CONTRA COSTA
CLEAN WATER
PROGRAM

STORMWATER C.3 GUIDEBOOK

Stormwater Quality Requirements for Development Applications

7th Edition
May 17, 2017
Visit www.cccleanwater.org for updates.

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Stormwater C.3 Guidebook

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Stormwater Glossary

Bay Area Stormwater Management Agencies Association (BASMAA)
Association of Bay Area municipal stormwater programs, including the Contra Costa Clean Water Program. BASMAA implements various regional activities mandated by the **Municipal Regional Permit**, provides a forum for promoting regional consistency among stormwater programs, and coordinates negotiations with the **Regional Water Board** on behalf of the permittees.

Best Management Practice (BMP)
Any procedure or device designed to minimize the quantity of pollutants that enter the storm drain system or to control stormwater flow.

Bioretention
The practice of capturing runoff within a matrix of soil and plant roots. Following capture, the runoff is evapotranspirated or infiltrated to surrounding and underlying soils. During frequent or intense runoff events, the soil-and-plant-root matrix may become saturated, in which case excess runoff may be discharged to an underdrain (**biotreatment**).

Biotreatment
The practice of filtering runoff through a matrix of soil and plant roots prior to discharge to a receiving water or municipal storm drain.

C.3
Provision in the **Municipal Regional Permit.** Requires the Permittees to use their planning authorities to include appropriate source control, site design, and stormwater treatment measures in new development and redevelopment projects to address pollutant discharges and prevent increases in runoff flows.

C.3 Web Page
http://www.cccleanwater.org/new-development-c-3/

California Stormwater Quality Association (CASQA)
Publisher of the California Stormwater Best Management Practices Handbooks.
https://www.casqa.org/sites/default/files/BMPHandbooks/BMP_NewDevRedev_Complete.pdf

California BMP Method
A method for determining the required volume of stormwater treatment facilities. Described in Section 5.5.1 of the California Stormwater Best Management Practice Manual (New Development) (CASQA, 2003).

Condition of Approval (COA) Requirements a municipality may adopt for a project in connection with a discretionary action (e.g., adoption of an EIR or negative declaration or issuance of a use permit). COAs may specify features required to be incorporated into the final plans for the project and may also specify uses, activities, and operational measures that must be observed over the life of the project.

Contra Costa Clean Water Program (CCCWP) CCCWP is established by an agreement among 19 Contra Costa cities and towns, Contra Costa County, and the Contra Costa County Flood and Water Conservation District. CCCWP implements common tasks and assists the member agencies to implement their local stormwater pollution prevention programs.

Design Storm A hypothetical rainstorm defined by rainfall intensities and durations.

Detention The practice of holding stormwater runoff in ponds, vaults, within berms, or in depressed areas and letting it discharge slowly to the storm drain system. See definitions of **infiltration** and **retention**.

Directly Connected Impervious Area Any impervious surface which drains into a catch basin, area drain, or other conveyance structure without first allowing flow across pervious areas (e.g. lawns).

Direct Infiltration Infiltration via methods or devices, such as dry wells or infiltration trenches, designed to bypass unsaturated surface soils and transmit runoff directly to groundwater.

Drawdown time The time required for a stormwater detention or infiltration facility to drain and return to the dry-weather condition. For detention facilities, drawdown time is a function of basin volume and outlet orifice size. For infiltration facilities, drawdown time is a function of basin volume and infiltration rate.

Flow Control Control of runoff rates and durations as required by Provision C.3.g. of the **Municipal Regional Permit**.

Harvesting and Reuse The practice of capturing runoff and storing it for later use. Typical nonpotable uses include toilet flushing, landscape irrigation, and industrial uses such as concrete production or washing.

Head In hydraulics, energy represented as a difference in elevation. In slow-flowing open systems, the difference in water surface elevation, e.g., between an inlet and outlet.

Hydrograph Runoff flow rate plotted as a function of time.

