site-specific testing of the infiltration rate(s) of the underlying soil is required, and the infiltration rate(s) must be determined using the Double-Ring Infiltrometer standard (American Society for Testing and Materials [ASTM] D3385). Underlying soils with in-situ infiltration rates of 0.5 inches per hour (in/hr) and up to 5.0 in/hr may be considered feasible for infiltration-based stormwater treatment measures. For underlying soils with an in-situ infiltration rate greater than 5.0 in/hr, modifications to the design of stormwater treatment measures may be necessary. For underlying soils with an in-situ infiltration rate less than 0.5 in/hr, the soils may need to be amended to increase the infiltration rate or infiltration-based stormwater treatment measures may not be feasible for the project site. In the case of a Regulated Project, alternative stormwater treatment measures must then be implemented.

Groundwater

Groundwater conditions at the project site must be evaluated prior to selecting, siting, sizing, and designing infiltration measures. Infiltration may be precluded if less than10 feet of separation is maintained between the lowest flow line or invert elevation of an infiltration structure and the seasonal high groundwater. In all cases, at least five feet of separation must be maintained between the flow line or invert of an infiltration structure and the seasonal high groundwater or mounded groundwater levels.[11]

In the Site Conditions Report, the Port Area Developer must demonstrate that the minimum groundwater separation will be maintained and in all seasons, even when accounting for potential groundwater mounding. The Site Conditions Report must discuss potential changes in the groundwater conditions that may result from the proposed project.

[11] See also Section 3.2.7.1 for design consideration of bioretention facilities.

For project sites where there may be high groundwater levels or if there are known groundwater or soil impacts, alternative stormwater treatment measures may need to be implemented (see **Section 3.3**, Alternative Stormwater Treatment measures). Note that groundwater conditions do not exempt the project applicant from implementing applicable stormwater control measures for a project site where required.

Existing Soil and Groundwater Contamination

The Port Area is located on the heavily urbanized waterfront of Oakland with over 100 years of industrial and commercial development. Given the development span and land uses, the possibility for soil and groundwater contamination must be considered. Resources such as the State Water Board's Geotracker Program, California Department of Toxics Substances Control Envirostor database, and Alameda County Environmental Cleanup Oversight Program FTP site are available to identify sites known to be contaminated. In some cases, soil sampling as part of the site evaluation may be necessary including testing in planned excavation areas to determine waste disposal costs. **Table 4** provides examples of potential contaminants associated with historical land uses typical of the seaport and the airport.

For projects located in areas with known soil or groundwater contamination, modifications to site design or stormwater treatment measures may be necessary to prevent the potential mobilization of the contaminants (see **Section 3.3**, Alternative Stormwater Treatment measures).

Table 4. Examples of Potential Contaminants Associated with Former Land Uses in the Port Area

Past Land Use	**Potential Contaminants (1)**
Airport terminals	Jet fuels; deicers; diesel fuel; chlorinated solvents; automotive wastes (2). heating oil; building wastes
Fleet/Trucking Terminals	Waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive waste
Former gas stations	Diesel fuel; gasoline; kerosene
Machine shops	Solvents; metals; miscellaneous organics; sludges; oily metal shavings; lubricant and cutting oils; degreasers (tetrachloroethylene); metal marking fluids; mold-release agents
Marine terminals	Diesel fuels; oil; wood preservative and treatment chemicals; paints; waxes; varnishes; automotive wastes
Former military installations	Wide variety of hazardous and nonhazardous wastes depending on the nature of the facility and operation: diesel fuels; jet fuels; solvents; paints; waste oils; heavy metals; radioactive wastes
Parking lots	Hydrocarbons; heavy metals
Railroad yards/ maintenance/fueling areas	Diesel fuel; herbicides for rights-of-way; creosote from preserving wood ties; solvents; paints; waste oils
Underground storage tanks	Diesel fuel; gasoline; heating oil; other chemical and petroleum products
Utility stations/maintenance areas	PCBs from transformers and capacitors; oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides from utility rights-of-way
Wood preserving/treating	Wood preservatives; creosote, pentachlorophenol, arsenic

(1) This table lists the common wastes, but not all potential wastes.

(2) Automotive wastes can include gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils

Adapted from Oregon Department of Environmental Quality www.deq.state.or.us/wq/dwp/docs/typcontaminants.pdf

Other Geotechnical Issues

Infiltration of stormwater runoff can also cause geotechnical issues, including settlement through collapsible soil, expansive soil movement, slope instability, and increased liquefaction hazard, due to a temporary increase in groundwater levels near infiltration-based stormwater treatment measures. Increased water pressure in soil pores reduces soil strength, which can make foundations more susceptible to settlement and slopes more susceptible to failure.

The geotechnical investigation must identify potential geotechnical issues and geological hazards that may result from implementing stormwater treatment measures. Recommendations from the geotechnical engineer may be based on soils boring data, drainage patterns, and proposed plan for stormwater management (e.g., if infiltration is used, the anticipated stormwater design volume). These recommendations are essential to preventing damage from increased subsurface water pressure on surrounding properties, public infrastructure, sloped banks, and even mudslides. Relevant findings from these investigations must be presented and discussed in the Site Conditions Report.

Topography

The project site topography must be evaluated for surface drainage patterns, topographic high and low points, and slopes. Each of these site characteristics impacts the type(s) of stormwater control measure(s) that will be most effective for the project site. For example, infiltration-based stormwater treatment measures are more effective on level/or gently-sloped. As part of this investigation, existing topographic mapping information and data or site-specific land surveying may be necessary to obtain the required information. The Site Conditions Report must discuss potential changes in the topography of the project site that may result from the project.

3.1.1.2 Other Site Considerations and Constraints

Managing Off-Site Drainage

Concentrated flows from off-site drainage may cause erosion if it is not properly conveyed through or around the project site or otherwise managed. The locations and sources of off-site run-on onto the project site must be identified and considered when identifying appropriate stormwater control measures so that the run-on can be properly managed. To the extent feasible, run-on should be directed away from the project treatment system. In cases where run-on commingles with the project runoff and is routed through a treatment system, the treatment system must be designed to treat the project flow and also manage (but not necessarily treat) the total incoming flow. Special care should be taken to ensure that the overflow devices are properly sized to handle the increased flow and prevent flooding.

Existing Utilities

Existing utilities located at a project site may limit the possible locations of stormwater control measures. For example, infiltration-based stormwater treatment measures cannot be located near utility lines where an increased volume of water could damage utilities. The proximity of underground features must also be identified for the project site. Stormwater infiltration must be avoided in the vicinity of existing underground utilities, and project designs that require relocation of existing utilities should be avoided, if possible.

Jurisdictional Wetlands and Waters at the Airport

Port Area Developers should be aware that the presence of wetlands at the airport may limit the siting of certain stormwater control measures. Approximately 25% of the airport is jurisdictional wetlands and waters. When present near the project site, jurisdictional wetlands and waters should be identified on the project site plan and their presence discussed in the Site Assessment section of the PCSM Plan.

3.1.1.3 Pollutants of Concern in Stormwater at the Project Site

As part of the PCSM Plan, the Project Area Developer must identify potential pollutants of concern that may be present at the project site prior to, during, and following construction. If necessary, the Port Area Developer may be required to implement appropriate source control measures and/or stormwater treatment measures to mitigate and/or eliminate the pollutants of concern in stormwater runoff.

Development can result in an increased discharge of pollutants to receiving waters. Pollutants of concern for a project site depend on the following factors:

- Project location;
- Land use and activities that have occurred on the project site in the past;
- Land use and activities that are likely to occur in the future; and
- Receiving water impairments.

As land use activities and stormwater management practices evolve, particularly with increased incorporation of stormwater control measures, characteristic stormwater runoff concentrations and pollutants of concern from various land use types are also likely to change. Common post-construction pollutants of concern based on typical land use activities are presented in **Table 5**.

Table 5. Typical Pollutants of Concern and Sources for Post-Construction Areas

Pollutant	Potential Sources
Sediment (total suspended solids and turbidity)	Streets, landscaped areas, driveways, roads, construction activities, atmospheric deposition, soil erosion
Pesticides and herbicides	Landscaped areas, roadsides, utility right-of-ways, commercial and industrial landscaped areas, soil wash-off,
Organic materials/oxygen demanding substances	Commercial landscaping, animal waste
Metals	Automobiles, bridges, atmospheric deposition, industrial areas, soil erosion, metal surfaces, combustion processes
Oil and grease, organics associated with petroleum	Roads, tarmacs, parking lots, vehicle maintenance areas, gas stations, illicit dumping to storm drains, automobile emissions, and fats, oils, and grease from restaurants
Pathogens	Lawns, roads, leaking sanitary sewer lines, sanitary sewer cross-connections, animal waste (domestic and wild), homeless encampments, sediments/biofilms in storm drain system
Nutrients	Landscape fertilizers, atmospheric deposition, automobile exhaust, soil erosion, animal waste, detergents
Trash and debris (gross solids and floatables)	Trash management areas, including dumpsters, trash enclosures, and trash cans, typically from commercial and industrial developments, and areas of high pedestrian traffic

Source: Adapted from Preliminary Data Summary of Urban Storm Water BMPs (USEPA, 1999); and Final Staff Report Amendments to the Water Quality Control Plan for the Ocean Waters of California to Control Trash and Part 1 Trash Provisions of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California (State Water Board, 2015).

3.1.2 Source Control Measures

This section applies to Small and Regulated Projects alike. Source control measures are designed to prevent pollutants from contacting stormwater runoff or prevent discharge of contaminated stormwater runoff to the storm drain system and/or receiving water. This section describes structural source control measures to be considered for implementation in conjunction with appropriate non-structural source control measures, such as good housekeeping and employee training, to optimize pollution prevention. The Port may require additional source control measures not included in this Manual for specific pollutants, activities, or land uses for a project.

At a minimum, all projects that include landscape irrigation must implement water efficient landscape irrigation design as a source control measure. Irrigation systems must be designed to conserve water and prevent water leaving the area of application. The design of irrigation system shall prevent excessive irrigation runoff by:

- Detecting and correcting leaks from the irrigation within 72 hours of discovering the leak. A pressure sensor can be incorporated to shut off the irrigation system if there is a sudden pressure drop, which may indicate a broken sprinkler head or water line;
- Properly designing and aiming sprinkler heads to only irrigate the planned application area; and
- Not irrigating during precipitation events. Precipitation sensors can be installed to shut off irrigation system during and after storm events.

Source control measures presented in this Manual apply to both stormwater and non-stormwater discharges. Non-stormwater discharges are discharges of any substance (e.g., excess irrigation, leaks and drainage from trash dumpsters, cooling water, and process wastewater) that is not comprised entirely of stormwater runoff. Any stormwater runoff that is mixed or comingled with non-stormwater flows is considered non-stormwater.

The following potential sources require source control measures be implemented to the extent technically feasible to mitigate pollutant mobilization in stormwater and non-stormwater runoff from the project site:

- Parking/storage areas and maintenance;
- Landscape/outdoor pesticide use;
- Building and grounds maintenance;
- Refuse areas;
- Outdoor storage of equipment or materials;
- Vehicle and equipment cleaning;
- Vehicle and equipment repair and maintenance;
- Fuel dispensing areas;
- Indoor and structural pest control;
- Accidental spills and leaks;
- Restaurants and other food service operations;
- Interior floor drains;
- Industrial processes;
- Loading docks;
- Fire sprinkler test water;
- Drain or wash water from boiler drain lines, condensate drain lines, rooftop equipment, drainage sumps, and other sources; and
- Unauthorized non-stormwater discharges.

Fact sheets for each source control measure are presented in **Appendix D**. These fact sheets include pollution prevention activities, Best Management Practices, design considerations, and maintenance requirements to ensure effective implementation of the source control measure.

3.1.3 Site Design Measures

Site design measures for Small Projects do not have to meet specific numeric design criteria for runoff reduction. However, implementation of **at least one site design measure is required**.

Site design measures can protect sensitive environmental features such as riparian areas and wetlands. The intention of site design principles is to reduce pollution, stormwater runoff peak flows and volumes, and other impacts associated with development. All projects subject to this Manual (both Small and Regulated Projects) must apply site design measures to reduce stormwater runoff from the project site. For Small Projects, a Port Area Developer is required to implement at least one site design measure. Small Projects do not have to meet specific numeric design criteria for the reduction of post project runoff. However, all projects, including Small Projects, must determine the stormwater runoff reduction resulting from implementation of site design measures. The State Water Board developed a Post-Construction Calculator to quantify the stormwater runoff reduction resulting from implementation of site design measures. Instructions for using the Post-Construction Calculator are available in the calculator spreadsheet and **Appendix I**. The Post-Construction Calculator is located on the State Water Board's Phase II Small Municipal Separate Storm Sewer System (MS4) Program website at: http://www.swrcb.ca.gov/water_issues/programs/stormwater/docs/phase_ii_municipal.shtml.

The Port Area Developer may propose an alternate method for calculating the runoff reduction achieved by the Site Design Measures. Alternative methods should be discussed with the Port's Environmental Programs and Planning Division prior to submitting the PCSM plan and discussed in detail in the PSCM plan.

The Phase II Permit identifies the following site design measures:

- Tree planting and preservation;
- Rooftop and impervious area disconnection;
- Green roofs;
- Vegetated swales;
- Porous pavement;
- Rain barrels and cisterns;
- Stream setbacks and San Francisco Bay buffers; and
- Soil quality improvement and maintenance.

The State Water Board has identified stormwater as a valuable resource for harvest and reuse.

3.1.3.1 Tree Planting and Preservation

Trees are essential to the hydrologic cycle and provide multiple benefits for stormwater management. Tree canopies provide significant precipitation interception (10-40 percent) depending on the type of tree and local climate conditions and result in a reduction in potential stormwater runoff volumes and flow rates. Precipitation that infiltrates near trees will be absorbed by roots and transpired. Trees also provide some pollutant removal through root uptake. Finally, trees enhance site aesthetics, increase property values, provide shading and cooling, provide erosion control, and improve air quality.

> Tree planting may not be appropriate for all areas of the Port, such as in the Airport Operations Area (AOA).

In general, consider, and implement if feasible, the following:

- Concentrate or cluster development on less sensitive areas of a project site. (Sensitive areas may include areas that have: higher infiltration capacities, mature desirable vegetation, habitat or aesthetic benefits.)
- Limit clearing and grading of trees and vegetation at the project site.
- Provide adequate setbacks from structures and other infrastructure to prevent root intrusion and potential damage.
- Coordinate any necessary irrigation requirements with the site irrigation system.

When site planning, the Port Area Developer should preserve existing trees and other vegetation at the project site. Preserving healthy existing site trees and vegetation is more effective for managing stormwater runoff than completely removing existing trees and vegetation and planting new trees and vegetation. Because trees provide a reduction in the volume and flow rate of stormwater runoff, stormwater runoff that may need to be managed by stormwater treatment measures, including sizing requirements may be reduced.

The Port Area Developer can also complement existing trees and vegetation with new climate-appropriate trees and vegetation as part of the project to provide additional stormwater management benefits. To receive these credits for stormwater management, the trees that are planted must meet the following requirements:

- Be planted within 25 feet of the project area for which the credit is applied;
- Have a minimum 25-foot crown diameter at tree maturity;
- Spaced so that crowns do not overlap at 15 years of growth;

See **Section 3.2.5** for calculation of stormwater volume or flow credits for preserving and planting trees at the project site.

3.1.3.2 Rooftop and Impervious Area Disconnection

Rooftop and impervious area disconnection can reduce stormwater runoff volumes and flows that enter the storm drain system. Rooftop drains can be disconnected from the storm drain system by directing stormwater runoff from rooftops across vegetation or other pervious surface. Disconnected impervious areas are any impervious areas that drain stormwater runoff over an adjoining vegetated area or other pervious surface. When these areas are disconnected from the storm drain system, stormwater runoff that moves through the vegetated area or other pervious surface will have decreased flow rate and reduced volumes due to infiltration and evaporation.

If the vegetated area to which stormwater runoff will flow is designed, climate-appropriate vegetation that will withstand periods of inundation must be used. See **Appendix G** for examples of suitable vegetation. The vegetated area or pervious surface receiving the stormwater runoff must also properly drain to prevent vector breeding.

If rooftop and impervious area disconnected from the storm drain system, the volume of stormwater runoff that may need to be managed by stormwater treatment measures may be reduced, which also reduces sizing requirements for the stormwater treatment measures. See **Section 3.2.5** for calculation of stormwater volume or flow credits.

3.1.3.3 Porous Pavement

Porous pavement, which includes permeable interlocking concrete pavers, pervious concrete, or porous asphalt pavement, can be used to manage stormwater runoff by storing stormwater runoff in porous pavement and its sub-layers of sand and gravel and infiltrating it into the underlying soil. Potential applications of porous pavement include, but are not limited to, sidewalks, patios, walkways, driveways, and parking lots. However, porous pavement may not be appropriate in heavily used areas, industrial or other locations where activities may introduce pollutants of concern, or areas where there are contaminated soils or groundwater. A geotechnical investigation, which is conducted in the Site Assessment (**Section 3.1.1**), must verify that porous pavement is technically feasible for the site. Because porous pavement relies on infiltration to mitigate stormwater runoff, regular maintenance to prevent occlusion is required to maintain the effectiveness of the porous pavement.

> Porous pavement may not be appropriate for all areas at the Port, such has heavy vehicle traffic areas and areas with existing soil or groundwater contamination.

When implementing porous pavement:

- Establish protective perimeters around the porous pavement to prevent inadvertent compaction by construction activities. If the underlying soils are compacted, ripping or loosening the top two inches of the underlying soils prior to construction may be needed to improve infiltration.
- Stabilize the entire area contributing runoff to the porous pavement before construction on the porous pavement commences. If this is not possible, all flows must be diverted around the porous pavement to protect it from sediment loads during construction. Sediment controls should also be implemented to prevent sediment from entering the porous pavement area. Follow all manufacturers' specifications for constructing and maintaining porous pavement.
- Stabilize the entire tributary area before allowing stormwater runoff into the porous pavement.

Use of porous pavement may reduce stormwater runoff volumes and flow rates. See **Section 3.2.5** for calculation of stormwater volume or flow credits for implementing porous pavement at the project site.

3.1.3.4 Green Roofs

See **Appendix E** (Fact Sheet LID-4) for more information on green roofs. Use of green roofs can reduce stormwater runoff volumes and flow rates. See **Section 3.2.5** for calculation of stormwater volume or flow credits for implementing green roofs at the project site. Green walls may also be an option for a project site, provided that the

> In addition to runoff reduction benefits, green roofs absorb sound and reduce heat island effects in urban areas.

project applicant can demonstrate an effective reduction in stormwater runoff.

3.1.3.5 Vegetated Swales

See **Appendix E** (Fact Sheet T-4) for more information on vegetated swales and its applications. Use of vegetated swales may reduce stormwater runoff volumes and flow rates. See **Section 3.2.5** for calculation of stormwater volume or flow credits for implementing vegetated swales at the project site.

3.1.3.6 Rain Barrels and Cisterns

Rain barrels and cisterns are containers that collect and store precipitation from rooftop drainage systems that would otherwise be lost to stormwater runoff and diverted to the storm drain system or receiving water. Collection of this precipitation reduces the volume of stormwater runoff and reduces the potential for mobilization of pollutants. Other benefits include providing water conservation benefits and using a small footprint on a project site. Rain barrels are placed above ground beneath a shortened downspout next to a home or building and typically range in size from 50 to 180 gallons. Cisterns are larger storage tanks that may be located above or below ground.

Stored precipitation is typically used for landscape irrigation, but may also be used for washing. Water stored in rain barrels or cisterns must be emptied between storm events to prevent overflow. Rain barrels or cisterns, that will retain water for longer than 96 hours, must be completely sealed to prevent entry of adult mosquitoes. Screen mesh must have openings less than 2 mm to exclude mosquitos. Water collected and stored in rain barrels and cisterns must not be discharged to the storm drain system. Rain barrels and cisterns must be properly maintained according to manufacturers' specifications to ensure continued effectiveness.

Because rain barrels and cisterns provide a reduction in the volume and flow rate of stormwater runoff, stormwater runoff that may need to be managed by stormwater treatment measures may be reduced, including sizing requirements. See **Section 3.2.5** for calculation of stormwater volume or flow credits for implementing rain barrels and/or cisterns at the project site.

3.1.3.7 Stream Setbacks and San Francisco Bay Buffers

Setbacks for development projects are required to prevent discharge directly into receiving waters. Stream setbacks and San Francisco Bay buffers are areas at a project site that are left undeveloped and pervious in order to prevent stormwater runoff from flowing directly from impervious surfaces into a stream or bay. These buffer areas can reduce the volume of stormwater runoff, reduce peak stormwater runoff flow rates, and provide some treatment and removal of pollutants in stormwater runoff. If setbacks and buffers are implemented, the volume of stormwater runoff that may need to be managed by stormwater treatment measures may be reduced, which also reduces sizing requirements for the stormwater treatment measures. See **Section 3.2.5** for calculation of stormwater volume or flow credits.

> Stream setbacks would be appropriate in the Airport Business Park adjacent to Damon Slough, Elmhurst Creek, and San Leandro Creek.

3.1.3.8 Soil Quality Improvement and Maintenance

Soil characteristics (e.g., soil type, porosity) can determine the methods that can be used at a project site to manage stormwater. These soil characteristics as well as soil compaction determine the feasibility of implementing stormwater treatment measures. Soil amendments, such as compost and aeration, can improve soils and provide an environment that promotes healthy vegetation, increase storage and provide treatment of stormwater runoff as it infiltrates into the subsurface, recharge groundwater levels, reduce the needs for chemical supplements (e.g., fertilizers), and minimize erosion and sedimentation.

Because soil amendments can reduce the volume of stormwater runoff that may need to be managed by stormwater treatment measures, credits may be applied for reducing the sizing requirements for the stormwater treatment measures. See **Section 3.2.5** for calculation of stormwater volume or flow credits.

3.2 REGULATED PROJECTS REQUIREMENTS

Regulated Projects create and/or replace 5,000 ft^2 or more of impervious surfaces.

Project applicants for Regulated Projects must submit a comprehensive, technical discussion describing compliance with the requirements of this Manual. The PCSM for these projects must provide the following information:

- Basic Project Information Worksheet (**Appendix C** Section 1);
- Site Assessment Worksheet (**Appendix C** Section 3) along with findings from a site assessment (**Section 3.2.1**) that must include a Site Conditions Report summarizing relevant findings from geotechnical investigations and identify pollutants of concern for stormwater at the project site;
- Source Control Measures Worksheet (**Appendix C** Section 3);
- Site Design Measures Worksheet **(Appendix C** Section 3);
- DMA Worksheet for each DMA, including calculation of the Stormwater Design Volume and/or Stormwater Design Flow and results from the Post-Construction Stormwater Runoff Calculator (**Appendix C** Section 3);
- Stormwater Treatment Measures Design Worksheet, if necessary (**Appendix C** Section 3);
- Proposed Operations and Maintenance Plan (see **Section 4**).

The PCSM Plan must also include a site plan that, at a minimum, illustrates:

- Project boundaries;
- Hydrologic features and significant vegetation (if any);
- Locations and footprints of existing impervious areas;
- Proposed locations and footprints of improvements creating new, or replaced impervious surfaces;
- Existing and proposed site drainage system and connections to off-site drainage;
- All DMAs with unique identifiers;
- Proposed locations and footprints of stormwater control measures (e.g., site design measures, source control measures, stormwater treatment measures) implemented to manage stormwater runoff; and
- Maintenance areas.

Flow charts of the design process for managing stormwater runoff for proposed Regulated Projects are presented in **Figure 2**.

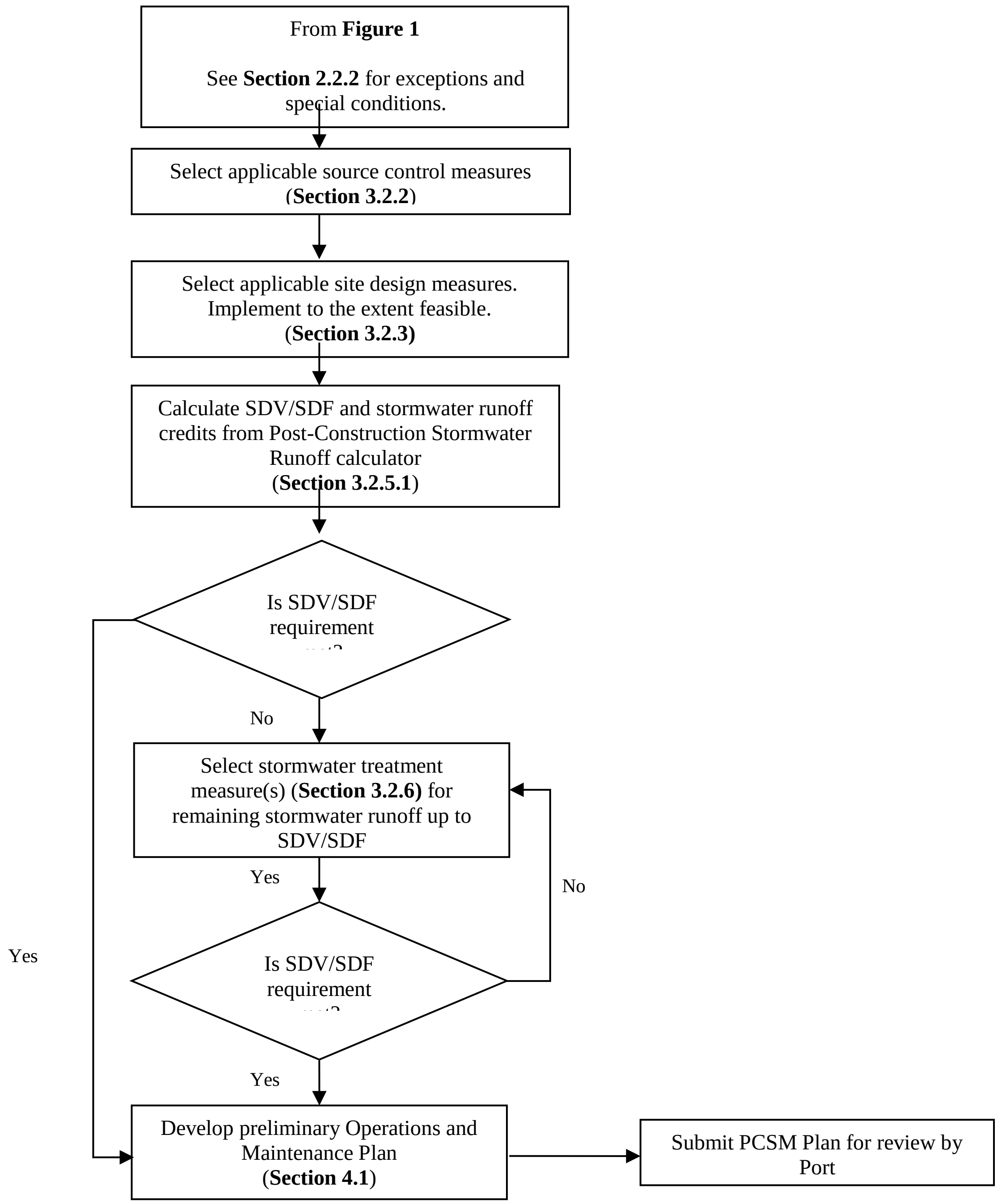


Figure 2. Design Process for Meeting Stormwater Requirements for Regulated Projects

3.2.1 Site Assessment

As required for Small Projects, Regulated Projects must undergo a comprehensive Site Assessment including the preparation of a Site Conditions Report. Details for a conducting a Site Assessment are included in **Section 3.1.1.**

3.2.2 Source Control Measures

As required for Small Projects, Regulated Projects must implement source control measures to the extent technically feasible. Details on selecting source control measures are included in **Section 3.1.2**.

3.2.3 Site Design Measures

Regulated Projects must implement site design measures to the extent technically feasible.

All projects subject to this Manual (Small and Regulated Projects alike) must apply site design measures to reduce stormwater runoff from the project site. While Small Projects are only required to implement one site design measure, Regulated Projects must implement site design measures to the extent technically feasible to meet the numeric sizing criteria (See **Section 3.2.5**). A discussion of Site Design Measures that may be implemented for Small and Regulated Projects alike is included in **Section 3.1.3**.

3.2.4 Identification of Drainage Management Areas (DMAs)

Drainage Management Areas (DMAs) are sub-watersheds within the project site that drain to one single point or treatment facility. For Regulated Projects, the PCSM Plan must include a map/diagram identifying each DMA for the project site.

3.2.5 Stormwater Design Volume/Flow Calculation

The requirements of the Phase II Permit are based on managing a specific volume or flow of stormwater runoff from the project site (stormwater design volume [SDV] or stormwater design flow [SDF]). By treating the SDV/SDF, it is expected that pollutant loads, which are typically higher at the beginning of storm events, will be prevented from or reduced in the discharge into the receiving waters. This section presents information on how to calculate the SDV and/or SDF that is used in designing stormwater treatment measures for a project site. **Table 6** below lists the type of sizing criteria, volume-based or flow-based, for a range of stormwater treatment measures discussed in the Manual. <u>The design standards for stormwater management outlined in this section do not meet applicable flood control requirements</u>.

Table 6. Flow-Based and Volume-Based Stormwater Treatment Measures

Manual Reference	Measures	Type of Sizing Criteria
Section 3.2.7	Bioretention(1)	Volume-based
Appendix E LID-1	Infiltration Basin	Volume-based
Appendix E LID-2	Infiltration Trench	Volume-based
Appendix E LID-3	Green Roof	Volume-based
Appendix E T-1	Stormwater Planter	Volume-based
Appendix E T-2	Tree-Well Filter	Volume-based
Appendix E T-3	Sand Filter	Volume-based
Appendix E T-4	Vegetated Swales	Flow-based
Appendix E T-5	Proprietary Stormwater Treatment Measures	Volume-based or flow-based, depending on selected measure
Appendix E HM-1	Extended Detention Basin	Volume-based
Appendix E HM-2	Wet Pond	Volume-based

(1) With few exceptions, the Phase II Permit (Provision F.5.g.2.d) requires the use of bioretention. See **Section 3.2.6** for details.

3.2.5.1 Stormwater Design Volume (SDV)

All stormwater treatment measures, together with site design measures (see **Section 3.2.3**), must mitigate (infiltrate or treat) the volume of stormwater runoff produced by the 85th percentile, 24-hour storm event based on historic rainfall records, determined as the maximized capture stormwater volume for the tributary area, from the formulae recommended in *Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87* (1998). This approach uses the following equation to calculate the unit stormwater volume, which is multiplied by the area of the DMA to calculate the SDV for sizing volume-based stormwater treatment measures:

$$C = 0.858 \times i^3 - 0.78 \times i^2 + 0.774 \times i + 0.04$$

Where:

C = stormwater runoff coefficient [unitless]; and
i = DMA imperviousness ratio [expressed as a decimal].[12]

$$P_0 = (a \times C) \times P_6$$

Where:

P_0 = unit stormwater volume [in];
a = regression constant (1.582 and 1.963 for 24-hr and 48-hr drawdown, respectively); and
P_6 = mean runoff-producing rainfall depth [in] = 0.48 in for the Port Area[13]

[12] See **Section 3.2.7.1** for additional explanation.

[13] Larry Walker Associates, 2015.

The SDV for each DMA is calculated using the following equation:

$$SDV = A \times \frac{P_0}{12}$$

Where:

SDV = stormwater design volume [ft^3];
A = total area of DMA [ft^2]; and
P_0 = unit stormwater volume [in].

If necessary, the project applicant must also consider run-on from areas surrounding the project site as part of the determination of the SDV.

3.2.5.2 Stormwater Runoff Coefficient

Projects typically consist of a variety of site elements that have different associated stormwater runoff coefficients. The stormwater runoff coefficient is a function of roughness and permeability across the surface over which the stormwater runoff drains. Stormwater runoff coefficients based on soil type for typical site elements that will be used to calculate the SDF are presented in **Table 7**.

Table 7. Stormwater Runoff Coefficients for Typical Site Elements

Site Element	Stormwater Runoff Coefficient (C_r) (1)
Asphalt/concrete pavement	0.95
Disturbed soil	0.25
Gravel pavement	0.35
Managed turf	0.25
Permeable pavement	(2)
Roofs	0.95

(1) Source: Adapted from the Center for Watershed Protection, Ellicott City, Maryland for Type C and D Soils
(2) Varies with product type. Consult manufacturer for appropriate design values.

3.2.5.3 Stormwater Design Flow

Stormwater treatment measures, based on the SDF, must mitigate (infiltrate or treat) the flow rate of stormwater runoff produced by a rain event equal to at least 0.2 in/hr intensity. The Rational Method is used to calculate the SDF according to the following equation:

$$SDF = 1.008 \times i \times A \times C_r$$

Where:

SDF = stormwater design flow [ft^3/s];
1.008 = unit conversion factor [hr/acre/in];
i = design rainfall intensity [0.2 in/hr];
A = total area of DMA [acre]; and; and
C_r = stormwater runoff coefficient for DMA (see **Table 7**).

3.2.5.4 Post-Construction Stormwater Runoff Reduction Calculator

The State Water Board developed a Post-Construction Calculator[14] to quantify the stormwater runoff reduction resulting from implementation of site design measures. Instructions for using the Post-Construction Calculator are available in the calculator spreadsheet and Appendix I. The Post-Construction Calculator is located on the State Water Board's Phase II Small Municipal Separate Storm Sewer System (MS4) Program website at: http://www.swrcb.ca.gov/water_issues/programs/stormwater/docs/phase_ii_municipal/120214_post_const_calc.xls.

For Small and Regulated Projects alike, the Port Area Developer can use the Post-Construction Calculator to quantify the stormwater runoff reduction resulting from implementing site design measures. The stormwater runoff reduction resulting from implementing site design measures, to the extent technical feasible, is a credit (SDM_{credit})[15] that reduces the amount of stormwater runoff volume or flow that must be further treated by stormwater treatment measures (i.e., bioretention, alternative stormwater treatment measures) for the DMA. By reducing the amount of stormwater runoff that requires additional treatment, the size of the stormwater treatment measure will also be reduced. If the calculator demonstrates that stormwater runoff is completely managed using site design measures, there is no need to design stormwater treatment measures at the project site.[16]

The output of the Post-Construction Calculator for each DMA must be submitted with the PCSM Plan.

The Port Area Developer may propose an alternate method for calculating the runoff reduction achieved by the Site Design Measures. Alternative methods should be discussed with the Port's Environmental Programs and Planning Division prior to submitting the PCSM plan and discussed in detail in the PSCM plan.

3.2.6 Stormwater Treatment Measures

After implementation of Site Design Measures in **Section 3.2.3** to the extent technically feasible, any excess runoff up to the SDV/SDF (determined using the methodology in **Section 3.2.5**) must be directed to one or more facilities for infiltration, evapotranspiration, and/or biotreatment. Stormwater treatment measures are designed to handle the frequent, smaller storm events, or the first flush stormwater runoff from larger storm events. The first flush of larger storm events is the initial period of the storm where stormwater runoff typically carries the highest concentration and loads of pollutants.

> If stormwater runoff is completely managed using site design measures, there is no need for stormwater treatment measures.

[14] Although the Post-Construction Calculator states that it is for Small Projects, it is the same calculator that is used for Regulated Projects.

[15] See explanation in Section 3.2.7.1

[16] This shall be determined by subtracting from a DMA's SDV the "Total Runoff Volume Reduction Credit" provided by the Post-Construction Calculator. A determination shall not be based on the result of the "Project-Related Volume Increase with Credits" on the left-hand side of the calculator or the text message immediately below (See Appendix I). Read about SDV_{adj} in **Section 3.2.7.1**.

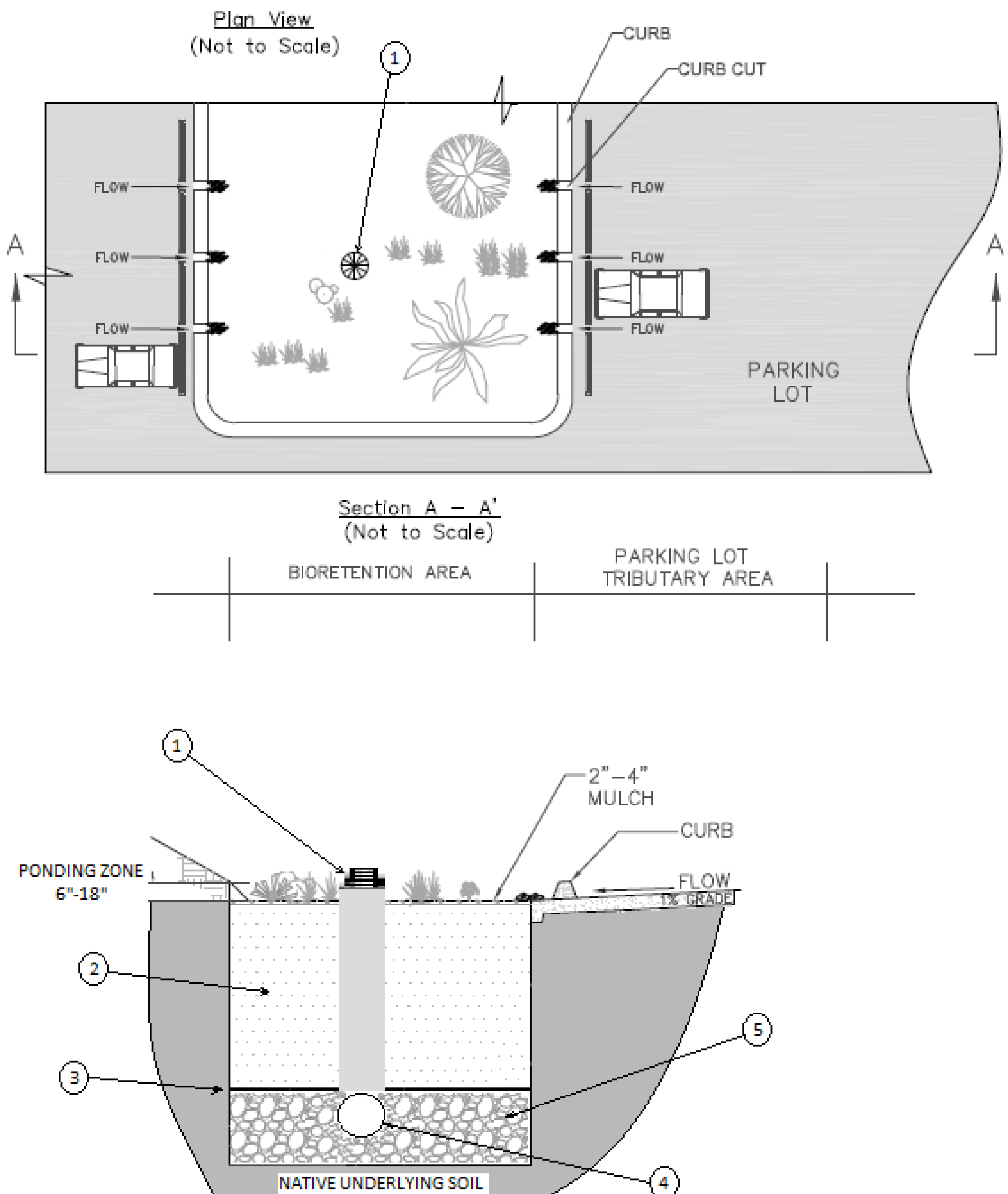
The Phase II Permit (Provision F.5.g.2.d) requires the use of bioretention unless (1) an alternative treatment measure that is equivalent to bioretention is proposed and demonstrated[17] (see **Section 3.3**), or (2) a specific exception applies[18] (see **Section 3.4**). The following section describes how to implement bioretention at a project site.

3.2.7 Bioretention

A bioretention facility, which is an LID stormwater control measure, is a vegetated shallow depression that is designed to receive, retain, and infiltrate stormwater runoff from downspouts, piped inlets, or sheet flow from adjoining impervious areas. A shallow ponding zone above the vegetated surface provides temporary storage of stormwater runoff. During storm events, stormwater runoff accumulates in the ponding zone and gradually infiltrates and filters through the engineered planting media before infiltrating into the underlying soil. Vegetation also holds water in the root zone that can be returned to the atmosphere by transpiration. Bioretention facilities are typically planted with climate-appropriate vegetation that do not require fertilization and can withstand periodic wet soils. An example schematic of a typical bioretention area is presented in **Figure 3**.

[17] Phase II Permit, Provision F.5.g.2.d (a)

[18] Phase II Permit, Provision F.5.g.2.d (c)



NOTES

1. OVERFLOW DEVICE: VERTICAL RISER OR EQUIVALENT
2. 1.5' PLANTING MEDIA; 3' PREFERRED. PLANTING MEDIA SPECIFICATIONS PER BIORETENTION TECHNICAL SPECIFICATIONS
3. 2-4" CALTRANS CLASS 2 PERMEABLE MATERIAL (PLANTING MEDIA/GRAVEL LAYER SEPARATION ZONE)
4. PERFORATED 8" MIN PVC SDR 26 OR C9000
5. 1' MIN 1"-2.5" DIAMETER STONE

Figure 3. Example Bioretention Facility Schematic

3.2.7.1 Design Criteria

The following sections describe the minimum design criteria for bioretention facilities.

Geotechnical

Due to the potential to contaminate groundwater and/or soils, cause slope instability, impact surrounding structures, and potential for insufficient infiltration capacity, a geotechnical investigation must be conducted during the site assessment process to verify the site suitability for bioretention. It is critical to understand how stormwater runoff will move through the soil (horizontally and vertically) and if there are any geological conditions that may inhibit the movement of water. Soil infiltration rates and the depth to the groundwater table must be evaluated to ensure that conditions are satisfactory for proper operation of a bioretention system. Bioretention facilities should not be located on sites with a slope greater than two percent. A Site Conditions Report summarizing the relevant findings from the geotechnical investigation must be submitted with the PCSM Plan.

Setbacks

Applicable setbacks must be implemented when siting a bioretention facility.

Pretreatment

Pretreatment, which refers to design features that provide settling of large particles before stormwater runoff enters a stormwater treatment measure, is important to ensure proper operation of a bioretention facility and reduce the long-term maintenance burden. Pretreatment must be provided if source control measures (see **Section 3.2.2**) are insufficient. Pretreatment measures (e.g., vegetated swales, proprietary devices) reduce the sediment load entering a bioretention facility in order to prevent the engineered planting media and/or underlying soil from being occluded prematurely and maintain the infiltration rate of the bioretention facility. Pretreatment for other pollutants may also be appropriate if source controls are not adequate to control the pollutants. In particular, for sites with high infiltration rates where pollutants may not be attenuated by the soil column, pretreatment is required to protect groundwater quality.

Flow Entrance and Energy Dissipation

The DMA(s) tributary to a bioretention facility must be graded to minimize erosion as stormwater runoff enters the facility by creating sheet flow conditions rather than a concentrated stream condition or by providing energy dissipation devices at the inlet. Typically, a minimum slope of 1 percent for pervious surfaces and 0.5 percent for impervious surfaces to the inlet of the bioretention facility should be maintained. The following types of flow entrances can be used for bioretention facilities:

- Level spreaders (e.g., slotted curbs) can be used to facilitate sheet flow.
- Dispersed low velocity flow across a landscaped area. Dispersed flow may not be possible given space limitations or if the bioretention facility controls roadway or parking lot flows where curbs are mandatory.
- Dispersed flow across pavement or gravel and past wheel stops for parking areas.

- Flow spreading trench around perimeter of the bioretention facility that may be filled with pea gravel or vegetated with 3:1 side slopes.
- Curb cuts for roadside or parking lot areas. Curb cuts must include rock or other erosion controls in the channel entrance to dissipate energy. The flow entrance should drop two to three inches from curb line and provide an area for settling and periodic removal of sediment and coarse material before flow disperses to the remainder of the bioretention facility.
- Piped entrances, such as roof downspouts, must include rock, splash blocks, or other erosion controls at the entrance to dissipate energy and disperse flows.

Drainage

Bioretention facilities provide stormwater runoff storage in the ponding zone and in the voids of the planting media and gravel layers and must completely drain into the underlying soils within 48 hours. The planting media and gravel layers and underlying soils must be allowed to dry out periodically in order to restore hydraulic capacity to receive stormwater runoff from subsequent storm events, maintain infiltration rates, maintain adequate soil oxygen levels for healthy soil biota and vegetation, and provide proper soil conditions for biodegradation and retention of pollutants.

Sizing

Step 1: Determine the Adjusted SDV (SDV_{adj})

Bioretention facilities are designed to capture and retain the SDV_{adj}, which is the difference between the SDV (**Section 3.2.5**) and the volume of stormwater runoff managed through site design measures (SDM_{credit}) (**Section 3.2.3**), for the tributary DMA(s).[19]

$$SDV_{adj} = SDV - SDM_{credit}$$

Step 2: Determine the design infiltration rate

Determine the in-situ infiltration rate of the underlying soil using the Double-Ring Infiltrometer standard (ASTM D3385). Apply a safety factor to the in-situ infiltration rate to determine the design infiltration rate. A typical safety factor of four can be used (i.e., multiply in-situ infiltration rate by 0.25). The design infiltration rate (f_{design}) must be between 0.5 and 5.0 in/hr. Soil amendments may be used to improve the flow of stormwater runoff into the underlying soil if the design infiltration rate is less than 0.5 in/hr. If the infiltration rate of the underlying soil is greater than 5.0 in/hr, an underdrain may not be necessary. The infiltration rate will decline between maintenance cycles as the surface of the bioretention facility becomes occluded and particulates accumulate in the infiltrative layer.

[19] The imperviousness ratio, "i", used in the calculation of SDV for impervious areas (including, if available, porous pavement and green roof) shall be 1, if credit is be determined separately (e.g., with the State Water Board's Post-Construction Stormwater Runoff Reduction Calculator).

Step 3: Determine size of bioretention facility design layers

Bioretention facilities consist of multiple layers that are designed to retain stormwater runoff. The design depths, which are used to size the bioretention facility, are presented in **Table 8**. Other design parameters for these layers are discussed in further detail in the following sections.

Table 8. Design Depths of Bioretention Facility Layers

Bioretention Facility Layer	Design depth
Ponding zone	0.5-1.5 ft
Planting media (excluding the mulch layer, if provided)	1.5-3.0 ft
Planting media/gravel layer separation zone (1)	0.16-0.33 ft (2-4 in)
Gravel	1 ft (min)

(1) In calculating the required bottom surface area of the bioretention facility, the planting media/ gravel layer separation zone is not considered because it is designed primarily to separate the planting media and gravel layer and not to retain stormwater runoff.

Step 4: Calculate the bottom surface area of the bioretention facility

Determine the bottom surface area (surface area at the base of side slopes, not at the top of side slopes) of the bioretention facility using the following equation:

$$A = \frac{SDV_{adj}}{d_{pz} + (\eta_{pm} \times d_{pm}) + (\eta_{gl} \times d_{gl})}$$

Where:

A = bottom surface area of bioretention facility [ft^2];
SDV_{adj} = adjusted stormwater design volume [ft^3];
d_{pz} = depth of ponding zone (0.5-1.5 ft) [ft];
η_{pm} = porosity of planting media [unitless];
d_{pm} = depth of planting media (min 1.5 ft) [ft];
η_{gl} = porosity of gravel layer [unitless]; and
d_{gl} = depth of gravel layer (min 1 ft) [ft].

The total depth of the bioretention facility must meet the following condition to ensure that the stormwater runoff will be infiltrated within the maximum drawdown time:

$$d_{pz} + (\eta_{pm} \times d_{pm}) + (\eta_{gl} \times d_{gl}) \leq \frac{f_{design}}{12} \times t_{max}$$

Where:

d_{pz} = depth of ponding zone (0.5-1.5 ft) [ft];
η_{pm} = porosity of planting media [unitless];
d_{pm} = depth of planting media (min 1.5 ft) [ft];
η_{gl} = porosity of gravel layer [unitless];
d_{gl} = depth of gravel layer (min 1 ft) [ft]
f_{design} = corrected in-situ infiltration rate of the underlying soil (0.5-5.0 in/hr) [in/hr]; and
t_{max} = drawdown time (max 48 hrs) [hr].

For the site layout and planning purposes, the top surface area, which can be calculated from the bottom surface area and slopes of the bioretention facility, will need to be determined.

Planting Media Layer

The Phase II Permit requires that the planting media layer:

- Have a minimum depth of 1.5 feet, excluding the mulch layer;
- Achieve a long-term, in-place minimum infiltration rate of at least 5 in/hr to support maximum stormwater runoff retention and pollutant removal; and
- Consist of 60 to 70 percent sand meeting the specifications of the ASTM C33 and 30 to 40 percent compost.

Compost must be a well-decomposed, stable, weed-free organic matter source derived from waste materials including yard debris, wood wastes, or other organic material and not including manure or biosolids meeting standards developed by the U.S. Composting Council (USCC). The product must be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

Mulch retains soil moisture, prevents erosion, and minimizes weed growth. To improve water efficiency, projects are required to provide at least two inches of mulch. Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. Annual placement (preferably in June after weeding) of one to two inches of mulch beneath plants will maintain the mulch layer.

Planting Media/Gravel Layer Separation Zone

The planting media and gravel layer must be separated by a permeable 2-4 inch layer of sand and stone that meets the grading requirements in **Table 9** to prevent migration of the planting media into the gravel layer.

Table 9. Planting Media/Gravel Layer Separation Layer Grading Requirements

Sieve Size	Percent Passing
1”	100
3/4”	90-100
3/8”	40-100
No. 4	25-100
No. 8	18-33
No. 30	5-15
No. 50	0-7
No. 200	0-3

Source: Caltrans Standard Specifications (2010) Class 2 Permeable Material

Gravel Layer

The gravel layer must consist of washed 1- to 2.5-inch diameter stone with a minimum 1-foot depth.

Underdrain

If necessary, an underdrain may be included in the design of a bioretention facility to convey treated stormwater runoff for further treatment, to the storm drain system, or to the receiving water. The underdrain must have a discharge elevation at the top of the gravel layer and a mainline diameter of eight inches using slotted PVC SDR 26 or C900. The slotted PVC allows for pressure cleaning and root cutting, if necessary. The slotted pipe should have two to four rows of slots cut perpendicular to the axis of the pipe or at right angles to the pitch of corrugations. Slots should be 0.04 to 0.1 in wide with a length of 1 to 1.25 in. Slots should be longitudinally-spaced such that the pipe has a minimum of one square inch opening per lineal foot and should face down. Underdrains should be sloped at a minimum of 0.5 percent in order to drain freely to an approved location.

The Phase II Permit (Provision F.5.g.2.d (b)) identifies the following two allowed variations for special site conditions, which must be demonstrated by the project applicant, for underdrain placement:

- Bioretention facilities located in areas with documented high concentrations of pollutants in the underlying soil or groundwater, where infiltration may contribute to a geotechnical hazard, or on elevated plazas or other structures may locate the underdrain at the bottom of the subsurface drainage/storage layer.
- If the bioretention facility is located in areas with high groundwater, highly infiltrative soils (in-situ infiltration rate greater than 5.0 in/hr), or where connection of the underdrain to a surface drain or to a subsurface storm drain is infeasible, the underdrain may be omitted.

Observation Well

A rigid non-perforated observation pipe with a diameter equal to the underdrain diameter must be connected to the underdrain to provide a clean-out port as well as an observation well to monitor infiltration rates. If the underdrain is located at the top of the gravel layer, the observation well may also extend to the bottom of the gravel layer to monitor drainage of the gravel layer. The wells/clean-out port must be connected to the slotted underdrain with the appropriate manufactured connections. The wells/clean-outs must extend at least six inches above the top elevation of the bioretention facility mulch and be capped with a lockable screw cap. The ends of the underdrain pipes not terminating in an observation well/clean-out port must also be capped.

Vegetation

It is recommended that a minimum of three climate-appropriate types of tree, shrub, and/or herbaceous groundcover species be incorporated in a bioretention facility to protect against failure due to disease and/or insect infestations of a single species. Trees may be planted on the slopes or above the slopes of the bioretention facility (i.e., not planted in the planting media layer). Select vegetation that:

- Can tolerate summer drought, ponding fluctuations, and saturated soil conditions for 48 hours;
- Will be dense and strong enough to stay upright, even in flowing water;

- Does not require fertilizers;
- Is not prone to pests and is consistent with Integrated Pest Management (IPM) practices; and
- Is consistent water conservation requirements, established by the Port or the East Bay Municipal Water District, including regulations governing water use during water shortage emergency conditions.[20]

A sample list of suitable vegetation species is included in **Appendix G**. Prior to installation, a California licensed landscape architect with experience in bioretention facility design must certify that all proposed vegetation is appropriate for the project site. During the period of vegetation establishment, stormwater runoff entering the bioretention facility must be controlled to prevent erosion.

Irrigation System

Bioretention facilities should be designed to minimize irrigation needs and if possible to not need irrigation after the initial plant establishment period. If needed, provide an irrigation system to maintain viability of vegetation. If possible, the general landscape irrigation system should incorporate the bioretention facility. The irrigation system must be designed to meet Port or East Bay Municipal Water District water efficiency standards and must comply with the requirements in **Section 3.2.2**. Supplemental irrigation may be required for the establishment period even if it is not needed later.

Overflow Device

An overflow device is required at the ponding depth near the inlet to the bioretention facility to divert stormwater runoff in excess of the design capacity of the bioretention facility. The following, or equivalent, should be provided:

- A vertical PVC pipe (SDR 26) to act as an overflow riser.
- The overflow riser(s) should be at least eight inches in diameter so it can be cleaned without damage to the pipe.
- The inlet to the riser must be at the ponding depth and capped with a spider cap to exclude floating mulch and debris. Spider caps must be screwed on or glued (i.e., not removable). The overflow device must convey stormwater runoff in excess of the design capacity of the bioretention facility to an approved discharge location (e.g., another stormwater treatment measure, storm drain system, receiving water).

Hydraulic Restriction Layer (Special Site Condition only)

The Phase II Permit[21] identifies an allowed variation for special site conditions, which must be demonstrated by the Port Area Developer, for bioretention facilities located in areas with documented high concentrations of pollutants in the underlying soil or groundwater, where infiltration may contribute to a geotechnical hazard, or on elevated plazas or other structures. In

[20] EBMUD Authority-Resolution Number 34026-15

[21] Provision F.5.g.2.d (b)(2)

these situations, a hydraulic restriction layer may be incorporated at the bottom of the gravel layer to prevent infiltration of stormwater runoff into the underlying soil. The hydraulic restriction layer should be installed generously with overlapping seams below the gravel layer of the bioretention facility prior to placing the gravel layer, planting media and gravel layer separation zone, and planting media layer. The specifications of the hydraulic restriction layer are presented in **Table 10**.

Table 10. Hydraulic Restriction Layer Specifications

Parameter	Test Method	Specifications
Material		Nonwoven geomembrane liner
Unit weight		8 oz/yd^3 (minimum)
Filtration rate		0.08 in/sec (minimum)
Puncture strength	ASTM D-751 (Modified)	125 lbs (minimum)
Mullen burst strength	ASTM D-751	400 lb/in^2 (minimum)
Tensile strength	AST D-1682	300 lbs (minimum)
Equiv. opening size	US Standard Sieve	No. 80 (minimum)

3.2.8 Construction Considerations

As part of the site planning process, the areas designated for bioretention must be identified on site maps and in the field. Establish protective perimeters to prevent compaction of underlying soils near and at the bioretention area and to protect the facility from construction related sediment loads.

During construction activities, if possible divert all flows around the areas intended for bioretention. Implement sediment controls to minimize sediment from entering the areas facility until the tributary area is fully stabilized.

Compaction of underlying soils near and at the bioretention facility must be avoided. If the underlying soils are compacted, ripping or loosening the top two inches of the underlying soils prior to construction of the bioretention facility may be needed to improve infiltration.

3.2.9 Inspection and Maintenance Requirements

Regular maintenance and inspection are important for proper function of bioretention facilities. Bioretention facilities require annual plant, soil, and mulch layer maintenance to ensure optimal infiltration, storage, and pollutant removal. Bioretention facility maintenance requirements, which consist primarily of landscape care, include:

- Irrigate vegetation as needed during prolonged dry periods. In general, climate-appropriate vegetation should be selected; this vegetation does not require irrigation after full establishment (two to three years). Regularly inspect the irrigation system, if provided, for clogs or broken pipes and repair as necessary.
- Inspect flow entrances, ponding area, and surface overflow areas, at a minimum annually, and replace soil, vegetation, and/or mulch layer in areas if erosion has occurred. Properly-designed facilities with appropriate flow velocities should not cause erosion except possibly during extreme events. If erosion occurs, the flow velocities and gradients within

the bioretention facility and energy dissipation and erosion protection strategies in the pretreatment area and flow entrance should be reassessed. If sediment is deposited in the bioretention facility, identify the source of the sediment within the tributary area, stabilize the source, and remove excess surface deposits.

- Inspect the bioretention facility after major storms to determine if erosion occurred and ensure that water infiltrates into the subsurface completely within the maximum drawdown time. If water is present in the bioretention facility more than 48 hours after a storm, the bioretention facility may be clogged. Maintenance activities triggered by a clogged facility include:
    - Check for debris/sediment accumulation, remove sediment (if any), and evaluate potential sources of sediment and vegetative or other debris. If suspected upstream sources are outside of the Port's jurisdiction, additional pretreatment may be necessary.
    - Determine if it is necessary to remove and replace the planting media and/or gravel layer to restore functionality of the bioretention facility.
- Prune and remove dead vegetation as needed. Replace all dead vegetation, and if specific vegetation has high mortality rates, assess the cause and, if necessary, replace with more appropriate species.
- Remove weeds and other invasive, poisonous, nuisance, or noxious vegetation as needed until the vegetation is established. Weed removal should become less frequent if the appropriate species are used and planting density is attained.
- Remove and properly dispose of trash and other litter.
- Select the proper soil mix and plants for optimal fertility, vegetation establishment, and growth to preclude the use of nutrient and pesticide supplements. Addition of nutrients and pesticides may contribute pollutant loads to receiving waters.
- In areas where heavy metals deposition is likely (e.g., industrial, vehicle operations, parking lots, roads, tarmacs), replace mulch annually. In areas where metals deposition is less likely (e.g., commercial retail zones), replace or add mulch as needed to maintain a two- to three-inch depth at least once every two years. Mulch and soils removed from the bioretention area must be tested for heavy metals to identify proper disposal methods.

> Consider frequent mulch replacement to minimize heavy metal accumulation.

- Eliminate standing water to prevent vector breeding. If standing water is observed more than 48 hours after a storm event, it may be necessary to remove and replace the planting media and/or gravel layer to restore functionality of the bioretention facility.
- Inspect, and clean if necessary, the underdrain and observation well/clean-out port. Inspect overflow devices for obstructions or debris, which should be removed immediately. Repair or replace damaged pipes upon discovery.

The Port requires the development of an Operations and Maintenance Plan for the on-going operation and maintenance of the stormwater control measures. The requirements for Operations and Maintenance Plans are discussed in **Section 4**.

3.2.10 Variations for Special Site Conditions

The Phase II Permit[22] allows for the bioretention design criteria discussed above to be modified for the following special site conditions, which must be demonstrated by the project applicant:

- Facilities located within 10 feet of structures or other potential geotechnical hazards established by a geotechnical engineer for the project may incorporate an impervious cutoff wall between the bioretention facility and the structure or other geotechnical hazard;
- Facilities with documented high concentrations of pollutants in underlying soil or groundwater, facilities located where infiltration could contribute to a geotechnical hazard, and facilities located on elevated plazas or other structures may incorporate an impervious liner and may locate the underdrain discharge at the bottom of the subsurface drainage/storage layer (this configuration is commonly known as a "flow-through planter");
- Facilities located in areas of high groundwater, highly infiltrative soils or where connection of underdrain to a surface drain or to a subsurface storm drain are infeasible, may omit the underdrain; and
- Facilities serving high-risk areas such as fueling stations, truck stops, and heavy industrial sites may be required to provide additional treatment to address pollutants of concern unless these high-risk sites are isolated from stormwater runoff or bioretention areas with little chance of spill migration.

While variations for special site conditions may be allowed, these are not exceptions for implementing bioretention or alternative stormwater treatment measures at the project site.

3.3 ALTERNATIVE STORMWATER TREATMENT MEASURES TO BIORETENTION

The Phase II Permit[23] allows the use of alternative stormwater treatment measure(s) in lieu of bioretention if the project applicant demonstrates that the proposed measure meets all of the following measures of equivalent effectiveness criteria when compared to the bioretention standards outlined in the Phase II Permit[24]:

> Jurisdictional waters (including wetlands) cannot be proposed as stormwater management/treatment measures.

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and
- Equal or greater accessibility and ease of inspection and maintenance.

[22] Provision F.5.g.2.d (b)

[23] Provision F.5.g.2.d (a)

[24] Provision F.5.g.2.d

Fact sheets for alternative stormwater treatment measures that may be proposed in the PCSM Plan are included in **Appendix E**. A list of these factsheets is noted in **Table 11**. Infiltration basins and infiltration trenches which are each designed to infiltrate stormwater runoff, are typically accepted alternatives to bioretention. Other measures, including proprietary design measures, may or may not meet the equivalent effectiveness criteria listed above. The Port Area Developer must demonstrate, in the PCSM Plan, how a proposed alternative stormwater treatment measure meets all of the equivalent effectiveness criteria. Treatment measures failing the equivalent effectiveness test may still be used if the project satisfies one or more of the exception criteria described in **Section 3.4** below.

Table 11. Alternative Stormwater Treatment Measures Fact Sheets

Factsheet	Alternative Measure
LID-1	Infiltration Basin
LID-2	Infiltration Trench
LID-3	Green Roof
T-1	Stormwater Planter
T-2	Tree-Well Filter
T-3	Sand Filter
T-4	Vegetated Swales
T-5	Proprietary Stormwater Treatment Measures
HM-1	Extended Detention Basin
HM-2	Wet Pond

3.4 EXCEPTIONS TO REQUIREMENTS FOR BIORETENTION OR BIORETENTION-EQUIVALENT FACILITIES

The Phase II Permit[25] allows specific exceptions to implementing bioretention upon demonstration by the project applicant that bioretention or alternative designs equivalent to bioretention (i.e., bioretention-equivalent facilities as described in **Section 3.3**) are technically infeasible. In these situations, other types of biotreatment or media filters (e.g., tree-well filters, in-vault media filters) may be used. Only projects that meet the criteria below may receive an exception from the bioretention requirements:

- Facilities receiving stormwater runoff solely from existing (pre-project) impervious areas; and
- Historic sites, structures, or landscapes that cannot alter their original configuration in order to maintain their historic integrity.

Meeting an exception listed above does not preclude a Port Area Developer from proposing and implementing an alternative stormwater treatment measure to manage stormwater. The project

[25] Provision F.5.g.2.d (c)

applicant must demonstrate an exception from implementing bioretention for managing stormwater runoff and propose alternative stormwater treatment measures applicable to the project site.

4 Stormwater Treatment Measures Operation and Maintenance

Continued effectiveness of stormwater control measures requires on-going inspection and maintenance. To ensure that such maintenance is provided, the Port requires the submittal of an Operations and Maintenance Plan and inclusion of stormwater treatment measure(s) maintenance requirements in the tenant lease agreement for Regulated Projects. In situations where the stormwater treatment measure(s) will be owned or maintained by the Port, the tenant lease agreement will allow Port staff access to the property to maintain the stormwater control measure(s).

Properly sited stormwater treatment measures are not considered waters of the U.S, therefore permits under the Clean Water Act should not be required for on-going maintenance.[26]

The Port Area Developer, his/her designee, or successor is responsible for complying with the Operations and Maintenance Plan. Failure to properly implement the Operations and Maintenance Plan may result in enforcement by the Port.

This section presents requirements for the Operations and Maintenance Plan and Maintenance Access Agreement and the Operations and Maintenance Verification Program.

4.1 OPERATION AND MAINTENANCE PLAN REQUIREMENTS

A draft Operations and Maintenance Plan is required as part of the PCSM Plan submittal to the Port with the Development Application. Upon completion of the project, a final Operations and Maintenance Plan must be submitted. The Operations and Maintenance Plan must address the following requirements, which are discussed in the following sections:

- Baseline information;
- Final as-built site map and details;
- Operation, inspection, and maintenance requirements and schedule;
- Spill plan;
- Training; and
- Annual Self-Certification Report by July 1.

Most of these requirements can be satisfied by completing the Operation and Maintenance Plan Template provided in **Appendix F** of this Manual.

[26] ‘‘The following are not ‘‘waters of the United States’’ even where they otherwise meet the terms of paragraphs (a)(4) through (8) of this section … (6) Stormwater control features constructed to convey, treat, or store stormwater that are created in dry land.” **Federal Register** /Vol. 80, No. 124 /Monday, June 29, 2015 /Rules pp. 37105**.** The Clean Water Rule: Definition of "Waters of the United States" published in the Federal Register (PDF) on June 29, 2015. The rule will become effective on August 28, 2015. http://www2.epa.gov/cleanwaterrule/prepublication-version-final-clean-water-rule)

4.1.1 Baseline Information

- List property owners or tenant-operators and persons responsible for operation and maintenance of the stormwater control measure(s) including contact information (i.e., phone numbers and addresses).
- Identify the intended method of funding for the on-going operation and maintenance of the stormwater control measure(s).
- List all installed stormwater control measure(s) including description of each stormwater control measure, date of installation, and design specifications.

4.1.2 Final As-Built Site Map and Details

A preliminary site map must be included in the Operations and Maintenance Plan as part of the PCSM Plan submittal. Final as-built site map and details, stamped by a by a certified geotechnical engineer, professional civil engineer, or professional geologist, must be included in the final Operations and Maintenance Plan.

- Provide a final as-built site map showing boundaries of the project site, acreage, drainage patterns/contour lines, and DMAs as well as any field modifications to approved designs during construction.
- Show each discharge location from the project site and any drainage flowing onto the project site (i.e., run-on).
- Distinguish between pervious and impervious surfaces on the map.
- Identify the location of each stormwater control measure, sanitary sewer systems, underground utility, and grade breaks for purposes of pollution prevention.
- With a legend, identify locations of expected sources of pollution generation (e.g., outdoor work and storage areas, heavy traffic areas, delivery areas, trash enclosures, fueling areas, wash-racks). Identify any areas having contaminated soil or where pollutants are stored or have been stored/ disposed of in the past.

4.1.3 Operation, Inspection, and Maintenance Requirements and Schedule

- Identify cleaning activities, including litter removal and disposal, and schedule. Identify any housekeeping procedures that may reduce maintenance requirements.
- Identify vegetation/landscape management methods and schedule. Distinguish between maintenance during the vegetation establishment period and expected long-term maintenance. These procedures must provide sufficient detail to a person unfamiliar with these maintenance methods to perform the activity or identify the specific skills or knowledge to perform and document the maintenance.
- Identify vector control practices.[27]

[27] California Department of Public Health. (2012). Best Management Practices for Mosquito Control in California. Retrieved on July 20, 2012 from http://www.westnile.ca.gov/resources.php.

- Identify equipment resource requirements necessary to operate and maintain stormwater control measures.
- Create an inspection and/or maintenance log template to document inspection and/or maintenance activities, including inspector names, dates, and stormwater control measure(s) inspected and maintained. The log should note any significant maintenance requirements due to spills or unexpected discharges.

4.1.4 Spill Plan

- Provide emergency notification procedures (phone and agency/persons to contact).
- As appropriate for site, provide emergency containment and cleanup procedures.
- Note downstream receiving waters.

4.1.5 Training

Provide information about training persons responsible for operating and maintaining stormwater treatment measure(s). This training should include:

- Good housekeeping procedures defined in the Operations and Maintenance Plan;
- Proper maintenance of all devices, including stormwater treatment measures;
- Identification and cleanup procedures for spills and overflows;
- Large-scale spill or hazardous material response; and
- Safety concerns when maintaining devices and cleaning up spills.

4.1.6 Self-Certification Annual Report

Annually, by July 1, the Port Area Developer, his/hers designee, or successor must provide to the Port Environmental Division a self-certification that the project’s stormwater treatment measures are being properly operated and maintained. The report shall, at a minimum, describe the inspection and maintenance activities performed during the previous year and append the related field logs. For Port projects, the applicable business line or engineering division must provide the annual self-certification. The final Operations and Maintenance Plan must provide details on how the Port Area Developer, his/hers designee, or successor will conduct its annual self-certification.

4.2 MAINTENANCE LEASE CONDITIONS

For stormwater control measures on leased properties, the tenant will be responsible for on-going maintenance in accordance with Port Ordinance 4311 and all applicable conditions in the lease agreement.

During the plan review process, the Port will also assess whether access by Port staff or performance bonds are needed. Access conditions are required if the Port will assume all or part of the responsibilities for operations and maintenance of stormwater control measures. If needed, access conditions will be added to the tenant lease or supplementary agreement.

The Port may require performance bonds for construction and during the initial establishment period. For vegetative-based control measures (i.e., bioretention facilities), a bond that is extended one year after project acceptance by the Port is required to ensure proper maintenance of the vegetation during the initial establishment period.

4.3 OPERATION AND MAINTENANCE VERIFICATION PROGRAM

The Phase II Permit[28] requires that the Port implement an Operations and Maintenance Verification Program for all stormwater treatment measures. As part of this requirement, the Port is required to develop a database or equivalent table of all Regulated Projects that have installed stormwater treatment measures. The following information must be included in the database or equivalent table:

- Name and address of the Regulated Project;
- Specific description of the location (in Port's GIS or PortView or a map showing the location) of the installed stormwater treatment measure(s)
- Date(s) that the stormwater treatment measure(s) (if any) were installed;
- Description of the type and size of the stormwater treatment measure(s) (if any) installed;
- Responsible operator(s) for each stormwater treatment measure(s) (if any) installed;
- Dates and findings of inspections (routine and follow-up) of the stormwater treatment measure(s) (if any) by the Port; and
- Any problems and/or corrective or enforcement actions taken.

[28] Provision F.5.g.4

APPENDIX A

Glossary and List of Acronyms

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Appendix A - List of Acronyms and Glossary

List of Acronyms

ASTM	American Society for Testing and Materials
BMP	Best Management Practice
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CWA	Clean Water Act (Federal Water Pollution Control Act)
DMA	Drainage Management Area
ESA	Environmentally Sensitive Area
HUC	Hydrologic Unit Code
IPM	Integrated Pest Management
LID	Low Impact Development
LUFT	Leaking Underground Fuel Tank
LUP	Linear Underground/Overhead Utility Projects
MEP	Maximum extent practicable
MS4	Municipal Separate Storm Sewer System
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit
PAH	Polycyclic aromatic hydrocarbons
PCSM	Post-Construction Stormwater Management Plan
SDF	Stormwater Design Flow
SDV	Stormwater Design Volume
SLIC	Spills, Leaks, Investigations, and Cleanups
STA	Seal of Testing Assurance
SWMM	Stormwater Management Model
TMDL	Total maximum daily load
TSS	Total suspended solids
USCC	United States Composting Council
USEPA	United States Environmental Protection Agency
USC	United States Code

Glossary

Beneficial Uses – The uses (e.g., domestic, municipal, agricultural, and industrial supply, power generation, recreation, aesthetic enjoyment, navigation and preservation of fish and wildlife, other aquatic resources or preserves) of waters of the state protected against degradation.

Berm – Earthen mound used to direct the flow of stormwater runoff around or through a structure.

Best Management Practices (BMPs) – Methods, measures, or practices designed and selected to reduce or eliminate the discharge of pollutants to surface waters from point and nonpoint source discharges including stormwater runoff. BMPs include structural and non-structure controls and operations and maintenance procedures that can be applied before, during, and/or after pollution producing activities.

Catch Basin – A catch basin, which is also known as a storm drain inlet, is an inlet to the storm drain system that typically includes a grate or curb inlet where stormwater runoff enters the catch basin and a sump to capture sediment, debris, and associated pollutants. Catch basins act as pretreatment for other treatment practices by capturing large sediments. The performance of catch basins at removing sediment and other pollutants depends on the design of the catch basin (e.g., the size of the sump), and routine maintenance to retain the storage available in the sump to capture sediment.

Clean Water Act – This is the Federal Water Pollution Control Act of 1972, as amended, Title 33 of the United States Code (USC) 1251, et. seq., which has been incorporated by reference in Chapter 5.5 of the California Water Code.

Commercial Development – Any development on private land that is not heavy industrial or residential. This category includes, but is not limited to, hospitals, laboratories and other medical facilities, educational institutions, recreational facilities, plant nurseries, car wash facilities, mini-malls, business complexes, shopping malls, hotels, office buildings, public warehouses, and light industrial complexes.

Common Plan or Development or Sale – United States Environmental Protection Agency (USEPA) regulations include the term “common plan of development or sale” to ensure that acreage within a common project does not artificially escape the permit requirements because construction activities are phased, split among smaller parcels, or completed by different owners/developers. In the absence of an exact definition of “common plan of development or sale,” the State Water Board is required to exercise its regulatory discretion in providing a common sense interpretation of the term as it applies to construction projects and permit coverage. The common plan of development is generally a contiguous area where multiple, distinct construction activities may be taking place at different times under one plan. A plan is generally defined as any piece of documentation or physical demarcation that indicates that construction activities may occur on a common plot. Such documentation could consist of a tract map, parcel map, demolition plans, grading plans, or contract documents. Any of these documents could delineate the boundaries of a common plan area. However, broad planning documents, such as land use master plans, conceptual master plans, or broad-based CEQA or NEPA documents that identify potential projects for an agency or facility are not considered common plans of development. An overbroad interpretation of the term would render meaningless the clear "one acre" federal permitting threshold and would potentially trigger permitting of almost any construction activity that occurs within an area that had previously received area-wide utility or road improvements.

Conduit – Any channel or pipe directing the flow of water.

Construction Site – Any project, including projects requiring coverage under the General Construction Permit, that involves soil disturbing activities, including, but not limited to, clearing, grading, paving, disturbances to ground such as stockpiling, and excavation.

Culvert – A covered channel or a large diameter pipe that crosses under a road, sidewalk, etc.

Detached Single Family Home Project – The building of one single new house or the addition and/or replacement of impervious surface associated with one single existing house, which is not part of a larger plan of development.

Detention – The temporary storage of stormwater runoff to allow treatment by sedimentation and metered discharge of stormwater runoff at reduced peak flow rates. The capture and subsequent release of stormwater runoff form the site at a slower rate than it is collected with the difference being held in temporary storage.

Development – Any construction, rehabilitation, redevelopment, or reconstruction of any public or private residential project (e.g., single-family, multi-family, planned unit of development); industrial, commercial, retail, and other non-residential project projects, including public agency projects; or mass grading for future construction.

Direct Discharge – A discharge that is routed directly to waters of the United States by means of a pipe, channel, or ditch, including a municipal separate storm sewer system, or through surface runoff.

Discharge of a Pollutant – The addition of any pollutant or combination of pollutants to waters of the United States from any point source, or any addition of any pollutant or combination of pollutants to waters of the contiguous zone or the ocean from any point source other than a vessel or other floating craft which is being used as a means of transportation. The term includes additions of pollutants to waters of the United States from: surface runoff which is collected or channeled by man; discharges through pipes, sewers, or other conveyances owned by a State, municipality, or other person which do not lead to a treatment works; and discharges through pipes, sewers, or other conveyances, leading into privately-owned treatment works.

Discharger – Any responsible party or site owner or operator within the Port's jurisdiction whose site discharges stormwater runoff or a non-stormwater discharge.

Disturbed Area – Area that is altered as a result of clearing, grading, and/or excavation.

Dry Weather – This refers to the season where prolonged dry periods occur. In California's Mediterranean climate, this usually corresponds to the period between May and September.

Erosion – The physical detachment of soil due to wind or water. Often the detached fine soil fraction becomes a pollutant transported by stormwater runoff. Erosion occurs naturally, but can be accelerated by land disturbance and grading activities such as farming, development, road building, and timber harvesting.

Erosion Control Measures – Measures used to minimize soil detachment. These may include:

- Vegetation, either undisturbed or planted (e.g., grasses, wildflowers); and
- Other materials, such as
    - Straw (applied over bare soil, crimped into soil);
    - Protective erosion control blankets;
    - Fiber (applied as mulch or hydromulch); and
    - Mulch (avoid plastics if possible).

Excavation – The process of removing earth, stone, or other materials, usually by digging.

Final Stabilization – All soil disturbing activities at each individual parcel within the site that have been completed in a manner consistent with the requirements of the State Water Resources Control Board *General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities* (Order No. 2012-0006-DWQ).

Flood Management Facilities – Facilities or structures designed for the explicit purpose of controlling flood waters safely in or around populated areas (e.g., dams, levees, bypass areas). Flood management facilities do not include traditional stormwater conveyance structures (e.g., stormwater sewerage, pump stations, catch basins).

Grading – The cutting and/or filling of the land surface to a desired slope or elevation.

Hydromodification – Modification of hydrologic pathways (i.e., precipitation, surface runoff, infiltration, groundwater flows, return flow, surface-water storage, groundwater storage, evaporation, transpiration) that results in negative impacts to watershed health and functions.

Hydrologic Unit Code (HUC) 12 Watershed – The HUC is the "address" of the watershed. The HUC is a numeric code of the United States Geological Survey (USGS) watershed classification system used to identify the watersheds, or drainage basins, at various scales. The HUC organizes watersheds by a nested size hierarchy, so large watershed boundaries for an entire region may be assigned a two-digit HUC, while small scale, local watershed boundaries (within the larger regional watershed) may be assigned a 12-digit HUC. A HUC-12 watershed averages 22 square miles in size.

Illicit Discharge – Any discharge to a storm drain system that is prohibited under local, state, or federal statutes, ordinances, codes, or regulations. The term illicit discharge includes all non-stormwater discharges not composed entirely of stormwater and discharges that are identified under the Discharge Prohibitions section of the 2013 MS4 Permit. The term illicit discharge does not include discharges that are regulated by a National Pollutant Discharge Elimination System (NPDES) permit (other than the NPDES permit for discharge from a municipal separate storm sewer system).

Impaired Waterbody – A waterbody (e.g., stream reaches, lakes, waterbody segments) with chronic or recurring monitored violations of the applicable numeric and/or narrative water quality criteria. An impaired water is a water that has been listed on the State of California 303(d) list or has not yet been listed, but otherwise meets the criteria for listing. A water is a portion of a surface water of the state, including ocean, estuary, lake, river, creek, or wetland. The water currently may not be meeting state water quality standards or may be determined to be threatened and have the potential to not meet standards in the future. The State of California's 303(d) list can be found at http://www.swrcb.ca.gov/quality.html.

Impervious Surface – A surface covering or pavement of a developed parcel of land that prevents the land's natural ability to absorb and infiltrate rainfall/stormwater. Impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots, roads, storage areas, impervious concrete and asphalt, and any other continuous watertight pavement or covering. Landscaped soil and pervious pavement, including pavers with pervious openings and seams, underlain with pervious soil or pervious storage material, such as a gravel layer sufficient to hold a specific volume of stormwater runoff are not impervious surfaces.

Industrial Development – Development or redevelopment of property to be used for industrial purposes, such as factories, manufacturing buildings, and research and development parks.

Infill Site – A site in an urbanized area where the immediate adjacent parcels are developed with one or more qualified urban uses or at least 75 percent of the perimeter of the site adjoins parcels that have previously been developed for qualified urban uses and no parcel within the site has been created within the past 10 years.

Infiltration – The downward entry of water into the surface of the soil.

Integrated Pest Management (IPM) – An ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism.

Linear Underground/Overhead Utility Projects (LUPs) – Include, but are not limited to, any conveyance, pipe, or pipeline for the transportation of any gaseous, liquid (including water and wastewater for domestic municipal services), liquiescent, or slurry substances; any cable line or wire for the transmission of electrical energy; any cable line or wire for communications (e.g., telephone, telegraph, radio, or television messages); and associated ancillary facilities. Construction activities associated with LUPs include, but are not limited to: (a) those activities necessary for the installation of underground and overhead linear facilities (e.g., conduits, substructures, pipelines, towers, poles, cables, wires, connectors, switching regulating and transforming equipment, and associated ancillary facilities); and include, but are not limited to, (b) underground utility mark-out, potholing, concrete and asphalt cutting and removal, trenching, excavation, boring and drilling, access road and pole/tower pad and cable/wire pull station, substation construction, substructure installation, construction of tower footings and/or foundations, pole and tower installations, pipeline installation, welding, concrete and/or pavement repair or replacement, and stockpile/borrow locations.

Low Impact Development (LID) – A sustainable practice that benefits water supply and contributes to water quality protection. Unlike traditional stormwater management, which collects and conveys stormwater runoff through storm drains, pipes, or other conveyances to a centralized stormwater facility, LID takes a different approach by using design techniques that infiltrate, filter, store, evaporate, and detain stormwater runoff close to the source of rainfall.

Maximum Extent Practicable (MEP) – The minimum required performance standard for implementation of the municipal stormwater management programs to reduce pollutants in stormwater. Clean Water Act §402(p)(3)(B)(iii) requires that municipal permits "shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the [United States Environmental Protection Agency] Administrator or the State determines appropriate for the control of such pollutants". MEP is the cumulative effect of implementing, evaluating, and making corresponding changes to a variety of technically appropriate and economically feasible BMPs, ensuring that the most appropriate controls are implemented in the most effective manner. This process of implementing, evaluating, revising, and adding new BMPs is commonly referred to as the iterative process.

Mixed-Use Development – Development or redevelopment of property to be used for two or more different uses, all intended to be harmonious and complementary. An example is a high-rise building with retail shops on the first 2 floors, office space on floors 3 through 10, apartments on the next 10 floors, and restaurant on the top floor.

Municipal Separate Storm Sewer System (MS4) – The regulatory definition of an MS4 (Title 40 of the Code of Federal Regulations [40 CFR] Part 122.26(b)(8)) is "a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body (created to or pursuant of state law) including special districts under state law such as a sewer district, flood control district or drainage discharge, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges into waters of the United States; (ii) designed or used for collecting or conveying stormwater; (iii) which is not a combined sewer; and (iv) which is not part of a Publicly-Owned Treatment Works (POTW) as defined at 40 CFR Part 122.2".

In practical terms, operators of MS4s can include municipalities and local sewer districts, state and federal departments of transportation, public universities, public hospitals, military bases, ports and airports, correctional facilities, etc.

National Pollutant Discharge Elimination System (NPDES) – The federal program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.

New Development – New development means land disturbing activities; structural development, including construction or installation of a building or structure, creation of impervious surfaces; and land subdivision on an area that has not been previously developed.

Nonpoint Source Pollution – Pollution that does not come from a point source. Nonpoint source pollution originates from diffuse sources that are mostly related to land use.

Non-Stormwater Discharge – A discharge that does not originate from precipitation events. They can include, but are not limited to, discharges of process water, air conditioner condensate, non-contact cooling water, vehicle wash water, sanitary wastes, concrete washout water, paint wash water, irrigation water, or pipe testing water.

Outfall – A point source as defined by 40 CFR Part 122.2 at the point where an MS4 discharges to the waters of the United States and does not include open conveyances connecting two MS4s, or pipes, tunnels, or other conveyances which connect segments of the same stream or other waters of the United States and are used to convey waters of the United States.

Parking Lot – Land area or facility for the parking or storage of motor vehicles used for business, commerce, industry, or personal use.

Pavement Replacement (also known as reconstruction) – Process of removing existing pavement down to the subbase and replacing it with new base course and new pavement.

Pavement Resurfacing (also known as overlay, asphalt overlay, pavement overlay) – Process of installing a new layer of pavement over existing pavement.

Pervious Pavement – Pavement that stores and infiltrates rainfall at a rate that exceeds conventional pavement.

Point Source – Any discernible, confined, and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operations, landfill leachate collection systems, vessel, or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

Pollutant – Dredged spoils, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials (except those regulated under the Atomic Energy Act of 1954, as amended [42 USC 2011 et. seq.]), heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Pollutants of Concern – Pollutants of concern found in urban runoff include sediments, non-sediment solids, nutrients, pathogens, oxygen-demanding substances, petroleum hydrocarbons, heavy metals, floatables, polycyclic aromatic hydrocarbons (PAHs), trash, and pesticides and herbicides.

Pollution – An alteration of the quality of the waters of the state by waste to a degree which unreasonably affects the beneficial uses of the water or facilities which serve those beneficial uses.

Precipitation – Any form of rain or snow.

Project Acceptance – Completion of all construction discretionary permitting to finalize project.

Publicly-Owned Treatment Works (POTW) – A treatment works defined by Section 212 of the Clean Water Act (33 USC 1292).

Redevelopment – Land-disturbing activity that results in the creation, addition, or replacement of exterior impervious surface area on a site on which some past development has occurred. Redevelopment does not include trenching, excavation and resurfacing associated with LUPs; pavement grinding and resurfacing of existing roadways; construction of new sidewalks, pedestrian ramps, or bike lanes on existing roadways; or routine replacement of damaged pavement such as pothole repair or replacement of short, non-contiguous sections of roadway.

Regulated Project – Refers to projects subject to the new development and redevelopment standards in Section F.5.g.2 of the Phase II General Permit.

Retention – The storage of stormwater runoff to prevent it from leaving the development site.

Riparian Areas – Plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent waterbodies. Riparian areas have one or both of the following characteristics: (1) distinctively different vegetative species than adjacent areas; and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland.

Roads – For the purposed of this Manual, roads refers to traditional streets and roadways as well as taxiways (Alpha, Bravo, Charlie, Delta, Echo, Foxtrot, Golf, Hotel, Juliet, Kilo, Lima, Papa, Romeo, Sierra, Tango, Uniform, Victor, Whiskey and Yankee), and runways (12/30, 10R/28L, 10L/28R, and 15/33).

Routine Maintenance and Repair Projects – Projects that maintain the original footprint and purpose of the facility.

Run-on – Discharges that originate off-site and flow onto the property of a separate project site.

Sediment – Solid particulate matter, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Sediment Control Measures – Measures used to trap and/or retain detached soil before discharging to receiving waters. These may include:

- Fiber rolls (e.g., keyed-in straw wattles, compost rolls);
- Silt fences;
- Retention basins; and
- Active treatment systems.

Sedimentation – The process of depositing soil particles, clays, sands, or other sediments that were picked up by stormwater runoff.

Smart Growth Projects – Projects that produce multiple-benefits such as economic, social, and environmental benefits. Smart growth projects commonly include high-density development projects that result in a reduction of stormwater runoff volume per capita as a result of reduced impervious surface.

Sheet Flow – Flow of water that occurs overland in areas, where there are no defined channels, such that water spreads out over a large area at a uniform depth.

Soil Amendment – Any material that is added to the soil to change its chemical properties, engineering properties, or erosion resistance that could become mobilized by stormwater runoff.

Source Control – Land use or site planning practices, or structural or non-structural measures, that aim to prevent runoff pollution by reducing the potential for contact with stormwater runoff at the source of pollution. Source control measures minimize the contact between pollutants and urban runoff.

Surface Drainage – Any above-ground runoff (e.g., sheet, shallow concentrated, open channel) that flows into the storm drain system.

Storm Drain – Above- and below-ground structures for transporting stormwater runoff.

Storm Drain System – The basic infrastructure in an MS4 that collects and conveys stormwater runoff to a treatment facility or receiving water.

Stormwater – Stormwater runoff, snowmelt runoff, surface runoff, and drainage, excluding infiltration and irrigation tailwater. Urban runoff and snowmelt runoff consisting only of those discharges, which originate from precipitation events. Stormwater is that portion of precipitation that flows across a surface to the storm drain system or receiving water.

Stormwater Runoff – Stormwater runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground. As stormwater runoff flows over land or impervious surfaces, it accumulates debris, chemicals, sediment, or other pollutants that could adversely affect water quality if the stormwater runoff is discharged untreated.

Stormwater Treatment System – Any engineered system designed to remove pollutants from stormwater runoff by settling, filtration, biological degradation, plant uptake, media absorption/adsorption, or other physical, biological, or chemical process. This includes landscape-based systems such as vegetated swales and bioretention facilities as well as proprietary stormwater treatment measures.

Structural Controls – Any structural facility designed and constructed to mitigate the adverse impacts of stormwater and urban runoff pollution.

Time of Concentration – The time it takes the most hydraulically-remote drop of water to travel through a watershed to a specific point of interest.

Total Maximum Daily Loads (TMDLs) – The maximum amount of a pollutant that can be discharge into a waterbody from all sources (point and nonpoint) and still maintain water quality standards. Under Section 303(d) of the Clean Water Act, TMDLs must be developed for all waterbodies that do not meet water quality standards even after the application of technology-based controls, more stringent effluent limitations required by a state or local authority, and other pollution control requirements, such as BMPs.

Total Suspended Solids (TSS) – The measure of the suspended solids in a water sample includes inorganic substances (e.g., soil particles) and organic substances (e.g., algae, aquatic plant/animal waste, particles related to industrial/sewage waste). The TSS test measures the concentration of suspended solids in water by measuring the dry weight of a solid material contained in a known volume of a sub-sample of a collected water sample. Results are reported in milligrams per liter.

Trash and Debris – Trash consists of litter and particles of litter. Section 68055.1(g) of the California Code of Regulations (CCR) defines litter as all improperly discarded waste material, including, but not limited to, convenience foods, beverage, and other product packages or containers constructed of steel, aluminum, glass, paper, plastic, and other natural and synthetic materials, thrown or deposited on the lands and waters of the state, but not including the properly discarded waste of the primary processing of agriculture, mining, logging, sawmilling, or manufacturing.

Treatment – Any method, technique, or process designed to remove pollutants and/or solids from polluted stormwater runoff, wastewater, or effluent.

Turbidity – The “cloudiness” of water quantified by the degree to which light traveling through a water column is scatted by the suspended organic and inorganic particles it contains. Results are typically reported in Nephelometric Turbidity Units (NTU).

Waste – Includes sewage and any and all other waste substances liquid, solid, gaseous, or radioactive, associated with human habitation, or of human or animal origin, or from any producing, manufacturing, or processing operation, including waste placed within containers of whatever nature, prior to, and for the purposes of, disposal.

Waste Load Allocation – The portion of the receiving water’s TMDL that is allocated to one of its existing or future point sources of pollution. Waste load allocations constitute a type of water quality-based effluent limitation.

Waters of the United States – This generally refers to surface waters, as defined by the USEPA in 40 CFR Part 122.2.

Water Quality Objectives – The limits or levels of water quality elements or biological characteristics established to reasonably protect the beneficial uses of water or to prevent pollution problems within a specific area. Water quality objectives may be numeric or narrative.

Water Quality Standards – State-adopted and USEPA-approved water quality standards for waterbodies. The standards prescribe the use of the waterbody and establish the water quality criteria that must be met to protect designated uses. Water quality standards also include the federal and state antidegradation policy.

Watershed Processes – Functions that are provided by watersheds, including, but not limited to, groundwater recharge, sediment supply and delivery, streamflow, and aquatic habitat.

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APPENDIX B

Jurisdictional Boundary Maps

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Figure 1a. Map of Port Jurisdictional Area, Maritime

PORT AREA COVERED BY SWMP (MARITIME AREA)

SHEET 1 OF 2	DATE: 6/17/2013
CREATED BY: KD	REVIEWED BY: CR
DATA SOURCES: URS, ESRI, PORT OF OAKLAND	

PORT OF OAKLAND URS

URS - Oakland CA - K.Dawdy C:\Port_GIS_Data\SWMP Port Area map\SWMP_area_map_v2.mxd

Figure 1b. Map of Port Jurisdictional Area, Aviation

URS - Oakland CA - K.Dawdy C:\Port_GIS_Data\SWMP Port Area map\SWMP_area_map_v2.mxd

APPENDIX C

Post-Construction Stormwater Management Plan Worksheets

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Section C-1: Basic Project Information

This worksheet must be filled out for all projects required to implement the *2015 Post-Construction Stormwater Design Manual*.

Project Site Address	
Owner Information	
Name	______
Title, if applicable	______
Company or Affiliation	______
Address	______
Telephone Number	______
Email Address	
Licensed Professional Certification	
Name	______
Title	______
Company or Affiliation	______
Address	______
Telephone Number	______
Email Address	______
Licensed geotechnical engineer, professional civil engineer, or professional geologist Stamp and Signature	

Appendix C
Post-Construction Stormwater Management Plan Worksheets

Type of Project

Is the proposed project:

- ◻ A routine maintenance or repair project that maintains the original purpose and footprint of the facility?
  - ◻ Exterior wall surface replacement
  - ◻ Pavement or tarmac resurfacing within an existing footprint
  - ◻ Replacement of damaged pavement or tarmac (e.g., pothole repair, short-non-contiguous sections of roadway less than 5,000 ft^2)
  - ◻ Re-roofing regardless of whether it is a full roof replacement or an overlay
- ◻ Interior remodels that do not modify the existing footprint?
- ◻ Excavation, trenching, and resurfacing associated with linear underground/overhead utility projects?
- ◻ Pavement grinding and resurfacing of existing roadways and parking lots?
- ◻ Construction of new sidewalks, pedestrian ramps, or bicycle lanes on existing roadways?
- ◻ Construction of sidewalks and bicycle lanes built as part of new streets or roads that are graded to runoff to adjacent vegetated areas?
- ◻ Construction of sidewalks, bicycle lanes, and trails with permeable surfaces?
- ◻ Construction of impervious trails graded to runoff to adjacent vegetated areas or other non-erodible permeable areas?
- ◻ Construction on wharves over water that drain runoff directly into the Bay?

The above projects are exempt from the requirements of the *2015 Post-Construction Stormwater Design Manual*. See Section 2.2.2 of the *2015 Post-Construction Stormwater Design Manual* for details on project exceptions. Submit Section 1 Basic Project Information as part of the application submittal.

If the proposed project is not exempt as identified above, identify the type of project:

- □ Small Project – These are projects that create and/or replace at least 2,500, but less than 5,000 square feet of impervious surface.
- □ Regulated Project – These are projects that create and/or replace greater than or equal to 5,000 square feet of impervious surface, road projects, and LUPs that create 5,000 square feet or more of newly constructed contiguous impervious surfaces.
  - □ New development
  - □ Redevelopment that increases the impervious surface area by 50 percent or more of the existing development
  - □ Redevelopment that increases the impervious surface area by less than 50 percent of the existing development
  - □ Road projects (roadways, runways, and taxiways)
    - □ New roads
    - □ Widening of existing roads
  - □ Linear Underground / Overhead Utility Projects (LUPs)

Description of the Project

Provide a description of the proposed project.

____

____

____

____

Owner Certification and Signature

The undersigned owner of the subject property is responsible for the implementation of the provisions of this Project Stormwater Management Plan consistent with the requirements of the 2015 Post-Construction Stormwater Design Manual, the Port of Oakland Ordinance No. 4311, and Provision F.5.g of the California State Water Resources Control Board Phase II Permit (Order No. 2013-0001-DWQ). If the undersigned transfers its interest in the property, its successors-in-interest shall bear the aforementioned responsibility to implement the Post-Construction Stormwater Management Plan. A copy of the final signed and fully approved Post-Construction Stormwater Management Plan shall be available on the subject site throughout the course of the development.

Owner Signature ____

Date ____________________

Section C-2: Small Projects

The following worksheets and reports are required as part of the Post-Construction Stormwater Management Plan submittal for Small Projects.

Site Assessment Worksheet

All projects are required to assess conditions at the project site. This information is used to plan the project site layout and identify potential sources of pollutants of concern. More information is available in Sections 3.1.1 of the *2015 Post-Construction Stormwater Design Manual*.

Source Control Measures Worksheet

All projects are required to implement source control measures to prevent pollutants from contacting stormwater runoff or prevent discharge of contaminated stormwater runoff from the project site. All projects that include landscape irrigation must implement the source control measure for landscape irrigation. More information is available in Section 3.1.2 of the *2015 Post-Construction Stormwater Design Manual*.

Site Design Measures Worksheet

Small Projects are required to implement at least one site design measure to the extent technically feasible and calculate the stormwater runoff volume credit using the State Water Resources Control Board's Post-Construction Calculator. The Post-Construction Calculator is available at: www.swrcb.ca.gov/water_issues/programs/stormwater/phase_ii_municipal.shtml. Complete a Site Design Measure Worksheet for each DMA as part of the Post-Construction Stormwater Management Plan submittal. More information is available in Sections 3.1.3 of the *2015 Post-Construction Stormwater Design Manual*.

Site Conditions Report

A Site Conditions Report prepared by or under the supervision of a competent, licensed professional, needs to address and discuss relevant findings of a geotechnical and site evaluation. See Section 3.1.1.1 of the *2015 Post-Construction Stormwater Design Manual.*

Project Site Plan

- A Project Site Plan must, at a minimum, illustrate:
- Site boundaries;
- Existing natural hydrologic features and significant vegetation (if any);
- Locations and footprints of existing impervious areas;
- Proposed locations and footprints of improvements creating new, or replaced impervious surfaces;
- Existing and proposed site drainage system and connections to off-site drainage; and
- Proposed locations and footprints of stormwater control measures (e.g., site design measures, source control measures) implemented to manage stormwater runoff.

Appendix C
Post-Construction Stormwater Management Plan Worksheets

Site Assessment Worksheet

All Projects (other than exempt projects) are required to assess conditions at the project site. This information is used to plan the project site layout and identify potential sources of pollutants of concern. More information is available in Sections 3.1.1 of the *2015 Post-Construction Stormwater Design Manual*.

General Project Site Information

Latitude ____________ Longitude ____________ Elevation ____________

Total Project Area (A_T) (ft^2) ____________

Total Existing Impervious Area (ft^2) ____________ Total Post-Project Impervious Area (ft^2) ____________

Receiving Water(s) ____________

Describe location(s) of discharge from the project site.

____

____

Describe Environmentally Sensitive Areas, if applicable.

____

____

Pollutants of Concern

Post-Project Land Use Type(s) ____________

Describe expected pollutant-generating activities.

Pre-project ____________

____

Post-project ____________

____

Identify pollutants of concern.

____

____

Source Control Measures Worksheet

Describe source control measures to be implemented for each potential pollutant generating activity or source present at the project site. If a potential pollutant generating activity or source is not present at the project site, indicate it as “N/A”.

Parking/storage areas and maintenance

____

____

Landscape/outdoor pesticide use

____

____

Building and grounds maintenance

____

____

Refuse areas

____

____

Outdoor storage of equipment or materials

____

____

Vehicle and equipment cleaning

____

____

Vehicle and equipment repair and maintenance

____

____

Fuel dispensing areas

____

____

Pools, spas, ponds, decorative fountains, and other water features

____

____

Source Control Measures Worksheet (cont'd)

Indoor and structural pest control

Accidental spills or leaks

Restaurants, grocery stores, and other food service operations

Interior floor drains

Industrial processes

Loading docks

Fire sprinkler test water

Drain or wash water from boiler drain lines, condensate drain lines, rooftop equipment, drainage sumps, and other sources

Unauthorized non-stormwater discharges

Site Design Measures

Small Projects are required to implement at least one site design measure and quantify the runoff reduction resulting from implementing the measure(s) using the State Water Resources Control Board's Post-Construction Calculator, which is available at: www.swrcb.ca.gov/water_issues/programs/stormwater/phase_ii_municipal.shtml. Consult Appendix I for further instructions on using the calculator. Additional information is also available in Sections 3.1 and 3.2.5 of the *2015 Post-Construction Stormwater Design Manual*.