Hydromodification Management
Control of runoff intensities and durations so as to reduce the potential for downstream erosion. Also see definition for **flow control.**

Hydrologic Soil Group
Classification of soils by the Natural Resources Conservation Service (NRCS) into A, B, C, and D groups according to infiltration capacity.

Impervious surface
Any material that prevents or substantially reduces infiltration of water into the soil. See discussion of imperviousness in Chapter Two.

Indirect Infiltration
Infiltration via facilities, such as bioretention areas, expressly designed to treat runoff and then allow infiltration to surface soils.

Infiltration
Seepage of runoff through soil to mix with groundwater. See definition of **retention.**

Infiltration Device
Any structure that is designed to infiltrate stormwater into the subsurface and, as designed, bypasses the natural groundwater protection afforded by surface or near-surface soil. See definition for **direct infiltration**.

Infiltration Rate
Rate at which water can be added to a soil without creating runoff.

Integrated Management Practice (IMP)
A facility **(BMP)** that provides small-scale treatment, retention, and/or detention and is integrated into site layout, landscaping and drainage design. See **Low Impact Development.**

Integrated Pest Management (IPM)
An approach to pest management that relies on information about the life cycles of pests and their interaction with the environment. Pest control methods are applied with the most economical means and with the least possible hazard to people, property, and the environment.

Lead Agency
The public agency that has the principal responsibility for carrying out or approving a project. (California Environmental Quality Act Guidelines §15367).

Low Impact Development (LID)
A stormwater management strategy aimed at maintaining or restoring the natural hydrologic functions of a site. LID design detains, treats, and infiltrates runoff by minimizing impervious area, using pervious pavements and green roofs, dispersing runoff to landscaped areas, and routing runoff to rain gardens, cisterns, swales, and other small-scale facilities distributed throughout a site.

Maximum Extent Practicable (MEP)
Standard, established by the 1987 amendments to the Clean Water Act, for the reduction of pollutant discharges from municipal storm drains.

Municipal Regional Permit
A stormwater NPDES permit and Waste Discharge Requirements issued by the San Francisco Bay Regional Water Quality Control Board to 76 cities, towns, and Flood Control Districts and reissued in November 2015.

Municipal Separate Storm Sewer System (MS4)
A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains) as defined in 40 CFR 122.26(b)(8).

National Pollutant Discharge Elimination System (NPDES)
As part of the 1972 Clean Water Act, Congress established the NPDES permitting system to regulate the discharge of pollutants from municipal sanitary sewers and industries. The NPDES was expanded in 1987 to incorporate permits for stormwater discharges as well.

Numeric Criteria
Sizing requirements for stormwater treatment facilities established in Provision C.3.d. of the **Municipal Regional Permit**.

Operation and Maintenance (O&M)
Refers to requirements in the **Municipal Regional Permit** to inspect treatment BMPs and implement preventative and corrective maintenance in perpetuity. See Chapter Five.

Percolation Rate
The rate at which water flows through a soil.

Permeable or Pervious or Porous Pavements
Pavements for roadways, sidewalks, or plazas that are designed to infiltrate runoff, including pervious concrete, pervious asphalt, porous pavers, and granular materials. See the Design Sheet for Pervious Pavements.

Permeability
The rate at which water flows through a saturated soil under steady state conditions.

Pre-Project
Conditions that exist on a development site immediately before the project to which municipal approvals apply.

Project
The whole of an action which has the potential for adding or replacing or resulting in the addition or replacement of roofs, pavement, or other impervious surfaces.

Proprietary Stormwater Treatment Facilities
Products designed and marketed by private businesses for treatment of stormwater. Many of these products do not meet requirements of the **Municipal Regional Permit.**

Rational Method A method of calculating runoff flows based on rainfall intensity, tributary area, and a factor representing the proportion of rainfall that runs off.

Regional Water Quality Control Board (Regional Water Board or RWQCB) California RWQCBs are responsible for implementing pollution control provisions of the Clean Water Act and California Water Code within their jurisdiction. There are nine California RWQCBs. Contra Costa County municipalities are under the jurisdiction of the RWQCB for the San Francisco Bay Region for stormwater discharges.