For the proposed project, identify the following information:

Proposed Site Design Measure	**Stormwater Runoff Volume Credit (ft^3)**
□ Stream setbacks and buffers	____________
□ Soil quality improvement and maintenance	____________
□ Tree planting and preservation	____________
□ Rooftop and impervious area disconnection	____________
□ Porous pavement	____________
Green roofs	____________
□ Vegetated swales	____________
□ Rain barrels/cisterns	____________
Total Stormwater Runoff Volume Credit (ft^3)	____________

The project applicant must include a printout of the Post-Construction Calculator results as part of the Project Post-Construction Stormwater Management Plan.

Section C-3: Regulated Projects

The following worksheets and reports are required as part of the Post-Construction Stormwater Management Plan submittal for Regulated Projects.

Site Assessment Worksheet

All projects are required to assess conditions at the project site. This information is used to plan the project site layout and identify potential sources of pollutants of concern. More information is available in Sections 3.2.1 of the *2015 Post-Construction Stormwater Design Manual*.

Source Control Measures Worksheet

All projects are required to implement source control measures to prevent pollutants from contacting stormwater runoff or prevent discharge of contaminated stormwater runoff from the project site. All proposed projects that include landscape irrigation must implement the source control measure for landscape irrigation. More information is available in Section 3.2.2 of the *2015 Post-Construction Stormwater Design Manual*.

Drainage Management Area Worksheet

Regulated Projects are required to delineate discrete drainage management areas for a project site and manage stormwater runoff according to those drainage management areas (DMA). Complete the Drainage Management Area Worksheet for each DMA at the project site. More information is available in Section 3.2.4 of the *2015 Post-Construction Stormwater Design Manual*.

Site Design Measures Worksheet

Regulated Projects are required to implement site design measures to the extent technically feasible and calculate the stormwater runoff volume credit using the State Water Resources Control Board's Post-Construction Calculator for each DMA. The Post-Construction Calculator is available at: www.swrcb.ca.gov/water_issues/programs/stormwater/phase_ii_municipal.shtml. More information is available in Sections 3.2.5 of the *2015 Post-Construction Stormwater Design Manual*. Complete a Site Design Measure Worksheet for each DMA as part of the Post-Construction Stormwater Management Plan submittal.

Stormwater Treatment Measures Worksheet

Regulated Projects are required to implement stormwater treatment control measures to manage the portion of the stormwater runoff volume not mitigated by site design measures. Bioretention is the preferred stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative treatment control measure that is equivalent to bioretention is proposed and justified, or (2) a specific exception applies. More information is available in Sections 3.2.6 of the *2015 Post-Construction Stormwater Design Manual*. Complete a Stormwater Treatment Control Measure Worksheet for each DMA where proposed site design measures do not fully manage stormwater runoff of the DMA and submit as part of the Post-Construction Stormwater Management Plan.

Site Conditions Report

A Site Conditions Report prepared by or under the supervision of a competent, licensed professional, needs to address and discuss relevant findings of a geotechnical and site evaluation. See Section 3.1.1.1 of the *2015 Post-Construction Stormwater Design Manual.*

Project Site Plan

A Project Site Plan must, at a minimum, illustrate:

- Site boundaries;
- Existing natural hydrologic features and significant vegetation (if any);
- Locations and footprints of existing impervious areas;
- Proposed locations and footprints of improvements creating new, or replaced impervious surfaces;
- Existing and proposed site drainage system and connections to off-site drainage;
- All DMAs with unique identifiers;
- Proposed locations and footprints of stormwater control measures (e.g., site design measures, source control measures, stormwater treatment control measures) implemented to manage stormwater runoff.

Operations and Maintenance Plan

Continued effectiveness of stormwater control measures requires on-going inspection and maintenance. To ensure that such maintenance is provided, the Port requires the submittal of an Operations and Maintenance Plan as described in Section 4 of the *2015 Post-Construction Stormwater Design Manual*.

Site Assessment Worksheet

General Project Site Information

Latitude ____________ Longitude ____________ Elevation ____________

Total Project Area (A_T) (ft^2) ____________

Total Existing Impervious Area (ft^2) ____________ Total Post-Project Impervious Area (ft^2) ____________

Receiving Water(s) ____________

Describe location(s) of discharge from the project site.

Describe Environmentally Sensitive Areas, if applicable.

Pollutants of Concern

Post-Project Land Use Type(s) ____________

Describe expected pollutant-generating activities.

Pre-project ____________

Post-project ____________

Identify pollutants of concern.

Source Control Measures Worksheet

Describe source control measures to be implemented for each potential pollutant generating activity or source present at the project site. If a potential pollutant generating activity or source is not present at the project site, indicate it as "N/A".

Parking/storage areas and maintenance

____

____

Landscape/outdoor pesticide use

____

____

Building and grounds maintenance

____

____

Refuse areas

____

____

Outdoor storage of equipment or materials

____

____

Vehicle and equipment cleaning

____

____

Vehicle and equipment repair and maintenance

____

____

Fuel dispensing areas

____

____

Pools, spas, ponds, decorative fountains, and other water features

____

____

Source Control Measures Worksheet (cont'd)

Indoor and structural pest control

____

____

Accidental spills or leaks

____

____

Restaurants, grocery stores, and other food service operations

____

____

Interior floor drains

____

____

Industrial processes

____

____

Loading docks

____

____

Fire sprinkler test water

____

____

Drain or wash water from boiler drain lines, condensate drain lines, rooftop equipment, drainage sumps, and other sources

____

____

Unauthorized non-stormwater discharges

____

____

Drainage Management Area Worksheet

Drainage Management Area (DMA) # ______________

Describe the DMA ____
____
____

Total Drainage Area (ft^2)	________
Existing Impervious Area (ft^2)	________
Post-Project Impervious Area (ft^2)	________
Soil Type	________
Infiltration Rate (in/hr)	________
Mean Runoff-Producing Rainfall Depth (P_6) (in)	0.48
Drawdown time (t_{max}) (hr) (24 or 48)	________
Regression constant (a) (1.582 for 24-hr drawdown, 1.963 for 48-hr drawdown)	________

Post-Project Condition:

Imperviousness ratio (i) = Post-Project Impervious Area ÷ Total Drainage Area (decimal)	________
Stormwater runoff coefficient (C) = $0.858 \times i^3 - 0.78 \times i^2 + 0.774 \times i + 0.04$	________
Unit stormwater volume (P_0) (in) = $a \times C \times P_6$	________
Stormwater Design Volume for the DMA (SDV) (ft^3) = $A \times P_0 \div 12$	________

Site Design Measures Worksheet

Drainage Management Area (DMA) # ______________

For this DMA, identify the following information:

Stormwater Design Volume without credits (ft^3) = SDV ______________

Stormwater Design Volume with credits (ft^3) = SDV_{adj} = SDV - SDM_{credit}
(This volume must be treated by stormwater treatment control measures.) ______________

Do proposed site design measures completely manage the SDV for this DMA?

- □ Yes, stormwater management requirement met for this DMA.
- □ No, proceed to Stormwater Treatment Measures Worksheet.

Proposed Site Design Measure	Stormwater Runoff Volume Credit (ft^3)
□ Stream setbacks and buffers	______________
□ Soil quality improvement and maintenance	______________
□ Tree planting and preservation	______________
□ Rooftop and impervious area disconnection	______________
□ Porous pavement	______________
Green roof	______________
□ Vegetated swales	______________
□ Rain barrels/cisterns	______________
Total Stormwater Runoff Volume Credit (SDM_{credit})	______________

For Regulated Projects, site design measures are required to be implemented to the degree technically feasible. For site design measures not implemented for this DMA, describe why they were not selected.

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____
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Stormwater Treatment Measures Design Worksheet

For each drainage management area (DMA), in which proposed site design measures did not fully manage the Stormwater Design Volume (SDV), complete this worksheet.

Drainage Management Area (DMA) # ____________

Design bioretention facility to manage the adjusted stormwater design volume (SDV_{adj}). Calculate the bottom surface area of a bioretention facility:

Stormwater Design Volume for the DMA (SDV) (ft^3)
See Drainage Management Area Worksheet. ____________

Total Stormwater Runoff Credit Volume (SDM_{credit}) (ft^3)
See Site Design Measure Worksheet. ____________

Adjusted Stormwater Design Volume (SDV_{adj}) (ft^3) = SDV - SDM_{credit} ____________

Design infiltration rate of underlying soils (f_{design}) (in/hr) ____________

Ponding zone depth (d_{pz}) (ft) (0.5-1.5 ft) ____________

Planting media layer depth (d_{pm}) (ft) (min 1.5 ft) ____________

Planting media porosity (η_{pm}) ____________

Gravel layer depth (d_{gl}) (ft) (min 1 ft) ____________

Gravel layer porosity (η_{gl}) ____________

Bottom surface area of a bioretention facility (ft^2) = $\frac{SDV_{adj}}{d_{pz}+(\eta_{pm}\times d_{pm})+(\eta_{gl}\times d_{gl})}$ ____________

Verify that: $d_{pz} + (\eta_{pm} \times d_{pm}) + (\eta_{gl} \times d_{gl}) \leq f_{design} \times t_{max} \div 12$. If not, redesign factors above.

Verify that the site has adequate space to implement bioretention facility sized above. If not, redesign factors above or provide additional stormwater site design or treatment control measures to manage remaining portion of the SDV.

Describe and provide justification for any variations to the bioretention facility for site-specific conditions. See Section 3.2.10 of the *2015 Post-Construction Stormwater Design Manual* for more information.

____

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Describe and provide justification if an alternative stormwater treatment control measure is proposed in lieu of a bioretention facility. An alternative stormwater treatment control measure proposed for a project must meet all the requirements of Section 3.3 of the *2015 Post-Construction Stormwater Design Manual*.

____

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Describe and provide justification for any exceptions to the requirements for bioretention. Exception to bioretention must meet all the requirements of Section 3.4 of the *2015 Post-Construction Stormwater Design Manual*. Identify and describe the proposed biotreatment or media filter system that will be used in lieu of bioretention.

____

____

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____

Summary of Stormwater Treatment Measures Design

Stormwater Design Volume for DMA (SDV) (ft^3) __________

1. Total Stormwater Runoff Credit Volume (SDM_{credit}) (ft^3) __________
2. Volume of Stormwater Runoff Managed by Bioretention Facility (ft^3) __________
3. Volume of Stormwater Runoff Managed by Other Stormwater Treatment Control Measure (identify each control measure)
    a. __________
    b. __________

Total Stormwater Runoff Volume Managed for DMA (ft^3) = sum of items 1-3 above. __________

If Total Stormwater Runoff Volume Managed for this DMA equals or exceeds the Stormwater Design Volume for this DMA, then design for stormwater management for this DMA is complete. If the Total Stormwater Runoff Volume Managed for this DMA is less than the Stormwater Design Volume for this DMA, redesign site design measures and stormwater treatment control measures until the entire Stormwater Design Volume for this DMA has been managed. Complete this exercise for each DMA.

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APPENDIX D

Source Control Measures Fact Sheets

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Appendix D - Source Control Measure Fact Sheets

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S-1: Accidental Spills and Leaks

Background

Spills and leaks are one of the largest contributors of pollutants in stormwater, and if not properly controlled, can adversely impact the storm drain system and receiving waters. Many activities have the potential for spills (accidental or illegal) and leaks. Proper spill response planning and preparation can result in effective response and mitigation to problems when they occur and potentially minimize the discharge of pollutants into the environment. An effective plan should have spill prevention and response procedures that identify potential spill areas, specify material handling and spill response procedures, and provide spill cleanup equipment and materials. Proper training of personnel is also necessary to prevent or control future spills.

Pollution Prevention Activities and Best Management Practices

A Spill Prevention and Control Plan must be developed to standardize the procedures for preventing, mitigating, and responding to spills on-site, which can discharge to the storm drain system. The Spill Prevention and Control Plan must include the following information:

- Description of the site, site address, owner, owner contact information, and activities and chemicals present on-site;
- Site map, which includes locations where chemicals and/or materials are stored;
- Notification and evacuation procedures;
- Clean-up instructions;
- Identification of appropriate contacts (e.g., owner, operator, regulatory agencies, emergency responders);
- Reporting procedures; and
- Identification of key spill response personnel.

Implement, if feasible, the following BMPs:

- Post “No Dumping” signs with appropriate contact information for reporting illegal dumping and disposal. Signs should also indicate fines and penalties for illegal dumping. Bright lighting and/or entrance barriers may also be used to discourage illegal dumping.
- Store and contain liquid materials such that if the storage unit failed, the contents will not discharge, flow, or be washed into the storm drain system or receiving waters. If necessary, provide secondary containment. If the material stored will separate from and float in water, install a spill control device in the catch basin that collects runoff from the storage tank area.

- Regularly inspect tanks and other storage facilities for leaks and spills. Replace tanks that are leaking, corroded, or otherwise damaged with tanks in good condition. Place drip pans or absorbent materials beneath mounted taps and at all potential drip and/or spill locations during filling and unloading storage tanks. Collected liquids or soiled absorbent materials may be reused or recycled or properly disposed of.
- Label all containers according to its contents. Provide hazardous materials labels if necessary.
- Sweep and clean the storage area regularly if it is paved. Do not hose down the area that conveys to a storm drain.
- Provide appropriate spill cleanup materials in a location near the storage facilities.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

In the event that a spill occurs, conduct the following activities:

- Follow the Spill Prevention and Control Plan.
- Clean up spills and leaks immediately. On paved surfaces, use physical and/or dry cleanup methods (e.g., brooms, sweepers, shovels) if possible. Use rags for small spills, a damp mop for general cleanup, and absorbent materials for larger spills. For large spills, specialized contractors may be necessary. Properly dispose of all materials used to clean up spills and leaks.
- Minimize the amount of water used to clean up spills and leaks.
- Report spills to the proper agencies, which may include the following:
    - Alameda County Department of Environmental Health;
    - San Francisco Bay Regional Water Quality Control Board;
    - State Water Resources Control Board;
    - United States Environmental Protection Agency; and
    - Local fire and/or police department.
- Spill information, such as type of material and quantity, patterns of occurrence, responsible parties, must be recorded.

S-2: Interior Floor Drains

Background

Interior floor drains typically collect process waters, cooling waters, wash waters, and sanitary wastewater. These discharges can carry pollutants such paint, oil, fuel and other automotive fluids, chemicals and other pollutants into the storm drain system and receiving waters. Pollution prevention activities and BMPs outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges through interior floor drains.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce potential pollutants that are discharged into the storm drain system through interior floor drains include the following:

- Label interior floor drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- Identify all interior floor drains on a site and/or facility map.
- Remove and properly dispose of trash and debris regularly so they do not enter the floor drain.
- Direct accumulated water from interior floor drains to treatment devices (e.g., oil and water separator) or the sanitary sewer system, if permitted.
- In areas where there are high-risk pollutants or a high risk of pollutant mobilization, seal interior floor drains and use alternative dry methods (e.g., sweeping) or wet vacuums to collect waste.
- Do not store materials that can be washed, blown, or otherwise mobilized near interior floor drains.
- If necessary, verify that interior floor drains do not connect to the storm drain system by smoke and/or dye testing or closed-circuit television inspection.
- Consider hydraulically-isolating interior floor drains with berms.
- Train, including providing periodic refresher training, personnel on proper disposal methods.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Spot clean leaks and drips routinely to prevent runoff of spillage. Place drip pans or absorbent materials under leaks.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

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S-3: Parking and Storage Areas and Maintenance

Background

Parking lots and storage areas may be a source of various pollutants, including trash, solids, hydrocarbons, oil and grease, and heavy metals that may be conveyed by stormwater and non-stormwater runoff to the storm drain system and/or receiving waters. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from parking and storage areas.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- Remove and properly dispose of trash and debris regularly. Post "No Littering" signs and enforce an anti-littering laws.
- Establish a frequency of cleaning and sweeping. Sweep all parking lots at least once before the wet season.
- For wet cleaning, block the storm drain, if present, or contain runoff. Dispose of wash water to a pervious surface or discharge to the sanitary sewer system, if permitted.
- For oily deposits, use absorbent materials prior to sweeping or washing.
- Train, including providing periodic refresher training, personnel on proper maintenance protocols for parking and storage areas.

If repairs to the parking or storage areas are needed, implement the following practices:

- Do not store materials near storm drain inlets. Cover and seal nearby storm drain inlets, where applicable, and manholes before applying seal coat, slurry seal, etc. Leave covers in place until the surface repair activities are completed. Clean and properly dispose of debris from the covered storm drain inlets or manholes.
- Apply concrete, asphalt, and seal coat during dry weather to prevent contamination from stormwater runoff.
- Use the minimum amount of water for dust control to minimize the potentially for site runoff.
- Use absorbent materials or pans to catch drips from paving equipment. Dispose of materials properly.

Design Considerations

For parking and storage areas that may be located in areas with a high risk of pollutant discharge, an impervious surface must be constructed using Portland cement concrete or an equivalent material. For parking and storage areas that may be located in areas with a low risk of pollutant discharge, permeable pavement may be used to help mitigate stormwater runoff volumes.

In general, downspouts and roofs should be directed away from parking and storage areas. To the maximum extent practicable, parking and storage areas should be designed (i.e., graded, bermed) to prevent stormwater run-on and runoff and contain spills. Storm drains should not be located in the immediate vicinity of parking and storage areas. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws. Design site to convey stormwater runoff from parking and storage areas to a stormwater treatment control measure for treatment.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Spot clean leaks and drips routinely to prevent runoff of spillage. If the parking or storage area is periodically washed, place a temporary plug in the downstream drain and pump out and properly dispose of accumulated water.
- Place drip pans or absorbent materials under leaks.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

S-4: Indoor and Structural Pest Control

Background

Indoor pest control is unlikely to be a source of pollution in stormwater. Structural pest control, if conducted using chemicals outside of the structure where it is exposed to stormwater runoff may mobilize chemicals into the storm drain system and receiving waters. Pollution prevention activities and BMPs outlined in this fact sheet are designed to reduce and/or eliminate the potential for discharge of pollutants in stormwater runoff from indoor and structural pest control activities.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Implement an integrated pest management (IPM) program, which is a sustainable approach for managing pests by using biological, cultural, physical, and chemical tools.
- Use baits for controlling pests and remove baits if pests are gone.
- Follow all federal, state, and local laws and regulations governing the use, storage, and disposal of pesticides and other chemicals and training of applicators and pest control advisors.
- Use pesticides only if there is an actual pest problem and not on a regular preventative schedule.
- Do not use pesticides outdoors if rain is expected. Apply pesticides only when wind speeds are low (less than 5 miles per hour). Calibrate pesticide application equipment to avoid excessive application. Employ techniques to minimize off-target application (i.e., spray drift) of pesticides.
- Do not mix or prepare pesticides for application near storm drains.
- Purchase only the amount of pesticides that can be reasonably used in the given time period (i.e., within expiration period).
- Triple rinse containers and use rinse water as product. Dispose of unused pesticides as hazardous waste. Dispose of empty containers according to the instructions on the label.
- Train, including providing periodic refresher training, personnel on proper use of pesticides. Pesticide application must be conducted under the supervision of a California qualified pesticide applicator. Train and encourage personnel to use of IPM methods to minimize use of chemical treatments.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Regularly inspect chemical storage containers and application equipment to ensure that they are not leaking. If chemical storage containers are leaking, provide secondary containment. If application equipment is damaged or leaking, repair or if necessary, replace the equipment.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

S-5: Landscape and Outdoor Pesticide Use

Background

Landscape maintenance and outdoor pest control may include the application of herbicides and pesticides. Stormwater and non-stormwater runoff may mobilize herbicides and pesticides into the storm drain system and receiving waters where these chemicals may cause environmental harm to aquatic life. Pollution prevention activities and BMPs outlined in this fact sheet are designed to reduce and/or eliminate the use of herbicides and pesticides in landscape maintenance and outdoor pest control activities that can impact receiving waters and wildlife.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Implement an integrated pest management (IPM) program, which is a sustainable approach for managing pests by using biological, cultural, physical, and chemical tools.
- Follow all federal, state, and local laws and regulations governing the use, storage, and disposal of herbicides, pesticides, and other chemicals and training of applicators and pest control advisors.
- Use pesticides only if there is an actual pest problem and not on a regular preventative schedule.
- Do not use herbicides or pesticides if rain is expected. Apply herbicides or pesticides only when wind speeds are low (less than 5 miles per hour). Calibrate herbicide or pesticide application equipment to avoid excessive application. Employ techniques to minimize off-target application (i.e., spray drift) of herbicides and pesticides.
- Do not mix or prepare herbicides or pesticides for application near storm drains.
- Purchase only the amount of herbicides or pesticides that can be reasonably used in the given time period (i.e., within expiration period).
- Triple rinse containers and use rinse water as product. Dispose of unused herbicides or pesticides as hazardous waste. Dispose of empty containers according to the instructions on the label.
- Use mechanical methods, including hand weeding, of vegetation removal rather than herbicides.
- Collect removed vegetation if it is near storm drain inlets by either bagging or manually picking up the material. Otherwise, certain vegetation may be left on-site to allow for decomposition and return of nutrients back into the soils.
- Provide erosion control if soils become exposed.

- Train, including providing periodic refresher training, personnel on proper use of herbicides and pesticides for landscape maintenance and outdoor use. Pesticide application must be conducted under the supervision of a California qualified pesticide applicator. Train and encourage personnel to use of IPM methods to minimize use of chemical treatments.

Design Considerations

For landscaping, climate-appropriate vegetation must be selected. Generally, climate-appropriate vegetation will reduce the use of herbicides and pesticides and require less irrigation necessary to maintain the health of the vegetation. Design the irrigation system to reduce excessive irrigation runoff in accordance with Section 3.2.2 of the *2015 Post-Construction Stormwater Design Manual*.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Regularly inspect chemical storage containers and application equipment to ensure that they are not leaking. If chemical storage containers are leaking, provide secondary containment. If application equipment is damaged or leaking, repair or if necessary, replace the equipment.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

S-6: Pools, Spas, Ponds, Fountains, and Other Water Features

Background

Pools, spas, ponds, fountains, and other water features may be periodically cleaned, including draining of the water feature, to maintain aesthetic appearances. Waters from these features may contain pollutants of concern (e.g., chlorine, algaecides) that may be toxic to aquatic life if these waters are discharged to the storm drain system or receiving water. Pollution prevention activities and BMPs outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from these water features.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Prevent issues with algae through regular maintenance activities including maintaining consistent chlorine levels and water treatment and circulation systems.
- Prevent corrosion of copper pipes by maintaining water chemistry characteristics (e.g., pH, hardness).
- For pools, spas, and fountains:
  - If algae control is needed, use alternatives control methods (e.g., sodium bromide) instead of copper-based algaecides.
  - Do not discharge water to a street or the storm drain system when draining pools, spas, or fountains. If permitted by the Port, discharge water to the sanitary sewer system. If water is dechlorinated, it may be recycled and used for landscape irrigation.
  - If permitted to discharge to the sanitary sewer, prevent backflow when draining a pool, spa, or fountain by maintaining an air gap between the discharge line and the sanitary sewer pipe (i.e., do not seal the connection between the two lines).
  - Provide drip pans or buckets beneath the drain pipe connections to catch leaks.
  - Do not clean filters in the street or near a storm drain. Rinse filters in a self-treating area (e.g., landscaped or turfed area). If this is not possible, discharge rinse water to the sanitary sewer system, if permitted.
- For ponds and other large water features:
  - Minimize and eliminate, if possible, the use of fertilizers around the water body. Fertilizers can biostimulate algae growth.

    - Consider introducing fish species into the pond that consume algae. Contact the California Department of Fish and Wildlife for more information.
    - Mechanically remove pond scum (blue-green algae) using a net.
    - Discourage the public from feeding wildlife (i.e., place signs that prohibit the feeding wildlife) to control bacteria.
    - Control erosion by:
        - Maintaining vegetated cover on the banks to prevent soil erosion. Apply mulch or leave clippings to serve as additional cover for soil stabilization and to reduce the stormwater runoff rate.
        - Designing areas to prevent non-stormwater runoff and erosion.
        - Promoting efficient irrigation practices.
        - Providing energy dissipation along the banks to minimize the potential for erosion.
        - Storing, confining, and covering excavated materials in areas away from ponds.
- Conduct inspections to detect illegal dumping and illicit discharges.
- Remove trash and debris regularly. Provide and maintain trash receptacles. Increase trash collection during peak months.
- Train, including providing periodic refresher training, personnel on proper maintenance protocols for pools, spas, ponds, fountains, and other water features.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks.

S-7: Restaurants, Grocery Stores, and Other Food Service Operations

Background

Restaurants, grocery stores, and other food service operations typically contain multiple areas (e.g., parking lot, trash storage area, outdoor eating areas) that may contribute to pollution of stormwater. Pollutants of concern for stormwater runoff from these facilities include cleaning chemicals, oil and grease, trash, food waste, and pesticides. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from these facilities.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Develop standard operating procedures to mitigate and/or eliminate the potential of discharge from food service operations.
- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- In general, use dry cleaning methods (e.g., sweeping) to clean facilities. Regularly remove and properly dispose of trash and litter. Separate recyclable materials from other trash.
- If chemicals are used (e.g., cleaning), purchase the least toxic products available. These chemicals are typically labeled “non-toxic”, “non-petroleum based”, “free of ammonia, phosphates, dye, or perfume”, or “readily biodegradable”. Avoid chlorinated compounds, petroleum distillates, phenols, formaldehyde, and caustic or acidic products. Use water-based products.
- Dispose of all discharge from cooling equipment into the sanitary sewer system and not the street, gutter, or storm drain system.
- Inspect and clean all waste grease removal devices (e.g., grease traps, grease interceptors) to keep them properly functioning.
- Collect oil, grease, and large quantities of oily liquids and properly dispose of it. Do not pour these substances into sinks, floor drains, storm drain system, or sanitary sewer system.
- Install screens and traps in sinks and floor drains to capture large solids. Clean these devices regularly.
- To minimize the potential for pests, keep facility clean and free from food wastes, dispose of trash daily into a closed trash container, properly store all food, and seal gaps in the facility (e.g., doors, windows, walls).

- For trash storage areas:
  - Store and transfer all solid and liquid wastes in watertight covered containers. Bag and seal food waste before putting it into the trash container. Do not place uncontained liquids or leaking containers or garbage bags into the trash container.
  - Provide an adequate number of trash containers. Inspect trash containers for damage and replace if necessary. Ensure that trash containers have covers. Lock trash containers to prevent illegal dumping.
  - Do not use water to wash out trash containers. Have the trash container leasing company clean out dirty trash containers.
- For equipment and outdoor cleaning:
  - Clean floor mats and filters in mop sink, floor drain, or proper outside area connected an oil and water separator prior to discharge to the sanitary sewer system. Do not wash these items in the parking lot, alley, sidewalk, or street.
  - Dispose of all wash water into the sanitary sewer system.
- For landscape and grounds maintenance:
  - If pesticides are used, do not over apply or apply when precipitation is forecasted.
  - Do not dispose of pesticides in the sink, floor drains, gutter, street, sanitary sewer system, or storm drain system. Leftover pesticides must either be used up or disposed of as hazardous waste.
  - If fountains are present on-site and algae control is needed, use alternatives control methods (e.g., sodium bromide) instead of copper-based algaecides.
- Train, including providing periodic refresher training, personnel on proper cleaning, disposal, and maintenance protocols.

Design Considerations

All design specifications for restaurants, grocery stores, and other food service operations are regulated by local building and fire codes, ordinances, and zoning requirements. In general, downspouts and roofs should be directed away from the structures, trash storage areas, and cleaning areas. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws. The following source control measures and their design features may be applicable to restaurants, grocery stores, and other food service operations:

- S-3: Parking/Storage Areas and Maintenance;
- S-4: Indoor and Structural Pest Control;
- S-5: Landscape and Outdoor Pesticide Use;

- S-6: Pools, Spas, Ponds, Fountains, and Other Water Features;
- S-8: Refuse Areas
- S-10: Outdoor Storage of Equipment or Materials;
- S-11: Vehicle and Equipment Cleaning;
- S-12: Vehicle and Equipment Repair and Maintenance; and
- S-14: Loading Docks

The project applicant must assess the applicability of the pollution prevention activities, BMPs, and design considerations associated with the source control fact sheets listed above.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Check trash containers regularly for leaks and replace if necessary.
- Provide drip pans or absorbent materials if drips or leaks are detected.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., screens, covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Restaurants, grocery stores, and other food service operations must be inspected periodically to ensure containment of accumulated water, prevention of stormwater run-on, and proper handling of stormwater runoff. Failure to properly maintain building and property may subject the property owner to citation.

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S-8: Refuse Areas

Background

Wastes from multi-family, commercial, and industrial sites are typically hauled away for disposal by either public or commercial carriers. Stormwater runoff from areas where trash is stored or handled can be polluted. Loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or receiving waters. Waste handling operations (i.e., dumpsters, litter control, waste piles) may be sources of stormwater pollution. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from refuse areas. This source control measure is not intended for single-family detached housing units.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- Sweep and clean the refuse areas regularly. Do not wash the refuse area if it drains to the storm drain system. If the refuse area is washed down, collect wash water and dispose of it to the sanitary sewer system.
- Provide an adequate number of trash containers. Periodically clean out the trash containers to prevent spillage. Inspect trash containers for damage and replace if necessary. Ensure that trash containers have covers.
- If hazardous chemicals are being stored for disposal, provide secondary containment.

Design Considerations

In designing refuse areas, it is important to note that waste haulers may have specific requirements for the refuse area. The recommendations in this fact sheet are not intended to conflict with the requirements established by the waste hauler. The waste hauler should be contacted prior to the design of trash storage and collection areas to determine established and accepted guidelines for designing trash collection areas. All hazardous waste must be handled in accordance with the legal requirements established in Title 22 of the California Code of Regulations. Refuse areas should be designed as follows:

- Construct/pave outdoor refuse storage and waste handling areas with Portland cement concrete or an equivalent impervious surface. Berm and/or grade the refuse area to prevent run-on, including diverting stormwater runoff from adjoining roofs and pavements away from the refuse area. Locate the refuse area at least 35 feet from storm drains.

- Install a screen or wall around the refuse area to prevent off-site transport of loose trash. Use lined bins or dumpsters to reduce leaking of liquid waste. Use waterproof lids on bins and dumpsters or provide a roof to cover the refuse area to prevent precipitation from entering the containers.
- Post signs on all dumpsters and/or inside the refuse area prohibiting the disposal of liquids and hazardous waste materials in accordance with any local waste disposal ordinance.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Check trash containers regularly for leaks and replace if necessary.
- Provide drip pans or absorbent materials in the refuse area if drips or leaks are detected.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., screens, covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Refuse areas must be inspected periodically to ensure containment of accumulated water, prevention of stormwater run-on, and proper handling of stormwater runoff. Failure to properly maintain building and property may subject the property owner to citation.

S-9: Industrial Processes

Background

Industrial processes, particularly if they are located outdoors, have the potential to contaminate stormwater runoff and the receiving waters. Depending on the activities on-site, there may be a variety of potential pollutants of concern. Pollution prevention activities and BMPs outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from areas where there are industrial processes.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- Perform industrial process activities during dry weather periods.
- Consider enclosing the industrial process in a building and connecting the floor drains to the sanitary sewer system.
- Cover the work area with a permanent roof if possible.
- Properly store equipment and materials to prevent contact with stormwater runoff.
- Hydraulically-isolate the industrial process to minimize contact of stormwater runoff and run-on by berming the process area. This will also help contain spills that may occur.
- Clean the industrial process area regularly and properly dispose of all wastes. If possible, use dry cleaning methods. If the industrial process area must be washed, collect wash water and properly dispose of it.
- Regularly remove and properly dispose of trash and litter.
- Use least toxic chemicals when possible.

Design Considerations

All design specifications for industrial processes are regulated by local building and fire codes, ordinances, and zoning requirements. In general, downspouts and roofs should be directed away from industrial processes. Storm drains should not be located in the immediate vicinity of industrial processes. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws. Depending on the industrial processes on-site, apply other source control measures as needed.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Regularly inspect equipment and check for leaks and drips. If leaks or drips are detected, repair, if necessary, the equipment, provide drip pans or absorbent materials, and spot clean leaks and drips routinely to prevent runoff of spillage.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., screens, covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Industrial process areas must be inspected periodically to ensure containment of accumulated water, prevention of stormwater run-on, and proper handling of stormwater runoff. Failure to properly maintain building and property may subject the property owner to citation.

S-10: Outdoor Storage of Equipment or Materials

Background

Outdoor facilities may be used to store equipment and/or materials. Equipment that is exposed to precipitation may mobilize pollutants. Materials, including raw materials, by-products, finished products, and waste products, stored outdoors can become sources of pollutants in stormwater runoff if not properly managed. Materials may be stored in a variety of ways, including bulk piles, containers, shelving, stacking, and tanks. The type of pollutants associated with equipment and materials stored outdoors will vary depending on the type of activity present on-site. Materials are classified into three categories based on the potential risk of pollutant release associated with stormwater runoff contact – high risk, medium risk, and low risk. General types of materials under each category are presented in Table E-1.

Table E-1. Classification of Materials for Potential Pollutant Risk

High Risk Materials	Medium Risk Materials	Low Risk Materials
• Recycled materials with discharge potential • Corrosives • Food items • Chalk/gypsum products • Scrap or salvage goods • Feedstock/grain • Fertilizers • Pesticides • Compost • Asphalt • Lime/lye/soda ash • Animal/human wastes • Rubber and plastic pellets or other small pieces • Uncured concrete/cement • Lead and copper, and any metals with oil/grease coating	• Clean recycled materials without discharge potential • Metal (excluding lead and copper, and any metals with oil/grease coating) • Sawdust/bark chips • Sand/soil • Unwashed gravel/rock	• Washed gravel/rock • Finished lumber (non-pressure treated) • Rubber or plastic products (excluding small pieces) • Clean, precast concrete products • Glass products (new) • Inert products • Gaseous products • Products in containers that prevent contact with stormwater (fertilizers and pesticides excluded)

Contamination of stormwater runoff may be prevented by eliminating the possibility of stormwater runoff contact with the equipment and material storage areas either through diversion, cover, or capture of the stormwater runoff. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from outdoor equipment and material storage areas.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- Keep the outdoor equipment and material storage area as clean and orderly as possible to reduce the potential for stormwater runoff to contact and/or mobilize potential pollutants of concern.
- Minimize the inventory of materials.
- Identify all storage areas for equipment and chemical and/or waste materials, including a tank/drum schedule indicating tank capacities, materials of construction, and contents, on site maps and/or plans.
- Accurately tracking the materials stored on-site.
- Try to keep materials in their original containers. Provide proper labeling of materials stored on-site.
- Train, including providing periodic refresher training, personnel on proper equipment and material handling procedures.

Design Considerations

All design specifications for equipment and material storage areas are regulated by local building and fire codes, ordinances, and zoning requirements. In general, downspouts and roofs should be directed away from outdoor equipment and materials storage areas. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws.

Outdoor equipment and material storage areas should be designed as follows:

- For high-risk equipment or materials:
    - Construct/pave storage area with Portland cement concrete or an equivalent impervious surface. Ensure that the surfacing material is chemically-resistant to the materials being stored.
    - Place equipment or materials in an enclosure (e.g., shed, cabinet) that prevents contact with stormwater or cover the entire storage area with a permanent canopy, roof, or awning to prevent precipitation from making contact with and collecting within the storage area. If the cover does not include sidewalls, include a roof overhang that extends beyond the grade break. Covers that are 10 feet high or less should extend a minimum of 3 feet beyond the perimeter of the storage area. Covers higher than 10 feet should extend a minimum of either 20 percent of the cover’s height or 5 feet beyond the perimeter of the storage area, whichever is greater.

    - Hydraulically-isolate the storage area with grading, berms, drains, dikes, or curbs to prevent stormwater run-on from surrounding areas or roof drains. Direct stormwater runoff from the cover away from the storage area to an approved stormwater discharge location.
- For medium-risk equipment or materials:
    - Construct/pave storage area with Portland cement concrete or an equivalent impervious surface.
    - At a minimum, completely cover equipment or material with temporary plastic sheeting during storm events.
    - For erodible material, provide grading and a structural containment barrier on at least three sides to prevent stormwater runoff from surrounding areas and migration of material due to wind erosion.
- For low-risk equipment or materials:
    - There are no requirements for surfacing or enclosures or covers.
    - Provide appropriate drainage from the storage area to minimize contact with the equipment or materials.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., screens, covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Outdoor equipment and material storage areas must be inspected periodically to ensure containment of accumulated water, prevention of stormwater run-on, and proper handling of stormwater runoff. Any enclosures and secondary/spill containment areas must be checked periodically to ensure spills are contained efficiently. Failure to properly maintain building and property may subject the property owner to citation.

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S-11: Vehicle and Equipment Cleaning

Background

Washing vehicles and equipment in areas where wash water flows onto the ground can pollute stormwater runoff and adversely impact receiving waters. Pollutants of concern in wash water include oil and grease, heavy metals, solvents, phosphates, and suspended solids. By containing, collecting, diverting, and properly disposing of wash water from vehicle and equipment cleaning areas to the sanitary sewer system, transport of these potential pollutants to the storm drain system and receiving waters is limited. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from vehicle and equipment cleaning areas.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- If possible, use properly maintained off-site commercial washing businesses. These businesses are typically better equipped to handle and properly dispose of wash water.
- If it is not possible to wash vehicles and equipment off-site,
  - Use biodegradable, phosphate-free detergent for washing activities.
  - Mark the area clearly as a wash area and that only washing is permitted in this area (e.g., do not allow oil changes and other maintenance to occur in this area).
  - Provide trash containers in the wash area.
  - Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
  - Use hoses with nozzles that automatically turn off when left unattended.
- Evaluate the feasibility of implementing a closed-loop recycling system that treats and reuses wash water. This type of system will also reduce the use of potable water. Do not discharge wash water into the storm drain system.
- Train, including providing periodic refresher training, personnel on proper cleaning and maintenance procedures.

Design Considerations

All design specifications for vehicle and equipment cleaning areas are regulated by local building and fire codes, ordinances, and zoning requirements. In general, downspouts and roofs should be directed away from vehicle and equipment cleaning areas, and such areas should slope towards a dead-end sump to collect stormwater runoff, non-stormwater runoff, and spills. If a dead-end sump is not used to collect stormwater, install an oil/water separator. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws. Vehicle and equipment cleaning areas should be designed as follows:

- Construct/pave cleaning areas with Portland cement concrete or an equivalent impervious surface.
- If possible, cover the cleaning area with a permanent canopy, roof, or awning to prevent precipitation from making contact with and collecting within the storage area. If the cover does not include sidewalls, include a roof overhang that extends beyond the grade break. Covers that are 10 feet high or less should extend a minimum of 3 feet beyond the perimeter of the cleaning area. Covers higher than 10 feet should extend a minimum of either 20 percent of the cover's height or 5 feet beyond the perimeter of the cleaning area, whichever is greater. Grade or berm the cleaning area to contain wash water within the covered area.
- If covering the cleaning area is not possible, provide an approved stormwater runoff diversion system along with a clarifier and sample box. Diverted stormwater runoff may require pretreatment and verification of pollutant concentrations.
- Direct wash water to treatment and recycle or pretreatment (e.g., clarifier) and proper connection to the sanitary sewer system. Obtain approval from the Port before discharging to the sanitary sewer system.
- Hydraulically-isolate the cleaning area with grading, berms, drains, dikes, or curbs to prevent stormwater run-on from surrounding areas or roof drains. Direct stormwater runoff from the cover away from the cleaning area to an approved stormwater discharge location.
- Do not locate storm drain inlets in the immediate vicinity of the cleaning area.
- Provide means, such as isolation valves, drain plugs, or drain covers, to prevent spills or accumulated water from entering the storm drain system. All wash water and hazardous and toxic wastes must be prevented from entering the storm drain system.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Regularly inspect vehicles and equipment for leaks. Place drip pans or absorbent materials under vehicles or equipment if they are leaking.
- Check incoming vehicles and equipment for leaking oil and fluids. Do not allow leaking vehicles or equipment on-site.
- Promptly transfer used fluids to the proper waste or recycling containers. Do not leave full drip pans or other open containers lying around.

- Oil filters disposed of in trash cans or dumpsters can leak oil and contaminate stormwater. Place the oil filter in a funnel over a waste oil recycling container to drain excess oil before disposal. Oil filters can be recycled.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Vehicle and equipment cleaning areas must be inspected periodically to ensure containment of accumulated water, prevention of stormwater run-on, and proper handling of stormwater runoff. Failure to properly maintain building and property may subject the property owner to citation.

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S-12: Vehicle and Equipment Repair and Maintenance

Background

Activities in vehicle and equipment repair and maintenance areas that can contaminate stormwater runoff include engine repair, service, and parking (e.g., leaking engines or parts). Pollutants of concern from these facilities include oil and grease, solvents, car battery acid, coolant, and gasoline as well as heavy metals and suspended solids. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from vehicle and equipment repair and maintenance areas.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Switch to non-toxic chemicals for maintenance when possible and use cleaning agents that can be recycled.
- Minimize the use of solvents. Use water-based solvents for cleaning.
- Recycle used oils and other vehicle or equipment fluids and parts.
- Keep accurate maintenance logs to evaluate materials removed.
- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water). Do not pour waste materials down storm drains.
- Keep vehicles and equipment clean and do not allow a build-up of oil and grease.
- Train, including providing periodic refresher training, personnel on proper area maintenance and waste disposal procedures.

Design Considerations

All design specifications for vehicle and equipment repair and maintenance areas are regulated by local building and fire codes, ordinances, and zoning requirements. In general, downspouts and roofs should be directed away from outdoor vehicle and equipment repair and maintenance areas, and such areas should slope towards a dead-end sump to collect stormwater runoff, non-stormwater runoff, and spills. If a dead-end sump is not used to collect stormwater, install an oil/water separator. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws. Vehicle and equipment repair and maintenance areas should be designed as follows:

- Construct/pave vehicle and equipment repair and maintenance area with Portland cement concrete or an equivalent impervious surface. Cover or enclose the vehicle and equipment repair and maintenance area. Where possible, conduct repair and maintenance activities indoors.

- Berm or grade vehicle and equipment repair and maintenance area to prevent stormwater run-on and runoff and contain spills.
- A pretreatment system may be necessary to treat wastes prior to disposal.
- Cover areas where parts and fluids are stored.
- Do not locate storm drains in the immediate vicinity of vehicle and equipment repair and maintenance area.
- Provide means, such as isolation valves, drain plugs, or drain covers, to prevent spills or accumulated water from entering the storm drain system. All wash water and hazardous and toxic wastes must be prevented from entering the storm drain system.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Perform all fluid removal or changing inside or under cover to prevent run-on of stormwater and runoff of spills. Use secondary containment (e.g., drain pan, drop cloth) to catch spills or leaks when removing or changing fluids.
- Regularly inspect vehicles and equipment for leaks, and repair immediately.
- Check incoming vehicles and equipment for leaking oil and fluids. Do not allow leaking vehicles or equipment on-site.
- Store wrecked vehicles or damaged equipment under cover.
- Place drip pans or absorbent materials under heavy equipment when not in use.
- Promptly transfer used fluids to the proper waste or recycling containers. Do not leave full drip pans or other open containers lying around.
- Oil filters disposed of in trash cans or dumpsters can leak oil and contaminate stormwater. Place the oil filter in a funnel over a waste oil recycling container to drain excess oil before disposal. Oil filters can be recycled.
- Store all batteries in secondary containment.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Vehicle and equipment repair and maintenance areas must be inspected periodically to ensure containment of accumulated water, prevention of stormwater run-on, and proper handling of stormwater runoff. Failure to properly maintain building and property may subject the property owner to citation.

S-13: Fuel Dispensing Areas

Background

Spills and leaks at fuel dispensing areas can be a significant source of pollution because fuels contain toxic materials and heavy metals that are not easily removed by stormwater treatment control measures. When stormwater runoff mixes with fuel spilled or leaked onto the ground, it becomes contaminated with petroleum-based materials that are harmful to humans, fish, and wildlife. Contamination can occur at large industrial sites or at small commercial sites such as retail gas outlets and convenience stores. Materials such as oil and grease, car battery acid, and coolant also have the potential to contribute to stormwater pollution due to spills at fuel dispensing areas. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from fuel dispensing areas.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Provide overflow protection devices on tank systems to warn the operator to automatically shut down transfer pumps when the storage tank reaches capacity.
- Clearly label all valves to reduce the potential for human error.
- Spot clean leaks and drips routinely to prevent runoff of spillage. If the fuel dispensing area is periodically washed, place a temporary plug in the downstream drain and pump out and properly dispose of accumulated water.
- Cover drains during transfer of fuel from the fuel truck to the fuel storage tank.
- Train, including providing periodic refresher training, personnel on proper fueling and cleanup procedures.

Design Considerations

All design considerations for fuel dispensing areas are regulated by local building and fire codes, ordinances, and zoning requirements. In general, downspouts and roofs should be directed away from fuel dispensing areas, and such areas should slope towards a dead-end sump to collect stormwater runoff, non-stormwater runoff, and spills. If a dead-end sump is not used to collect stormwater, install an oil/water separator. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws. Fuel dispensing areas should be designed as follows:

- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).

- Construct/pave fuel dispensing area with Portland cement concrete, or an equivalent smooth impervious surface. Do not use asphalt concrete to construct/pave the fuel dispensing/maintenance area. The fuel dispensing area is defined as extending 6.5 feet from the corner of each fuel dispenser or the length at which the hose and nozzle assembly may be operated plus 1 foot, whichever is greater. Paving around the fuel dispensing area may exceed the minimum dimensions listed above. Use asphalt sealant to protect asphalt-paved areas surrounding the fuel dispensing area.
- Cover the fuel dispensing area with a permanent canopy, roof, or awning to prevent precipitation from making contact with and collecting within the storage area. Covers that are 10 feet high or less should extend a minimum of 3 feet beyond the perimeter of the fuel dispensing area. Covers higher than 10 feet should extend 5 feet beyond the perimeter of the fuel dispensing area.
- For facilities designed to accommodate very large vehicles or equipment that would prohibit the use of covers, hydraulically-isolate the uncovered fuel dispensing area and direct stormwater runoff from the area through upstream controls to an approved stormwater discharge location.
- Design fuel dispensing area pad with a two to four percent slope to prevent ponding, and include a grade break that separates the area from the rest of the site. Prevent stormwater run-on from surrounding areas or roof drains from entering the fuel dispensing area by:
    - Installing a perimeter trench drain around the fuel dispensing area pad. The perimeter drain must drain to either the sanitary sewer system, if approved, or into an approved below-grade containment vault with at least 60 cubic feet of storage capacity. The containment vault must be emptied, as needed, and the contents disposed of in accordance with applicable laws; and/or
    - Elevating the entire fuel dispensing area pad and provide a perimeter drain to isolate the pad. The pad should be graded such that any spills will stay on the pad for clean up using dry methods.
- Direct stormwater runoff from the cover away from the fuel dispensing area to an approved stormwater discharge location. Do not locate storm drain inlets within 10 feet if the hydraulically-isolated fuel dispensing area.
- Provide means, such as isolation valves, drain plugs, or drain covers, to prevent spills or accumulated from entering the storm drain system. When possible and appropriate, use dry cleanup methods, such as sweeping for removal of litter and debris and use of absorbents for liquid spills and leaks.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Install vapor recovery nozzles to help control drips as well as air pollution.

- Discourage “topping-off” of fuel tanks.
- Use secondary containment when transferring fuel from the tank truck to the fuel tank.
- Fit the underground storage tanks with spill containment and overfill prevention systems meeting the requirements of Section 2635(b) of Title 23 of the California Code of Regulations.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., screens, covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Fuel dispensing areas must be inspected periodically to ensure containment of accumulated water, prevention of stormwater run-on, and proper handling of stormwater runoff. Failure to properly maintain building and property may subject the property owner to citation.

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S-14: Loading Docks

Background

Materials spilled, leaked, or lost during loading activities may collect on impervious surfaces or in the soil and be carried away by stormwater runoff or when the area is cleaned. Precipitation can also wash pollutants from machinery used to move materials. In particular, loading docks have the potential to contribute heavy metals, nutrients, suspended solids, oils, and grease to stormwater runoff due to the heavy truck traffic and loading activities. Depressed loading docks (e.g., truck wells) are contained areas that can also accumulate water. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from loading docks.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with stormwater runoff include the following:

- Parking tank trucks and delivery vehicles in designated areas where spills and leaks can be contained.
- Limit exposure of material to precipitation whenever possible.
- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- Develop an operations plan that describes procedures for loading activities.
- Train, including providing periodic refresher training, personnel on proper loading and cleanup procedures.

Design Considerations

All design specifications for loading docks are regulated by local building and fire codes, ordinances, and zoning requirements. In general, downspouts and roofs should be directed away from loading docks, and such areas should slope towards a dead-end sump to collect stormwater runoff, non-stormwater runoff, and spills. If a dead-end sump is not used to collect stormwater, install an oil/water separator. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws. Loading docks should be designed as follows:

- Construct/pave loading docks with Portland cement concrete or an equivalent impervious surface. Ensure that the surfacing material is chemically-resistant to materials being handled in the loading dock area.
- Cover the loading dock to a distance of at least 10 feet beyond the loading dock or building face if there is no raised dock. If the cover or roof structure does not include sidewalls, then the roof overhang must extend beyond the grade break. The overhang must extend a minimum of 20 percent of the roof height.

- For interior transfer bays, provide a minimum 10-foot “No Obstruction Zone” to allow trucks or trailers to extend at least 5 feet inside the building. Identify “No Obstruction Zone” clearly on site plans and paint zone with high visibility floor paint. If covers or interior transfer bays are not feasible, install a seal or door skirt and provide a cover to shield all material transfers between trailers and building.
- For loading docks, hydraulically-isolate the first six feet of paved area measured from the building or dock face with grading, berms, or drains to prevent stormwater run-on from surrounding areas or roof drains. Direct stormwater runoff and drainage from surrounding areas away from hydraulically-isolated areas to an approved stormwater discharge point.
- For interior transfer bays or bay doors, prevent stormwater runoff from surrounding areas from entering the building with grading or drains. Do not install interior floor drains in the “No Obstruction Zone”. Hydraulically-isolate the “No Obstruction Zone” from any interior floor drains.
- Do not install direct connections to storm drains from depressed loading docks. Connect drains or direct drainage from hydraulically-isolated loading dock to an approved sediment/oil/water separator system connected an approved discharge location. Provide a manual emergency spill diversion valve upstream of separator system to direct flow, in the event of a spill, to an approved spill containment vault sized to contain a volume equal to 125% of largest container handled at the facility. Provide additional emergency means, such as drain plugs or drain covers, to prevent spills or contaminated stormwater runoff from entering the storm drain system.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Use drip pans underneath hose, and pipe connections and other leak-prone areas during liquid transfer operations.
- Check equipment regularly for leaks, including valves, pumps, and connections.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Loading docks must be inspected periodically to ensure containment of accumulated water, prevention of stormwater run-on, and proper handling of stormwater runoff. Failure to properly maintain building and property may subject the property owner to citation.

S-15: Fire Sprinkler Test Water

Background

Water is discharged from fire sprinklers during testing and maintenance. If the water is allowed to leave the site and discharge into the storm drain system, it may mobilize pollutants. Pollution prevention activities and BMPs outlined in this fact sheet are designed to prevent pollutants from entering the storm drain system or receiving waters from discharge of fire sprinkler test water.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential pollutants coming in contact with fire sprinkler test water include the following:

- When preparing for a fire sprinkler test or maintenance, sweep or vacuum the area where the water is anticipated to flow to remove trash and other debris.
- Protect storm drain inlets using sandbags to create a berm to prevent water from flowing into it.
- Temporarily plug other nearby drains.
- Direct fire sprinkler test water to a vegetated area using portable berms and/or sandbags. If a vegetated area is not nearby, create a berm using sandbags to capture water and use a wet-vacuum to collect and dispose of fire sprinkler test water into the sanitary sewer system.
- Train, including providing periodic refresher training, personnel on proper disposal of fire sprinkler test water.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

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S-16: Drain or Wash Water

Background

If drain or wash water from boiler drain lines, condensate drain lines, rooftop equipment, drainage sumps, and other sources is allowed to leave a site, the water may mobilize pollutants and enter the storm drain system or receiving water. Pollution prevention activities and BMPs outlined in this fact sheet are designed to prevent pollutants from entering the storm drain system or receiving waters from discharge of drain or wash water from boiler drain lines, condensate drain lines, rooftop equipment, drainage sumps, and other sources.

Pollution Prevention Activities and Best Management Practices

Direct drain or wash water from boiler drain lines, condensate drain lines, rooftop equipment, drainage sumps, and other sources to a vegetated area. If a vegetated area is not nearby, collect the water and dispose of it into the sanitary sewer system. Train, including providing periodic refresher training, personnel on proper disposal of this water.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

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S-17: Unauthorized Non-Stormwater Discharges

Background

Non-stormwater discharges are flows that do not consistent entirely of stormwater. Some non-stormwater discharges (e.g., uncontaminated groundwater) do not contain pollutants and may be discharged to the storm drain. Other non-stormwater discharges may pose an environmental threat, including discharges originating from illegal dumping internal floor drains, appliances, industrial processes, sinks, and toilets that are connected to the storm drain system. These types of discharges, which may include process waters, cooling waters, wash waters, and sanitary wastewater, can carry pollutants such paint, oil, fuel and other automotive fluids, chemicals and other pollutants into the storm drain system and receiving waters. Pollution prevention activities and BMPs outlined in this fact sheet are designed to eliminate these unauthorized non-stormwater discharges.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may eliminate unauthorized non-stormwater discharges include the following:

- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- Develop protocols for identifying, investigating, and responding to unauthorized non-stormwater discharges. Train personnel, including law enforcement, to identify and document unauthorized non-stormwater discharges.
- Regularly inspect and cleanup hot spots and other storm drain areas where illegal dumping and disposal occurs. During inspections, look for evidence of non-stormwater discharges (e.g., discoloration, odors) and determine if it poses a threat to water quality. Implement proper spill cleanup procedures (S-1: Accidental Leaks and Spills).
- Investigate, and if possible, isolate the source and identify the responsible party, of the non-stormwater discharge. If necessary, conduct smoke and/or dye testing to identify cross-connections and/or use closed-circuit television systems to inspect pipes.
- Collect samples of non-stormwater discharge for water quality testing.
- Provide public education and outreach to reduce the potential for non-stormwater discharges and provide information about proper disposal of waste materials, including liquids. Provide the public with a mechanism (e.g., hotline, website) for reporting instances of non-stormwater discharges.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

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S-18: Building and Grounds Maintenance

Background

Stormwater runoff from building and grounds maintenance activities can be contaminated with pollutants such as hydrocarbons, solvents, fertilizers, pesticides, solids, trash, heavy metals, and oil and grease. Pollution prevention activities, BMPs, and design considerations outlined in this fact sheet are designed to reduce and/or eliminate pollutants in potential discharges from building and grounds maintenance activities.

Pollution Prevention Activities and Best Management Practices

Pollution prevention activities and BMPs that may reduce the potential impacts from buildings and grounds maintenance activities include the following:

- Label drains, by paint or stencil, to indicate where they flow (e.g., treatment or storage device, sanitary sewer system, storm drain system, receiving water).
- Use non-toxic chemicals, including chemicals that can be recycled, for maintenance when possible.
- Remove and properly dispose of trash and debris regularly.
- Recycle materials (e.g., residual paints, solvents, lumber,) as much as possible.
- When washing buildings, rooftops, and other large structures, collect wash water using a sump pump, wet vacuum, or similar device and properly dispose of it. If soaps and detergents are not used, disperse wash water into vegetated areas.
- For building repair, remodeling, and construction:
    - Cover nearby storm drains prior to starting work.
    - Do not discharge any toxic substance or liquid waste on the pavement, ground, or near a storm drain.
    - Use ground or drop cloths under exterior painting, scraping, or sandblasting work. Properly dispose of materials.
    - Clean paintbrushes and tools with water-based paints such that wash water can be disposed of in the sanitary sewer. Paintbrushes and tools with non-water-based paints must be cleaned with solvents, which much be collected and recycled.
- Use mechanical methods, including hand weeding, of vegetation removal rather than herbicides. Provide erosion control if soils become exposed. Recycle yard trimmings on-site.
- For fertilizer and pest management:

  - Implement an integrated pest management (IPM) program, which is a sustainable approach for managing pests by using biological, cultural, physical, and chemical tools.
  - Follow all federal, state, and local laws and regulations governing the use, storage, and disposal of fertilizers, pesticides, and other chemicals and training of applicators and pest control advisors.
  - Use pesticides only if there is an actual pest problem and not on a regular preventative schedule.
  - Do not use fertilizers or pesticides if rain is expected. Apply fertilizers or pesticides only when wind speeds are low (less than 5 miles per hour). Calibrate fertilizer or pesticide application equipment to avoid excessive application. Employ techniques to minimize off-target application (i.e., spray drift) of fertilizers and pesticides.
  - Do not mix or prepare fertilizers or pesticides for application near storm drains.
  - Purchase only the amount of fertilizers or pesticides that can be reasonably used in the given time period (i.e., within expiration period).
  - Work fertilizers into the soil rather than dumped or broadcast onto the surface. Clean pavement and sidewalk if fertilizer is spilled on these surfaces.
  - Triple rinse containers and use rinse water as product. Dispose of unused fertilizers or pesticides as hazardous waste. Dispose of empty containers according to the instructions on the label.
- Collect removed vegetation if it is near storm drain inlets by either bagging or manually picking up the material. Otherwise, certain vegetation may be left on-site to allow for decomposition and return of nutrients back into the soils.
- Train, including providing periodic refresher training, personnel on proper procedures for conducting building and grounds maintenance activities. This training should also include proper use of chemicals.

Design Considerations

For landscaping, climate-appropriate vegetation must be selected. Generally, climate-appropriate vegetation will reduce the use of fertilizers, pesticides, and other chemicals and require less irrigation necessary to maintain the health of the vegetation. Design the irrigation system to reduce excessive irrigation runoff in accordance with Section 3.2.2 of the *2015 Post-Construction Stormwater Design Manual*.

Spill Prevention and Response

Refer to S-1 for Accidental Spills and Leaks. Other spill prevention measures include:

- Regularly inspect chemical storage containers and application equipment to ensure that they are not leaking. If chemical storage containers are leaking, provide secondary containment. If application equipment is damaged or leaking, repair or if necessary, replace the equipment.
- Train, including providing periodic refresher training, personnel on spill prevention and cleanup procedures.

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APPENDIX E

Alternative Stormwater Treatment Measures Fact Sheets

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Appendix E
Alternative Stormwater Treatment Control Measure Fact Sheets

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LID-1: Infiltration Basin

Description

An infiltration basin is a shallow earthen basin constructed in naturally permeable soil designed for retaining and infiltrating stormwater runoff into the underlying soils and the groundwater table. The bottoms of the basins are typically vegetated with dry-land grasses or irrigated turf grass. Infiltration basins can provide stormwater runoff treatment through a variety of natural mechanisms (i.e., filtration, adsorption, biological degradation) as water flows through the soil profile.

Because stormwater runoff is infiltrated into an infiltration basin, the potential for groundwater contamination or mobilization of existing soil or groundwater contamination must be carefully considered. Infiltration basins are typically not suitable for sites that use or store chemicals or hazardous materials, unless these materials are prevented from entering the basin, or un-remediated “brownfield sites” where there is known groundwater or soil contamination.

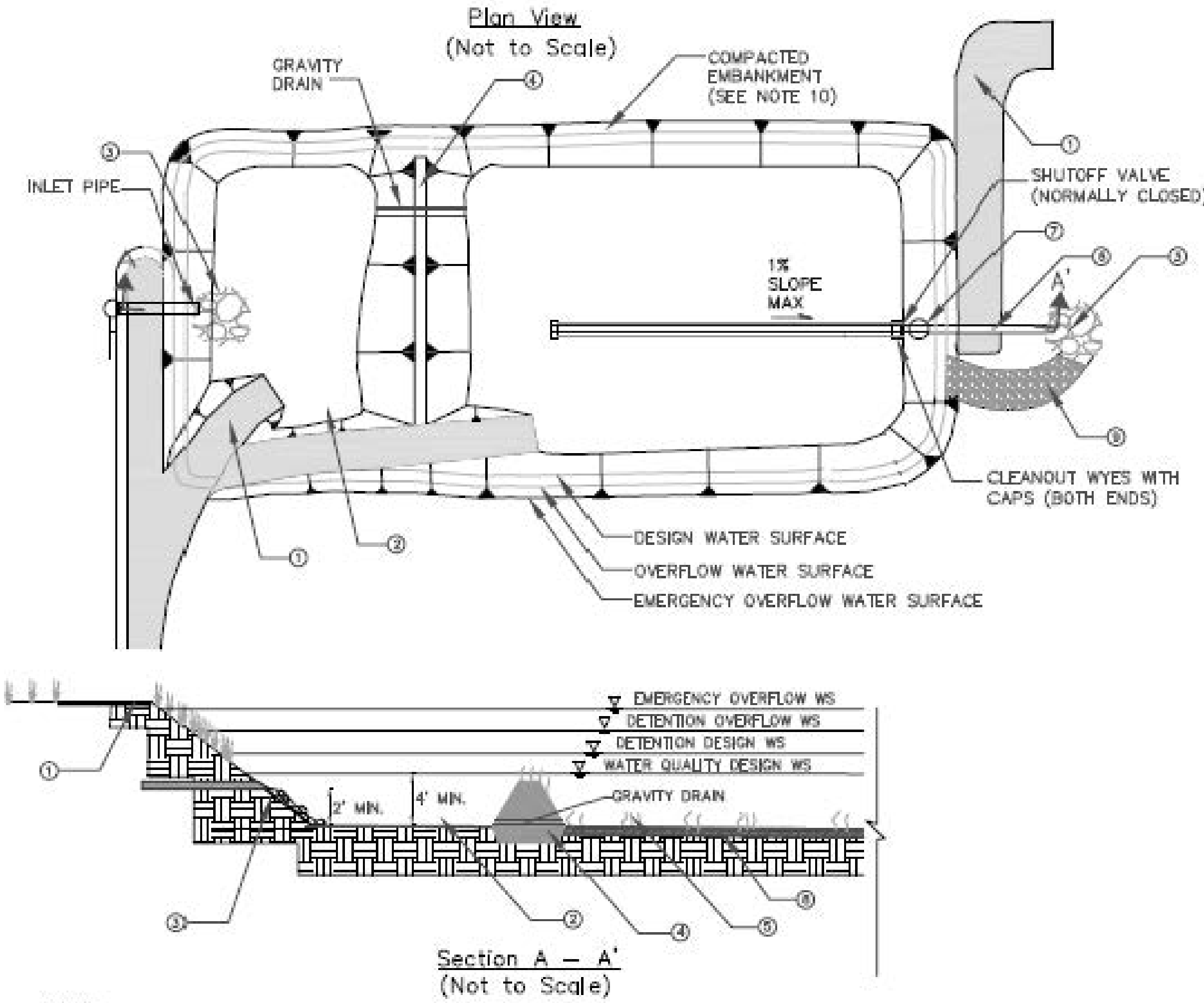
An example schematic of a typical infiltration basin is presented in Figure E-1.

Use and Applicability

The Phase II Permit (Provision F.5.g.2.d) identifies bioretention as the standard stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative stormwater treatment control measure that is equivalent to bioretention is proposed and demonstrated (Provision F.5.g.2.d.(a)), or (2) a specific exemption applies (Provision F.5.g.2.d.(c)). An infiltration basin can be proposed as an alternative to bioretention if it meets <u>all</u> of the following measures of equivalent effectiveness:

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and
- Equal or greater accessibility and ease of inspection and maintenance.

An infiltration basin, which is designed to infiltrate stormwater runoff, is an acceptable alternative to bioretention.



NOTES:

1. MAINTENANCE RAMP SHOULD BE PAVED. SLOPE SHOULD NOT EXCEED 12%. MAINTENANCE RAMP SHOULD PROVIDE ACCESS TO BOTH THE FIRST CELL AND MAIN BASIN.
2. UPSTREAM PRETREATMENT SHALL BE PROVIDED. SEDIMENT FOREBAY WITH VOLUME EQUAL TO 25% OF TOTAL INFILTRATION BASIN VOLUME MAY BE USED IN LIEU OF UPSTREAM PRETREATMENT. DEPTH SHALL BE 4' MIN TO 8' MAX PLUS AN ADDITIONAL 1 FOOT MIN SEDIMENT STORAGE DEPTH.
3. RIP RAP APRON OR OTHER ENERGY DISSIPATION.
4. EXTEND EARTHEN BERM ACROSS ENTIRE WIDTH OF THE INFILTRATION BASIN.
5. INFILTRATION BASIN BOTTOM AND SIDE SLOPES SHALL BE PLANTED WITH DROUGHT TOLERANT VEGETATION. DEEP ROOTED VEGETATION PREFERRED FOR BASIN BOTTOM. NO TOPSOIL SHALL BE ADDED TO INFILTRATION BASIN BED.
6. SIZE OUTLET PIPE FOR FLOOD CONTROL FLOW
7. WATER QUALITY OUTLET STRUCTURE.
8. OVER EXCAVATE BASIN BOTTOM 1 FOOT. RE-PLACE EXCAVATED MATERIAL UNIFORMLY WITHOUT COMPACTION. AMENDING EXCAVATED MATERIAL WITH 2" - 4" OF COARSE SAND IS RECOMMENDED FOR SOILS WITH BORDER LINE INFILTRATION CAPACITY.
9. INSTALL EMERGENCY OVERFLOW SPILLWAY AS NEEDED. SEE FIGURE 2-4 FOR DETAILS
10. EMBANKMENT SIDE SLOPES SHALL BE NO STEEPER THAN 3H:1V BOTH OUTSIDE AND INSIDE.

Figure E-1. Example Infiltration Basin Schematic

Design Specifications

The following sections provide design specifications for infiltration basins.

Geotechnical

Due to the potential to contaminate groundwater and/or soils, cause slope instability, impact surrounding structures, and potential for insufficient infiltration capacity, a geotechnical investigation must be conducted during the site assessment process to verify the site suitability for infiltration. It is critical to understand how stormwater runoff will move through the soil (horizontally and vertically) and if there are any geological conditions that may inhibit the movement of water. Soil infiltration rates and the depth to the groundwater table must be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration basin. Infiltration basins cannot be located on sites with a slope greater than 10 percent in order to promote infiltration and uniform ponding. A Site Conditions Report summarizing the relevant findings from the geotechnical investigation must be submitted with the Project Stormwater Plan.

Setbacks

Applicable setbacks must be implemented when siting an infiltration basin.

Pretreatment

Pretreatment, which refers to design features that provide settling of large particles before stormwater runoff enters a stormwater treatment control measure, is important to ensure proper operation of an infiltration basin and reduce the long-term maintenance burden. Pretreatment (e.g., vegetated swales, proprietary devices) must be provided to reduce the sediment load entering an infiltration basin in order to prevent the underlying soils from being occluded prematurely and maintain the infiltration rate of the infiltration basin. Additionally for sites with high infiltration rates, pretreatment is required to protect groundwater quality.

An alternative design for an infiltration basin can include a sediment forebay to remove sediment from stormwater runoff. The sediment forebay must be separated from the infiltration basin by a berm or similar feature, and must be equal to 25 percent of the total infiltration basin volume. The sediment forebay must be designed with a minimum length-to-width ratio of 2:1 and must completely drain to the main infiltration basin through an eight-inch (minimum) low-flow outlet. All inlets must enter the sediment forebay. If there are multiple inlets into the sediment forebay, the length-to-width ratio is based on the average flow path length for all inlets.

Flow Entrance and Energy Dissipation

The drainage management area(s) (DMA[s]) tributary to the infiltration basin must be graded to minimize erosion as stormwater runoff enters the basin or by providing energy dissipation devices at the inlet. Piped entrances must include rock, splash blocks, or other erosion controls at the entrance to dissipate energy and disperse flows. If a sediment forebay is included in the design, the energy dissipation devices must be installed at the inlet to the sediment forebay. Flow velocity into the sediment forebay must be 4 ft/s or less.

Drainage

Infiltration basins provide stormwater runoff storage above ground and must completely drain within 48 hours. The underlying soils must be allowed to dry out periodically in order to restore hydraulic capacity to receive stormwater runoff from subsequent storm events, maintain infiltration rates, maintain adequate soil oxygen levels for healthy soil biota and vegetation, and provide proper soil conditions for biodegradation and retention of pollutants. The use of vertical piping, either for distribution or infiltration enhancement, is prohibited. This application may be classified as a Class V Injection Well per 40 CFR Part 146.5(e)(4).

Sizing

Step 1: Determine the SDV_{adj}

Infiltration basins are designed to capture and retain the SDV_{adj}, which is the difference between the SDV (Section 3.2.5) and the volume of stormwater runoff managed through site design measures (Section 3.2.3), for the tributary DMA(s).

Step 2: Determine the design infiltration rate

Determine the in-situ infiltration rate of the underlying soil using the Double-Ring Infiltrometer standard (ASTM D3385). Apply a safety factor to the in-situ infiltration rate to determine the design infiltration rate (f_{design}). A typical safety factor of 4 can be used (i.e., multiply in-situ infiltration rate by 0.25). The design infiltration rate must be between 0.5 and 5.0 in/hr. Soil amendments may be used to improve the flow of stormwater runoff into the underlying soil if the design infiltration rate is less than 0.5 in/hr. The infiltration rate will decline between maintenance cycles as the surface of the infiltration basin becomes occluded and particulates accumulate in the infiltrative layer.

Step 3: Calculate the surface area of the infiltration basin

Determine the required size of the infiltration surface by assuming the SDV_{adj} will fill the available ponding depth. The maximum depth of stormwater runoff that can be infiltrated within the maximum drawdown time (48 hrs) is calculated using the following equation:

$$d_{max} = \frac{f_{design}}{12} \times t$$

Where:

d_{max} = Maximum depth of water that can be infiltrated within the required drawdown time [ft];

f_{design} = Design infiltration rate [in/hr]; and
t = Maximum drawdown time (max 48 hrs) [hr].

Select the ponding depth (d_p) such that:

$$d_{max} \geq d_p$$

Where:

d_{max} = Maximum depth of water that can be infiltrated within the maximum drawdown time [ft]; and
d_p = Ponding depth [ft].

Calculate the infiltrating surface area (bottom of the infiltration basin) required:

$$A = \frac{SDV_{adj}}{\frac{f_{design}}{12} \times T + d_p}$$

Where:

A = Surface area of the bottom of the infiltration basin [ft^2];
SDV_{adj} = Adjusted stormwater design volume [ft^3];
f_{design} = Design infiltration rate [in/hr];
T = Time to fill infiltration basin (use 2 hrs) [hr]; and
d_p = Ponding depth [ft].

The bottom of infiltration basin must be the underlying soil that is over-excavated at least one foot in depth with the soil replaced uniformly without compaction. Amending excavated soil with 2 to 4 inches of coarse sand (~15 to 30 percent porosity) is recommended.

Overflow Device

An overflow device is required at the ponding depth near the inlet of the infiltration basin to divert stormwater runoff in excess of the design capacity of the infiltration basin. The following, or equivalent, must be provided:

- A vertical PVC pipe (SDR 26) to act as an overflow riser.
- The overflow riser(s) should be at least eight inches in diameter so it can be cleaned without damage to the pipe.
- The inlet to the overflow riser must be at the ponding depth and capped with a spider cap to exclude floating debris. Spider caps must be screwed on or glued (i.e., not removable). The overflow device must convey stormwater runoff in excess of the design capacity of the infiltration basin to an approved discharge location (e.g., another stormwater treatment control measure, storm drain system, receiving water).

Embankments

Embankments are earthen slopes or berms used to detain or redirect the flow of water. For infiltration basins, the embankments must be design with the following specifications:

- All earthworks must be conducted in accordance with the Port's Standard Specifications.
- The side slopes must be no steeper than 3:1 (H:V).
- The minimum top width of all berm embankments must be 20 feet, unless otherwise approved by the Port.
- Berm embankments must be constructed on the consolidated underlying soil or adequately compacted and stable fill soils approved by a licensed geotechnical engineer. The soils must be free of loose surface soil materials, roots, and other organic debris.
- Berm embankments must be constructed of compacted soil (95 percent minimum dry density, Modified Proctor method per ASTM D1557) and placed in 6-inch lifts.
- Berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width. This requirement may be waived if specifically recommended by a licensed geotechnical engineer.
- Low growing, climate-appropriate grasses must be planted on downstream embankment slopes.

Vegetation and Landscaping

- A thick mat of climate-appropriate grass must be established on the infiltration basin floor and embankment side slopes following construction. Grasses help prevent erosion and increase evapotranspiration, and their rhizomes discourage compaction within the root zone to help maintain infiltration rates. Additionally, active growing vegetation helps break up surface crusts that accumulate from sedimentation of fine particulates. Note that grass may need to be irrigated during the establishment period.
- Landscaping outside of the infiltration basin, but within the easement/right-of-way, may be included as long as it does not hinder maintenance access and operations.
- Trees or shrubs must not be planted within 10 feet of inlet or outlet pipes or manmade drainage structures such as spillways, flow spreaders, or earthen embankments. Species with roots that seek water (e.g., willow, poplar) may not be planted within 50 feet of pipes or manmade structures. Weeping willow (*Salix babylonica*) may not be planted in or near infiltration basins.
- Plant species that are not climate-appropriate are not permitted. A sample list of suitable vegetation species is included in Appendix H. Prior to installation, a

landscape architect must certify that all proposed vegetation is appropriate for the project site.

Maintenance Access

Maintenance access must be provided to the structures associated with the infiltration basin (e.g., pretreatment, inlet, overflow devices) if it is publicly-maintained. Manhole and catch basin lids must be in or at the edge of the access road. An access ramp to the infiltration basin bottom is required to facilitate the entry of sediment removal and vegetation maintenance equipment without compacting the bottom and side slopes of the infiltration basin.

Unless otherwise required by the Port, access roads must meet the following design specifications:

- All access ramps and roads must be paved with a minimum of six inches of concrete over three inches of crushed aggregate base material. This requirement may be modified depending on the soil conditions and intended use of the road at the discretion of the Port.
- The maximum grade is 12 percent unless otherwise approved by the Port.
- Centerline turning radius must be a minimum of 40 feet.
- Access roads less than 500 feet long must have a 12-foot wide pavement within a minimum 15-foot wide bench. Access roads greater than 500 feet long must have a 16-foot wide pavement within a minimum 20-foot wide bench.
- All access roads must terminate with turnaround areas of 40-feet by 40-feet. A hammer type turnaround area or a circle drive around the top of the infiltration basin is also acceptable.
- Adequate double-drive gates and commercial driveways are required at street crossings. Gates must be located a minimum of 25 feet from the street curb except in residential areas where the gates may be located along the property line provided there is adequate sight distance to see oncoming vehicles at the posted speed limit.

Restricted Construction Materials

Use of pressure-treated wood or galvanized metal at or around an infiltration basin is prohibited.

Construction Considerations

If possible, the entire tributary area of the infiltration basin should be stabilized before construction commences. If this is not possible, all flows must be diverted around the infiltration basin to protect it from sediment loads during construction. Sediment controls must be implemented to prevent sediment from entering the basin. Compaction of underlying soils near and at the infiltration basin must be avoided. Establish protective perimeters to prevent inadvertent compaction by construction activities. The equipment used to construct the infiltration basin should have extra wide, low-pressure tires and must not enter the infiltration basin.

If the underlying soils are compacted, ripping or loosening the top two inches of the underlying soils prior to construction of the infiltration basin may be required to improve infiltration. Final grading must produce a level basin bottom without low spots or depressions. After construction is completed, the entire tributary area to the infiltration basin must be stabilized before allowing stormwater runoff to enter it.

Maintenance Requirements

Maintenance and regular inspections must be conducted to ensure proper function of an infiltration basin. The following activities must be conducted to maintain infiltration basin:

- Conduct regular inspection and routine maintenance of pretreatment device(s).
- If a sediment forebay is included, remove sediment buildup exceeding 50 percent of the sediment storage capacity, as indicated by the steel markers. Remove sediment from the rest of the infiltration basin when it accumulates six inches. Test removed sediments for toxic substance accumulation in compliance with current disposal requirements if visual or olfactory indications of pollution are noticed. If toxic substances are detected at concentrations exceeding thresholds of Title 22, Section 66261 of the California Code of Regulations, dispose of the sediment in a hazardous waste landfill and investigate and mitigate the source of the contaminated sediments to the maximum extent possible.
- Remove and dispose of trash and debris, as needed, but at least prior to the beginning of the wet season.
- Inspect infiltration basin frequently to ensure that water infiltrates into the subsurface completely within the maximum drawdown time. If water is present in the infiltration basin more than 48 hours after a storm, the infiltration basin may be clogged. Maintenance activities triggered by a clogged basin include:
    - Check for debris/sediment accumulation, rake surface and remove sediment (if any), and evaluate potential sources of sediment and vegetative or other debris. If suspected upstream sources are outside of the Port’s jurisdiction, additional pretreatment may be necessary.
    - Determine if it is necessary to remove the top layer of the underlying soils to restore infiltrative capacity.
- Eliminate standing water to prevent vector breeding.
- Maintain vegetation as needed to sustain the aesthetic appearance of the site, and as follows:
    - Prune and/or remove vegetation, large shrubs, or trees that limit access or interfere with operation of the infiltration basin.
    - Mow grass to four to nine inches high and remove grass clippings.

  - Rake and remove fallen leaves and debris from deciduous plant foliage.
  - Remove invasive, poisonous, nuisance, or noxious vegetation and replace with climate-appropriate vegetation.
  - Remove dead vegetation if it exceeds 10 percent of area coverage. Replace vegetation immediately to maintain cover density and control erosion where soils are exposed.
  - Do not use herbicides or other chemicals to control vegetation
  - Re-establish vegetation, which may require replanting and/or reseeding, following sediment removal activities.
- Inspect inlet structure for erosion and re-grade if necessary.
- Inspect overflow devices for obstructions or debris, which should be removed immediately. Repair or replace damaged pipes upon discovery.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.

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LID-2: Infiltration Trench

Description

An infiltration trench is a narrow trench constructed in naturally pervious soils designed for retaining and infiltrating stormwater runoff into the underlying soils and groundwater table. Infiltration trenches, which are typically filled with gravel and sand, provide stormwater runoff treatment through various natural mechanisms (i.e., filtration, adsorption, biological degradation) as water flows through the soil profile.

An infiltration trench differs from an infiltration basin in that the former is used for small drainage areas and stores stormwater runoff underground within the void spaces of rocks or stones while the latter is used for larger drainage areas and stormwater runoff is stored within a visible ponded surface.

Because stormwater runoff is infiltrated into an infiltration trench, the potential for groundwater contamination or mobilization of existing soil or groundwater contamination must be carefully considered. Infiltration trenches are typically not suitable for sites that use or store chemicals or hazardous materials, unless they are prevent from entering the trench, or un-remediated "brownfield sites" where it is known groundwater or soil contamination.

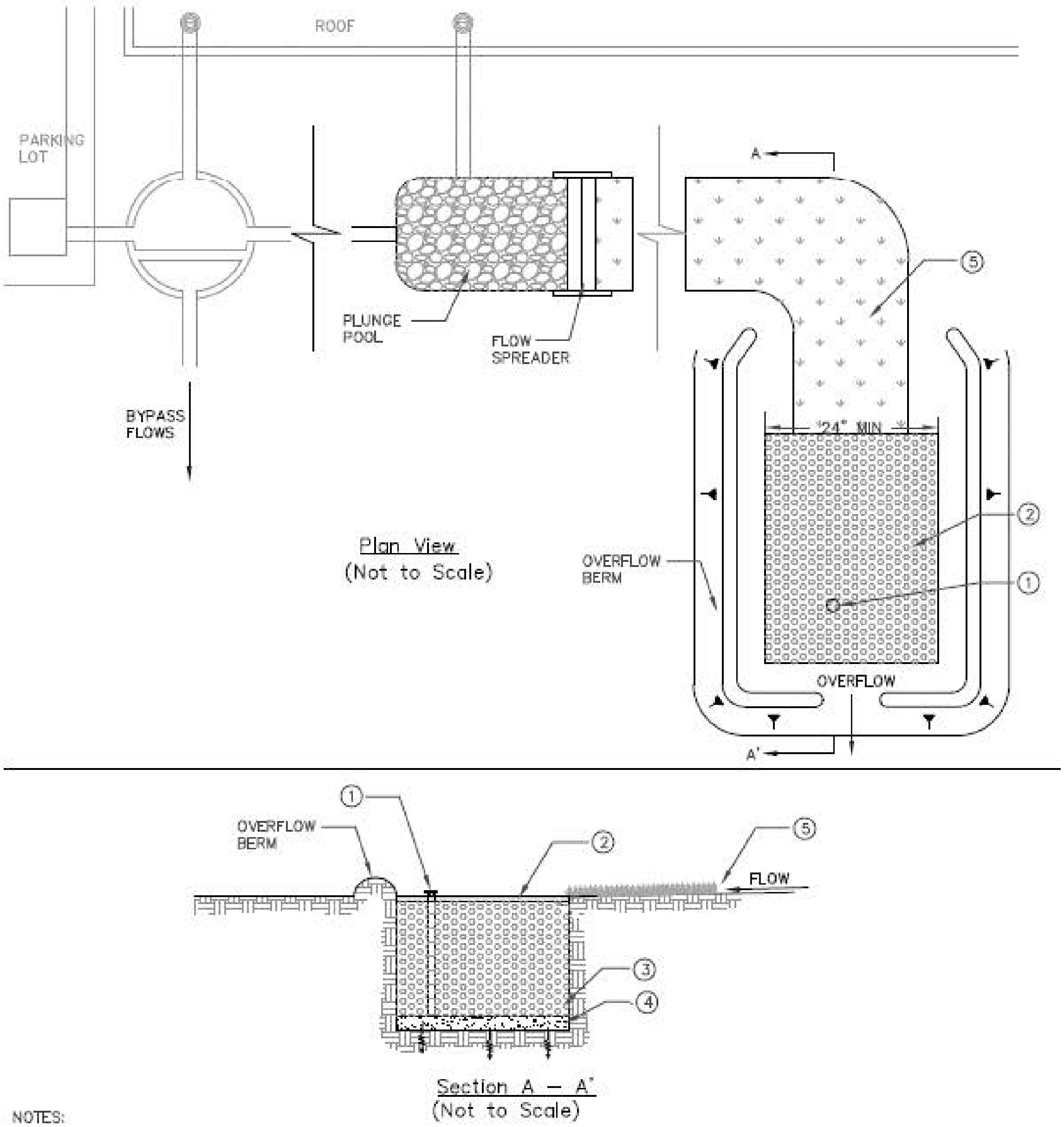
An example schematic of a typical infiltration trench is presented in Figure E-2.

Use and Applicability

The Phase II Permit (Provision F.5.g.2.d) identifies bioretention as the standard stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative stormwater treatment control measure that is equivalent to bioretention is proposed and demonstrated (Provision F.5.g.2.d.(a)), or (2) a specific exemption applies (Provision F.5.g.2.d.(c)). An infiltration trench can be proposed as an alternative to bioretention if it meets all of the following measures of equivalent effectiveness:

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and
- Equal or greater accessibility and ease of inspection and maintenance.

An infiltration trench, which is designed to infiltrate stormwater runoff, is an acceptable alternative to bioretention.



NOTES:

1. OBSERVATION WELL WITH LOCKABLE ABOVE-GROUND CAP
2. 2" PEA GRAVEL FILTER LAYER
3. 3' – 5' DEEP TRENCH FILLED WITH 2" – 6" DIAMETER CLEAN STONE WITH 30% – 40% VOIDS
4. 6" DEEP SAND FILTER LAYER (OR FABRIC EQUIVALENT)
5. RUNOFF FILTERS THROUGH VEGETATED SWALE

Figure E-2. Example Infiltration Trench Schematic

Design Specifications

The following sections provide design specifications for infiltration trenches.

Geotechnical

Due to the potential to contaminate groundwater and/or soils, cause slope instability, impact surrounding structures, and potential for insufficient infiltration capacity, a geotechnical investigation must be conducted during the site assessment process to verify the site suitability for infiltration. It is critical to understand how stormwater runoff will move through the soil (horizontally and vertically) and if there are any geological conditions that may inhibit the movement of water. Soil infiltration rates and the depth to the groundwater table must be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration trench. Infiltration trenches cannot be located on sites with a slope greater than 15 percent. A Site Conditions Report summarizing relevant findings from the geotechnical investigation must be submitted with the Project Stormwater Plan.

Setbacks

Applicable setbacks must be implemented when siting an infiltration trench.

Pretreatment

Pretreatment, which refers to design features that provide settling of large particles before stormwater runoff enters a stormwater treatment control measure, is important to ensure proper operation of an infiltration trench and reduce the long-term maintenance burden. Pretreatment (e.g., vegetated swales, proprietary devices) must be provided to reduce the sediment load entering an infiltration trench in order to prevent the underlying soils from being occluded prematurely and maintain the infiltration rate of the infiltration trench. Additionally for sites with high infiltration rates, pretreatment is required to protect groundwater quality.

Flow Entrance and Energy Dissipation

The drainage management area(s) (DMA[s]) tributary to the infiltration trench must be graded to minimize erosion as stormwater runoff enters the trench by creating sheet flow conditions rather than a concentrated stream condition or by providing energy dissipation devices at the inlet. Typically, a minimum slope of 1 percent for pervious surfaces and 0.5 percent for impervious surfaces to the inlet of the infiltration trench should be maintained. The following types of flow entrances can be used for infiltration trenches:

- Level spreaders (e.g., slotted curbs) can be used to facilitate sheet flow.
- Dispersed low velocity flow across a landscape area. Dispersed flow may not be possible given space limitations or if the infiltration trench is controlling roadway or parking lot flows where curbs are mandatory.

- Dispersed flow across pavement or gravel and past wheel stops for parking areas.
- Flow spreading trench around perimeter of infiltration trench that may be filled with pea gravel or vegetated with 3:1 side slopes.
- Curb cuts for roadside or parking lot areas. Curb cuts must include rock or other erosion controls in the channel entrance to dissipate energy. The flow entrance should drop two to three inches from the curb line and provide an area for settling and periodic removal of sediment and coarse material before flow disperses to the remainder of the infiltration trench.
- Piped entrances that must include rock, splash blocks, or other erosion controls at the entrance to dissipate energy and disperse flows.

Drainage

Infiltration trenches provide stormwater runoff storage in the voids of the rock fill and must completely drain within 48 hours. The underlying soils must be allowed to dry out periodically in order to restore hydraulic capacity to receive stormwater runoff from subsequent storm events, maintain infiltration rates, and provide proper soil conditions for biodegradation and retention of pollutants. The use of vertical piping, either for distribution or infiltration enhancement, is prohibited. This application may be classified as a Class V Injection Well per 40 CFR Part 146.5(e)(4).

Sizing

Step 1: Determine the SDV_{adj}

Infiltration trenches are designed to capture and retain the SDV_{adj}, which is the difference between the SDV (Section 3.2.5) and the volume of stormwater runoff managed through site design measures (Section 3.2.3), for the tributary DMA(s).

Step 2: Determine the design infiltration rate

Determine the in-situ infiltration rate of the underlying soil using the Double-Ring Infiltrometer standard (ASTM D3385). Apply a safety factor to the in-situ infiltration rate to determine the design infiltration rate (f_{design}). A typical safety factor of 4 can be used (i.e., multiply in-situ infiltration rate by 0.25). The design infiltration rate must be between 0.5 and 5.0 in/hr. Soil amendments may be used to improve the flow of stormwater runoff into the underlying soil if the design infiltration rate is less than 0.5 in/hr. The infiltration rate will decline between maintenance cycles as the surface of the infiltration trench becomes occluded and particulates accumulate in the infiltrative layer.

Step 3: Calculate the surface area

Determine the size of the required infiltration surface by assuming the SDV_{adj} will fill the available void spaces in the media layers. The maximum depth of stormwater runoff that can be infiltrated within the maximum drawdown time (48 hrs) is calculated using the following equation:

$$d_{max} = \frac{f_{design}}{12} \times t$$

Where:

d_{max} = Maximum depth of water that can be infiltrated within the maximum drawdown time [ft];
f_{design} = Design infiltration rate [in/hr]; and
t = Maximum drawdown time (max 48 hrs) [hr].

The maximum depth of water that can be infiltrated within the maximum drawdown time is constrained by the following equation:

$$d_{max} \geq n_t \times d_t$$

Where:

d_{max} = Maximum depth of water that can be infiltrated within the maximum drawdown time [ft];
n_t = Infiltration trench media layer porosity; and
d_t = Depth of infiltration trench fill [ft].

Calculate the infiltrating surface area (bottom of the infiltration trench) required:

$$A = \frac{SDV_{adj}}{\frac{f_{design}}{12} \times T + n_t \times d_t}$$

Where:

A = Surface area of the bottom of the infiltration trench [ft^2];
SDV_{adj} = Adjusted stormwater design volume [ft^3];
f_{design} = Design infiltration rate [in/hr];
T = Time to fill the infiltration trench (use 2 hrs) [hr];
n_t = Infiltration trench fill porosity; and
d_t = Depth of infiltration trench fill [ft].

Infiltration trenches must be designed and constructed to be at least 24 inches wide and 3 to 5 feet deep with a longitudinal slope not to exceed 3 percent. The media layers must have the following composition and thickness:

- Top layer: 2 inches of pea gravel
- Middle layer: 3 to 5 feet of washed 2- to 6-inch gravel with void spaces of approximately 30 to 40 percent

- Bottom layer: 6 inches of sand or hydraulic restriction layer.

The bottom of infiltration trench, below the media layers, must be the underlying soils that is over-excavated at least one foot in depth with the soil replaced uniformly without compaction. Amending the excavated soil with 2 to 4 inches of coarse sand (~15 to 30 percent porosity) is recommended.

Hydraulic Restriction Layer

The entire infiltrative area, including the side slopes must be lined with a hydraulic restriction layer to prevent soil from migrating into the top layer and reducing the infiltration capacity. If a hydraulic restriction layer is used in lieu of six inches of sand, it should be installed at the bottom of the infiltration trench prior to placing the media layers. The hydraulic restriction layer should be installed generously with overlapping seams. The specifications of the hydraulic restriction layer are presented in Table E-1.

Table E-1. Hydraulic Restriction Layer Specifications for Infiltration Trenches

Parameter	**Test Method**	**Specifications**
Material		Nonwoven geomembrane liner
Unit weight		8 oz/yd^3 (minimum)
Filtration rate		0.08 in/sec (minimum)
Puncture strength	ASTM D-751 (Modified)	125 lbs (minimum)
Mullen burst strength	ASTM D-751	400 lb/in^2 (minimum)
Tensile strength	AST D-1682	300 lbs (minimum)
Equiv. opening size	US Standard Sieve	No. 80 (minimum)

Observation Well

An observation well must be installed to check water levels, drawdown time, and evidence of clogging. The observation well is a vertical section of perforated PVC pipe, four- to six-inch diameter, installed flush with the top of the infiltration trench on a footplate and with a locking, removable cap.

Overflow Device

An overflow device is required near the inlet of the infiltration trench to divert stormwater runoff in excess of the design capacity of the infiltration trench. For rooftop drainage, the distance between the downspouts and the overflow device should be maximized in order to increase the opportunity for stormwater runoff retention and infiltration. The following, or equivalent, must be provided:

- A vertical PVC pipe (SDR 26) to act as an overflow riser.
- The overflow riser(s) should be at least eight inches in diameter so it can be cleaned without damage to the pipe.

- The inlet to the overflow riser must be at the top of the infiltration trench with a spider cap to exclude floating debris. Spider caps must be screwed on or glued (i.e., not removable). The overflow device must convey stormwater runoff in excess of the design capacity of the infiltration basin to an approved discharge location (e.g., another stormwater treatment control measure, storm drain system, receiving water).

Vegetation

Infiltration trenches must be kept free of vegetation. Trees and other large vegetation must be planted away from infiltration trenches such that drip lines do not overhang the infiltration area.

Maintenance Access

The infiltration trench must be safely accessible during wet and dry weather conditions if it is publicly-maintained. An access road along the entire length of the infiltration trench is required unless the trench is located along an existing road or parking lot that can be safely used for maintenance access. If the infiltration trench becomes plugged and fails, access is needed to excavate the infiltration trench and replace the media layers. When rehabilitating an infiltration trench, all dimensions of the infiltration trench must be increased by a minimum of two inches to provide a fresh surface for infiltration. To prevent damage and compaction, access must able to accommodate a backhoe working at “arm’s length” from the infiltration trench.

Restricted Construction Materials

Use of pressure-treated wood or galvanized metal at or around an infiltration trench is prohibited.

Construction Considerations

If possible, the entire tributary area of the infiltration trench should be stabilized before construction commences. If this is not possible, all flows must be diverted around the infiltration trench to protect it from sediment loads during construction. Sediment controls must be implemented to prevent sediment from entering the trench. Compaction of underlying soils near and at the infiltration trench must be avoided. Establish protective perimeters to prevent inadvertent compaction by construction activities. The equipment used to construct the infiltration trench should have extra wide, low-pressure tires and must not enter the infiltration trench.

If the underlying soils are compacted, ripping or loosening the top two inches of the underlying soils prior to construction of the infiltration trench may be required to improve infiltration. Final grading must produce a level bottom without low spots or depressions. Clean, washed gravel should be placed in the excavated trench in lifts and lightly compacted with a plate compactor. Unwashed gravel can result in clogging. After construction is completed, the entire tributary area to the infiltration trench must be stabilized before allowing stormwater runoff to enter it.

Maintenance Requirements

Maintenance and regular inspections must be conducted to ensure proper function of an infiltration trench. The following activities must be conducted to maintain an infiltration trench:

- Conduct regular inspection and routine maintenance for pretreatment device(s).
- Inspect infiltration trench and its observation well frequently to ensure that water infiltrates into the subsurface completely within the maximum drawdown time. If water is present in the observation well more than 48 hours after a storm, the infiltration trench may be clogged. Maintenance activities triggered by a potentially clogged facility include:
  - Check for debris/sediment accumulation, rake surface and remove sediment (if any), and evaluate potential sources of sediment and vegetative or other debris. If suspected upstream sources are outside of the Port's jurisdiction, additional pretreatment may be necessary.
  - Assess the condition of the top layer for sediment buildup and crusting. Remove the top layer of pea gravel and replace. If slow draining conditions persist, the entire infiltration trench may need to be excavated and replaced.
- Eliminate standing water to prevent vector breeding.
- Remove and dispose of trash and debris as needed, but at least prior to the beginning of the wet season.
- Inspect inlet structure for erosion and re-grade if necessary.
- Inspect overflow devices for obstructions or debris, which should be removed immediately. Repair or replace damaged pipes upon discovery.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.

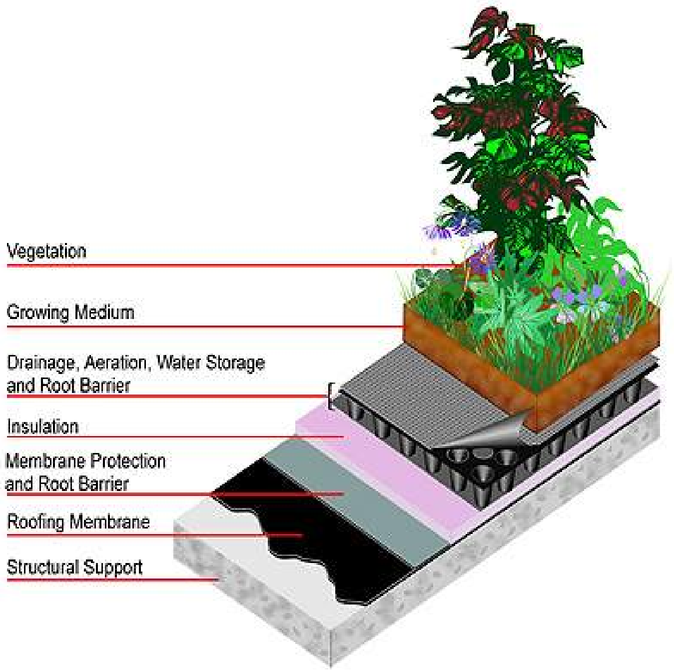
LID-3: Green Roof

Description

A green roof is a multi-layered system comprised of light-weight growth media and a specialized mix of vegetation underlain by a root barrier, a drainage layer, and a waterproofing membrane to protect the building structure. There are two types of green roofs: intensive and extensive. Intensive green roofs are characterized by thick soil depths, heavy weights, and elaborate plantings that include shrubs and trees. Extensive green roofs consist of a thin soil layer and a cover of grass, sedums, or moss.

Green roofs reduce stormwater runoff volume and peak discharge flow rates by retaining precipitation within the pore space of the growing medium and slowly releasing the water via evaporation from soil and transpiration by plants. Green roofs improve stormwater runoff quality through biological, physical, and chemical processes that occur within the plants and growth media to prevent airborne pollutants from entering the storm drain system. A drain system and overflow to an approved conveyance and destination/disposal method is also required.

A schematic of a typical green roof is presented in Figure E-4.



Source: American Wick

Figure E-3. Green Roof Schematic

Advantages

- Reduces size of downstream stormwater quality BMPs
- Requires no additional space
- Provides thermal insulation, which reduces energy costs
- Extends roof life by protecting underlying roof material from climatic extremes, ultraviolet light, and damage
- Reduces amount of airborne pollutants entering the storm drain system.
- Reduces volume and peak flows of stormwater runoff
- Absorbs air pollution, collects airborne particulate matter, and negates acid rain effects
- Provides “islands” or “stepping stone” habitat for wildlife, particularly avian species
- Reduces urban heat island effect
- Provides sound insulation to reduce noise transfer (i.e., air traffic)

Disadvantages

- Are likely best incorporated into plans for new buildings that provide adequate structural support; however, can be retrofitted for existing buildings
- Increases building costs due to special structural design requirements

- Requires appropriate vegetation selection, maintenance, and irrigation because of long dry season in the Bay Area

General Constraints and Implementation Considerations

- The climate, particularly temperature and rainfall patterns, must be considered.
- The size, slope, height, and directional orientation of the roof must be considered. Green roofs are typically installed on flat roofs, but may be installed on roofs with slopes up to 10 percent unless the project applicant can provide documentation for steeper slopes.
- The amount of stormwater runoff mitigated by a green roof is directly proportional to the area it covers, the depth and type of the growing medium, slope, and the type of plants selected.
- Green roofs must be designed to handle the green roof load, including during periods of saturation. Green roofs are appropriate for industrial and commercial facilities and large residential buildings (i.e., condominiums, apartment complexes). Green roofs may also be used for small residential buildings under some circumstances.
- Safe access must be available for workers and materials during both construction and maintenance. Residents should understand the maintenance requirements necessary to keep the green roof functional.
- Visibility, architectural fit, and aesthetic preferences should be identified.
- Green roofs should be evaluated for compatibility with other systems (i.e., solar panels).
- Irrigation systems are necessary to maintain viability of green roofs. The irrigation system for the green roof should be coordinated with the design of general irrigation system, as applicable.
- Vegetation should be selected, installed, and maintained by experienced horticulturists or landscaping contractors who understand the local environment and climate.
- Green roof components, particularly the vegetation, must be protected until established.
- Construction of the green roof in sections provides for easier inspection and maintenance access to the waterproofing membrane and roof drains.

Design Specifications

Proprietary green roof applications must comply with the vendor's design specifications for installation and maintenance. In the case of a conflict between vendor guidelines and Port requirements, the more stringent standards shall apply. Design specifications for green roofs are listed in Table E-3. Other design specifications for green roofs are discussed in the sections below.

Table E-2. Green Roof Design Specifications

Design Parameter	Extensive Green Roof	Intensive Green Roof
Growth media	Typical depth: 2-6 inches Mix should have high mineral content	Typical depth: 8 inches Mix should have high mineral content
Load	10-30 psf	60 psf
Vegetation	Variety of vegetated ground cover and grasses. Select vegetation that is drought-tolerant and requires little maintenance	Large trees, shrubs, and complex gardens. Select vegetation that is drought-tolerant and requires little maintenance
Waterproofing membrane	Resistant to biological and root attack	Resistant to biological and root attack
Public access	Usually not designed for public access	Accommodated and encouraged
Maintenance	Annual maintenance walks should be performed until plants are established	Significant maintenance required
Drainage	Simple irrigation and drainage system	Complex irrigation and drainage system

On-Site Retention Volume

The volume of stormwater runoff retained on-site by a green roof is calculated using the following equation:

$$V_{ret} = d_{gm} \times A_r \times W_{gm}$$

Where:

V_{ret} = Volume of stormwater runoff retained on-site by a green roof [ft^3];
d_{gm} = Depth of growth medium [ft];
A_r = Roof top surface area [ft^2]; and
W_{gm} = Available water holding capacity of growth medium [assume default W_{gm}=0.1].

Growth Media

For extensive green roofs, the growth medium is generally well-drained, 2 to 6 inches thick, and weighing 10 to 30 psf. For intensive green roofs, a minimum soil depth of 8 inches and weight of 60 psf should be used. A simple mix of 25 percent topsoil, 25 percent compost, and 50 percent pumice perlite may be sufficient for many applications. Some companies have their own growth medium specifications. Other components may include digested fiber, expanded clay or shale, or coir. Soil coverage to prevent erosion must be established immediately upon installation by using mulch, vegetation mats, or other approved protection method.

Vegetation

Green roof vegetation should have the following characteristics:

- Drought-tolerant, requiring little or no irrigation after establishment;
- A growth pattern that allows the plant to thoroughly cover the soil. At least 90 percent of the overall surface must be covered within two years of installation;
- Self-sustaining, without the need for fertilizers, pesticides, or herbicides;
- Able to withstand heat, cold, and high winds;
- Very low maintenance requirements (e.g., needing little/no mowing or trimming);
- Perennial or self-sowing; and
- Fire resistant.

A mix of sedum/succulent plant communities is recommended because they possess many of these attributes. Herbs, forbs, grasses, and other low ground covers can also be used to provide additional benefits and aesthetics; however, these plants may need more watering and maintenance to survive and maintain their appearance.

Waterproof Membrane

A good quality waterproofing material must be used on the roof surface. Waterproof membranes are made of various materials, such as modified asphalts (bitumens), synthetic rubber ethylene propylene diene monomer (EPDM), hypolan chlorosulfonated polyethylene (CSPE), and reinforced polyvinyl chloride (PVC). Waterproofing materials may come in sheets or rolls or in liquid form, and have different strengths and functional characteristics. Some waterproofing materials require root inhibitors and other materials to protect the membrane. Numerous companies manufacture waterproofing materials appropriate for green roofs.

Protection Boards or Materials

Protection boards or materials, which are typically made of soft fibrous materials, protect waterproofing membrane from damage during construction and over the life of the green roof.

Root Barrier

Root barriers are made of dense materials that inhibit root penetration. The need for a root barrier depends on the waterproofing membrane selected. Modified asphalts usually require a root barrier while EPDM and reinforced PVC generally do not. Check with the manufacturer to determine if a root barrier is required for a particular product. Membranes impregnated with pesticides are not allowed. Manufacturers must provide the Port with evidence that membranes impregnated with copper will not leach out at levels of concern.

Structural Roof Support

The structural roof support must be sufficient to hold the additional weight of the green roof, including during periods of saturation. For retrofit projects, check with an architect, structural engineer, or roof consultant to determine the condition of the existing building structure and what might be needed to support a green roof (i.e., additional decking, roof trusses, joists, columns, foundations). Generally, the building structure must be adequate to hold an additional 10 to 25 pounds psf saturated weight, depending on the vegetation and growth medium used. (This is in addition to snow load requirements.) An existing rock ballast roof may be structurally sufficient to hold a 10 to 12 psf green roof. (Ballast typically weighs 10 to 12 psf.)

For new development, the architects and structural engineers must address the structural requirements of the green roof during the design process. Greater flexibility and options are available for new buildings than for retrofit. The procedures for the remaining components are the same for both reroofing and new construction.

Gravel Ballast

Gravel ballast is sometimes placed along the perimeter of the roof and at air vents or other vertical elements. The need for gravel ballast depends on operational and structural design issues. They are sometimes used to provide maintenance access, especially to vertical elements requiring periodic maintenance. In many cases very little, if any, ballast is needed. In some situations a header or separation board may be placed between the gravel ballast and adjacent elements (such as soil or drains). If a root barrier is used, it must extend under the gravel ballast and growth medium and up the side of the vertical elements.

Installation

Four methods (or combinations of them) are generally used to install the vegetation: vegetation mats, plugs/potted plants, sprigs, and seeds.

- Vegetation mats are sod-like, pre-germinated mats that achieve immediate full-plant coverage. They provide immediate erosion control, do not need mulch, and minimize weed intrusion. They also need minimal maintenance during the establishment period and little on-going watering and weeding.

- Plugs or potted plants may provide more design flexibility than mats. However, they take longer to achieve full coverage, are more prone to erosion, need more watering during establishment, and require mulching and more weeding.
- Sprigs are hand broadcast. They require more weeding, erosion control, and watering than vegetation mats.
- Seeds can be either hand broadcast or hydroseeded. Like sprigs, they require more weeding, erosion control, and watering than vegetation mats.

Drainage Layer

There are numerous ways to provide drainage. Products range from manufactured perforated plastic sheets to a thin layer of gravel. Some green roof designs do not require any drainage layer other than the growth medium itself, depending on roof slope and size (e.g., pitched and small flat roofs).

Drainage System

As with a conventional roof, a green roof must safely drain stormwater runoff in excess of the design volume from the roof to an approved location.

Irrigation System

Temporary irrigation to establish plants is recommended. A permanent irrigation system using potable water may be used, but an alternative means of irrigation such as air conditioning condensate or other non-potable sources is recommended.

Maintenance Requirements

Maintenance and regular inspections are important for proper function of green roofs. Once a properly installed green roof is established, its maintenance requirements are usually minimal. Intensive green roofs tend to have higher maintenance requirements compared to extensive green roofs due to its increased weight and more concentrated plantings. Written guidance and the operations and maintenance manual for the green roof should be provided to all new owners and tenants. The following are general maintenance requirements:

- Inspect waterproofing membrane two to three times per year including prior to winter and after periods of heavy stormwater runoff.
- Inspect soil for evidence of erosion from wind or water. If erosion channels are evident, stabilize them with additional soil substrate/growth medium and cover with additional plants.
- Operate and maintain structural components of the green roof according to manufacturer's requirements.
- Keep drain inlets unrestricted. Clear inlet pipe when soil substrate, vegetation, debris, or other materials clog the drain inlet. Identify and correct sources of

sediment and debris. Determine if the drain inlet pipe is in good condition and correct as needed.

- Remove debris to prevent inlet drain clogging and interference with plant growth.
- Maintain vegetation to provide 90 percent plant cover. During the establishment period, replace plants once per month as needed. After the establishment period, replace dead plants as needed. Remove plant litter and nuisance and prohibited vegetation regularly. Remove weeds manually without herbicides or pesticides. Do not apply fertilizers. Mow grass as needed and remove clippings.
- During drought conditions, mulch or shade cloth may be applied to prevent excess solar damage and water loss.
- Irrigate green roof either through hand watering or automatic sprinkler systems. If automatic sprinklers are used, follow manufacturer's instructions for operations and maintenance. During the establishment period (one to three years), provide sufficient irrigation to assure plant establishment. Following the establishment period (after three years), provide sufficient irrigation to maintain plant cover.
- Exercise spill prevention measures from mechanical systems located on roofs when handling substances that can contaminate stormwater runoff.
- Provide training and/or written guidance information for operating and maintaining green roofs to all property owners and tenants. Provide a copy of the operations and maintenance plan to all property owners and tenants.
- Provide safe and efficient access to the green roof. Maintain egress and ingress routes to design specifications. Clear walkways of obstructions and maintain them to design specifications.
- Eliminate standing water to prevent vector breeding.

A summary of potential problems that may need to be addressed by maintenance activities is presented in Table E-4.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.

Table E-3: Green Roof Troubleshooting Summary

Problem	Conditions When Maintenance Is Needed	Maintenance Required
Vegetation	Overgrown vegetation	Mow and trim as needed.
	Dead plants present	Remove dead plants and re-plant as needed.
	Presence of invasive, poisonous, nuisance, or noxious vegetation or weeds	Remove this vegetation.

Problem	Conditions When Maintenance Is Needed	Maintenance Required
Contaminants and Pollution	Any evidence of oil, gasoline, contaminants, or other pollutants	Remove any evidence of visual contamination.
Erosion/Sediment Accumulation	Undercut or eroded areas at inlet structures	Stabilize eroded areas with additional soil/growth medium and cover with additional plants.
	Accumulation of sediment, debris, and oil/grease on surface or inlet	Remove sediment, debris, and/or oil/grease.
Obstructions	Flow into green roof impeded	Remove obstruction.
Vector Breeding	Standing water	Remove standing water. Implement Integrated Pest Management.

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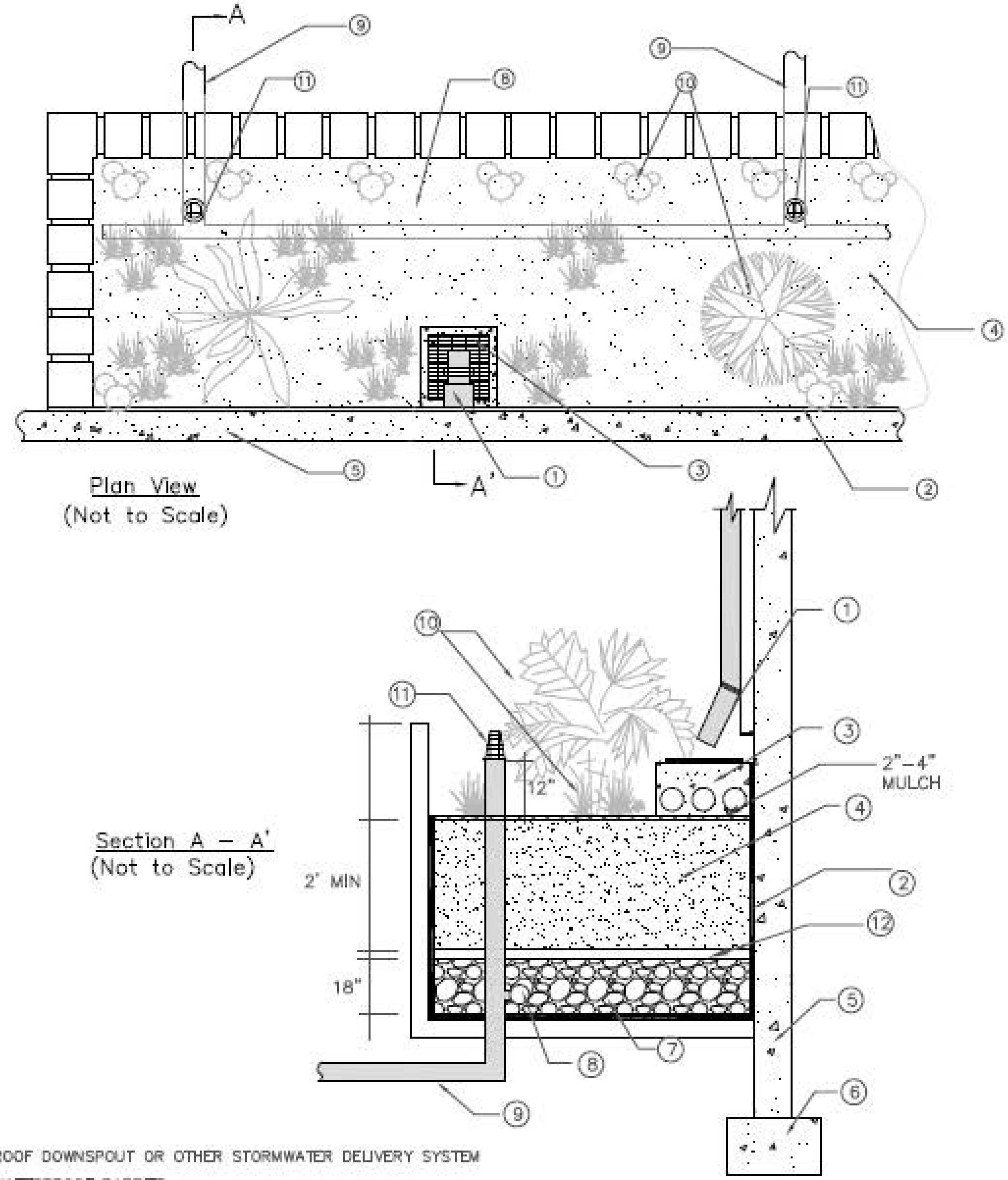
T-1: Stormwater Planter

Description

A stormwater planter, or a flow-through planter, is a stormwater treatment control measure that is completely contained within an impermeable structure with an underdrain. Stormwater planters are similar to bioretention facilities and function as a soil- and plant-based filtration device that remove pollutants though a variety of physical, biological, and chemical treatment processes. A stormwater planter consists of a ponding area, mulch layer, planting media, plants, and an underdrain within the planter box. As stormwater runoff passes through the planting media, pollutants are filtered, adsorbed, and biodegraded by the soil and plants. Stormwater planters contain climate-appropriate vegetation that does not require fertilizers and can withstand wet soils for at least 48 hours. Stormwater planters are only capable of treating stormwater runoff from smaller areas (up to 15,000 square feet of impervious surfaces).

Stormwater planters may be placed adjacent to or near buildings, other structures, or sidewalks. Stormwater planters used directly adjacent to buildings beneath downspouts, which will disconnect the downspout, must be properly lined on the building side, and the overflow outlet discharges away from the building to ensure water does not percolate into footings or foundations. They can also be placed further away from buildings by conveying roof runoff in shallow engineered open conveyances, shallow pipes, or other drainage structures.

An example schematic of a typical stormwater planter is presented in Figure E-5.



NOTES:

1. ROOF DOWNSPOUT OR OTHER STORMWATER DELIVERY SYSTEM
2. WATERPROOF BARRIER
3. SHALLOW ENERGY DISSIPATOR BASIN DISPERSES FLOW AT SOIL SURFACE
4. SOIL MIX (SEE PLANTING MEDIA SECTION)
5. BUILDING
6. FOUNDATION. INSTALL FOUNDATION DRAINS AS NEEDED
7. GRAVEL BEDDING (SEE UNDERDRAIN)
8. PERFORATED PIPE SHALL RUN ENTIRE LENGTH OF PLANTER
9. CONNECTION TO DOWNSTREAM CONVEYANCE SYSTEM
10. PLANTS
11. SET OVERFLOW 2" BELOW THE TOP OF THE PLANTER
12. OPTIONAL CHOKING GRAVEL LAYER

Figure E-4. Example Stormwater Planter Schematic

Use and Applicability

The Phase II Permit (Provision F.5.g.2.d) identifies bioretention as the standard stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative stormwater treatment control measure that is equivalent to bioretention is proposed and demonstrated (Provision F.5.g.2.d.(a)), or (2) a specific exemption applies (Provision F.5.g.2.d.(c)). A stormwater planter can be proposed as an alternative to bioretention if it meets all of the following measures of equivalent effectiveness:

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and
- Equal or greater accessibility and ease of inspection and maintenance.

The Phase II Permit (Provision F.5.g.2.d.(b)) allows the use of stormwater planters in project areas with documented high concentrations of pollutants in the underlying soil or groundwater, where infiltration may contribute to a geotechnical hazard, and that are located on elevated plazas or adjacent to structures. Under these allowed variations for site-specific conditions, a hydraulic restriction layer may be incorporated or the underdrain may be located at the bottom of the gravel layer.

The Phase II Permit (Provision F.5.g.2.d.(c)) also allows the use of stormwater planters in project areas for the following types of Regulated Projects:

- Projects creating or replacing an acre or less of impervious area, and located in a designated pedestrian-oriented commercial district (i.e., smart growth projects), and having at least 85 percent of the entire project site covered by permanent structures;
- Facilities receiving runoff solely from existing (pre-project) impervious areas; and
- Historic sites, structures, or landscapes that cannot alter their original configuration in order to maintain their historic integrity.

Design Specifications

The following sections provide design specifications for stormwater planters.

Geotechnical

Due to the potential to contaminate groundwater and/or soils, cause slope instability, impact surrounding structures, and potential for insufficient infiltration capacity, a geotechnical investigation must be conducted during the site assessment process to verify the site suitability for a stormwater planter. It is critical to understand how stormwater runoff will move through the soil (horizontally and vertically) and if there are any geological conditions that may inhibit the movement of water. Soil infiltration rates and the depth to the groundwater table must be evaluated to ensure that conditions are satisfactory for proper operation of a stormwater planter. Stormwater planters can only be located on sites with a slope of less than 10 percent. A Site Conditions Report summarizing the relevant findings from the geotechnical investigation must be submitted with the Project Stormwater Plan.

Setbacks

Applicable setbacks must be implemented when siting a stormwater planter.

Pretreatment

Pretreatment, which refers to design features that provide settling of large particles before stormwater runoff enters a stormwater treatment control measure, is important to ensure proper operation of a stormwater planter and reduce the long-term maintenance burden. If stormwater planters are used to manage stormwater runoff from rooftops that drain directly to the planter, pretreatment may not be necessary because stormwater runoff from rooftops are not expected to have large particles. For other applications of a stormwater planter, pretreatment (e.g., vegetated swales, proprietary devices) is required to be provided to reduce the sediment load entering a stormwater planter in order to prevent the underlying soils from being occluded prematurely and maintain the infiltration rate of the stormwater planter.

Flow Entrance and Energy Dissipation

The drainage management area(s) (DMA[s]) tributary to a stormwater planter must be graded to minimize erosion as stormwater runoff enters the planter by creating sheet flow conditions rather than a concentrated stream condition or by providing energy dissipation devices at the inlet. Typically, a minimum slope of 1 percent for pervious surfaces and 0.5 percent for impervious surfaces to the inlet of the stormwater planter should be maintained. The following types of flow entrances can be used for a stormwater planter:

- Level spreaders (e.g., slotted curbs) can be used to facilitate sheet flow.
- Dispersed low velocity flow across a landscaped area. Dispersed flow may not be possible given space limitations or if the stormwater planter controls roadway or parking lot flows where curbs are mandatory.
- Dispersed flow across pavement or gravel and past wheel stops for parking areas.
- Flow spreading trench around perimeter of the stormwater planter that may be filled with pea gravel or vegetated with 3:1 side slopes.
- Curb cuts for roadside or parking lot areas. Curb cuts must include rock or other erosion controls in the channel entrance to dissipate energy. The flow entrance should drop two to three inches from curb line and provide an area for settling

and periodic removal of sediment and coarse material before flow disperses to the remainder of the stormwater planter.

- Piped entrances, such as roof downspouts, must include rock, splash blocks, or other erosion controls at the entrance to dissipate energy and disperse flows.

Drainage

Stormwater planters provide stormwater runoff storage in the ponding zone and in the voids of the planting media and gravel layers and must completely drain within 48 hours. The planting media and gravel layers must be allowed to dry out periodically in order to restore hydraulic capacity to receive stormwater runoff from subsequent storm events, maintain infiltration rates, maintain adequate soil oxygen levels for healthy soil biota and vegetation, and provide proper soil conditions for biodegradation and retention of pollutants.

Sizing

Step 1: Determine the Adjusted SDV (SDV_{adj})

Stormwater planters are designed to capture and retain the SDV_{adj}, which is the difference between the SDV (Section 3.2.5) and the volume of stormwater runoff managed through site design measures (Section 3.2.3), for the tributary DMA(s).

Step 2: Determine size of stormwater planter design layers

Stormwater planters consist of several layers that are designed to retain stormwater runoff. The design depths, which are used to size the stormwater planter, are presented in Table E-5. Other design parameters for these layers are discussed in further detail in the following sections.

Table E-4. Design Depths of Stormwater Planter Layers

Stormwater Planter Layer	Design depth
Ponding zone	0.5-1.0 ft
Planting media (excluding the mulch layer, if provided)	1.5-3.0 ft
Planting media/gravel layer separation zone (1)	2-4 in
Gravel	1 ft (min)
Hydraulic restriction layer	n/a

(1) In calculating the required bottom surface area of the stormwater planter, the planting media/ gravel layer separation zone is not considered because it is designed primarily to separate the planting media and gravel layer and not to retain stormwater runoff.

Step 3: Calculate the bottom surface area of the stormwater planter

Determine the bottom surface area (surface area at the base of side slopes, not at the top of side slopes) of the stormwater planter using the following equation:

$$A = \frac{SDV_{adj}}{d_{pz} + (\eta_{pm} \times d_{pm}) + (\eta_{gl} \times d_{gl})}$$

Where:

A = bottom surface area of stormwater planter [ft^2];
SDV_{adj} = adjusted stormwater design volume [ft^3];
d_{pz} = depth of ponding zone (0.5-1.0 ft) [ft];
η_{pm} = porosity of planting media [unitless];
d_{pm} = depth of planting media (min 1.5 ft) [ft];
η_{gl} = porosity of gravel layer [unitless]; and
d_{gl} = depth of gravel layer (min 1 ft) [ft].

Any stormwater planter shape configuration is possible as long as the other design specifications are met. The minimum stormwater planter width is 30 inches.

Stormwater Planter Walls

Stormwater planter walls must be made of stone, concrete, brick, clay, plastic, wood, or other stable, permanent material. The use of pressure-treated wood or galvanized metal at or around a stormwater planter is prohibited.

Planting Media Layer

Because stormwater planters are a variation of bioretention facilities, the Phase II Permit requires that the planting media layer:

- Have a minimum depth of 1.5 feet, excluding the mulch layer, if provided;
- Achieve a long-term, in-place minimum infiltration rate of at least 5 in/hr to support maximum stormwater runoff retention and pollutant removal; and
- Consist of 60 to 70 percent sand meeting the specifications of the American Society for Testing and Materials (ASTM) C33 and 30 to 40 percent compost.

Compost must be a well-decomposed, stable, weed-free organic matter source derived from waste materials including yard debris, wood wastes, or other organic material and not including manure or biosolids meeting standards developed by the US Composting Council (USCC). The product must be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

Mulch is recommended for the purpose of retaining moisture, preventing erosion, and minimizing weed growth. Projects subject to the California Model Water Efficiency Landscaping Ordinance (or comparable local ordinance) will be required to provide at least two inches of mulch. Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. If mulch is used for a stormwater planter, two to four inches (average three inches) of mulch should be used at the initiation of the planter. Annual placement (preferably in June after weeding) of one to two inches of mulch beneath plants will maintain the mulch layer.

Planting Media/Gravel Layer Separation Zone

The planting media and gravel layer must be separated by a permeable 2-4 inch layer of sand and stone that meets the grading requirements in Table E-6.

Table E-5. Planting Media/Gravel Layer Separation Layer Grading Requirements

Sieve Size	Percent Passing
1”	100
3/4”	90-100
3/8”	40-100
No. 4	25-100
No. 8	18-33
No. 30	5-15
No. 50	0-7
No. 200	0-3

Source: Caltrans Standard Specifications (2010) Class 2 Permeable Material

Gravel Layer

The gravel layer must consist of washed 1- to 2.5-inch diameter stone with a minimum 1-foot depth.

Hydraulic Restriction Layer

The hydraulic restriction layer, which can be a 60-mil PVC or 30-mil polyethylene pond liner with bentonite clay mats, must be placed below the gravel layer to prevent infiltration of stormwater runoff below the stormwater planter. If the stormwater planter is located near structures, the hydraulic restriction layer must also be applied along the walls of the stormwater planter to prevent stormwater runoff from percolating to these structures. The hydraulic restriction layer should be installed generously with overlapping seams prior to constructing the layers of the stormwater planter.

Underdrain

Stormwater planters require an underdrain to collect and discharge stormwater runoff that has been filtered through the planting media, but not infiltrated, to another stormwater treatment control measure, storm drain system, or receiving water. The underdrain must have a discharge elevation at the bottom of the gravel layer and a mainline diameter of eight inches using slotted PVC SDR 26 or C9000. Slotted PVC allows for pressure cleaning and root cutting, if necessary. The slotted pipe should have two to four rows of slots cut perpendicular to the axis of the pipe or at right angles to the pitch of corrugations. Slots should be 0.04 to 0.1 inches wide with a length of 1 to 1.25 inches. Slots should be longitudinally-spaced such that the pipe has a minimum of one square inch opening per lineal foot and should face down. Underdrains should be sloped at a minimum of 0.5 percent in order to drain freely to an approved location.

Observation Well

A rigid non-perforated observation pipe with a diameter equal to the underdrain diameter must be connected to the underdrain to provide a clean-out port as well as an observation well to monitor infiltration rates. The wells/clean-out port must be connected to the slotted underdrain with the appropriate manufactured connections. The wells/clean-outs must extend six inches above the top elevation of the stormwater planter mulch and be capped with a lockable screw cap. The ends of the underdrain pipes not terminating in an observation well/clean-out port must also be capped.

Vegetation

It is recommended that a minimum of three climate-appropriate types of tree, shrub, and/or herbaceous groundcover species be incorporated in a stormwater planter to protect against failure due to disease and insect infestations of a single species. Select vegetation that:

- Can tolerate summer drought, ponding fluctuations, and saturated soil conditions for up to 48 hours.
- Will be dense and strong enough to stay upright, even in flowing water;
- Does not require fertilizers;
- Is not prone to pests and is consistent with Integrated Pest Management practices (IPM); and
- Is consistent with local water conservation ordinance requirements.

A sample list of suitable vegetation species is included in Appendix H. Prior to installation, a landscape architect must certify that all proposed vegetation is appropriate for the project site. Stormwater runoff must be diverted around the stormwater planter during the period of vegetation establishment.

Irrigation System

Provide an irrigation system to maintain viability of vegetation, if necessary. If possible, the general landscape irrigation system should incorporate the stormwater planter. The irrigation system must be designed to local code or ordinance specifications and must comply with the requirements of Section 3.2.2. Supplemental irrigation may be required for the establishment period even if it is not needed later.

Overflow Device

An overflow device is required at the ponding depth near the inlet of the stormwater planter to divert stormwater runoff in excess of the design capacity of the stormwater planter. For rooftop drainage, the distance between the downspouts and the overflow outlet should be maximized in order to increase the opportunity for stormwater runoff retention and filtration. The following, or equivalent, must be provided:

- A vertical PVC pipe (SDR 26) to act as an overflow riser.
- The overflow riser(s) should be eight inches or greater in diameter so it can be cleaned without damage to the pipe.
- The inlet to the riser should be at the ponding depth and capped with a spider cap to exclude floating mulch and debris. Spider caps must be screwed on or glued (i.e., not removable). The overflow device must convey stormwater runoff in excess of the design capacity of the stormwater planter to an approved discharge location (e.g., another stormwater treatment control measure, storm drain system, receiving water).

Construction Considerations

If possible, the entire tributary area of the stormwater planter should be stabilized before construction commences. If this is not possible, all flows must be diverted around the stormwater planter to protect it from sediment loads during construction. Sediment controls must be implemented to prevent sediment from entering the stormwater planter. Final grading must produce a level bottom without low spots or depressions. After construction is completed, the entire tributary area to the stormwater planter must be stabilized before allowing stormwater runoff to enter it.

Maintenance Requirements

Maintenance and regular inspections must be conducted to ensure proper function of a stormwater planter. A stormwater planter requires annual plant, soil, and mulch layer maintenance to ensure optimal infiltration, storage, and pollutant removal capabilities. Stormwater planter maintenance requirements, which consist primarily of landscape care procedures, include:

- Irrigate vegetation as needed during prolonged dry periods. In general, climate-appropriate vegetation will not require irrigation after establishment (two to three years). Regularly inspect the irrigation system, if provided, for clogs or broken pipes and repair as necessary.
- Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace soil, vegetation, and/or mulch layer in areas if erosion has occurred. Properly-designed facilities with appropriate flow velocities should not cause erosion except potentially during in extreme events. If erosion occurs, the flow velocities and gradients within the stormwater planter and energy dissipation and erosion protection strategies in the pretreatment area, if provided, or flow

entrance should be reassessed. If sediment is deposited in the stormwater planter, identify the source of the sediment within the tributary area, stabilize the source, and remove excess surface deposits.

- Prune and remove dead vegetation as needed. Replace all dead vegetation, and if specific plants have a high mortality rate, assess the cause and, if necessary, replace with more appropriate species. Repair, seed, and re-plant damaged areas immediately.
- Remove weeds and other invasive, poisonous, nuisance, or noxious vegetation as needed until the vegetation is established. Weed removal should become less frequent if the appropriate species are used and planting density is attained.
- Remove and properly dispose of trash and other litter.
- Eliminate standing water to prevent vector breeding. If standing water is observed more than 48 hours after a storm event, it may be necessary to remove and replace the planting media and/or gravel layer to restore functionality of the stormwater planter.
- Inspect, and clean if necessary, the underdrain and observation well/clean-out port. Inspect overflow devices for obstructions or debris, which should be removed immediately. Repair or replace damaged pipes upon discovery.
- Repair structural deficiencies to the stormwater planter including rot, cracks, and failure.
- Implement IPM practices if pests are present in the stormwater planter.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.

T-2: Tree-Well Filter

Description

Source: Low Impact Development Center (top) and University of New

A tree-well filter is similar to a stormwater planter and consists of one or multiple chambered pre-cast concrete boxes with a small tree or shrub planted in a bed filled with planting media. Tree-well filters are typically installed along the edge of a parking lot or roadway, where a street tree might normally be planted, and is designed to receive, retain, and infiltrate stormwater runoff from adjoining paved areas. During storm events, stormwater runoff enters the chamber and gradually infiltrates and filters through the planting media into the underlying soil, or collected by an underdrain system.

Treatment occurs through a variety of natural mechanisms as the stormwater runoff filters through the root zone of the vegetation and during detention of the stormwater runoff in the pore space of the planting media. A portion of stormwater runoff held in the root zone of the soil media is returned to the atmosphere through transpiration by the vegetation. Stormwater runoff that reaches the bottom of the tree-well filter and does not infiltrate into underlying soils is collected and discharged through an underdrain.

Tree-well filters are ideally suited for small areas such as parking lot islands, perimeter building planters, street medians, roadside swale features, and site entrance or buffer features. Tree-well filters can be integrated into other landscape areas. The maximum tributary area of a tree-well filter is one acre.

An example schematic of a typical tree-well filter is presented in Figure E-6.

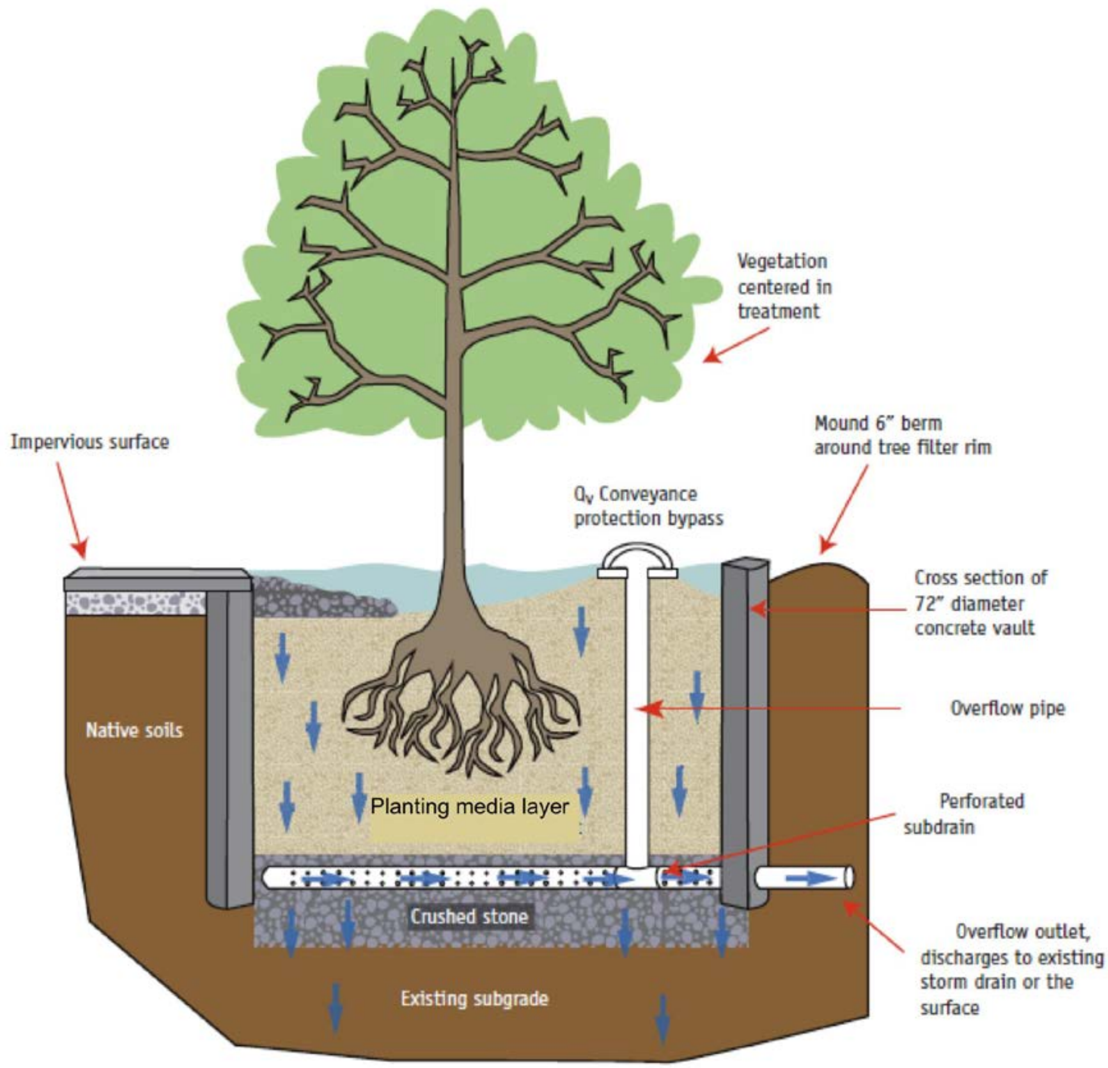


Figure E-5. Example Tree-Well Filter Schematic

Use and Applicability

The Phase II Permit (Provision F.5.g.2.d) identifies bioretention as the standard stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative stormwater treatment control measure that is equivalent to bioretention is proposed and demonstrated (Provision F.5.g.2.d.(a)), or (2) a specific exemption applies (Provision F.5.g.2.d.(c)). A tree well filter can be proposed as an alternative to bioretention if it meets all of the following measures of equivalent effectiveness:

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and

- Equal or greater accessibility and ease of inspection and maintenance.

The Phase II Permit (Provision F.5.g.2.d.(b)) allows the use of tree-well filters in project areas with documented high concentrations of pollutants in the underlying soil or groundwater, where infiltration may contribute to a geotechnical hazard, and that are located on elevated plazas or adjacent to structures. Under these allowed variations for site-specific conditions, a hydraulic restriction layer may be incorporated or the underdrain may be located at the bottom of the gravel layer.

The Phase II Permit (Provision F.5.g.2.d.(c)) also allows the use of tree-well filters in project areas for the following types of Regulated Projects:

- Projects creating or replacing an acre or less of impervious area, and located in a designated pedestrian-oriented commercial district (i.e., smart growth projects), and having at least 85 percent of the entire project site covered by permanent structures;
- Facilities receiving runoff solely from existing (pre-project) impervious areas; and
- Historic sites, structures, or landscapes that cannot alter their original configuration in order to maintain their historic integrity.

Design Specifications

The following sections provide design specifications for tree-well filters.

Geotechnical

Due to the potential to contaminate groundwater and/or soils, cause slope instability, impact surrounding structures, and potential for insufficient infiltration capacity, a geotechnical investigation must be conducted during the site assessment process to identify potential geotechnical hazards. It is critical to understand how stormwater runoff will move through the soil (horizontally and vertically) and if there are any geological conditions that may inhibit the movement of water. Soil infiltration rates and the depth to the groundwater table must be evaluated to ensure that conditions are satisfactory for proper operation of a tree-well filter. Tree-well filters can only be located on sites with a slope of less than 10 percent. A Site Conditions Report summarizing the relevant findings from the geotechnical investigation must be submitted with the Project Stormwater Plan.

Pretreatment

Pretreatment, which refers to design features that provide settling of large particles before stormwater runoff enters a stormwater treatment control measure, is important to ensure proper operation of a tree-well filter and reduce the long-term maintenance burden. If tree-well filters are used to manage stormwater runoff from rooftops that drain directly to the filter, pretreatment may not be necessary because stormwater runoff from rooftops are not expected to have large particles. For other applications of a stormwater planter, pretreatment (e.g., vegetated swales, proprietary devices) is required to be provided to reduce the sediment load entering a tree-well filter in order to prevent the underlying soils from being occluded prematurely and maintain the infiltration rate of the tree-well filter.

Flow Entrance and Energy Dissipation

The drainage management area(s) (DMA[s]) tributary to a tree-well filter must be graded to minimize erosion as stormwater runoff enters the filter by creating sheet flow conditions rather than a concentrated stream condition or by providing energy dissipation devices at the inlet. Typically, a minimum slope of 1 percent for pervious surfaces and 0.5 percent for impervious surfaces to the inlet of the tree-well filter should be maintained. The following types of flow entrances can be used for a tree-well filter:

- Level spreaders (e.g., slotted curbs) can be used to facilitate sheet flow.
- Dispersed low velocity flow across a landscaped area. Dispersed flow may not be possible given space limitations or if the tree-well filter controls roadway or parking lot flows where curbs are mandatory.
- Dispersed flow across pavement or gravel and past wheel stops for parking areas.
- Curb cuts for roadside or parking lot areas. Curb cuts must include rock or other erosion controls in the channel entrance to dissipate energy. The flow entrance should drop two to three inches from curb line and provide an area for settling and periodic removal of sediment and coarse material before flow disperses to the remainder of the tree-well filter.
- Piped entrances, such as roof downspouts, must include rock, splash blocks, or other erosion controls at the entrance to dissipate energy and disperse flows.

Drainage

Tree-well filters provide stormwater runoff storage in the ponding zone and in the voids of the planting media and gravel layers and must completely drain within 48 hours. The planting media and gravel layers must be allowed to dry out periodically in order to restore hydraulic capacity to receive stormwater runoff from subsequent storm events, maintain infiltration rates, maintain adequate soil oxygen levels for healthy soil biota and vegetation, and provide proper soil conditions for biodegradation and retention of pollutants.

Sizing

Step 1: Determine the Adjusted SDV (SDV_{adj})

Tree-well filters are designed to capture and retain the SDV_{adj}, which is the difference between the SDV (Section 3.2.5) and the volume of stormwater runoff managed through site design measures (Section 3.2.3), for the tributary DMA(s).

Step 2: Determine size of tree-well filter design layers

Tree-well filters consist of several layers that are designed to retain stormwater runoff. The design depths, which are used to size the tree-well filter, are presented in Table E-7. Other design parameters for these layers are discussed in further detail in the following sections.

Table E-6. Design Depths of Tree-Well Filter Layers

Tree-Well Filter Layer	Design depth
Ponding zone	0.5-1.0 ft
Planting media (excluding the mulch layer, if provided)	1.5-3.0 ft
Planting media/gravel layer separation zone (1)	2-4 in
Gravel	1 ft (min)
Hydraulic restriction layer	n/a

(1) In calculating the required bottom surface area of the tree-well filter, the planting media/gravel layer separation zone is not considered because it is designed primarily to separate the planting media and gravel layer and not to retain stormwater runoff.

Step 3: Calculate the bottom surface area of the tree-well filter

Determine the bottom surface area (surface area at the base of side slopes, not at the top of side slopes) of the tree-well filter using the following equation:

$$A = \frac{SDV_{adj}}{d_{pz} + (\eta_{pm} \times d_{pm}) + (\eta_{gl} \times d_{gl})}$$

Where:

A = bottom surface area of tree-well filter [ft^2];
SDV_{adj} = adjusted stormwater design volume [ft^3];
d_{pz} = depth of ponding zone (0.5-1.0 ft) [ft];
η_{pm} = porosity of planting media [unitless];
d_{pm} = depth of planting media (min 1.5 ft) [ft];
η_{gl} = porosity of gravel layer [unitless]; and
d_{gl} = depth of gravel layer (min 1 ft) [ft].

Tree-well filters can have a non-rectangular footprint to fit site landscape design.

Planting Media Layer

Because tree-well filters are a variation of bioretention facilities, the Phase II Permit requires that the planting media layer:

- Have a minimum depth of 1.5 feet, excluding the mulch layer, if provided;

- Achieve a long-term, in-place minimum infiltration rate of at least 5 in/hr to support maximum stormwater runoff retention and pollutant removal; and
- Consist of 60 to 70 percent sand meeting the specifications of the American Society for Testing and Materials (ASTM) C33 and 30 to 40 percent compost.

Compost must be a well-decomposed, stable, weed-free organic matter source derived from waste materials including yard debris, wood wastes, or other organic material and not including manure or biosolids meeting standards developed by the US Composting Council (USCC). The product must be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

Mulch is recommended for the purpose of retaining moisture, preventing erosion, and minimizing weed growth. Projects subject to the California Model Water Efficiency Landscaping Ordinance (or comparable local ordinance) will be required to provide at least two inches of mulch. Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. If mulch is used for a tree-well filter, two to four inches (average three inches) of mulch should be used at the initiation of the filter. Annual placement (preferably in June after weeding) of one to two inches of mulch beneath plants will maintain the mulch layer.

Planting Media/Gravel Layer Separation Zone

The planting media and gravel layer must be separated by a permeable 2-4 inch layer of sand and stone that meets the grading requirements in Table E-8.

Table E-7. Planting Media/Gravel Layer Separation Layer Grading Requirements

Sieve Size	Percent Passing
1”	100
3/4”	90-100
3/8”	40-100
No. 4	25-100
No. 8	18-33
No. 30	5-15
No. 50	0-7
No. 200	0-3

Source: Caltrans Standard Specifications (2010) Class 2 Permeable Material

Gravel Layer

The gravel layer must consist of washed 1- to 2.5-inch diameter stone with a minimum 1-foot depth.

Hydraulic Restriction Layer

The hydraulic restriction layer, which can be a 60-mil PVC or 30-mil polyethylene pond liner with bentonite clay mats, must be placed below the gravel layer to prevent infiltration of stormwater runoff below the tree-well filter. If the tree-well filter is located near structures, the hydraulic restriction layer must also be applied along the walls of the tree-well filter to prevent stormwater runoff from percolating to these structures. The hydraulic restriction layer should be installed generously with overlapping seams prior to constructing the layers of the tree-well filter.

Underdrain

Tree-well filters require an underdrain to collect and discharge stormwater runoff that has been filtered through the planting media, but not infiltrated, to another stormwater treatment control measure, storm drain system, or receiving water. The underdrain must have a discharge elevation at the bottom of the gravel layer and a mainline diameter of eight inches using slotted PVC SDR 26 or C9000. Slotted PVC allows for pressure cleaning and root cutting, if necessary. The slotted pipe should have two to four rows of slots cut perpendicular to the axis of the pipe or at right angles to the pitch of corrugations. Slots should be 0.04 to 0.1 inches wide with a length of 1 to 1.25 inches. Slots should be longitudinally-spaced such that the pipe has a minimum of one square inch opening per lineal foot and should face down. Underdrains should be sloped at a minimum of 0.5 percent in order to drain freely to an approved location.

Observation Well

A rigid non-perforated observation pipe with a diameter equal to the underdrain diameter must be connected to the underdrain to provide a clean-out port as well as an observation well to monitor infiltration rates. The wells/clean-out port must be connected to the slotted underdrain with the appropriate manufactured connections. The wells/clean-outs must extend six inches above the top elevation of the tree-well filter mulch and be capped with a lockable screw cap. The ends of the underdrain pipes not terminating in an observation well/clean-out port must also be capped.

Vegetation

Select a tree that:

- Can tolerate summer drought, ponding fluctuations, and saturated soil conditions for up to 48 hours;
- Is suited to well-drained soil;
- Will be dense and strong enough to stay upright, even in flowing water;
- Does not require fertilizers;
- Is not prone to pests and is consistent with Integrated Pest Management (IPM) practices; and

- Is consistent with local water conservation ordinance requirements.

A sample list of suitable tree species is included in Appendix H. Prior to installation, a landscape architect must certify that proposed trees are appropriate for the project site.

Irrigation System

Provide an irrigation system to maintain viability of tree, if necessary. If possible, the general landscape irrigation system should incorporate the tree-well filter. The irrigation system must be designed to local code or ordinance specifications and must comply with the requirements of Section 3.2.2. Supplemental irrigation may be required for the establishment period even if it is not needed later.

Overflow Device

An overflow device is required at the ponding depth of the tree-well filter to divert stormwater runoff in excess of the design capacity of the tree-well filter. For rooftop drainage, the distance between the downspouts and the overflow outlet should be maximized in order to increase the opportunity for stormwater runoff filtration through the planting media. The following, or equivalent, must be provided:

- A vertical PVC pipe (SDR 26) to act as an overflow riser.
- The overflow riser(s) should be eight inches or greater in diameter so it can be cleaned without damage to the pipe.
- The inlet to the riser should be at the ponding depth and capped with a spider cap to exclude floating mulch and debris. Spider caps must be screwed on or glued (i.e., not removable). The overflow device should convey stormwater runoff in excess of the design capacity of the tree-well filter to an approved discharge location (e.g., another stormwater treatment control measure, storm drain system, receiving water).

Construction Considerations

If possible, the entire tributary area of the tree-well filter should be stabilized before construction commences. If this is not possible, all flows must be diverted around the tree-well filter to protect it from sediment loads during construction. Sediment controls must be implemented to prevent sediment from entering the tree-well filter. Final grading must produce a level bottom without low spots or depressions. After construction is completed, the entire tributary area to the tree-well filter must be stabilized before allowing stormwater runoff to enter it.

Maintenance Requirements

Maintenance and regular inspections must be conducted to ensure proper function of a tree-well filter. In general, tree-well filter maintenance requirements are typical landscape care procedures and include:

- Irrigate tree as needed during prolonged dry periods. In general, climate-appropriate trees will not require significant irrigation. Regularly inspect the irrigation system, if provided, for clogs or broken pipes and repair as necessary.
- Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace planting media and/or mulch layer in areas if erosion has occurred. Properly designed facilities with appropriate flow velocities should not cause erosion except potentially during in extreme events. If erosion occurs, the flow velocities and gradients within the tree-well filter and flow dissipation and erosion protection strategies in the flow entrance should be reassessed. If sediment is deposited in the tree-well filter, identify the source of the sediment within the tributary area, stabilize the source, and remove excess surface deposits.
- Prune the tree as needed.
- Repair, seed, and re-plant damaged areas immediately.
- Remove weeds and other invasive, poisonous, nuisance, or noxious vegetation as needed until the vegetation is established. Weed removal should become less frequent if the appropriate species are used and planting density is attained.
- Eliminate standing water to prevent vector breeding. If standing water is observed more than 48 hours after a storm event, it may be necessary to remove and replace the planting media and/or gravel layer to restore functionality of the tree-well filter.
- Inspect, and clean if necessary, the underdrain and observation well/clean-out port. Inspect overflow devices for obstructions or debris, which should be removed immediately. Repair or replace damaged pipes upon discovery.
- Implement IPM practices if pests are present in the tree-well filter.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.

T-3: Sand Filter

Description

A sand filter operates similar to a stormwater planter; however, instead of filtering stormwater runoff through engineered planting media, stormwater runoff is filtered through a constructed sand bed with an underdrain system. Stormwater runoff enters a sand filter and spreads over the surface. As flows increase, water backs up on the surface of the filter where it is held until it can percolate through the sand. The treatment pathway is vertical (downward through the sand). High flows in excess of the design volume are diverted to prevent overloading of the filter. Stormwater runoff that percolates through the sand is collected with an underdrain that conveys it to another stormwater treatment control measure, storm drain system, or receiving water. As stormwater runoff passes through the sand, pollutants are trapped in the pore spaces between sand grains or adsorbed to the sand surface.

Sand filters can be placed underground and have the capability of reducing the peak stormwater runoff flow for small storms.

An example schematic of a typical sand filter is presented in Figure E-7.

Use and Applicability

The Phase II Permit (Provision F.5.g.2.d) identifies bioretention as the standard stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative stormwater treatment control measure that is equivalent to bioretention is proposed and demonstrated (Provision F.5.g.2.d.(a)), or (2) a specific exemption applies (Provision F.5.g.2.d.(c)). A sand filter can be proposed as an alternative to bioretention if it meets all of the following measures of equivalent effectiveness:

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and
- Equal or greater accessibility and ease of inspection and maintenance.

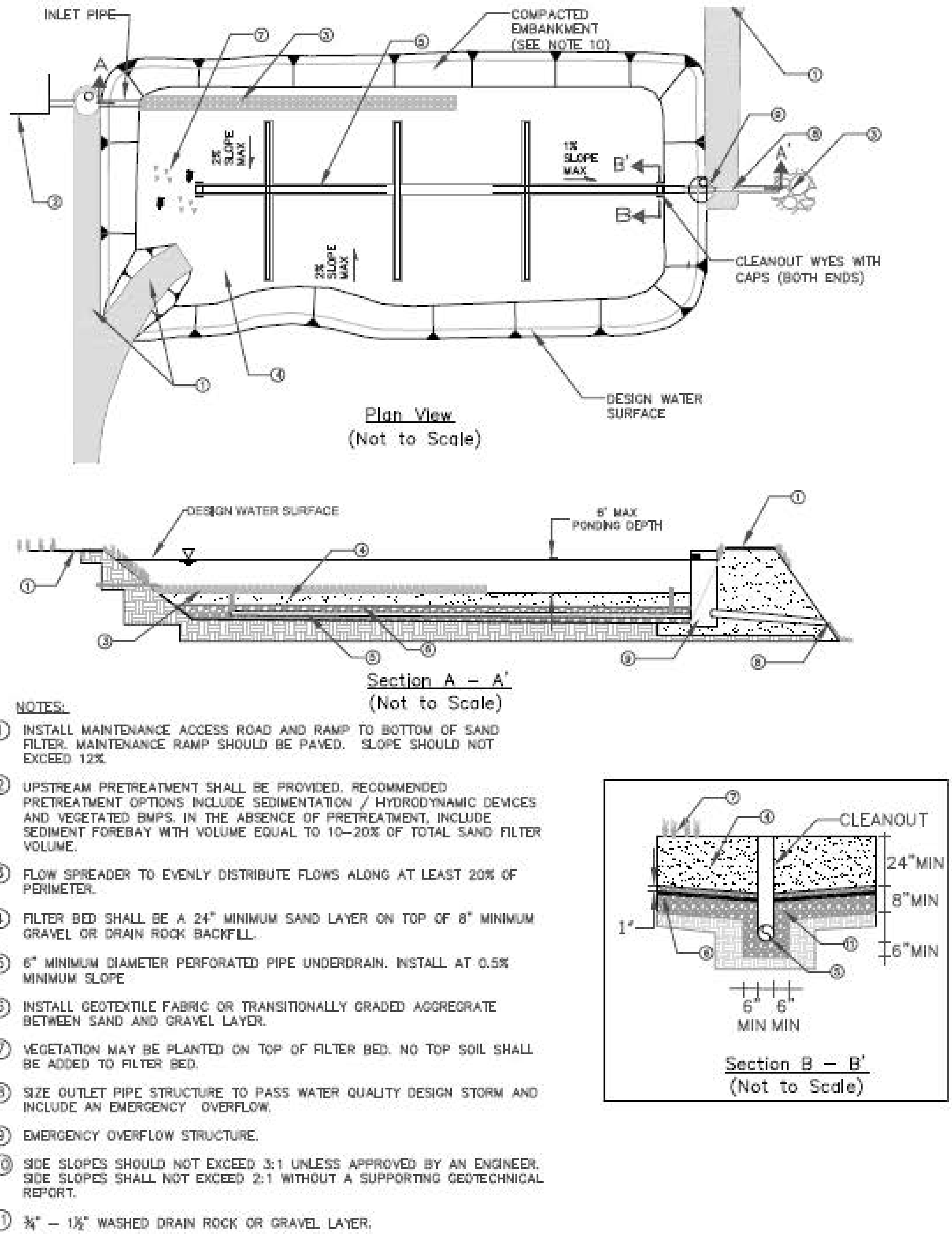


Figure E-6. Example Sand Filter Schematic

However, sand filters are unable to infiltrate or evapotranspire an equivalent amount of stormwater runoff when compared to bioretention. While sand filters cannot be used as an alternative to bioretention, there are two specific situations where they may be implemented as part of the stormwater management strategy at a project site. For project sites that have high-risk areas, such as fueling stations, truck stops, auto repairs, and heavy industrial sites, additional treatment may be required to address pollutants of concern unless these areas are isolated from stormwater runoff with little chance of spill migration.

The Phase II Permit (Provision F.5.g.2.d.(c)) also allows the use of sand filters in project areas for the following types of Regulated Projects:

- Projects creating or replacing an acre or less of impervious area, and located in a designated pedestrian-oriented commercial district (i.e., smart growth projects), and having at least 85 percent of the entire project site covered by permanent structures;
- Facilities receiving runoff solely from existing (pre-project) impervious areas; and
- Historic sites, structures, or landscapes that cannot alter their original configuration in order to maintain their historic integrity.

Design Specifications

The following sections provide design specifications for sand filters.

Setbacks

Applicable setbacks must be implemented when siting a sand filter.

Pretreatment

The primary challenge associated with sand filters is maintaining the filtration capacity, which is critical to its performance. If the flow entering the sand filter has high sediment concentrations, clogging of the sand filter is likely. Contribution of eroded soils or leaf litter may also reduce the filtration and associated treatment capacity of the sand filter.

Pretreatment, which refers to design features that provide settling of large particles before stormwater runoff enters a stormwater treatment control measure, is important to ensure proper operation of a sand filter and reduce the long-term maintenance burden. Pretreatment (e.g., vegetated swales, proprietary devices) must be provided to reduce the sediment load entering a sand filter in order to prevent the filtration media from being occluded prematurely and maintain the filtration capacity of the sand filter.

An alternative design for a sand filter can include a sediment forebay to remove sediment from stormwater runoff. The sediment forebay must be separated from the san filter by a berm or similar feature, which may be constructed out of earthen embankment material, grouted riprap, or other structurally-sound material, and must be equal to 10 to 20 percent of the total sand filter volume. A gravity drain outlet (minimum four-inch diameter) from the forebay must extend the entire width of the internal berm. The forebay outlet to the sand filter must be off-set from the inlet flow line to prevent short-circuiting. Permanent steel post depth markers must be placed in the forebay to identify the settled sediment removal limits at 50 and 100 percent of the forebay sediment storage depth.

Flow Entrance and Energy Dissipation

Sand filters must be placed off-line to prevent scouring of the filter bed by high flows. The drainage management area(s) (DMA[s]) tributary to the sand filter must be graded to minimize erosion as stormwater runoff enters the filter by creating sheet flow conditions rather than a concentrated stream condition. A flow spreader must be installed at the inlet along one side of the sand filter to evenly distribute stormwater runoff across the entire width of the sand filter and to prevent erosion of the filter surface. The flow spreader must be provided for a minimum of 20 percent of the filter perimeter. If the length-to-width ratio of the filter is 2:1 or greater, the flow spreader must be located on the longer side and for a minimum length of 20 percent of the perimeter of the sand filter. Erosion protection must be provided along the first foot of the sand filter bed adjacent to the flow spreader.

Drainage

Sand filters provide stormwater runoff storage in the ponding zone and in the voids of the sand media and must completely drain within 48 hours. The sand filter must be allowed to dry out periodically in order to restore hydraulic capacity to receive stormwater from subsequent storm events, maintain filtration rates, and provide proper conditions retention of pollutants.

Sizing

Step 1: Determine the Adjusted SDV (SDV_{adj})

Sand filters are designed to capture and retain the SDV_{adj}, which is the difference between the SDV (Section 3.2.5) and the volume of stormwater runoff managed through site design measures (Section 3.2.3), for the tributary DMA(s).

Step 2: Determine maximum ponding depth

Determine the maximum ponding depth (d_{pz}) above the sand filter. Aside from providing temporary storage of stormwater runoff, the ponding zone determines the hydraulic head over the filter bed surface, which increases the flow rate through the sand. This depth is defined as the depth at which water begins to overflow the reservoir above the sand filter and depends on the site topography and hydraulic constraints. The maximum ponding depth is six feet. There must also be a minimum freeboard of one foot.

Step 3: Determine sand filter bed depth

The depth of the sand filter bed (D) must be at least two feet, but three feet is preferred.

Step 4: Determine the design hydraulic conductivity

Determine the design saturated hydraulic conductivity (K) of the sand conditioned rather than clean. This approach represents the average sand bed condition as silt is captured and held in the sand bed instead of clean sand that will become occluded during the first use of the sand filter.

Step 5: Calculate the sand filter surface area

Determine the surface of the sand filter area using the following equation:

$$A_{sf} = \frac{SDV_{adj} \times R \times D}{K \times t \times (h + D)}$$

Where:

A_{sf} = surface area of the sand filter bed [ft^2];
SDV_{adj} = adjusted stormwater design volume [ft^3];
R = adjustment factor [use R=0.7];
D = sand filter bed depth (maximum 3 ft) [ft];
K = Design hydraulic conductivity [use 3 ft/day];
t = Maximum drawdown time [use 48 hours]; and
h = Average depth of ponding zone [ft, use $d_{pz}/2$].

The size of the sand filter is determined by assuming that the inflow is immediately discharged through the filter as if there was no ponding zone. An adjustment factor (0.7) is applied to compensate for the greater filter size resulting from this method.

Sand filters may be designed in any geometric configuration, but rectangular with a 1.5:1 length-to-width ratio or greater is preferred.

Sand Filter Walls

The walls of the sand filter may be vertical retaining walls, provided: (a) they are constructed of reinforced concrete; (b) a fence, which prevents access, is provided along the top of the wall (see fencing below) or further back; and (c) the design is approved by a licensed civil engineer and the Port.

Interior side slopes up to the overflow device must be no steeper than 3:1 (H:V) unless stabilization has been approved by a licensed geotechnical engineer. Exterior side slopes shall be no steeper than 2:1 (H:V) unless stabilization has been approved by a licensed geotechnical engineer. For any slope (interior or exterior) greater than 2:1 (H:V), a geotechnical report must be submitted and approved by the Port.

Sand Specification

The ideal effective diameter of the sand for a sand filter (d10) should be small enough to ensure a high quality effluent from the sand filter while preventing penetration of solids to such a depth that it cannot be removed by surface scraping (~2-3 inches). This effective diameter is between 0.20 and 0.35 mm. Additionally, the coefficient of uniformity, C_u = d60/d10, should be less than 3. The sand media should consist of a medium sand with very little fines meeting ASTM C33 size gradation (by weight) or equivalent as presented in Table E-9. Finally, the silica (SiO_2) content of the sand should be greater than 95 percent by weight.

Table E-8. Sand Filter Media Sand Specifications

U.S. Sieve Size	Percent Passing by Weight
3/8 inch	100%
U.S. No. 4	95-100%
U.S. No. 8	80-100%
U.S. No. 16	50-85%
U.S. No. 30	25-60%
U.S. No. 50	5-30%
U.S. No. 100	<10%

Hydraulic Restriction Layer

Either a hydraulic restriction layer, which can be a 60-mil PVC or 30-mil polyethylene pond liner with bentonite clay mats, or a 2-inch transition gradation layer (preferred) must be placed between the sand layer and the drain rock or gravel backfill layer. If a liner is used, one inch of drain rock or gravel backfill should be place above the liner to allow for a transitional zone between sand and gravel and reduce pooling of water at the liner interface. The hydraulic restriction layer should be installed generously with overlapping seams.

Underdrain

Sand filters are require an underdrain to collect and discharge treated stormwater runoff to another stormwater treatment control measure, storm drain system, or receiving water. There are several underdrain system options, which must be reinforced to withstand the weight of the overburden, that can be used:

- A central underdrain collection pipe with lateral collection pipes in a minimum eight-inch gravel backfill or drain rock bed.
- Longitudinal pipes in a minimum eight-inch gravel backfill or drain rock bed, with a collection pipe at the outfall of the sand filter.
- Small sand filters may use a single underdrain pipe in a minimum eight-inch gravel backfill or drain rock bed.

All underdrain pipes must have a minimum mainline diameter of six inches using perforated PVC to allow for pressure water cleaning, if necessary, and ensure free draining of the sand filter bed. Round perforations must be at least 0.5-inch in diameter and the pipe must be laid with perforations downward. The maximum perpendicular distance between any two lateral collection pipes or from the edge of the sand filter and the collection pipes is nine feet. All pipes must be placed with a minimum slope of 0.5 percent.

The underdrain must be placed in a gravel backfill where at least eight inches of gravel backfill must be maintained over all underdrain pipes, and at least six inches must be maintained on both sides and beneath the pipe to prevent damage by heavy equipment during maintenance. Either drain rock or gravel backfill may be used between pipes. The bottom gravel layer must have a diameter at least twice the size of the openings into the storm drain system. The grains should be hard, preferably rounded, with a specific gravity of at least 2.5, and free of clay, debris and organic impurities.

Clean-out risers with diameters equal to the underdrain pipes must be placed at the terminal ends of all pipes and extend to the surface of the filter. A valve box should be provided for access to the clean-outs and the clean-out assembly must be water tight to prevent short circuiting of the sand filter.

To prevent uses that may compact and damage the filter surface, permanent structures are not permitted on sand filters (i.e., playground equipment).

Vegetation

Sand filters must be located away from trees or other plants producing leaf litter.

Overflow Device

While sand filters may only be placed off-line, an overflow device near the inlet to the sand filter must still be provided to divert stormwater runoff in excess of the design capacity of the sand filter or in the event the sand filter becomes clogged. The following, or equivalent, must be provided:

- A vertical PVC pipe (SDR 26) to act as an overflow riser.
- The overflow riser(s) should be eight inches or greater in diameter so it can be cleaned without damage to the pipe.
- The inlet to the riser should be at the freeboard depth and capped with a spider cap to exclude floating debris. Spider caps must be screwed on or glued (i.e., not removable). The overflow device must convey stormwater runoff in excess of the design capacity of the sand filter to an approved discharge location (e.g., another stormwater treatment control measure, storm drain system, receiving water).

Exterior Landscaping

Landscaping outside of the sand filter, but within the easement/right-of-way, is required and must adhere to the following specifications such that it will not hinder maintenance operations:

- No trees or shrubs may be planted within ten feet of inlet or outlet pipes or manmade drainage structures such as overflow devices, flow spreaders, or earthen embankments. Species with roots that seek water, such as willow or poplar, must not be used within 50 feet of pipes or manmade structures.
- Non-climate-appropriate plant species are not permitted.

Fencing

Safety is provided by fencing of the stormwater treatment control measure. Fences shall be designed and constructed in accordance with Port standards and must be located at or above the top of overflow device elevation.

Maintenance Access

Maintenance access must be provided to the structures associated with the sand filter (e.g., pretreatment, inlet, overflow devices) if it is publicly-maintained. Manhole and catch basin lids must be in or at the edge of the access road. An access ramp to the sand filter bottom is required to facilitate the entry of sediment removal (and vegetation maintenance) equipment.

Unless otherwise required by the Port, access roads must meet the following design specifications:

- All access ramps and roads must be paved with a minimum of six inches concrete over three inches of crushed aggregate base material. This requirement may be modified depending on the soil conditions and intended use of the road at the discretion of Port.
- The maximum grade is 12 percent unless otherwise approved by the Port.
- Centerline turning radius must be a minimum of 40 feet.
- Access roads less than 500 feet long must have a 12-foot wide pavement within a minimum 15-foot wide bench. Access roads greater than 500 feet long must have 16-foot wide pavement within a minimum 20-foot wide bench.
- All access roads must terminate with turnaround areas of 40-feet by 40-feet. A hammer type turn around area or a circle drive around the top of the sand filter is also acceptable.
- Adequate double-drive gates and commercial driveways are required at street crossings. Gates should be located a minimum of 25 feet from the street curb except in residential areas where the gates may be located along the property line provided there is adequate sight distance to see oncoming vehicles at the posted speed limit.

Restricted Construction Materials

The use of pressure-treated wood or galvanized metal at or around the sand filter is prohibited. The use of galvanized fencing is permitted if in accordance with the Fencing requirement above.

Construction Considerations

Sand filters are generally suited for sites where there is no base flow, and the sediment load is relatively low. For underground sand filters, the load-carrying capacity of the filter structure must be considered if it is located under parking lots, driveways, roadways, and certain sidewalks.

If possible, the entire tributary area of the sand filter should be stabilized before construction commences. If this is not possible, all flows must be diverted around the sand filter to protect it from sediment loads during construction. Sediment controls must be implemented to prevent sediment from entering the sand filter. Final grading must produce a level basin bottom without low spots or depressions. After construction is completed, the entire tributary area to the sand filter must be stabilized before allowing stormwater runoff to enter it.

Maintenance Requirements

Maintenance and regular inspections must be conducted to ensure proper function of sand filters. Sand filters are subject to clogging by fine sediment, oil and grease, and other debris (e.g., trash and organic matter such as leaves).The following activities must be conducted to maintain a sand filter:

- Inspect pretreatment devices and the sand filter every six months during the first year of operation. Inspections should also occur immediately following a storm event to assess the filtration capacity of the sand filter. Once it is determined that the sand filter is performing as designed, the frequency of inspection may be reduced to once per year.
- If a sediment forebay is included, remove sediment buildup exceeding 50 percent of the sediment storage capacity, as indicated by the steel markers. Test removed sediments for toxic substance accumulation in compliance with current disposal requirements if visual or olfactory indications of pollution are noticed. If toxic substances are detected at concentrations exceeding thresholds of Title 22, Section 66261 of the California Code of Regulations, dispose of the sediment in a hazardous waste landfill and investigate and mitigate the source of the contaminated sediments to the maximum extent possible.
- Inspect the sand filter to ensure that water percolates into filter media completely within the maximum drawdown time. If water is present in the sand filter more than 48 hours after a storm, the sand filter may be clogged. Maintenance activities triggered by a clogged filter include:

    - Check for debris/sediment accumulation, rake surface and remove sediment (if any), and evaluate potential sources of sediment and vegetative or other debris. If suspected upstream sources are outside of the Port's jurisdiction, additional pretreatment may be necessary.
    - Determine if it is necessary to remove and replace the top layer of the sand filter bed to restore filtration capacity.
- Remove and dispose of trash and debris, as needed, but at least prior to the beginning of the wet season.
- Eliminate standing water to prevent vector breeding.
- Inspect the inlet structures for erosion and re-grade if necessary.
- Inspect the flow spreader and level and/or clean it so that flows are spread evenly over the sand filter bed.
- Inspect, and clean if necessary, the underdrain system. Inspect overflow devices for obstructions or debris, which should be removed immediately. Repair or replace damaged pipes upon discovery.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.

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T-4: Vegetated Swales

Description

Vegetated swales are open, shallow channels with low-lying vegetation covering the side slopes and bottom that collect and slowly convey stormwater runoff to a downstream stormwater treatment control measure, storm drain system, or receiving water. Vegetated swales can provide limited pollutant removal through settling and filtration in the vegetation (usually grasses) lining the channels, reduce stormwater runoff volume through infiltration and evapotranspiration, and reduce the flow velocity. An effective vegetated swale achieves uniform sheet flow over and through a densely vegetated area for a period of several minutes.

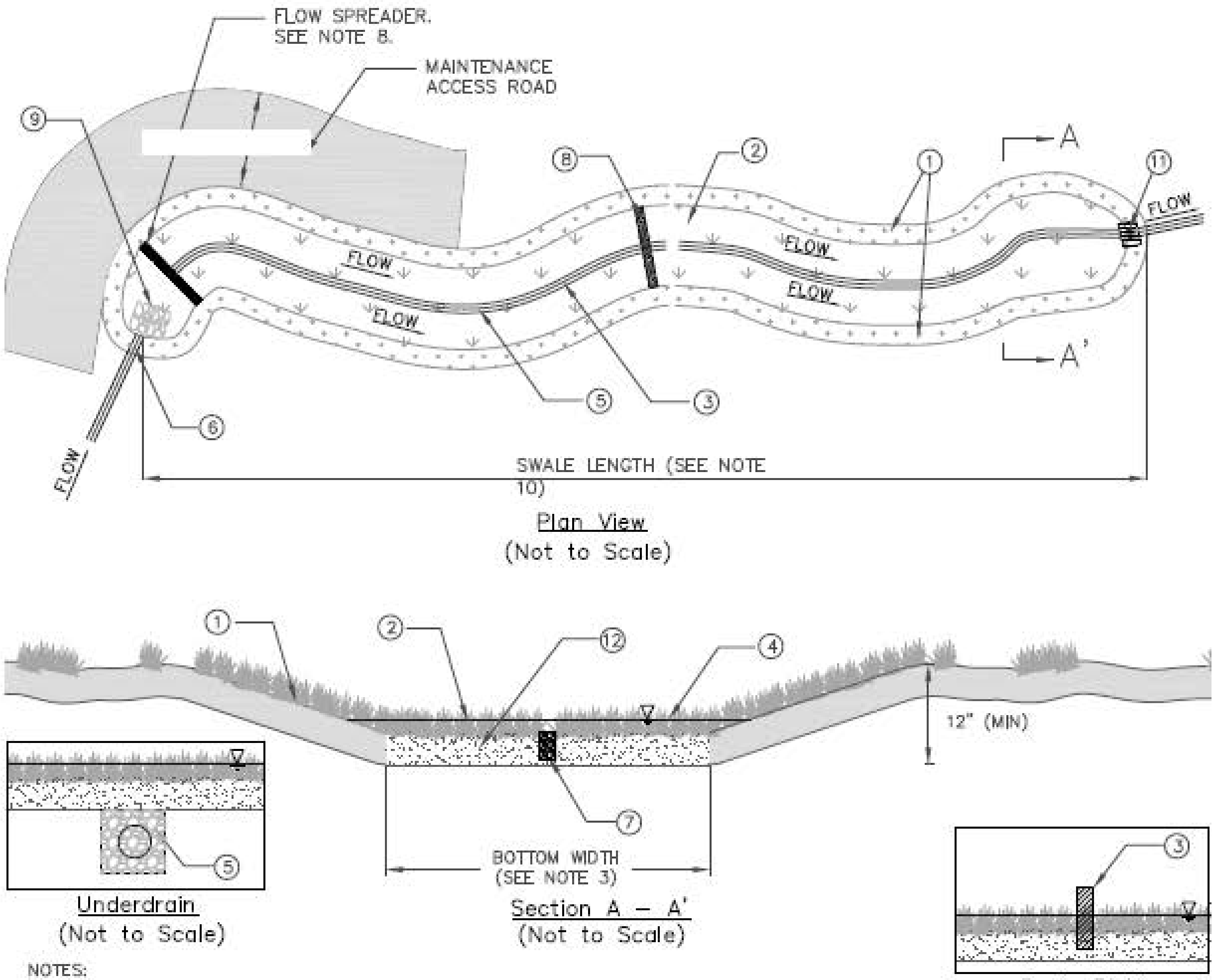
An example schematic of a typical vegetated swale is presented in Figure E-8.

Use and Applicability

Vegetated swales likely will not meet the measures of equivalent effectiveness (Provision F.5.g.2.d.(a) of the Phase II Permit) that is required in order to use this stormwater treatment control measure as an alternative to bioretention. However, vegetated swales can be used to convey stormwater runoff to downstream stormwater treatment control measures or as pretreatment.

In addition, according to Provision F.5.g.2.d.(c) of the Phase II Permit, vegetated swales may be considered in lieu of bioretention or bioretention-equivalent measures for the following types of Regulated Projects:

- Projects creating or replacing an acre or less of impervious area, and located in a designated pedestrian-oriented commercial district (i.e., smart growth projects), and having at least 85 percent of the entire project site covered by permanent structures;
- Facilities receiving runoff solely from existing (pre-project) impervious areas; and
- Historic sites, structures, or landscapes that cannot alter their original configuration in order to maintain their historic integrity.



NOTES:

1. VEGETATED SIDE SLOPES AT 2H:1V MAXIMUM SLOPE. MOWED TURF SWALES AT 3H:1V MAXIMUM.
2. GRASS HEIGHT SHALL BE 4" – 6" HIGH.
3. SWALE DIVIDER REQUIRED FOR BOTTOM WIDTHS > 10'. MINIMUM REQUIRED BOTTOM WIDTH IS 2' EXCLUDING WIDTH OF LOW FLOW CHANNEL. MAXIMUM BOTTOM WIDTH WITH DIVIDER IS 16'.
4. DEPTH OF FLOW FOR WATER QUALITY TREATMENT MUST NOT EXCEED TWO-THIRDS OF THE GRASS HEIGHT AND NOT GREATER THAN 4" (INFREQUENTLY MOWED) OR 2" (FREQUENTLY MOWED).
5. 6" PERFORATED UNDERDRAIN IN 9" DEEP COARSE AGGREGATE BED CONNECTED TO STORM DRAIN. REQUIRED FOR SLOPES < 1.5% OR AS NEEDED.
6. INLET PIPE WITH INLET PROTECTION.
7. IF NO UNDERDRAIN, LOW FLOW DRAIN SHALL EXTEND ENTIRE LENGTH OF SWALE AND SHALL HAVE A DEPTH OF 6" MINIMUM AND WIDTH NO MORE THAN 5% SWALE BOTTOM WIDTH. ANCHORED PLATE FLOW SPREADER IF USED, SHALL HAVE V-NOTCHES (MAX TOP WIDTH = 5% OF SWALE WIDTH) OR HOLES TO ALLOW PREFERENTIAL EXIT OF LOW FLOWS.
8. INSTALL CHECK DAMS OR GRADE CONTROL STRUCTURES FOR SLOPES > 6% AT 50' MAXIMUM SPACING TO ACHIEVE A MAXIMUM EFFECTIVE LONGITUDINAL SLOPE OF 6%. FLOW SPREADERS SHALL BE PROVIDED AT INLET AND AT THE BASE OF EACH CHECK DAM SEE FIGURE 3-2.
9. INSTALL ENERGY DISSIPATOR AT THE INLET OF VEGETATED SWALE.
10. SWALE LENGTH SHALL BE 100' OR LENGTH REQUIRED TO PROVIDE 10 MINUTES RESIDENCE TIME, WHICH EVER IS GREATER.
11. INSTALL APPROPRIATE OUTLET STRUCTURE. ACCOMODATE LOW FLOW CHANNEL AND/OR UNDERDRAIN (IF PRESENT).
12. AMEND SOILS WITH 2" OF COMPOST TILLED INTO 6" OF NATIVE SOIL UNLESS NATIVE SOIL ORGANIC CONTENT > 10%.

Figure E-7. Example Vegetated Swale Schematic

Design Specifications

The following sections provide design specifications for vegetated swales.

Geotechnical

Due to the potential to contaminate groundwater and/or soil, cause slope instability, and impact surrounding structures, a geotechnical investigation must be conducted during the site assessment to verify the site suitability for vegetated swales. It is important to understand how stormwater runoff will move through the soil (horizontally and vertically) and if there are any geological conditions that could inhibit the movement of water. Soil infiltration rates and the depth to the groundwater table must be evaluated to ensure that conditions are satisfactory for proper operation of vegetated swales. Vegetated swales cannot be located at sites with a slope greater than five percent to prevent channel erosion. For sites that have limited slop, ponding in the vegetated swale may occur. A Site Conditions Report summarizing the relevant findings from the geotechnical investigation must be submitted with the Project Stormwater Plan.

Setbacks

Applicable setbacks must be implemented when siting vegetated swales.

Flow Entrance and Energy Dissipation

The drainage management area(s) (DMA[s]) tributary to the vegetated swale must be graded to minimize erosion as stormwater runoff enters the swale or by providing energy dissipation devices at the inlet. An anchored plate flow spreader must be provided at the inlet to the vegetated swale. Equivalent methods for spreading flows evenly throughout the width the swale are acceptable. The specifications for the flow spreader are listed below:

- The top surface of the flow spreader plate must be level, projecting a minimum of two inches above the ground surface of the vegetated swale, or V-notched with notches six to ten inches on center and one to four inches deep (use shallower notches with closer spacing).
- The flow spreader plate must extend horizontally beyond the bottom width of the vegetated swale to prevent water from eroding the side slope. The horizontal extent should be such that the bank is protected for all flows up to the SDF_{adj} that will enter the swale.
- Flow spreader plates must be securely fixed in place.
- Flow spreader plates may be made of either concrete, stainless steel, or other durable material.
- Anchor posts are constructed of four inches square of concrete, tubular stainless steel, or other material resistant to decay.

The flow spreader will dissipate the entrance velocity and distribute flow uniformly across the whole vegetated swale. If check dams are used to reduce the longitudinal slope, a flow spreader must be installed at the toe of each vertical drop according to the specifications listed in the following Check Dams section below. If flow is to be introduced through curb cuts, the pavement should be placed slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

Drainage

Vegetated swales provide temporary stormwater runoff storage above ground as it conveys stormwater runoff to a downstream stormwater treatment control measure. Some stormwater runoff may infiltrate into the underlying soil.

Sizing

Step 1: Determine the SDF_{adj}

Vegetated swales are designed to capture and manage the SDF_{adj}, which is the difference between the SDF (Section 3.2.5) and the volume of stormwater runoff managed through site design measures (Section 3.2.3), for the tributary DMA(s).

Step 2: Calculate Bottom Width of Vegetated Swale

The width of the bottom of the vegetated swale is calculated using Manning's equation for open channel flow, as follows:

$$SDF_{adj} = \left(\frac{1.49}{n}\right) \times A \times R^{2/3} \times S^{0.5}$$

Where:

SDF_{adj} = stormwater design flow [ft^3/s];
n = Manning's roughness coefficient;
A = flow area [ft^2];
R = hydraulic radius [ft]; and
S = channel slope [ft/ft].

For shallow flow depths in vegetated swales, channel side slopes are ignored in the calculation of bottom width. Use the following equation (a simplified form of Manning's formula) to estimate the vegetated swale bottom width:

$$b = SDF_{adj} \times \left(\frac{1.49}{n_s}\right) \times y^{2/3} \times s^{0.5}$$

Where:

b = bottom width of vegetated swale [ft]
SDF_{adj} = stormwater design flow [ft^3/s];
n_s = Manning's roughness coefficient (use 0.2 for shallow conditions);
y = stormwater design flow depth [ft]; and
s = longitudinal slope (along direction of flow) [ft/ft].

Proceed to Step 3 if the calculated bottom width is between two and ten feet. A minimum two-foot bottom width is required. If the calculated bottom width is less than two feet, increase the width to two feet, and recalculate the design flow depth, y, using the same SDF_{adj} and n_s, but with b equal to two feet. The maximum allowable bottom width is ten feet. If the calculated bottom width exceeds ten feet, then one of the following steps is necessary to reduce the design bottom width:

- Increase the longitudinal slope (*s*) to a maximum of 6 feet in 100 feet (0.06 feet per foot);
- Increase the design flow depth (*y*) to a maximum of four inches; or
- Place a divider lengthwise along the vegetated swale bottom (see Figure E-8) at least three-quarters of the vegetated swale length (beginning at the inlet), without compromising the design flow depth and lateral slope requirements. The vegetated swale width can be increased to a maximum of 16 feet if a divider is provided.

Step 3: Determine the Design Flow Velocity

To calculate the design flow velocity through the vegetated swale, use the flow continuity equation:

$$v = \frac{SDF_{adj}}{A}$$

Where:

v = design flow velocity [ft/s];
SDF_{adj} = stormwater design flow [ft^3/s]; and
A = $by + Zy^2$ = Cross-sectional area of flow at design depth [ft^2] where Z = side slope length per unit height (e.g., Z = 3 if side slope is 3:1 H:V) .

If the design flow velocity exceeds 1 ft/s, go back to Step 2 and modify one or more of the design parameters (i.e., longitudinal slope, bottom width, or flow depth) to reduce the design flow velocity to 1 ft/s or less. If the design flow velocity is calculated to be less than 1 ft/s, proceed to Step 4. It is ideal to have the design velocity as low as possible to improve treatment effectiveness, reduce re-suspension of sediment, and reduce vegetated swale length requirements.

Step 4: Calculate Length of Vegetated Swale

Use the following equation to determine the length of the vegetated swale to achieve a hydraulic residence time of at least 10 minutes (600 seconds):

$$L = 60 \times t_{hr} \times v$$

Where:

L = minimum allowable swale length [ft];
t_{hr} = hydraulic residence time [min]; and
v = design flow velocity [ft/s].

The minimum length for a vegetated swale is 100 feet. If the calculated length for the vegetated swale is less than 100 feet, increase the length to a minimum of 100 feet and leaving the bottom width unchanged. If a larger vegetated swale can be fitted on the project site, consider using a greater length to increase the hydraulic residence time and improve pollutant removal. If the calculated length is too long for the project site or if it would cause layout problems (e.g., encroachment into shaded areas), proceed to Step 5 to further modify the layout. If the length of the vegetated swale can be accommodated on the project site, sizing of the vegetated swale is completed.

Step 5: Adjust Vegetated Swale Layout to Fit On-site

If the length of the vegetated swale calculated in Step 4 is too long for the project site, the length can be reduced (minimum of 100 feet) by increasing the bottom width up to a maximum of 16 feet, as long as the 10-minute retention time is maintained. However, the length cannot be increased in order to reduce the bottom width because Manning's depth-velocity-flow rate relationships will not be preserved. If the bottom width is increased to greater than ten feet, a low flow berm is needed to divide the vegetated swale cross-section in half to prevent channelization.

The length can be adjusted by calculating the top area of the vegetated swale and providing an equivalent top area with the adjusted dimensions.

Calculate the top area of the vegetated swale based on its length in Step 4:

$$A_{top} = \left(b_i + b_{slope}\right) \times L_i$$

Where:

A_{top} = top area at the design depth [ft^2];
b_i = bottom width calculated in Step 2 [ft];
b_{slope} = additional top width above the side slope for the design depth (for 3:1 H:V side slope and a 4-inch water depth, b_{slope} = 2 ft) [ft]; and
L_i = initial length calculated in Step 4 [ft].

Use the vegetated swale top area and a reduced swale length, L_f, to increase the bottom width using the following equation:

$$L_f = \frac{A_{top}}{(b_f + b_{slope})}$$

Where:

L_f = reduced vegetated swale length [ft];
A_{top} = top area at the design depth [ft^2];
b_f = increased bottom width [ft]; and
b_{slope} = additional top width above the side slope for the design depth (for 3:1 H:V side slope and a 4-inch water depth, b_{slope} = 2 ft) [ft].

Recalculate the design flow velocity according to Step 3 using the revised cross-sectional area based on the increased bottom width. Revise the design as necessary if the design flow velocity exceeds 1 ft/s. If necessary, recalculate to ensure that the 10-minute hydraulic residence time is maintained.

Step 6: Design Other Vegetated Swale Features

Other sizing specifications for vegetated swales include the following:

- The water depth in the vegetated swale must not exceed four inches (or two-thirds of the expected vegetation height) except for frequently mowed turf swales. For mowed turf swales, the water depth must not exceed two inches. Once design specifications have been determined, the resulting flow depth for the design flow is checked. If the depth restriction is exceeded, swale parameters (e.g., longitudinal slope, width) must be adjusted to reduce the flow depth. Overall depth from the top of the side walls to the swale bottom shall be at least 12 inches.
- In general, trapezoidal channel shape is assumed for sizing calculations, but a more naturalistic channel cross-section is preferred.
- Vegetated swale length can be increased by meandering the swale. Gradual meandering bends in the swale are desirable for aesthetic purposes and to promote slower flow.
- The minimum width of the vegetated swale bottom is two feet to allow for ease of mowing. The maximum width of the vegetated swale bottom is ten feet unless a dividing berm is provided. If a dividing berm is provided, the maximum width of the vegetated swale bottom can be 16 feet.
- The longitudinal slope (along the direction of flow) must be between 1 and 6 percent. If the longitudinal slope is less than 1.5 percent and the soils are poorly drained (e.g., silts and clays), then an underdrain must be installed. If the longitudinal slope is greater than 6 percent, check dams with vertical drops of 12 inches or less must be provided to achieve a bottom slope of 6 percent or less between the drop structures.
- The lateral slope (horizontal to the direction of flow) is zero (flat) to discourage channelization.

- A side slope of 2:1 (H:V) is acceptable, but milder slopes are necessary if turf is used (maximum 3:1 H:V).
- A low flow drain must be provided for dry weather flows extending the entire length of the swale. The drain must have a minimum depth of six inches and a width no more than five percent of the calculated bottom swale width. The width of the drain is in addition to the required bottom width. If an anchored plate is used for flow spreading at the swale inlet, the plate wall must have V-notches (maximum top width = five percent of swale width) or holes to allow low flow into the drain. If an underdrain is installed, the vegetated swale does not require a low flow drain.

Check Dams

The effectiveness of vegetated swales may be enhanced by adding check dams at approximately 50 foot increments along the length. Check dams maximize retention time within the vegetated swale, decrease flow velocity, and promote particulate settling. However, check dams may not be appropriate if prolonged ponding occurs.

If check dams are required, they can be designed using riprap, earthen berms, or removal stop logs. Check dams must be placed to achieve the desired slope (less than 6 percent) and desired velocity (less than 1 ft/s for the SDF_{adj}) at a maximum of 50 feet apart. If riprap is used, the material should consist of well-graded stone consisting of a mixture of rock sizes. The following is an example of an acceptable gradation:

Particle Size	% Passing by Weight
24 in	100%
15 in	75%
9 in	50%
4 in	10%

Swale Divider

- If a swale divider is used, the divider must be constructed of a firm material (e.g., concrete, compacted soil seeded with grass) that will resist weathering and not erode. Use of treated wood is prohibited. Selection of divider material must take into account maintenance activities, such as mowing.
- The divider must have a minimum height of one inch greater than the design depth.
- Earthen berms must be no steeper than 2:1(H:V).
- Material other than earth must be embedded to a depth sufficient to be stable.

Underlying Base

The underlying soil for a vegetated swale must be amended with two inches of well-rotted compost, unless the organic content is already greater than 10 percent. The compost must be mixed into the underlying soils to a depth of six inches to prevent soil layering and washout of compost. The compost must contain no sawdust, green or under-composted material, unsterilized manure, or any other toxic or harmful substance.

Underdrain

If necessary, an underdrain may be included in the design of a vegetated swale to convey stormwater runoff that has been filtered through the soil media, but not infiltrated, to another stormwater treatment control measure, storm drain system, or receiving water. The underdrain must have a mainline diameter of eight inches using slotted PVC SDR 26 or C9000. Slotted PVC allows for pressure water cleaning and root cutting, if necessary. The slotted pipe should have two to four rows of slots cut perpendicular to the axis of the pipe or at right angles to the pitch of corrugations. Slots should be 0.04 to 0.1 inches wide with a length of 1 to 1.25 inches. Slots should be longitudinally-spaced such that the pipe has a minimum of one square inch opening per lineal foot and should face down. Underdrains should be sloped at a minimum of 0.5 percent in order to drain freely to an approved location.

The underdrain must be placed in a gravel envelope (Class 2 Permeable Material per Caltrans Spec. 68-1.025) that measures three feet wide and six inches deep. The underdrain is elevated from the bottom of the vegetated swale by six inches within the gravel envelope. The top and sides of the underdrain pipe should be covered with gravel to a minimum depth of 12 inches. The underdrain and gravel envelope must be covered with a hydraulic restriction layer to prevent clogging. The following aggregate can be used for the gravel envelope:

Particle Size (ASTM D422)	% Passing by Weight
¾ inch	100%
¼ inch	30-60%
#8	20-50%
#50	3-12%
#200	0-1%

Clean-out risers with diameters equal to the underdrain pipe must be placed at the terminal ends of the underdrain and can be incorporated into the flow spreader and outlet structure to minimize maintenance obstacles in the vegetated swale. Intermediate clean-out risers may also be placed in the check dams or grade control structures. The clean-out risers shall be capped with a lockable screw cap.

Vegetation

The vegetated swale must be vegetated with a mix of erosion-resistant, climate-appropriate plants that effectively bind the soil and require less maintenance, including chemical treatments. Vegetated swales can provide some stormwater runoff treatment through maximization of water contact with vegetation and the soil surface. Vegetation must meet the following specifications:

- Above the design elevation, a typical climate-appropriate lawn mix or landscape plants can be used provided they do not shade the vegetated swale.
- Vegetated swales must be located away from large trees that may drop leaves or needles. Excessive tree debris may smother the grass or impede stormwater runoff flow through the swale.
- Climate-appropriate grasses must be specified to minimize irrigation requirements. Irrigation may be required if seeds are planted in spring or summer.
- Vegetative cover should be at least four inches in height, although six inches is preferred.

A sample list of suitable vegetation species is included in Appendix H. Prior to installation, a landscape architect must certify that all proposed vegetation is appropriate for the project site. Stormwater runoff must be diverted around the vegetated swale during the period of vegetation establishment.

Irrigation System

Provide an irrigation system to maintain the viability of vegetation, if necessary. If possible, the general landscape irrigation system should be incorporate the vegetated swales. The irrigation system must be designed to local code or ordinance specifications and must comply with the requirements in Section 3.2.2. Supplemental irrigation may be required for the establishment period even if it is not needed later.

Restricted Construction Materials

Use of pressure-treated wood or galvanized metal at or around the vegetated swale is prohibited.

Construction Considerations

Areas to be used for vegetated swales should be clearly marked before site work begins to avoid soil disturbance and compaction during construction. No vehicular traffic, except that specifically used to construct the vegetated swale, should be allowed within 10 feet of the swale areas. Vegetated swales can be integrated into roadside buffers or parking lot landscaping. For parking lots, if tire curbs are provided and parking stalls are shortened, cars may overhang the vegetated swale.

If possible, the entire tributary area of the vegetated swale should be stabilized before construction commences. Stormwater runoff must be diverted around the vegetated swale during the period of vegetation establishment. Sediment controls must be implemented to prevent sediment from entering the vegetated swale area. After construction is completed the entire tributary area to the vegetated swale must be stabilized before allowing stormwater runoff to enter it.

Maintenance Requirements

Maintenance and regular inspections must be conducted to ensure proper function of vegetated swales. The following activities must be conducted to maintain vegetated swales:

- Inspect vegetated swales for erosion or damage to vegetation after every storm greater than 0.50 inches. Vegetated swales should be checked for debris and litter and areas of sediment accumulation.
- Remove sediment and debris from the flow spreader if it is blocking flows. Repair splash pads, as needed, to prevent erosion. Check and re-level the flow spreader if necessary.
- Remove sediment if vegetation growth is inhibited in more than 10 percent of the swale or if sediment is blocking even distribution and entry of stormwater runoff. Re-plant and/or re-seed vegetation, as needed, following sediment removal activities to re-establish vegetation.
- Stabilize slopes with appropriate erosion control measures if the underlying soils are exposed or erosion channels are forming.
- Remove trash and debris, as needed, but at least annually prior to the beginning of the wet season.
- Inspect vegetation for health and density to ensure that it is providing sufficient treatment and protecting the underlying soils from erosion. As needed, conduct the following maintenance activities for the vegetation:
    - Replenish mulch to ensure survival of vegetation.
    - Prune and/or remove vegetation, large shrubs, or trees that interfere with the operation of the vegetated swale.
    - Mow grass to four to six inches and remove grass clippings.
    - Remove fallen leaves and debris from deciduous plant foliage.
    - Remove invasive, poisonous, nuisance, and noxious vegetation and replace with climate-appropriate vegetation
    - Remove dead vegetation if greater than 10 percent of area coverage or when swale function is impaired. Replace and establish vegetation before the wet season to maintain cover density and control erosion where soils are exposed. It may be necessary to re-grade eroded areas prior to replacing vegetation.

- Eliminate standing water to prevent vector breeding. If standing water is observed more than 72 hours after a storm event, it may be necessary to till the underlying soils and re-vegetate.
- Inspect, and repair if necessary, check dams that are causing altered water flow and/or channelization. Remove obstructions as needed.
- Inspect, and clean if necessary, the underdrain pipe. Repair or replace damaged pipes upon discovery.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.

T-5: Proprietary Stormwater Treatment Control Measures

Introduction

The 2015 Post-Construction Stormwater Design Manual provides information for selecting and designing the more common stormwater treatment control measures for projects. Stormwater treatment control measures included in this appendix are non-proprietary (public domain) designs that have been reviewed and evaluated by the Port and determined to be generally acceptable.

Proprietary devices are commercial products that typically aim at providing stormwater treatment in space-limited applications, often using patented innovative technologies. The most commonly encountered classes of proprietary stormwater treatment control measures include hydrodynamic separation, catch basin insert technologies, cartridge filter-type controls, and proprietary biotreatment devices.

Hydrodynamic separation devices (alternatively, swirl concentrators) are devices that remove trash, debris, and coarse sediment from incoming flows using screening, gravity settling, and centrifugal forces generated by forcing the influent into a circular motion. By having the water move in a circular fashion, rather than a straight line, it is possible to obtain significant removal of suspended sediments and attached pollutants with less space as compared to wet vaults and other settling devices. Hydrodynamic separation has been adapted for stormwater treatment by several manufacturers and is currently used to remove trash, debris, and other coarse solids down to sand-sized particles. Several types of hydrodynamic separation devices are also designed to remove floating oils and grease using sorbent media.

Catch basin inserts are manufactured filters or fabric placed in a drop inlet to remove sediment and debris and may include sorbent media to remove floating oils and grease. Most types of catch basin inserts fall into one of three configurations: socks, boxes, and trays. Sock-type filters, which are intended for vertical (drop) inlets, are typically constructed of a fabric (e.g., polypropylene) that may be attached to a frame or the grate of the inlet. Boxes, which are typically constructed of plastic or wire mesh, include a polypropylene “bag”, shaped as a box, that is placed in the wire mesh to allow for settling and filtration of stormwater runoff. Trays are designed to hold different types of media (e.g., polypropylene, porous polymer, treated cellulose, activated carbon) to treat stormwater runoff. Catch basin inserts are an easy, inexpensive retrofitting option because drain inlets are already a component of most storm drain systems. Inserts are usually only suitable for mitigating relatively small tributary areas (less than one acre) because they are limited by treatment capacity and influent flow rate.

Cartridge filter-type devices typically consist of a series of vertical filters contained in a vault or catch basin that provide treatment through filtration and sedimentation. The vault may be divided into multiple chambers where the first chamber acts as a pre-settling basin for removal of coarse sediment while another chamber acts as the filter bay and houses the filter cartridges. The performance and capacity of a cartridge filter installation depends on the properties of the media contained in the cartridges. Cartridge filter manufacturers often provide an array of media types each with varying properties, targeting various pollutants and a range of particle sizes. Commonly used media include media that target solids, such as perlite, and media that target both dissolved and non-dissolved constituents, such as compost leaf media, zeolite, and iron-infused polymers. Manufacturers try to distinguish their products through innovative designs that aim at providing self-cleaning and draining, uniformly loaded, and clog resistant cartridges that functional properly over a wide range of hydraulic loadings and pollutant concentrations.

Proprietary biotreatment devices are devices that are manufactured to mimic natural systems such as wetlands by incorporating plants, soil, and microbes engineered to provide treatment at higher flow rates or higher volumes and with smaller footprints than their natural counterparts. Influent flows are typically filtered through natural media (e.g., mulch, compost, soil, plants, microbes) and either infiltrated or collected by an underdrain and delivered to the storm drain system. Tributary areas for biotreatment devices tend to be limited to 0.5 to 1.0 acres.

The vendors of the various proprietary stormwater treatment control measures provide detailed documentation for device selection, sizing, and maintenance requirements. Tributary area sizes are limited to the capacities of the largest available model. The latest manufacturer supplied documentation must be used for sizing and selection of all proprietary devices.

Proprietary stormwater treatment control measure vendors are constantly updating and expanding their product lines, so refer to the latest design guidance from the vendors. General guidelines on the performance, sizing, and operation and maintenance of proprietary devices are provided in the following sections.

Use and Applicability

In order to provide a rationale and basis for approval of proprietary treatment control measures, the Port has elected to recognize, as approved for general and pilot use, those proprietary treatment control measures that are approved for general, conditional, or pilot use by other selected major stormwater programs that have established and are actively conducting a comprehensive testing protocol and approval process. Currently, the Port recognizes the lists of proprietary treatment control measures approved for general, condition, and pilot use from the following stormwater programs:

- Sacramento Stormwater Quality Partnership (http://www.beriverfriendly.net/newdevelopment/propstormwatertreatdevice)
- State of Washington Department of Ecology Stormwater Program (http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html)

The Port may recognize lists from other stormwater programs in the future and will update this list accordingly.

The Phase II Permit (Provision F.5.g.2.d) identifies bioretention as the standard stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative stormwater treatment control measure that is equivalent to bioretention is proposed and demonstrated (Provision F.5.g.2.d.(a)), or (2) a specific exemption applies (Provision F.5.g.2.d.(c)). Proprietary treatment controls can be proposed as an alternative to bioretention if it meets all of the following measures of equivalent effectiveness:

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and
- Equal or greater accessibility and ease of inspection and maintenance.

In general, proprietary treatment control measures may not be able to meet all measures of equivalent effectiveness listed above in order to be accepted as an alternative to bioretention. However, proprietary treatment control measures may be used in combination with other stormwater treatment control measures (e.g., pretreatment) to reduce sediment and pollutant loads.

In addition, proprietary treatment control measures may be used for projects that satisfy one or more of the exception criteria per Provision F.5.g.2.d.(c) of the Phase II Permit

Expected Performance

For hydrodynamic devices, it has been stated with respect to combined sewer overflows that the practical lower limit of hydrodynamic separation is a particle with a settling velocity of 12 to 16.5 ft/hr (0.10 to 0.14 cm/s). As such, the focus for hydrodynamic separation in combined sewer overflows has been with settleable solids generally 200 μm and larger, given the presence of the lighter organic solids. For inorganic sediment, the above settling velocity range represents a particle diameter of 50 to 100 μm. Thus, hydrodynamic separation devices are effective for removal of course sediment, trash, and debris and useful for pretreatment in combination with other types of stormwater treatment control measures that target smaller particle sizes.

Because there is a wide range of catch basin insert configurations, it is not possible to generalize the expected performance. Inserts are primarily used for catching coarse sediments and floatable trash and are effective for pretreatment in combination with other types of stormwater treatment control measures. Trash and large objects can greatly reduce the effectiveness of catch basin inserts with respect to sediment and hydrocarbon capture. Frequent maintenance and the use of screens and grates to keep trash out may decrease the likelihood of clogging and prevent obstruction and bypass of incoming flows.

Cartridge filters are proven to provide efficient removals for both dissolved and non-dissolved pollutants. However, cartridge filters are less adept at handling high flow rates when compared to catch basin inserts and hydrodynamic devices due to the enhanced treatment provided through the filtration mechanism.

Because proprietary biotreatment devices are relatively new compared to the other types of proprietary treatment devices discussed in this fact sheet, there are fewer third party studies on proprietary biotreatment devices. The available performance information is mostly vendor-supplied. According to the vendors, like their natural counterparts, proprietary biotreatment devices are highly efficient at mitigating dissolved metals, nutrients, and suspended solids.

Sizing

Hydrodynamic devices, catch basin inserts, and cartridge filters are flow-based stormwater treatment control measures, but can be sized to capture and treat a design stormwater runoff volume with additional facilities to manage stormwater runoff flow. Proprietary biotreatment devices on the other hand include both volume-based and flow-based stormwater treatment control measures. Volume-based proprietary devices should be sized to capture and treat the design stormwater runoff volume if used as a standalone stormwater treatment control measure.

Auxiliary components of proprietary devices such as sorbent media, screens, baffles, and sumps are selected based on site-specific conditions such as the expected loading and the desired frequency of maintenance. Sizing of proprietary devices is reduced to a simple process whereby a model can simply be selected from a table or a chart based on a few known quantities (e.g., tributary area, location, design flow rate, design volume). Some manufacturers can size devices for potential clients or offer calculators on their websites that simplify the design process even further and lessens the possibility of using obsolete design information. For the latest sizing guidelines, refer to the manufacturer's website.

Operation and Maintenance

The Port require execution of a Maintenance Access agreement to be recorded by the property owner for the on-going operation and maintenance of all privately-maintained stormwater treatment control measures, including proprietary treatment control measures. The property owner is responsible for compliance with the Maintenance Access Agreement. An example Maintenance Access Agreement is presented in Appendix F.

Hydrodynamic Separation Devices

Hydrodynamic separators do not have moving parts and are not maintenance intensive. However, maintenance is important to ensure that the device operates as efficiently as possible. Proper maintenance involves frequent inspections throughout the first year of installation, especially after major storm events. These systems are considered full when the sediment level is within one foot from the top of the unit, at which point it must be cleaned out. Removal of sediment can be performed with a sump vacuum or vactor truck. Some hydrodynamic separator devices may contribute to mosquito breeding if they do not fully drain stormwater runoff between storm events. Refer to manufacturer's guidelines for inspection and maintenance activities.

Catch Basin Inserts

Catch basin inserts can be maintenance-intensive because of their susceptibility for accumulating trash and debris. Regular maintenance activities include the clean-up and removal of accumulated trash and sediment while major maintenance activities include replacing filter media (if expended) and/or repairing/replacing fabrics. Refer to manufacturer's guidelines for inspection and maintenance activities.

Cartridge Filters

For cartridge filters, maintenance activities include periodically removing trash, debris, and sediment from the vault floor, typically twice per year depending on the accumulation rate, using a sump vacuum or vactor truck. The cartridges may need to be replaced when they become saturated, which will occur approximately every other year depending on the pollutant accumulation rate. The manufacturers of these devices typically provide contract operation and maintenance services.

All stormwater vaults that contain standing water can become a breeding area for vectors. Manufacturers have developed systems, such as a perforated pipe installed in the bottom of the vault that is encased in a filter sock to prevent clogging, to completely drain the vault.

Biotreatment Devices

Maintenance of biotreatment devices can be provided by the manufacturer and typically consists of routine inspection and hand removal of accumulated trash and debris. Vactor trucks or mechanical maintenance activities are not needed for biotreatment devices.

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HM-1: Extended Detention Basin

Description

Extended detention basins are permanent basins formed by excavation and/or construction of embankments to temporarily detain stormwater runoff to allow for settling of sediment particles before the stormwater runoff is discharged. An extended detention basin reduces peak stormwater runoff flow rates and provides stormwater runoff treatment. Extended detention basins are designed to drain completely between storm events over a specified period of time.

Stormwater runoff enters a sediment forebay where coarse solids are removed prior to flowing into the main cell of the basin where finer sediment and associated pollutants settle as stormwater is detained and slowly released through a controlled outlet structure. The slopes, bottom, and forebay of extended detention basins are typically vegetated. During storm events that exceed the design capacity, stormwater runoff will pass through the extended detention basin and discharge over a primary overflow outlet untreated, or during extreme events, over a spillway.

An example schematic of a typical extended detention basin is presented in Figure E-9.

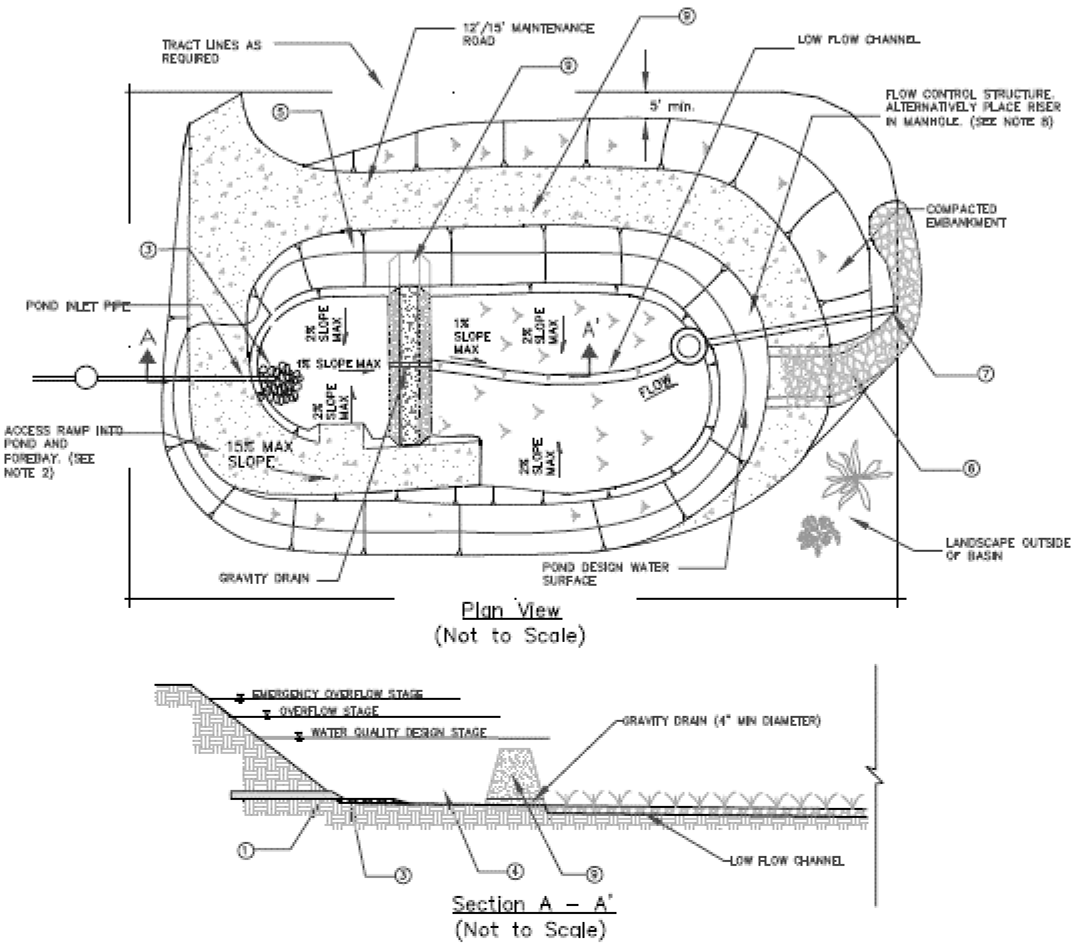
Use and Applicability

The Phase II Permit (Provision F.5.g.2.d) identifies bioretention as the standard stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative stormwater treatment control measure that is equivalent to bioretention is proposed and demonstrated (Provision F.5.g.2.d.(a)), or (2) a specific exemption applies (Provision F.5.g.2.d.(c)). An extended detention basin can be proposed as an alternative to bioretention if it meets all of the following measures of equivalent effectiveness:

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and
- Equal or greater accessibility and ease of inspection and maintenance.

In addition, according to Provision F.5.g.2.d.(c) of the Phase II Permit, extended detention basins may be considered in lieu of bioretention or bioretention-equivalent measures for the following types of Regulated Projects:

- Projects creating or replacing an acre or less of impervious area, and located in a designated pedestrian-oriented commercial district (i.e., smart growth projects), and having at least 85 percent of the entire project site covered by permanent structures;
- Facilities receiving runoff solely from existing (pre-project) impervious areas; and
- Historic sites, structures, or landscapes that cannot alter their original configuration in order to maintain their historic integrity.



NOTES:

1. INLET PIPE SHALL BE DESIGNED AND LOCATED SO THAT NON–EROSIVE VELOCITIES OCCUR IN THE FOREBAY
2. MAINTENANCE RAMP SHOULD BE PAVED. SLOPE SHOULD NOT EXCEED 12%. MAINTENANCE RAMP SHOULD PROVIDE ACCESS TO BOTH THE FOREBAY AND MAIN BASIN.
3. RIP RAP APRON OR OTHER INLET ENERGY DISSIPATION SHALL BE PROVIDED SUCH THAT VELOCITIES IN THE FOREBAY ARE < 4 FT/S.
4. SEDIMENT FOREBAY SHOULD BE SIZED TO PROVIDE 25% OF THE TOTAL BASIN VOLUME.
5. SIDE SLOPES SHOULD NOT EXCEED 3:1 UNLESS APPROVED BY AN ENGINEER. SIDE SLOPES SHALL NOT EXCEED 2:1 WITHOUT A SUPPORTING GEOTECHNICAL REPORT.
6. EMERGENCY SPILLWAY MUST BE SIZED TO PASS CAPITAL DEVELOPMENT PEAK FLOW FOR ON–LINE BASINS, AND WATER QUALITY DESIGN FLOW FOR OFF–LINE BASINS.
7. OUTLET PIPE. ENERGY DISSIPATION SHALL BE PROVIDED UNLESS DISCHARGE IS TO PIPE OR HARDENED CHANNEL
8. OUTLET STRUCTURE SHOULD BE SIZED TO DRAIN WATER QUALITY VOLUME IN 36 – 48 HOURS. ALTERNATIVELY PLACE RISER STRUCTURE IN A MANHOLE
9. INSTALL EARTHEN BERM OR EQUIVALENT. TOP OF BERM SHALL BE 2' MINIMUM BELOW DESIGN WATER QUALITY STAGE. BERM SHALL BE KEYED INTO EMBANKMENT A MINIMUM OF 1' ON BOTH SIDES.

Figure E-8. Example Extended Detention Basin Schematic

Design Specifications

The following sections provide design specifications for extended detention basins.

Geotechnical

A geotechnical investigation must be conducted during the site assessment process to verify site conditions for an extended detention basin. It is critical to understand how stormwater runoff will move through the soil (horizontally and vertically) and if there are any geologic conditions that may impact the movement of water. Soil infiltration rates and the depth to the groundwater table must be evaluated to ensure that conditions are satisfactory for proper operation of an extended detention basin. Extended detention basins can be used with almost all soils and geology with design adjustments for rapidly draining soils. If rapidly draining soils are present, extended detention basins must be designed by a licensed geotechnical engineer to include lower permeability soils in the subgrade to prevent rapid, untreated infiltration. Extended detention basins are typically located on sites with a slope no greater than 15 percent. A Site Conditions Report summarizing the relevant findings from the geotechnical investigation must be submitted with the Project Stormwater Plan.

Setbacks

Applicable setbacks must be implemented when siting an extended detention basin.

Pretreatment

Pretreatment, which refers to design features that provide settling of large particles before stormwater runoff enters a stormwater treatment control measure, is important to ensure proper operation of an extended detention basin and reduce the long-term maintenance burden. Pretreatment (e.g., vegetated swales, proprietary devices) may be provided to reduce the sediment load entering an extended detention basin in order to prevent sediment buildup that will reduce the capacity of the detention basin.

If a sediment forebay is used for pretreatment to remove coarse solids, it may be constructed with an internal berm made out of earthen embankment material, grouted riprap, or other structurally-sound material. The sediment forebay must be designed as follows:

- All inlets to the extended detention basin must enter the sediment forebay first.
- The sediment forebay must have a minimum volume equal to 25 percent of the total extended detention basin volume.
- Permanent steel post depth markers must be placed in the sediment forebay to identify the settled sediment removal limits at 50 and 100 percent of the sediment storage depth.
- The longitudinal slope (direction of flow) in the sediment forebay will be one percent.

- A gravity drain outlet from the sediment forebay (minimum four-inch diameter) must extend the entire width of the internal berm.
- The sediment forebay outlet must be off-set from the inflow flow line to prevent short-circuiting.

Flow Entrance and Energy Dissipation

The drainage management area(s) (DMA[s]) tributary to the extended detention basin must be graded to minimize erosion as stormwater runoff enters the basin or by providing energy dissipation devices at the inlet. Piped entrances must include rock, splash blocks, or other erosion controls at the entrance to dissipate energy and disperse flows. If a sediment forebay is included in the design, the energy dissipation devices must be installed at the inlet to the sediment forebay. Flow velocities into the sediment forebay must be 4 ft/s or less.

Drainage

Extended detention basins provide stormwater runoff storage above ground. Because extended detention basins are used primarily to meet flood control requirements, the basin must completely drain within 72 hours in order to allow the basin to receive stormwater runoff from subsequent storm events and prevent vector breeding.

Sizing

Step 1: Determine the Stormwater Runoff Volume

If the extended detention basin is demonstrated and approved as an alternative to bioretention, it must be designed to capture and manage the SDV_{adj}, which is the difference between the SDV (Section 3.2.5) and the volume of stormwater runoff managed through site design measures (Section 3.2.3), for the tributary DMA(s).

IStep 2: Design Extended Detention Basin Dimensions

The dimensions of the extended detention basin must meet the following specifications:

- The total extended detention basin volume must be the volume of stormwater runoff (Step 1) that must be managed plus an additional five percent to allow for total suspended solids (TSS) accumulation. The extended detention basin must also have a minimum freeboard of one foot above the maximum water surface elevation over the spillway.
- To improve TSS removal, the length-to-width ratio at half basin depth must be a minimum of 1.5:1.
- The cross-sectional geometry across the width of the extended detention basin should be approximately trapezoidal with a maximum interior side slope of 3:1 (H:V) unless otherwise permitted by the Port.

- Pond walls may be vertical retaining walls provided: (a) they are constructed of reinforced concrete; (b) a fence is provided along the top of the wall (see Fencing below) or further back; and (c) the design is stamped by a licensed civil engineer and approved by the Port.
- A low flow channel, which is a narrow, shallow trench filled with pea gravel (or equivalent) that runs the length of the extended detention basin, must be provided to drain the basin of dry weather flows. Lining the low flow channel with concrete is recommended to prevent erosion. The low flow channel must have a depth of six inches and a width of one foot and tie into the outlet structure.
- The longitudinal slope (direction of flow) in the main basin may range from zero to one percent. The bottom of the extended detention basin must have a two percent slope toward the low flow channel.

Outlet Structure

An extended detention basin must drain within 72 hours after a storm event. The outlet structure is designed to release the bottom 50 percent of the detention volume (half-full to empty) over 24 to 36 hours and the top 50 percent (full to half-full) in 48 to 72 hours. Detention of low flows, which account for the majority of incoming flows, for longer periods enhances stormwater runoff treatment.

A trash rack or gravel pack around perforated risers may be provided to protect outlet orifices from clogging. Trash racks are better suited for use with perforated vertical plates for outlet control and allow easier access to outlet orifices for purposes of inspection and cleaning. Trash racks must be sized to prevent clogging of the primary outlet without restricting the hydraulic capacity of the outlet control orifices.

The two options that can be used for the outlet structure are:

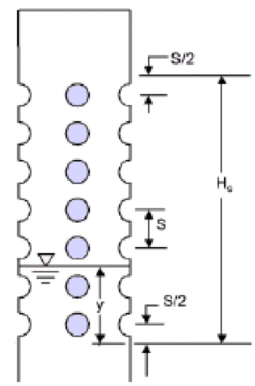
- Uniformly perforated riser structures; and
- Multiple orifice structures (orifice plate).

The primary overflow (typically a riser pipe connected to the outlet works) must be sized to pass the stormwater runoff volumes exceeding the design stormwater runoff volume. The primary overflow is intended to protect against overtopping or breaching of the extended detention basin embankment. Seepage collars may need to be installed on outlet pipes to prevent seepage through embankments. The outlet structure can be placed in the extended detention basin with a debris screen (see Figure E-10) or housed in a standard manhole (see Figure E-11).

Uniformly Perforated Riser Outlet Sizing Methodology (Figure E-10)

The following characteristics influence the perforated riser outlet sizing:

- Shape of the extended detention basin (i.e., trapezoidal);
- Depth and volume of the extended detention basin;
- Elevation and depth of first row of holes;
- Elevation and depth of last row of holes;
- Size of holes;
- Number of rows and number of holes per row; and
- Desired drawdown time.



The rate of discharge from a perforated riser structure with uniform holes at equal spacing can be calculated using the following:

$$Q = C_p \times \frac{2 \times A_p}{3 \times H_s} \times \sqrt{2 \times g} \times H^{3/2}$$

Where:

Q = riser discharge rate [ft^3/s];
C_p = discharge coefficient for perforations (use 0.61);
A_p = cross-sectional area of all the holes [ft^2];
H_s = distance from s/2 below the lowest row of holes to s/2 above the top row of holes (McEnroe 1988) [ft];
s = Center to center vertical spacing between perforations [ft];
g = Acceleration due to gravity (use 32.2 ft/s); and
H = Effective head on the orifice (measured from the center of orifice to water surface) [ft].

For the iterative computations needed to size the holes in the riser and determine the riser height, a simplified version of the equation above may be used, as shown below:

$$Q = k \times H^{3/2}$$

Where:

$$k = C_p \times \frac{2 \times A_p}{3 \times H_s} \times \sqrt{2 \times g}$$

Uniformly perforated riser designs are defined by the depth or elevation of the first row of perforations, the length of the perforated section of pipe, and the size or diameter of each perforation.

Multiple Orifice (Non-Uniform Outlet) Sizing Methodology (Figure E-11)

The following characteristics influence the multiple orifice outlet sizing:

- Shape of the extended detention basin (i.e., trapezoidal);

- Depth and volume of the extended detention basin;
- Elevation of each orifice; and
- Desired drawdown time.

The rate of discharge from a single orifice can be calculated using the following equation:

$$Q = C \times A \times (2 \times g \times H)^{0.5}$$

Where:

Q = orifice discharge rate [ft^3/s];
C = discharge coefficient;
A = cross-sectional area of orifice or pipe [ft^2];
g = acceleration due to gravity (use 32.2 ft/s);
H = effective head on the orifice (measured from the center of orifice to water surface) [ft].

Multiple orifice designs are defined by the depth (or elevation) and the size (or diameter) of each orifice.

Overflow Structure and Spillway

An overflow spillway or overflow riser must be provided. If an overflow spillway potentially discharges to a steep slope, an overflow riser and a spillway must be provided. The overflow device must be designed to pass the maximum storm size diverted to the extended detention basin, with a minimum one-foot freeboard, directly to an approved discharge location (e.g., another stormwater treatment control measure, storm drain system, receiving water).

The emergency overflow spillway must be constructed of grouted riprap and designed to withstand the energy of the spillway flows (Figure E-12). Spillways must meet the California Department of Water Resources, Division of Safety of Dams *Guidelines for the Design and Construction of Small Embankment Dams* (www.water.ca.gov/damsafety/docs/GuidelinesSmallDams.pdf).

Embankments

Embankments are earthen slopes or berms used to detain or redirect the flow of water. For extended detention basins, the embankments must be designed with the following specifications:

- All earthworks must be conducted in accordance with the Port's Standard Specifications.
- The interior side slopes up to the overflow water surface must be no greater than 3:1 (H:V) unless stabilization has been approved by a licensed geotechnical engineer.

- The exterior side slopes must be no greater than 2:1 (H:V) unless stabilization has been approved by a licensed geotechnical engineer.
- The minimum top width of all berm embankments must be 20 feet, unless otherwise approved by the Port.
- Berm embankments must be constructed on consolidated underlying soils or adequately compacted and stable fill soils approved by a licensed geotechnical engineer. Soils must be free of loose surface soil materials, roots, and other organic debris.
- Berm embankments must be constructed of compacted soil (95 percent minimum dry density, Modified Proctor method per ASTM D1557) and placed in six inch lifts.
- Berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width. This requirement may be waived if specifically recommended by a licensed geotechnical engineer.
- Low growing, climate-appropriate grasses must be planted on the exterior embankment slopes.

Vegetation and Landscaping

- A thick mat of climate-appropriate grass must be established on the extended detention basin floor and embankment side slopes following construction. Grasses help prevent erosion and increase evapotranspiration. Additional active growing vegetation helps break up surface crusts that accumulate from sedimentation of fine particulates. Note that grass may need to be irrigated during the establishment period.
- Landscaping outside of the extended detention basin, but within the easement/right-of-way, may be included as long as it does not hinder maintenance access and operations.
- Trees or shrubs must not be planted within 10 feet of inlet or outlet pipes or manmade drainage structures such as spillways or earthen embankments. Species with roots that seek water (e.g., willow, poplar) must not be planted within 50 feet of pipes or manmade drainage structures. Weeping willow (*Salix babylonica*) may not be planted in or near extended detention basins.
- Plant species that are not climate-appropriate are not permitted. A sample list of suitable vegetation species is included in Appendix H. Prior to installation, a landscape architect must certify that all proposed vegetation is appropriate for the project site.

Fencing

Safety is provided by fencing of the stormwater treatment control measure. Fences shall be designed and constructed in accordance with Port standards and must be located at or above the top of overflow structure elevation.

Maintenance Access

Maintenance access must be provided to the structures associated with the extended detention basin (e.g., pretreatment, inlet, outlet, overflow structure) if it is publicly-maintained. Manhole and catch basin lids must be in or at the edge of the access road. An access ramp to the extended detention basin bottom is required to facilitate the entry of sediment removal and vegetation maintenance equipment.

Access roads must meet the following design specifications:

- All access ramps and roads must be paved with a minimum of six inches concrete over three inches of crushed aggregate base material. This requirement may be modified depending on the soil conditions and intended use of the road at the discretion of the Port.
- The maximum grade is 12 percent unless otherwise approved by the Port.
- Centerline turning radius must be a minimum of 40 feet.
- Access roads less than 500 feet long must have 12-foot wide pavement within a minimum 15-foot wide bench. Access roads greater than 500 feet long must have 16-foot wide pavement within a minimum 20-foot wide bench.
- All access roads must terminate with turnaround areas of 40-feet by 40-feet. A hammer type turn around area or a circle drive around the top of the extended detention basin is also acceptable.
- Adequate double-drive gates and commercial driveways are required at street crossings. Gates should be located a minimum of 25 feet from the street curb except in residential areas where the gates may be located along the property line provided there is adequate sight distance to see oncoming vehicles at the posted speed limit.

Restricted Construction Materials

The use of pressure-treated wood or galvanized metal at or around an extended detention basin is prohibited. The use of galvanized fencing is permitted if in accordance with the Fencing requirement above.

Construction Considerations

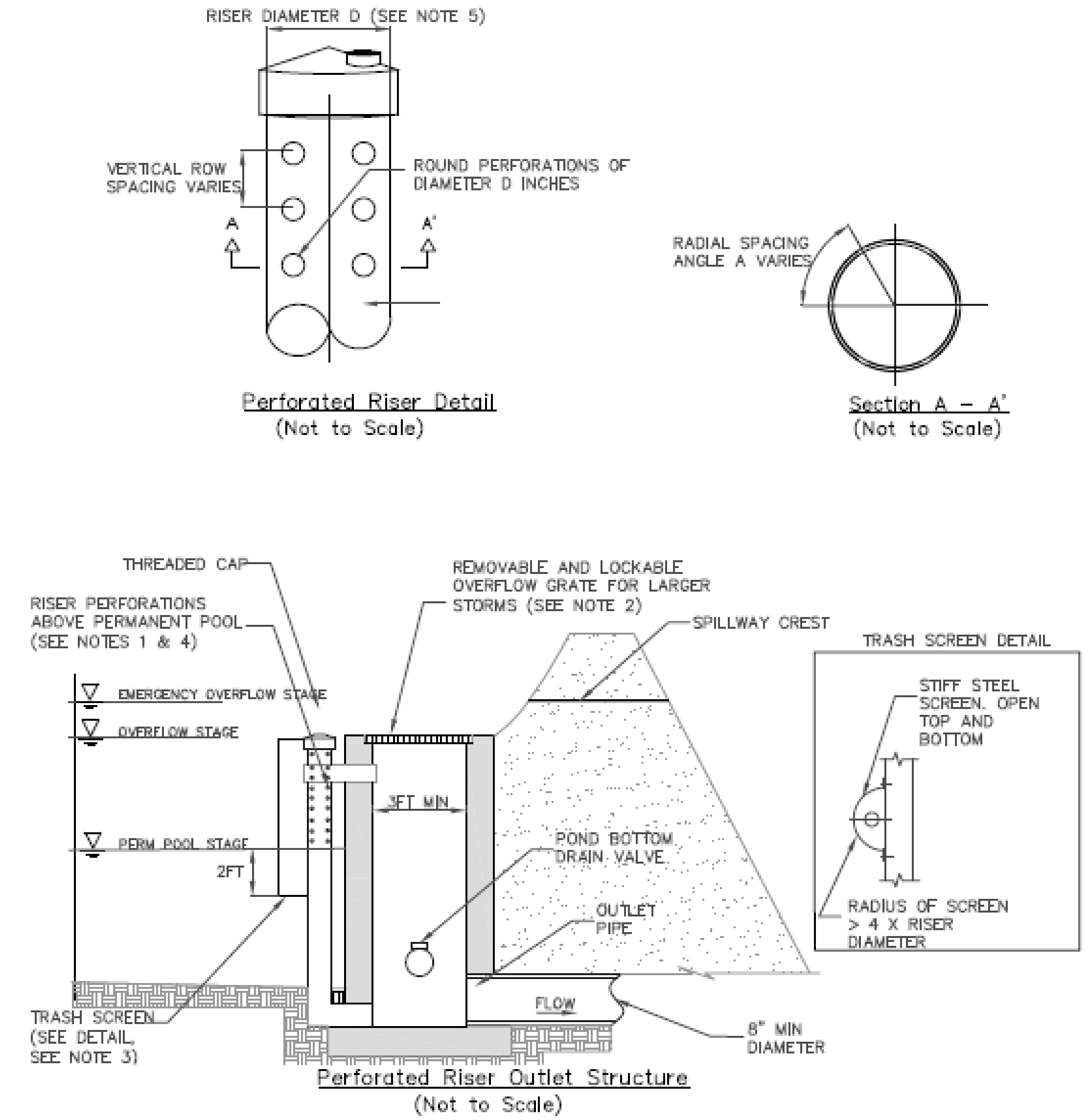
In general, approximately 0.5 to 2 percent of the tributary development area is required for an extended detention basin. If constructed early in the development project, an extended detention basin can serve as a sediment trap for the tributary area. Depending on the underlying soil, extended detention basins may provide incidental infiltration of stormwater runoff; however, extended detention basins are not designed for this purpose. In areas with rapidly percolating soils, the underlying soils may need to be amended under the guidance of a licensed geotechnical engineer or an impermeable liner may be need to be installed to prevent significant infiltration of stormwater runoff into the soils. The areas planned for extended detention basins should be clearly marked before site work begins to avoid soil disturbance and minimize compaction during construction. After construction is completed, the entire tributary area to the extended detention basin must be stabilized.

Maintenance Requirements

Maintenance and regular inspections must be conducted to ensure proper function of an extended detention basin. The following activities must be conducted to maintain an extended detention basin:

- At a minimum, inspect the extended detention basin annually. Inspections after major storm events are encouraged.
- Remove sediment accumulation exceeding 50 percent of the sediment storage capacity in the sediment forebay, as indicated on the permanent steel post depth markers. Remove sediment from the remainder of the basin when six inches of sediment accumulates. Test removed sediments for toxic substance accumulation in compliance with current disposal requirements if visual or olfactory indications of pollution are noticed. If toxic substances are detected at concentrations exceeding thresholds of Title 22, Section 66261 of the California Code of Regulations, dispose of the sediment in a hazardous waste landfill and investigate and mitigate the source of the contaminated sediments to the maximum extent possible.
- Remove trash and debris, as needed, but at least annually prior to the beginning of the wet season.
- Maintain vegetation as needed to sustain the aesthetic appearance of the site and to prevent clogging of outlets as follows:
    - Prune and/or remove vegetation, large shrubs, or trees that limit access or interfere with operation of the extended detention basin.
    - Mow grass to four to nine inches high and remove grass clippings.
    - Rake and remove fallen leaves and debris from deciduous plant foliage.
    - Remove invasive, poisonous, nuisance, or noxious vegetation and replace with climate-appropriate vegetation.
    - Remove dead vegetation if it exceeds 10 percent of area coverage. Replace vegetation immediately to maintain cover density and control erosion where soils are exposed. It may be necessary to re-grade eroded areas prior to replacing vegetation.
    - Do not use herbicides or other chemicals to control vegetation.
- Inspect inlet structure for erosion and re-grade if necessary.
- Inspect overflow structure for obstructions or debris, which should be removed immediately. Repair or replace damaged structures if necessary.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.



NOTES:

1. RISER PIPE SHALL BE SIZED TO PROVIDE 36 TO 48–HOUR FULL BRIM DRAW DOWN TIME.
2. TOTAL OUTLET CAPACITY: CAPITAL DEVELOPED PEAK FLOW FOR ON–LINE BASINS AND WATER QUALITY DESIGN FLOW FOR OFF–LINE BASINS.
3. SCREEN OPENINGS SHALL BE AT LEAST ¼" AND SHALL NOT EXCEED THE DIAMETER OF THE PERFORATIONS ON THE RISER.
4. RISER PIPE PERFORATION DIAMETER SHALL BE NO LESS THAN ½" AND NO MORE THAN 2"
5. MINIMUM PIPE DIAMETER (D) IS 2'
6. RISER PIPE MATERIAL IS CMP

Figure E-9. Perforated Riser Structure

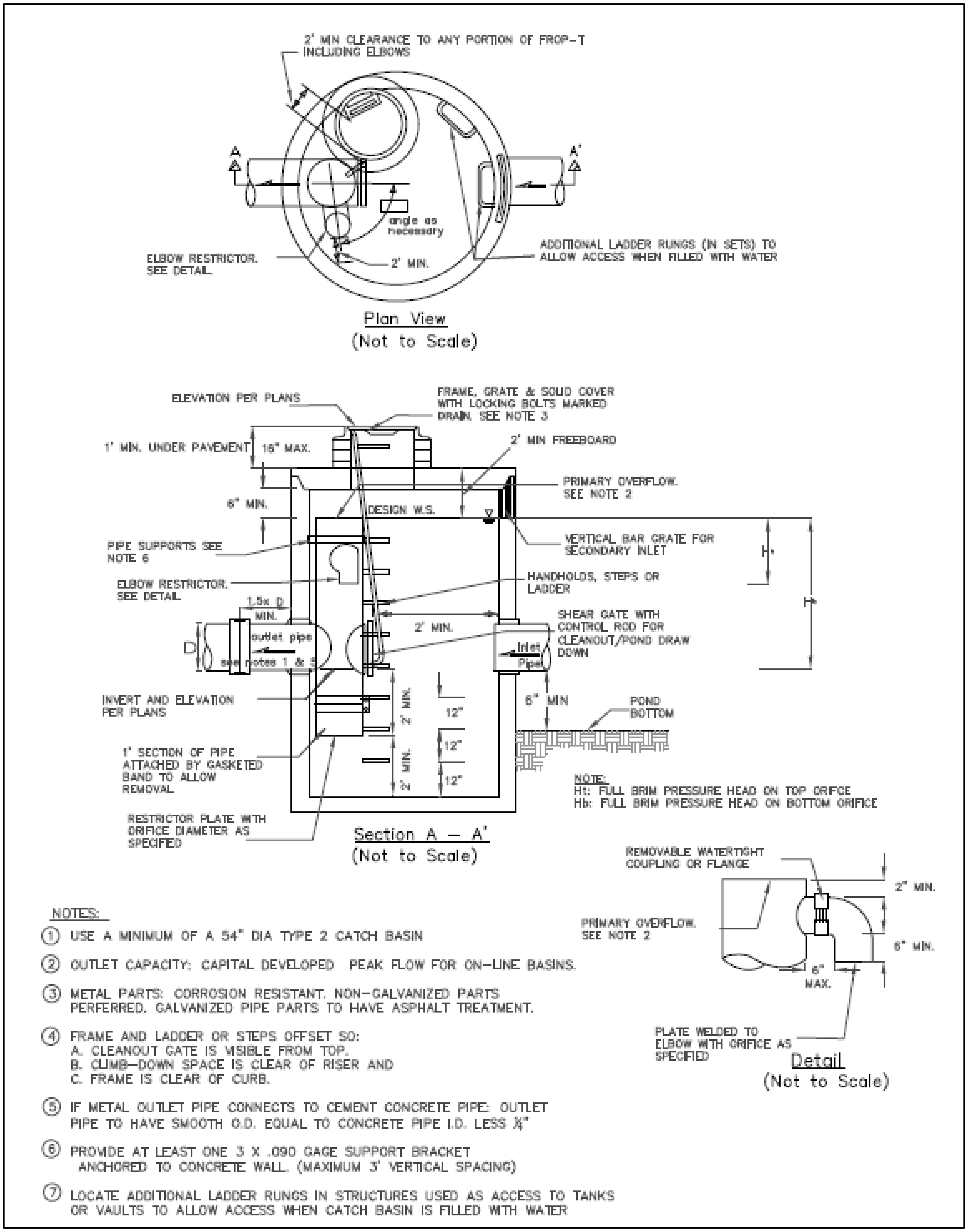


Figure E-10. Multiple Orifice Outlet

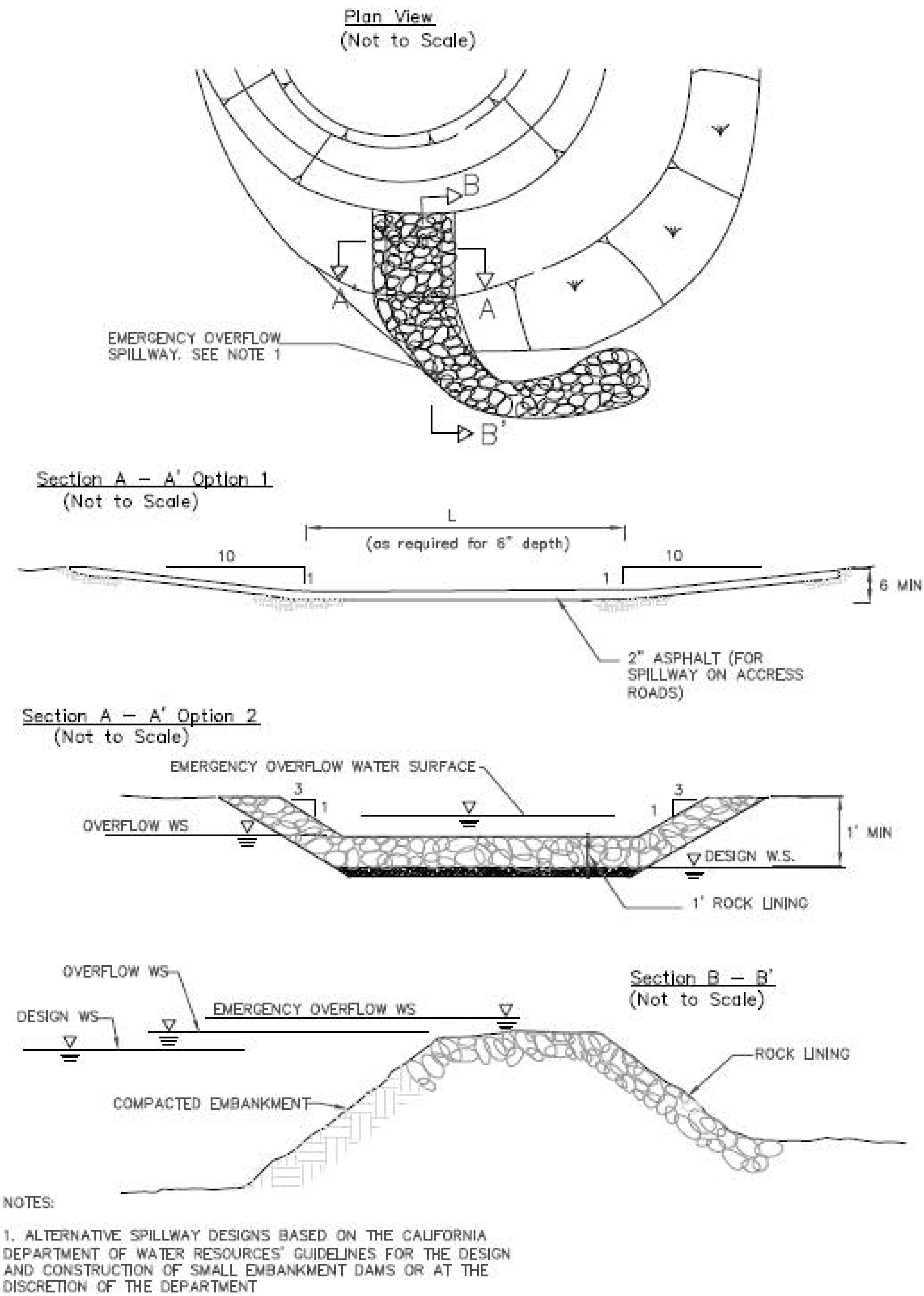


Figure E-11. Spillway Design Schematic

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HM-2: Wet Pond

Description

Wet ponds are open earthen basins that feature a permanent pool of water that is displaced by stormwater runoff, in part or in total, during storm events. Like extended detention basins, wet ponds are designed to temporarily retain stormwater runoff, which reduces peak stormwater runoff flow rates and provides some stormwater runoff treatment. Wet ponds differ from extended detention basins in that influent stormwater runoff mixes with and displaces the permanent pool as it enters the pond. A dry weather base flow is required to maintain a permanent pool in the wet pond. The primary treatment mechanism is sedimentation as stormwater runoff resides in this pool, but pollutant removal, particularly nutrients, also occurs through biological activity in the wet pond.

Wet ponds may also be designed with extended detention above the permanent pool. The extended detention portion of the wet pond above the permanent pool, if provided, functions like an extended detention basin to provide additional hydromodification control. If there is no extended detention provided, wet ponds must be sized to provide a minimum permanent pool volume.

An example schematic of a wet pond with extended detention is presented in Figure E-13.

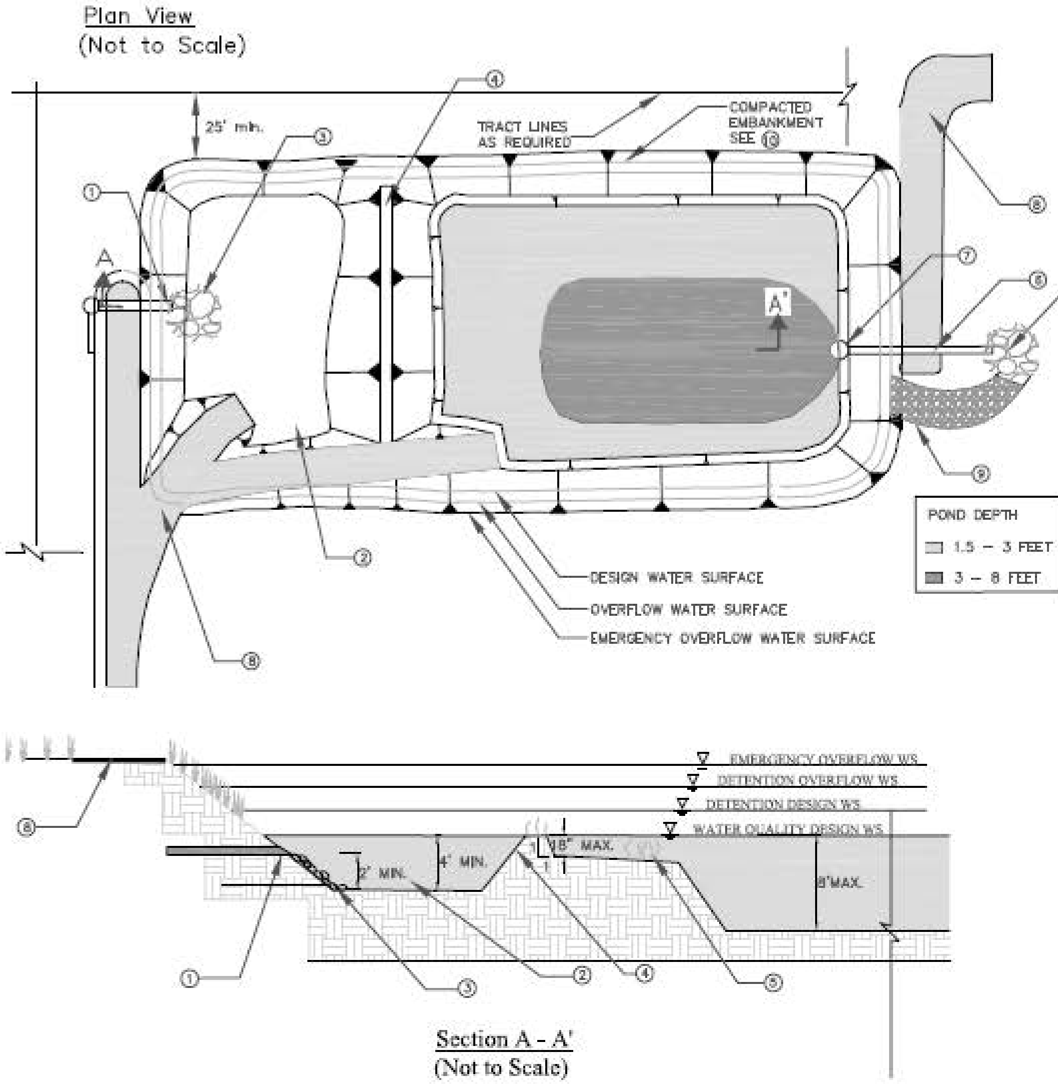
Use and Applicability

The Phase II Permit (Provision F.5.g.2.d) identifies bioretention as the standard stormwater treatment control measure unless (1) it is determined to be infeasible and an alternative stormwater treatment control measure that is equivalent to bioretention is proposed and demonstrated (Provision F.5.g.2.d.(a)), or (2) a specific exemption applies (Provision F.5.g.2.d.(c)). A wet pond can be proposed as an alternative to bioretention if it meets all of the following measures of equivalent effectiveness:

- Equal or greater amount of stormwater runoff infiltrated or evapotranspired;
- Equal or lower pollutant concentrations in stormwater runoff that is discharged after biotreatment;
- Equal or greater protection against shock loadings and spills; and
- Equal or greater accessibility and ease of inspection and maintenance.

In addition, according to Provision F.5.g.2.d.(c) of the Phase II Permit, wet ponds may be considered in lieu of bioretention or bioretention-equivalent measures for the following types of Regulated Projects:

- Projects creating or replacing an acre or less of impervious area, and located in a designated pedestrian-oriented commercial district (i.e., smart growth projects), and having at least 85 percent of the entire project site covered by permanent structures;
- Facilities receiving runoff solely from existing (pre-project) impervious areas; and
- Historic sites, structures, or landscapes that cannot alter their original configuration in order to maintain their historic integrity.



NOTES:

① INLET PIPE SHOULD BE SUBMERGED WITH A MINIMUM OF 2' DISTANCE FROM THE BOTTOM

② FIRST CELL VOLUME SHALL EQUAL 25% TO 35% OF TOTAL WETPOND VOLUME. DEPTH SHALL BE 4' MIN TO 8' MAX PLUS AN ADDITIONAL 1' MIN SEDIMENT STORAGE DEPTH.

③ RIP RAP APRON OR OTHER ENERGY DISSIPATION.

④ BERM SHALL EXTEND ACROSS ENTIRE WIDTH OF THE WETPOND.

⑤ EMERGENT VEGETATION SHALL BE PLANTED IN REGIONS OF THE POND THAT ARE 3' DEEP OR LESS.

⑥ SIZE OUTLET PIPE TO PASS 100-YEAR PEAK FLOW FOR ON-LINE PONDS AND WATER QUALITY PEAK FLOW FOR OFF-LINE PONDS.

⑦ WATER QUALITY OUTLET STRUCTURE.

⑧ MAINTENANCE ACCESS ROAD SHOULD PROVIDE ACCESS TO BOTH THE FIRST CELL AND MAIN BASIN.

⑨ INSTALL EMERGENCY OVERFLOW SPILLWAY AS NEEDED.

Figure E-12. Example Wet Pond Schematic

Design Specifications

The following sections provide design specifications for wet ponds.

Geotechnical

A geotechnical investigation must be conducted during the site assessment process to verify site conditions for a wet pond. It is critical to understand how stormwater runoff will move through the soil (horizontally and vertically) and if there are any geologic conditions that may impact the movement of water. Soil infiltration rates and the depth to the groundwater table must be evaluated to ensure that conditions are satisfactory for proper operation of a wet pond.

Implementation of a wet pond in an area with rapidly draining soils requires impermeable liners to maintain permanent pools and/or micro-pools in the pond. Liners can be either synthetic materials (geomembrane liner) or imported lower permeability soils (e.g., clays). A water balance must be conducted to determine whether a liner is required. The following conditions can be used as a guideline:

- The sediment forebay must retain at least three feet of water year-round in order for pre-settling to be effective.
- The permanent pool must retain water for at least ten months of the year. Because plants can adapt to periods of summer drought, a limited drought period is allowed in the permanent pond. This may allow for a soil liner rather than a synthetic liner.

If low permeability soils are used for the impermeable liner, a minimum of 18 inches of the underlying soil amended with topsoil or compost (one part compost mixed with three parts of the underlying soil) must be placed over the liner. If a synthetic liner is used, a soil depth of two feet is recommended to prevent damage to the liner during planting.

Wet ponds are typically located on sites with a slope no greater than 15 percent. A Site Conditions Report summarizing the relevant findings from the geotechnical investigation and water balance must be submitted with the Project Stormwater Plan.

Setbacks

Applicable setbacks must be implemented when siting a wet pond.

Pretreatment

Pretreatment, which refers to design features that provide settling of large particles before stormwater runoff enters a stormwater treatment control measure, is important to ensure proper operation of a wet pond and reduce the long-term maintenance burden. Pretreatment may be provided to reduce the sediment load entering a wet pond in order to prevent sediment buildup that will reduce the capacity of the wet pond.

For wet ponds, typically a sediment forebay is used for pretreatment to remove coarse solids. The sediment forebay may be constructed with an internal berm made out of earthen embankment material, grouted riprap, or other structurally-sound material. The sediment forebay must be designed as follows:

- All inlets to the wet pond must enter the sediment forebay first.
- The sediment forebay must have a minimum volume equal to 5 to 10 percent of the total wet pond volume.
- Permanent steel post depth markers must be placed in the sediment forebay to identify the settled sediment removal limits at 50 and 100 percent of the sediment storage depth.
- The depth of the sediment forebay must be between four and eight feet, excluding sediment storage. One foot of sediment storage must be provided in the sediment forebay.
- A gravity drain outlet from the sediment forebay (minimum four-inch diameter) must extend the entire width of the internal berm.
- The sediment forebay outlet must be off-set from the inflow flow line to prevent short-circuiting.
- The sediment forebay outlet must be off-set from the inflow flow line to prevent short-circuiting.

Flow Entrance and Energy Dissipation

The drainage management area(s) (DMA[s]) tributary to the wet pond must be graded to minimize erosion that may enter the wet pond. The inlet to the wet pond must be submerged with the inlet pipe invert a minimum of two feet from the bottom (not including sediment storage). The top of the inlet pipe should be submerged at least one foot, if possible. A submerged inlet will dissipate energy from incoming flow. The distance from the bottom is required to minimize resuspension of settled sediments. Alternative inlet designs that meet these objectives are acceptable.

Drainage

Wet ponds provide stormwater runoff storage above ground. Wet ponds must have a base flow to maintain the permanent pool at least ten months of the year.

Sizing

Step 1: Calculate the Stormwater Runoff Volume

If the wet pond is demonstrated and approved as an alternative to bioretention, it must be designed to capture and manage the SDV_{adj}, which is the difference between the SDV (Section 3.2.5) and the volume of stormwater runoff managed through site design m measures (Section 3.2.3), for the tributary DMA(s).

Step 2: Determine Active Design Volume for Wet Pond without Extended Detention

The active volume of the wet pond (V_a) is equal to the stormwater runoff volume (Step 1) plus an additional five percent for sediment accumulation.

$$V_a = 1.05 \times V_{SW}$$

Where:

V_a = active volume of wet pond [ft^3]; and
V_{SW} = stormwater runoff volume [ft^3].

Step 3: Determine Preliminary Geometry

Based on site constraints, determine the pond geometry and the storage available by developing an elevation-storage relationship for the wet pond. Note that a more natural geometry may be used and is in many cases recommended; the preliminary wet pond geometry calculations are used for sizing purposes only.

Calculate the width of the wet pond footprint (W_{tot}) as follows:

$$W_{tot} = \frac{A_{tot}}{L_{tot}}$$

Where:

W_{tot} = total width of wet pond [ft];
A_{tot} = total surface area of wet pond footprint [ft^2]; and
L_{tot} = total length of wet pond [ft].

Calculate the length of the active volume surface area ($L_{av\text{-}tot}$), including the internal berm, but excluding the freeboard as follows:

$$L_{av-tot} = L_{tot} - 2 \times Z \times d_{fb}$$

Where:

$L_{av\text{-}tot}$ = length of the active volume surface of wet pond [ft];
L_{tot} = total length of wet pond [ft];
Z = interior side slope as length per unit height [ft/ft]; and
d_{fb} = freeboard depth (minimum 1 ft) [ft].

Calculate the width of the active volume surface area ($W_{av\text{-}tot}$), including the internal berm, but excluding the freeboard as follows:

$$W_{av-tot} = W_{tot} - 2 \times Z \times d_{fb}$$

Where:

$W_{av\text{-}tot}$ = width of the active volume surface of wet pond [ft];
W_{tot} = total width of wet pond footprint [ft];
Z = interior side slope as length per unit height [ft/ft]; and
d_{fb} = freeboard depth (minimum 1 ft) [ft].

Calculate the total active volume surface area ($A_{av\text{-}tot}$), including the internal berm, but excluding the freeboard as follows:

$$A_{av-tot} = L_{av-tot} \times W_{av-to}$$

Where:

$A_{av\text{-}tot}$ = total active volume surface area [ft^2];
$L_{av\text{-}tot}$ = length of total active volume surface of wet pond [ft]; and
$W_{av\text{-}tot}$ = width of total active volume surface of wet pond [ft].

Calculate the area of the berm (A_{berm}) as follows:

$$A_{berm} = L_{berm} \times W_{berm}$$

Where:

A_{berm} = area of berm [ft^2];
L_{berm} = length of berm [ft]; and
W_{berm} = width of berm [ft].

Calculate the active volume surface area ($A_{av\text{-}tot}$), excluding the internal berm and freeboard as follows:

$$A = A_{av-tot} - A_{berm}$$

Where:

A = active volume surface area, including the internal berm, but excluding the freeboard [ft^2];
$A_{av\text{-}tot}$ = total active volume surface area, including the internal berm, but excluding the freeboard [ft^2]; and
A_{berm} = Area of berm [ft^2].

Step 4: Determine Dimensions of Sediment Forebay (if included)

If a sediment forebay is included in the design, the wet pond must be divided into two cells separated by a berm. If a sediment forebay is not included in the design, skip this step and all subsequent design calculations will be zero or omitted for the purposing of sizing the sediment forebay. The sediment forebay must have a minimum volume equal to 5 to 10 percent of the total wet pond volume. The berm volume does not count as part of the total volume.

Calculate the active volume of the sediment forebay (V_f) as follows:

$$V_f = \frac{V_a \times \%V_f}{100}$$

Where:

V_f = active volume of sediment forebay [ft^3];
V_a = active volume of wet pond [ft^3]; and
$\%V_f$ = percent of stormwater runoff volume in sediment forebay (minimum 5 percent) [%].

Calculate the surface area for the active volume of sediment forebay (A_f) as follows:

$$A_f = \frac{V_f}{d_f}$$

Where:

A_f = surface area of active volume of sediment forebay [ft^2];
V_f = active volume of sediment forebay [ft^3]; and
d_f = average depth of the active volume of sediment forebay (2-4 ft) [ft].

Calculate the length of the sediment forebay (L_f). Note that the inlet(s) and outlet(s) of the sediment forebay should be configured to maximize the hydraulic residence time.

$$L_f = \frac{A_f}{W_f}$$

$$W_f = W_{av-tot} = L_{berm}$$

Where:

L_f = length of sediment forebay [ft];
A_f = surface area of active volume of sediment forebay [ft^2];
W_f = width of sediment forebay [ft];
$W_{av\text{-}tot}$ = width of total active volume surface area [ft]; and
L_{berm} = length of berm [ft].

Step 5: Determine Dimensions of Permanent Pool

The permanent pool consists of the remainder of the active volume of the wet pond. Calculate the active volume of the permanent pool (V_p) as follows:

$$V_p = V_a - V_f$$

Where:

V_p = active volume of permanent pool of wet pond [ft^3];
V_a = active volume of wet pond [ft^3]; and
V_f = active volume of the sediment forebay [ft^3].

The minimum permanent pool surface area includes 0.3 acres of permanent pool per acre-foot of permanent pool volume. Calculate $A_{p,min}$:

$$A_{p,min} = 0.3\frac{acres}{acre - ft} \times V_p$$

Where:

$A_{p,min}$ = minimum permanent pool surface area [ft^2]; and
V_p = Active volume of the permanent pool [ft^3].

Calculate the actual permanent pool surface area (A_p) as follows:

$$A_p = A - A_f$$

Where:

A_p = actual surface area of permanent pool [ft^2];
A = active volume surface area, including the internal berm, but excluding the freeboard [ft^2]; and
A_f = active volume of sediment forebay [ft^2].

Verify that A_p is greater than $A_{p,min}$. If A_p is less than $A_{p,min}$, modify the input parameters to increase A_p until it is greater than $A_{p,min}$. If site constraints limit this criterion, then another site for the wet pond may need to be selected.

Calculate the top length of the permanent pool (L_p) as follows:

$$L_p = \frac{A_p}{W_p}$$

$$W_p = W_f = W_{av-tot} = L_{berm}$$

Where:

A_p = surface area of permanent pool [ft^2];
W_p = width of permanent pool [ft];
W_f = width of sediment forebay [ft];
$W_{av\text{-}tot}$ = width of total active volume surface area [ft]; and
L_{berm} = length of berm [ft].

Verify that the length-to-width ratio of the permanent pool is at least 1.5:1 with greater than 2:1 preferred. If the length-to-width ratio is less than 1.5:1, modify the input parameters until a ratio of at least 1.5:1 is achieved. If the input parameters cannot be modified as a result of site constraints, another site for the wet pond may need to be selected.

Step 6: Design Other Wet Pond Features

Other sizing specifications for the wet pond include the following:

- A minimum freeboard of one foot above the maximum water surface elevation must be maintained.
- A 25-foot (minimum) buffer must be provided around the top perimeter of the wet pond.
- The flow path length-to-width ratio must be a minimum of 1.5:1, but preferably 3:1 or greater. A higher flow path length to width ratio increases the removal efficiency of total suspended solids (TSS).
- The edge of the wet pond should slope from the surface of the permanent pool to a depth of 12 to 18 inches at a slope of 1:1 (H:V) or greater. If soil conditions cannot support a 1:1 (H:V) slope, then the steepest slope that can be supported should be used or a shallow retaining wall constructed (18 inches maximum). Beyond the edge of the wet pond, a bench sloped at 4:1 (H:V) maximum should extend into the wet pond to a depth of at least three feet. A steeper slope may be used beyond the three foot depth to a maximum of eight feet. The steep slope at the water's edge will minimize very shallow areas that can support vector breeding.
- Wet ponds must be designed with a hydraulic residence time for dry weather flows of less than seven days to minimize vector breeding and stagnation issues.
- At least 25 percent of the permanent pool must be deeper than three feet to prevent growth of emergent vegetation across the entire pond. If greater than 50 percent of the permanent pool is deeper than six feet deep, a recirculation system (e.g., fountain, aerator) must be provided to prevent stratification, stagnation, and low dissolved oxygen conditions.

Step 7: Design Berm

The berm separating the sediment forebay, if one is provided, and the permanent pool must meet the following specifications:

- The top of the berm must be either at the stormwater runoff volume (Step 1) water surface or submerged one foot below the stormwater runoff volume water surface.
- The side slopes of the berm must meet the following specifications:
  - If the top of the berm is at the stormwater runoff volume water surface, the berm side slopes must be no steeper than 3:1 (H:V); or

- If the top of berm is submerged one foot below the stormwater runoff volume water surface, the upstream side slope has a maximum slope of 2:1 (H:V).

Step 8: Design Extended Detention (if necessary)

If extended detention is included, then the extended detention volume must provide detention of 10 percent of the stormwater runoff volume (Step 1) while the surcharge volume makes up the remaining 90 percent of the sizing.

Outlet Structure

An outlet pipe and structure must be sized, at a minimum, to pass stormwater runoff volumes exceeding the design stormwater runoff volume (Step 1). The outlet pipe may be a perforated riser strapped to a manhole (Figure E-14) or placed in an embankment suitable for extended detention or may be back-sloped to a catch basin with a grated opening (jail house window) or manhole with a cone grate (birdcage) (Figure E-15). The grate or birdcage openings provide an overflow route should the wet pond outlet pipe become clogged. Seepage collars may be required on outlet pipes to prevent seepage through embankments. Energy dissipation controls must also be used at the outlet from the wet pond unless it discharges to the storm drain system or a hardened channel.

Overflow Structure and Spillway

An overflow spillway or overflow riser must be provided. If an overflow spillway potentially discharges to a steep slope, an overflow riser and a spillway must be provided. The overflow device must be designed to pass the maximum storm size diverted to the wet pond, with a minimum one-foot freeboard, directly to an approved discharge location (e.g., another stormwater treatment control measure, storm drain system, receiving water).

The emergency overflow spillway must be constructed of grouted riprap and designed to withstand the energy of the spillway flows (Figure E-12). Spillways must meet the California Department of Water Resources, Division of Safety of Dams *Guidelines for the Design and Construction of Small Embankment Dams* (www.water.ca.gov/damsafety/docs/GuidelinesSmallDams.pdf).

Embankments

Embankments are earthen slopes or berms used to detain or redirect the flow of water. For wet ponds, the embankments must be designed with the following specifications:

- All earthworks must be conducted in accordance with the Port's Standard Specifications.
- The interior side slopes up to the overflow water surface must be no greater than 3:1 (H:V) unless stabilization has been approved by a licensed geotechnical engineer.

- The exterior side slopes must be no greater than 2:1 (H:V) unless stabilization has been approved by a licensed geotechnical engineer.
- The minimum top width of all berm embankments must be 20 feet, unless otherwise approved by the Port.
- Berm embankments must be constructed on consolidated underlying soil or adequately compacted and stable fill soils approved by a licensed geotechnical engineer. Soils must be free of loose surface soil materials, roots, and other organic debris.
- Berm embankments must be constructed of compacted soil (95 percent minimum dry density, Modified Proctor method per ASTM D1557) and placed in six inch lifts.
- Berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width. This requirement may be waived if specifically recommended by a licensed geotechnical engineer.
- Low growing, climate-appropriate grasses must be planted on the exterior of the embankment slopes.

Water Supply

A water balance must be conducted to demonstrate that adequate water supply will be present to maintain a permanent pool of water during a drought year when precipitation is 50 percent of average for the site. The water balance must consider evapotranspiration, infiltration, precipitation, spillway discharge, and nuisance flow (where appropriate). If a water balance indicates that losses will exceed inputs, a source of water must be provided to maintain the water surface elevation for at least ten months of the year. The water supply must be of sufficient quantity and quality to not have an adverse impact on the water quality of the wet pond.

Vegetation and Landscaping

- A thick mat of climate-appropriate grass must be established on the wet pond embankment exterior side slopes following construction. Grasses help prevent erosion. Note that grass may need to be irrigated during the establishment period.
- If the permanent pool is three feet or shallower, the bottom area must be planted with emergent wetland vegetation for 25 to 75 percent coverage. A mix of erosion-resistant plant species that effectively bind the soil must be used on the interior slopes and a diverse selection of climate-appropriate plants must be specified for the pool bottom. The pool bottom must not be planted with trees, shrubs, or other large woody plants that may interfere with maintenance activities.
- Landscaping outside of the wet pond, but within the easement/right-of-way, may be included as long as it does not hinder maintenance operations.

- Trees or shrubs must not be planted within 10 feet of inlet or outlet pipes or manmade drainage structures such as spillways or earthen embankments. Species with roots that seek water (e.g., willow, poplar) must not be planted used within 50 feet of pipes or manmade drainage structures. Weeping willow (*Salix babylonica*) may not be planted in or near wet ponds.
- Plant species that are not climate-appropriate are not permitted. A sample list of suitable vegetation species is included in Appendix H. Prior to installation, a landscape architect must certify that all proposed vegetation is appropriate for the project site.

Fencing

Safety is provided by fencing of the stormwater quality control measure. Fences shall be designed and constructed in accordance with Port standards and must be located at or above the top of the overflow structure elevation.

Maintenance Access

Maintenance access must be provided to the structures associated with the wet pond (e.g., sediment forebay, inlet, outlet, overflow structure) if it is publicly-maintained. Manhole and catch basin lids must be in or at the edge of the access road. An access ramp to the wet pond bottom is required to facilitate the entry of sediment removal and vegetation maintenance equipment.

Access roads must meet the following design specifications:

- All access ramps and roads must be paved with a minimum of six inches concrete over three inches of crushed aggregate base material. This requirement may be modified depending on the soil conditions and intended use of the road at the discretion of the Port.
- The maximum grade is 12 percent unless otherwise approved by the Port.
- Centerline turning radius must be a minimum of 40 feet.
- Access roads less than 500 feet long must have 12-foot wide pavement within a minimum 15-foot wide bench. Access roads greater than 500 feet long must have 16-foot wide pavement within a minimum 20-foot wide bench.
- All access roads must terminate with turnaround areas of 40-feet by 40-feet. A hammer type turn around area or a circle drive around the top of the wet pond is also acceptable.
- Adequate double-drive gates and commercial driveways are required at street crossings. Gates should be located a minimum of 25 feet from the street curb except in residential areas where the gates may be located along the property line provided there is adequate sight distance to see oncoming vehicles at the posted speed limit.

Restricted Construction Materials

The use of pressure-treated wood or galvanized metal at or around a wet pond is prohibited. The use of galvanized fencing is permitted if in accordance with the Fencing requirement above.

Construction Considerations

In general, approximately two to three percent of the tributary development area is required for a wet pond. Wet ponds are most appropriate for sites with low-permeability soil, which help to maintain the permanent pool. Depending on the underlying soil, a wet pond may provide incidental infiltration of stormwater runoff; however, wet ponds are not designed for this purpose. An impermeable liner may be required to maintain the permanent pool in areas with rapidly draining soils. The areas planned for wet ponds should be clearly marked before site work begins to avoid soil disturbance. After construction is completed, the entire tributary area to the wet pond must be stabilized.

Maintenance Requirements

Maintenance and regular inspections must be conducted to ensure proper function of a wet pond. The following activities must be conducted to maintain a wet pond:

- At a minimum, inspect the wet pond annually. Inspections after major storm events are encouraged.
- Remove sediment accumulation exceeding 50 percent of the sediment storage capacity of the sediment forebay, as indicated on the permanent steel post depth markers. Test removed sediments for toxic substance accumulation in compliance with current disposal requirements if visual or olfactory indications of pollution are noticed. If toxic substances are detected at concentrations exceeding thresholds of Title 22, Section 66261 of the California Code of Regulations, dispose of the sediment in a hazardous waste landfill and investigate and mitigate the source of the contaminated sediments to the maximum extent possible.
- Remove trash and debris, as needed, but at least annually prior to the beginning of the wet season.
- Maintain site vegetation as frequently as necessary to maintain the aesthetic appearance of the site and to prevent clogging of outlets, creation of dead spaces, and barriers to mosquito fish to access pooled areas, and as follows:
    - Prune and/or remove vegetation, large shrubs, or trees that limit access or interfere with operation of the wet pond.
    - Remove invasive, poisonous, nuisance, or noxious vegetation and replace with climate-appropriate vegetation.
    - Remove dead vegetation if it exceeds 10 percent of area coverage. Replace vegetation immediately to maintain cover density and control

erosion where soils are exposed. It may be necessary to re-grade eroded areas prior to replacing vegetation.

    - Do not use herbicides or other chemicals to control vegetation.
    - Remove algae mats that cover more than 20 percent of the surface of the wet pond.

- Inspect inlet structure for erosion and re-grade if necessary.
- Inspect overflow structure for obstructions or debris, which should be removed immediately. Repair or replace damaged structures if necessary.

For stormwater control measures on leased properties where the tenant will be responsible for on-going maintenance, the Port will include conditions in the tenant lease.

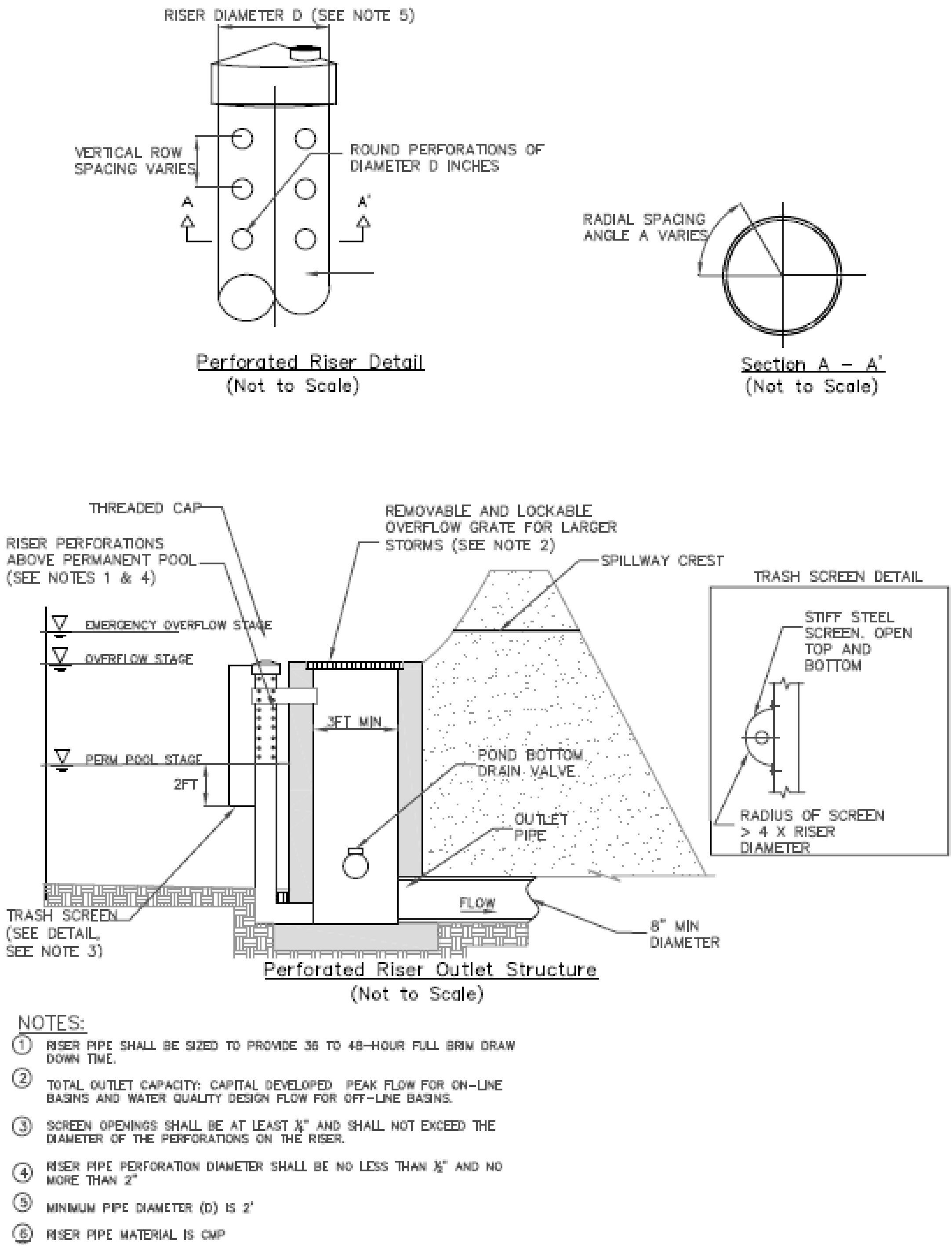
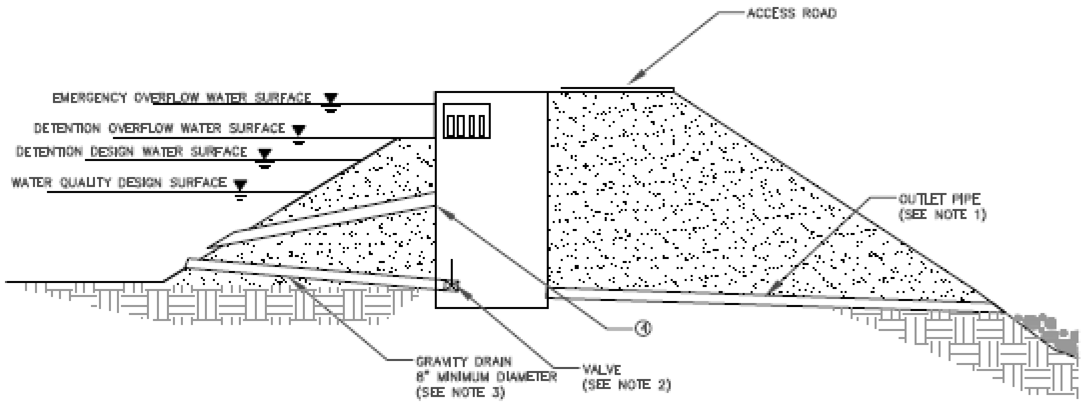


Figure E-13. Riser Outlet Schematic



Inverted Pipe Outlet Structure
(Not to Scale)

NOTES:

1. SIZE OUTLET PIPE SYSTEM TO PASS CAPITAL PEAK FLOW FOR ON–LINE PONDS AND WATER QUALITY PEAK FLOW FOR OFF–LINE PONDS.
2. VALVE MAY BE LOCATED INSIDE MANHOLE OR OUTSIDE WITH APPROVED OPERATIONAL ACCESS
3. INVERT OF DRAIN SHALL BE 6" MINIMUM BELOW TOP OF INTERNAL BERM. LOWER PLACEMENT IS DESIRABLE. INVERT SHALL BE 6" MINIMUM ABOVE BOTTOM OF POND.
4. OUTLET PIPE INVERT SHALL BE AT WETPOOL WATER SURFACE ELEVATION

Figure E-14. Inverted Pipe Outlet Schematic

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APPENDIX F

Operations and Maintenance Plan Template

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Appendix F
Operation and Maintenance Plan Template for Regulated Projects

Instructions for Developing an Operation and Maintenance Plan

An Operation and Maintenance Plan is required for all Stormwater Treatment Measures (i.e., bioretention or bioretention-equivalent measures) installed at Regulated Projects. Requirements of such a plan are described in **Section 4** of the *2015 Post-Construction Stormwater Design Manual*.

In addition to the worksheets provided below, the Plan must include the following:

- Final As-Built Site Map and Details showing boundaries of the project site, acreage, drainage patterns/contour lines, and DMAs as well as any field modifications to approved designs during construction. Preliminary Drawings are acceptable for the initial submittal of the O&M Plan. Final As-Built Drawings must accompany the final submittal.
- Show each discharge location from the project site and any drainage flowing onto the project site (i.e., run-on).
- Distinguish between pervious and impervious surfaces on the map.
- Identify the location of each stormwater control measure, sanitary sewer systems, underground utility, and grade breaks for purposes of pollution prevention.
- With a legend, identify locations of expected sources of pollution generation (e.g., outdoor work and storage areas, heavy traffic areas, delivery areas, trash enclosures, fueling areas, wash-racks). Identify any areas having contaminated soil or where pollutants are stored or have been stored/ disposed of in the past.
- An inspection and maintenance log template to document inspection and maintenance activities, including inspector names, dates, and stormwater treatment measure(s) inspected and maintained. The log should note any observed problems and corrective actions taken including any due to spills or unexpected discharges.

Annually, by July 1, the Port Area Developer, his/hers designee, or successor must provide to the Port Environmental Division a self-certification that the project's stormwater treatment measure(s) are being properly operated and maintained. The report shall, at a minimum, describe the inspection and maintenance activities performed during the previous year and append the related field logs. For Port projects, the applicable business line or engineering division must provide the annual self-certification. A self-certification template is provided.

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Appendix F
Operation and Maintenance Plan Template for Regulated Projects

Basic Project Information

Company / Project	
Project Site Address	
Owner / Operator Information	
Owner Name	______________________
Person(s) responsible for operating / maintaining stormwater treatment measures	______________________ ______________________ ______________________
Company or Affiliation	______________________
Address	______________________
Telephone Number	______________________
Email Address	
Describe method of funding on-going maintenance and operation of stormwater treatment measures	
______________________ ______________________	
Stormwater Treatment Measures	
Measure:	______________________
Installation Date:	______________________
Design Specifications:	______________________ ______________________ ______________________ ______________________ ______________________ ______________________

Stormwater Treatment Measures (continued)	
Measure:	______________________
Installation Date:	______________________
Design Specifications:	______________________
Measure:	______________________
Installation Date:	______________________
Design Specifications:	______________________
Measure:	______________________
Installation Date:	______________________
Design Specifications:	______________________

Attach additional sheets if needed.

Appendix F
Operation and Maintenance Plan Template for Regulated Projects

Operation, Inspection, and Maintenance Requirements and Schedule

Complete one sheet for each Stormwater Treatment Measure

Stormwater Treatment Measure:	
Identify cleaning activities, including litter removal and any housekeeping procedures:	
Schedule:	
Identify vegetation/ landscape management methods:	During vegetation-establishment period:
	Long term maintenance:
Maintenance schedule:	
Identify vector control practices:	
Identify equipment needed to operate and maintain the stormwater treatment measure:	

Spill Plan

Complete one sheet for each Stormwater Control Measure

Stormwater Treatment Control Measure:
Downstream receiving water:
Emergency notification contacts
Name: ______ Title: ______ Company/ Agency ______ Telephone number: ______ Email: ______
Name: ______ Title: ______ Company/ Agency ______ Telephone number: ______ Email: ______
Name: ______ Title: ______ Company/ Agency ______ Telephone number: ______ Email:
Cleanup procedures for spills and overflows

Training

Provide information about training persons responsible for operating and maintaining stormwater treatment measure(s). This training should include:

- Good housekeeping procedures defined in the Operations and Maintenance Plan;
- Proper maintenance of all devices, including stormwater treatment measures;
- Identification and cleanup procedures for spills and overflows;
- Large-scale spill or hazardous material response; and
- Safety concerns when maintaining devices and cleaning up spills.

Describe training procedures:

____
____
____
____
____
____
____
____
____
____
____

Training schedule / frequency:

____
____

Attached information

- ☐ Preliminary As Built Drawings (with preliminary O&M Plan)
- ☐ Final As Built Drawings (with final O&M Plan)
- ☐ Inspection Checklist
- ☐ Maintenance Log

EXAMPLE

Annual Self-Certification, due July 1st

Company / Project	
Project address	
Lessee Name	
Lessee Address	
Telephone Number	
Email Address	
Reporting Period	July 1st 20__ to June 30th 20___

___________________________, a Lessee of the Port of Oakland at the Oakland International Airport (“Lessee”) represents, in accordance with the General Permit for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems, NPDES Order No. 2013-0001-DWQ, (“Phase II Permit”) issued by the California State Water Resources Control Board (“SWRCB”) with respect to the reporting period stated above the following, the Lessee has:

(1) Performed or caused to be performed inspection and maintenance activities at stormwater treatment measures described in the Project’s Operations and Maintenance Plan

(2) Completed maintenance and inspection field logs are attached to this Self-Certification

☐ The Foregoing is true, except as provided in an attachment (check to indicate attachment)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons that manage the system or who those persons directly responsible for gathering the information, to the vest of my knowledge and belief, the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Lessee agrees to waive and release the Port and Port officers, employees, agents and members of the Board of Port Commissioners from any and all claims, including claims of negligence, and liability that may arise from any act or failure to act by the Port in connection with the Port's providing advice, guidance, or assistance to Lessee or any other tenant, sub-tenant or assignee regarding compliance with any laws, ordinances, general rules, permits or regulations relating to human or public health, the environment, water, water quality, sanitation, safety, welfare or discharges to the air or water including, but not limited to, the following actions or activities: furnishing educational materials to, and organizing meetings for, OAK tenants; explaining the alleged requirements of the Clean Water Act ("CWA"), the regulations promulgated pursuant thereto, or the terms, conditions or means of complying with any permits required by or issued pursuant to the CWA.

______________________	__________
Facility Representative	Date
______________________	__________
Name (please print)	Title

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APPENDIX G

Suitable Vegetation Species

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Appendix G – Suitable Vegetation Species

For stormwater treatment control measures designed for biotreatment (e.g., bioretention, stormwater planters, tree-well filters), the primary purposes of vegetation are to reduce pollutants in stormwater runoff and provide increased transpiration to reduce stormwater runoff volume. Vegetation also maintains soil porosity and prevents erosion. In selecting appropriate vegetation for stormwater treatment control measures, the following factors must be considered:

- Can the vegetation tolerate summer drought, ponding fluctuations, and saturated soil conditions following a storm event?
- Is the vegetation climate-appropriate?
- Is the vegetation dense and strong enough to stay upright even in flowing water?
- Does the vegetation require fertilizers or other nutrient supplements?
- Is the vegetation prone to pests or disease?
- What are the irrigation requirements for the vegetation?
- Is it consistent with local water conservation ordinance requirements?

A sample list of suitable vegetation species is provided in Table G-1. Information in Table G-1 includes the plant type (i.e., perennial and ground cover, grasses, shrubs, trees), irrigation requirements, and saturation tolerance (i.e., Zones 1 or 2). The plant list, was adapted from Water Use Classification of Landscape Species (WUCOLS IV) database[1] and Appendix F of the Bay Area Stormwater Management Agencies Association Post-Construction Manual (July 2014)[2] and Terraphase Engineering and WRA Environmental Consultants (May 2015)[3]. The Western Sunset Zone Guide[4] is another source that provides useful information on climate-appropriate plants.

In biotreatment systems Zone 1 is the lower area where the soil experience extended periods of saturation. Vegetation suitable for Zone 1 are common riparian, and wetland plants capable of surviving in saturated soils for long durations throughout the year. However, most of these types of plants are not drought-tolerant and require some irrigation throughout the growing season. Zone 2 is at the higher grade in the biotreatment system and the soil is saturated for shorter periods. Vegetation suitable for Zone 2 includes plants common in riparian/upland transition areas, moist woodlands, and seasonal wetlands. These plants are capable of surviving in saturated soils for shorter durations especially in the winter or spring and are drought-tolerant, but could benefit from some year-round irrigation.

The project applicant is not limited to the vegetation listed in Table G-1 and may proposed other climate-appropriate vegetation suitable for biotreatment systems. Vegetation for biotreatment systems must be designed by a landscape architect experienced with biotreatment systems.

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[1] Water Use Classification of Landscape Species (http://ucanr.edu/sites/WUCOLS/, Last Accessed May 15, 2015).
[2] Bay Area Stormwater Management Agencies Association. Design Guidance for Stormwater Treatment and Control for Projects in Marin, Sonoma, Napa, and Solano Counties. July 14, 2014.
[3] Terraphase Engineering and WRA Environmental Consultants Oakland International Airport South Field Bioswale Civil/Hydraulic and Landscape Recommendations, Final Memorandum, May 22, 2015.
[4] Western Sunset Zone Guide (http://www.sunset.com/garden/climate-zones/climate-zones-intro-us-map, Last Accessed May 18, 2015).

Appendix G – Suitable Vegetation Species

Table G-1. Suitable Vegetation Species

Species Name	Common Name	Vegetation Type				California Native	Irrigation Requirement			Saturation Tolerance	
		Perennial and Ground Cover	Grass/ Grass-like	Shrub	Tree		Very Low	Low	Moderate	Zone 1	Zone 2
Artemisia douglasiana	California mugwort	X				X		X		X	X
Chondropetalum tectorum	cape reed	X						X		X	X
Epipactis gigantea	stream orchid	X				X			X	X	X
Erigeron glaucus	beach aster	X				X			X		X
Heuchera micrantha	crevice alum root	X				X			X		X
Iris douglasiana	Douglas iris	X				X		X			X
Juncus pallidus	pale rush	X							X	X	X
Juncus patens	blue rush; spreading rush	X				X		X	X	X	X
Mirabilis multiflora	four o' clock	X				X		X			X
Scaevola 'Mauve Clusters'	fan flower	X						X			X
Sisyrinchium californicum	golden-eyed grass	X				X			X	X	X
Verbena lasiostachys	robust verbena	X				X		X		X	X
Phormium sp.	New Zealand flax	X						X			X
Agrostis exerata	spike bentgrass		X						X	X	X
Bouteloua gracilis	blue grama		X					X			X
Bromus carinatus	California brome					X		X			X
Carex barbarea	Santa Barbara sedge		X			X		X		X	X
Carex divulsa	grassland sedge		X						X	X	X
Carex pansa	sand dune sedge		X			X			X	X	X
Carex praegracilis	California field sedge		X			X			X	X	X

Appendix G – Suitable Vegetation Species

Species Name	Common Name	Vegetation Type				California Native	Irrigation Requirement			Saturation Tolerance	
		Perennial and Ground Cover	Grass/ Grass-like	Shrub	Tree		Very Low	Low	Moderate	Zone 1	Zone 2
Carex nudata	California black sedge		X			X		X		X	X
Danthonia californica	California oatgrass		X			X			X	X	X
Distichlis spicata	salt grass		X			X			X	X	X
Festuca arundinacea	tall fescue		X					X			X
Festuca californica	California fescue		X			X		X			X
Festuca glauca	common blue fescue		X					X			X
Festuca rubra	creeping red fescue		X			X			X		X
Muhlenbergia rigens	deer grass		X			X		X			X
Alyogyne huegelil	blue hibiscus			X				X			X
Baccharis pilularis consanguinea	bush baccharis;			X		X		X		X	X
Cornus sericera	redtwig dogwood			X		X		X		X	X
Carpenteria californica	bush anemone			X		X		X		X	X
Erigeron glaucus	seaside daisy			X		X		X			X
Heteromeles arbutifolia	toyon			X		X	X				X
Physocarpus capitatus	pacific ninebark			X		X			X	X	X
Rhododendron occidentale	western azalea			X		X			X	X	X
Ribes speciosum	fuchsia flowering gooseberry			X		X		X			X
Rosa californica	California wild rose			X		X		X		X	X
Rosa gymnocarpa	wood rose			X		X			X		X
Acer negundo	box elder				X	X			X	X	X

Species Name	Common Name	Vegetation Type: Perennial and Ground Cover	Vegetation Type: Grass/ Grass-like	Vegetation Type: Shrub	Vegetation Type: Tree	California Native	Irrigation Requirement: Very Low	Irrigation Requirement: Low	Irrigation Requirement: Moderate	Saturation Tolerance: Zone 1	Saturation Tolerance: Zone 2
Chilopsis linearis	desert willow				X	X	X			X	X
Fraxinus latifolia	Oregon ash				X	X			X	X	X
Fraxinus velutina	Arizona ash				X	X			X		X
Myrica californica	Pacific wax myrtle				X			X			X
Pittosporum eugenioides	tarata				X				X		X
Platanus racemosa	California sycamore				X	X			X		X
Populus fremontii	western cottonwood				X	X			X		X
Pyrus kawakamii	evergreen pear				X				X		X
Quercus agrifolia	coast live oak				X	X	X				X
Umbellularia californica	California bay				X	X			X		X

APPENDIX H

Sample Calculations

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Stormwater Design Volume

The following are examples of how to calculate the stormwater design volume (SDV) for two drainage management areas, one which is pervious and one which is impervious. For the purpose of these examples, it is assumed that a 30,000 ft^2 (20,000 ft^2 impervious, 10,000 ft^2 pervious) site will be developed. The project will be designed with a 48-hour drawdown period.

Example 1: Pervious Drainage Management Area

Calculate the stormwater runoff coefficient using the following equation:

$$C = 0.858 \times i^3 - 0.78 \times i^2 + 0.774 \times i + 0.04$$
$$= 0.858 \times 0^3 - 0.78 \times 0^2 + 0.774 \times 0 + 0.04 = 0.04$$

Where:

C = stormwater runoff coefficient [unitless]; and
i = DMA imperviousness ratio [expressed as a decimal]. For pervious areas, this ratio is 0.

Calculate the unit stormwater volume using the following equation:

$$P_0 = (a \times C) \times P_6 = (1.963 \times 0.04) \times 0.48\ in = 0.038\ in$$

Where:

P_0 = unit stormwater volume [in];
a = regression constant (1.963 for 48-hr drawdown); and
P_6 = 0.48 in (mean runoff-producing rainfall depth see Section 3.2.5 of the *2015 Post-Construction Stormwater Design Manual*).

Calculate the SDV using the following equation:

$$SDV = A \times \frac{P_0}{12} = 10{,}000\ ft^2 \times \frac{0.038\ in}{12\ in/ft} = 31.7\ ft^3$$

Where:

SDV = stormwater design volume [ft^3];
A = total area of drainage management area [ft^2]; and
P_0 = unit stormwater volume [in].

In this example, the pervious drainage management area will generate 31.7 ft^3 of stormwater runoff that must be managed.

Example 2: Impervious Drainage Management Area

Calculate the stormwater runoff coefficient using the following equation:

$$C = 0.858 \times i^3 - 0.78 \times i^2 + 0.774 \times i + 0.04$$
$$= 0.858 \times 1^3 - 0.78 \times 1^2 + 0.774 \times 1 + 0.04 = 0.89$$

Where:

C = stormwater runoff coefficient [unitless]; and
i = DMA imperviousness ratio [expressed as a decimal]. For impervious areas, this ratio is 1.

Calculate the unit stormwater volume using the following equation:

$$P_0 = (a \times C) \times P_6 = (1.963 \times 0.89) \times 0.48\ in = 0.84\ in$$

Where:

P_0 = unit stormwater volume [in];
a = regression constant (1.963 for 48-hr drawdown); and
P_6 = 0.48 in (mean runoff-producing rainfall depth see Section 3.2.5 of the *2015 Post-Construction Stormwater Design Manual*).

Calculate the SDV using the following equation:

$$SDV = A \times \frac{P_0}{12} = 20{,}000\ ft^2 \times \frac{0.84\ in}{12\ in/ft} = 1{,}400\ ft^3$$

Where:

SDV = stormwater design volume [ft^3];
A = total area of drainage management area [ft^2]; and
P_0 = unit stormwater volume [in].

In this example, the impervious drainage management area will generate 1,400 ft^3 of stormwater runoff that must be managed using stormwater control measures.

Stormwater Design Flow

The following are examples of how to calculate the stormwater design flow (SDF) for two drainage management areas, one which is pervious and one which is impervious. For the purpose of these examples, it is assumed that the project site is 30,000 ft^2 with 20,000 ft^2 of pavement and 10,000 ft^2 of managed turf overlaying Type C soils.

Example 3: Pervious Drainage Management Area

Calculate the SDF using the following equation:

$$SDF = 1.008 \times i \times A \times C_r = 1.008 \times 0.2\ in/hr \times 0.23\ ac \times 0.25 = 0.012\ cfs$$

Where:

SDF = stormwater design flow [ft^3/s or cfs];
1.008 = unit conversion factor;
i = design rainfall intensity [0.2 in/hr];
A = total area of drainage management area [acre]; and
C_r = stormwater runoff coefficient for drainage management area (see Table 7 of the *2015 Post-Construction Stormwater Standards Manual*).

In this example, the pervious drainage management area will generate a stormwater flow rate of 0.012 cfs that must be managed.

Example 4: Impervious Drainage Management Area

Calculate the SDF using the following equation:

$$SDF = 1.008 \times i \times A \times C_r = 1.008 \times 0.2\ in/hr \times 0.46\ ac \times 0.95 = 0.088\ cfs$$

Where:

SDF = stormwater design flow [ft^3/s or cfs];
1.008 = unit conversion factor;
i = design rainfall intensity [0.2 in/hr];
A = total area of drainage management area [acre]; and
C_r = stormwater runoff coefficient for drainage management area (see Table 7 of the *2015 Post-Construction Stormwater Standards Manual*).

In this example, the impervious drainage management area will generate a stormwater flow rate of 0.088 cfs that must be managed using stormwater control measures.

Bioretention Facility Design

This example design of a bioretention facility is based on the SDV calculated in Example 2 above (1,400 ft^3). As before, it is assumed that a 30,000 ft^2 (20,000 ft^2 impervious, 10,000 ft^2 pervious) site will be developed. For the purposes of this example, it is assumed that 20,000 ft^2 porous pavement will be implemented as a site design measure. The project will be designed with a 48-hour drawdown period.

Step 1: Determine the Adjusted SDV (SDV_{adj})

Use the State Water Resources Control Board's Post-Construction Calculator to determine the volume credit (SDM_{credit}). The Post-Construction Calculator is available at http://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/phase_ii_municipal/120214_post_const_calc.xls Instructions for using the Post-Construction Calculator are available in the calculator spreadsheet and **Appendix I**.

For the purposes of this example, under the *Volume Calculator* tab, Step1a, enter 0.48 in for the design storm. Under the *Porous Pavement* tab enter 20,000 ft^2 under column F next to "Area od Poured Porous Concrete or Asphalt Pavement with less than 4 inches of gravel base (washed stone)". The calculator will determine the "Total Runoff Volume Reduction Credit" as 198 ft^3.

The SDV_{adj} is calculated using the following equation:

$$SDV_{adj} = SDV - SDM_{credit} = 1{,}400\ ft^3 - 198\ ft^3 = 1{,}202\ ft^3$$

Where:

SDV_{adj} = adjusted stormwater design volume [ft^3];
SDV = stormwater design volume [ft^3]; and
SDM_{credit} = site design measure volume credit [ft^3].

Step 2: Determine the Design Infiltration Rate

For this example, the in-situ infiltration rate of the underlying soil is 2.80 in/hr. After applying a safety factor of 4, the design infiltration rate is 0.70 in/hr.

Step 3: Determine Size of Bioretention Facility Design Layers

The typical design depths of the layers of the bioretention facility are presented in Table 8 of the *2015 Post-Construction Stormwater Standards Manual*. For this example, the following design depths of the layers of the bioretention facility are used:

Bioretention Facility Layer	Design depth
Ponding zone	1.5 ft
Planting media (excluding the mulch layer, if provided)	2 ft
Planting media/gravel layer separation zone (1)	4 in
Gravel	1 ft

Step 4: Calculate the Bottom Surface Area of the Bioretention Facility

Calculate the bottom surface area of the bioretention facility (surface area at the base of side slopes, not at the top of side slopes) assuming porosities of the planting media and gravel layers of 0.25 and 0.40, respectively, using the following equation:

$$A = \frac{SDV_{adj}}{d_{pz} + (\eta_{pm} \times d_{pm}) + (\eta_{gl} \times d_{gl})} = \frac{1{,}202\ ft^3}{1.5\ ft + (0.25 \times 2\ ft) + (0.40 \times 1\ ft)} = 501\ ft^2$$

Where:

A = bottom surface area of bioretention facility [ft^2];
SDV_{adj} = adjusted stormwater design volume [ft^3];
d_{pz} = depth of ponding zone [ft];
η_{pm} = porosity of planting media [unitless];
d_{pm} = depth of planting media [ft];
η_{gl} = porosity of gravel layer [unitless]; and
d_{gl} = depth of gravel layer [ft].

To verify that the bioretention facility is designed to infiltrate stormwater runoff within the maximum drawdown time, verify that the following equation is satisfied:

$$d_{pz} + (\eta_{pm} \times d_{pm}) + (\eta_{gl} \times d_{gl}) \leq \frac{f_{design}}{12} \times t_{max}$$

Where:

d_{pz} = depth of ponding zone [ft];
η_{pm} = porosity of planting media [unitless];
d_{pm} = depth of planting media [ft];
η_{gl} = porosity of gravel layer [unitless];
d_{gl} = depth of gravel layer [ft]
f_{design} = design infiltration rate [in/hr]; and
t_{max} = drawdown time (max 48 hrs) [hr].

$$1.5\ ft + (0.25 \times 2\ ft) + (0.40 \times 1\ ft) = 2.4\ ft \leq \frac{0.70\ in/hr}{12\ in/ft} \times 48\ hr = 2.8\ ft$$

The design of this bioretention facility will meet the maximum drawdown time.

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APPENDIX I

SWRCB Post-Construction Calculator Instructions for Port Area Projects

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Appendix I – SWRCB Post-Construction Calculator Instructions for Port Area Projects

Post-Construction Water Balance Calculator

User may make changes from any cell that is orange or brown in color (similar to the cells to the immediate right). Cells in green are calculated for you.

(Step 1a) If you know the 85th percentile storm event for your location enter it in the box below

0.48

(Step 1b) If you can not answer 1a then select the county where the project is located (click on the cell to the right for drop-down): This will determine the average 85th percentile 24 hr. storm event for your site, which will appear under precipitation to left.

(Step 1c) If you would like a more percise value select the location closest to your site. If you do not recgonize any of these locations, leave this drop-down menu at location. The average value for the County will be used.

Ignore

Project Information

Project Name:	*Optional*
Waste Discharge Identification (WDID):	*Optional*
Date:	*Optional*
Sub Drainage Area Name (from map):	*Optional*

Runoff Calculations

(Step 2) Indicate the Soil Type (dropdown menu to right):	**Group C Soils**	**Low infiltration. Sandy clay loam. Infiltration rate 0.05 to 0.15 inch/hr when wet.**
(Step 3) Indicate the existing **dominant** non-built land Use Type (dropdown menu to right):	*Open Space: grass cover <50%*	
(Step 4) Indicate the proposed **dominant** non-built land Use Type (dropdown menu to right):	*Solid lawn, grass, pasture or meadow covering the open space*	

Runoff Curve Numbers

Existing Runoff Curve Number	86
Proposed Development Runoff Curve Number	87

	Complete Either		
	Sq Ft	**Acres**	**Acres**
(Step 5) Total Project Site Area:	15000		0.34
(Step 6) Sub-watershed Area:	10000		0.23
Percent of total project :	68%		

Design Storm

Based on the County you indicated above, we have included the 85 percentile average 24 hr event - P85 (in)^ for your area.	0.48	in
The Amount of rainfall needed for runoff to occur (Existing runoff curve number -P from existing RCN (in)^)	0.33	In
P used for calculations (in) (the greater of the above two criteria)	0.48	In

^Available at www.cabmphandbooks.com

(Step 7) Sub-watershed Conditions	Complete Either		Calculated Acres
Sub-watershed Area (acres)	Sq Ft	Acres	0.23
Existing Rooftop Impervious Coverage	Ignore		0.00
Existing Non-Rooftop Impervious Coverage			0.00
Proposed Rooftop Impervious Coverage	2000		0.05
Proposed Non-Rooftop Impervious Coverage	4000		0.09

Credits	Acres	Square Feet
Porous Pavement	0.06	2,614
Tree Planting	0.00	0
Downspout Disconnection	0.00	0
Impervious Area Disconnection	0.00	0
Green Roof	0.00	0
Stream Buffer	0.00	0
Vegetated Swales	0.00	0
Subtotal	0.06	2,614
Subtotal Runoff Volume Reduction Credit	4 Cu. Ft.	

(Step 9) Impervious Volume Reduction Credits	Volume (cubic feet)
Rain Barrels/Cisterns	0 Cu. Ft.
Soil Quality	0 Cu. Ft.
Subtotal Runoff Volume Reduction	0 Cu. Ft.
Total Runoff Volume Reduction Credit	4 Cu. Ft.

Ignore

Enter 0.48

WDID is 201M2000004

Choose the land use types that best describe the pre- & post-project conditions in non-built areas. Examples shown here may be used for projects in the Port Area where available choices do not match site-specific conditions.

If available, include porous pavement as part of impervious coverage here and then take credit below

Site design measures credit (SDM_{credit})

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APPENDIX J

References

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Appendix J – References

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