Regulated Project A land development project that exceeds the thresholds in Municipal Regional Permit Provision C.3.b. See Table 1-1 on p. 4.

Retention Practices such as infiltration, harvest and use, and evapotranspiration that reduce the amount of runoff discharged from a site.

Self-retaining area An area designed to retain runoff. Self-retaining areas may include graded depressions with landscaping or pervious pavements.

Self-treating area Natural, landscaped, or turf areas that drain overland off-site or to the storm drain system.

Source Control A facility or procedure to prevent pollutants from entering runoff.

Stormwater Control Plan A plan specifying and documenting permanent features and facilities to control pollutants and stormwater flows for the life of the project.

Stormwater Control Operation & Maintenance Plan A plan detailing operation and maintenance requirements for stormwater treatment and flow-control facilities incorporated into a project.

Storm Water Pollution Prevention Plan (SWPPP) A plan providing for temporary measures to control sediment and other pollutants during construction.

Treatment Removal of pollutants from runoff, typically by filtration or settling.

WEF Method A method for determining the minimum design volume of stormwater treatment facilities, described in *Urban Runoff Quality Management* (WEF/ASCE, 1998).

Water Board See **Regional Water Quality Control Board.**

Water Quality Volume (WQV) For stormwater treatment facilities that depend on detention to work, the volume of water that must be detained for a minimum specified **drawdown time** to achieve pollutant removal.

How to Use this Guidebook

Read the overview in Chapter One to get a general understanding of the requirements. Then follow the step-by-step instructions in Chapter Two to prepare your Stormwater Control Plan.

THIS *Guidebook* will help you ensure that your project complies with the C.3 requirements in the California Regional Water Quality Control Boards' Municipal Regional Permit. The requirements are complex and technical. Most applicants will require the assistance of a qualified civil engineer, architect, or landscape architect. Because every project is different, you should begin by scheduling a **pre-application meeting** with municipal planning staff.

To use the *Guidebook,* start by reviewing **Chapter One** to find out whether and how Provision C.3 applies to your project. Chapter One also provides an overview of the entire process of planning, design, construction, operation, and maintenance leading to compliance.

Then proceed to **Chapter Two** and follow the step-by-step guidance to prepare a Stormwater Control Plan for your site. The Stormwater Control Plan is submitted with your application for entitlements and development approvals.

Chapter Three, the Low Impact Development Design Guide, includes guidance for integrating Low Impact Development (LID) features and LID facilities (Integrated Management Practices, or IMPs) into your site design and landscape design, and instructions for preparing and presenting your design and calculations for treatment and flow controls. The calculations must be included in your Stormwater Control Plan to show compliance with permit requirements.

As you proceed with planning, design, and construction of your project, consult **Chapter Four** for design criteria and for tips for overseeing construction of LID features and facilities.

In **Chapter Five** you'll find a detailed description of the process for ensuring operation and maintenance of your treatment and flow control facilities over the life of the project. The chapter includes step-by-step instructions for preparing a Stormwater Facilities Operation and Maintenance Plan.

Local Requirements
Cities, towns, or the County may have requirements that differ from, or are in addition to, this county-wide Guidebook. See Appendix A for local requirements.

Throughout each Chapter, you'll find links to references and resources to help you understand the regulations, complete your Stormwater Control Plan, and design stormwater control measures for your project.

Construction-Phase Controls
Your Stormwater Control Plan is a separate document from the Storm Water Pollution Prevention Plan (SWPPP). A SWPPP provides for temporary measures to control sediment and other pollutants during construction. See the CCCWP website for information on requirements for construction-phase controls.

The most recent version of the *Guidebook,* including updates and errata, is on the Contra Costa Clean Water Program (CCCWP) website. The on-line *Guidebook* is in Adobe Acrobat format. If you are reading the *Guidebook* on an electronic device, you can use hyperlinks to navigate the document and—with an internet connection—also access various references. The hyperlinks are throughout the text, as well as in "References and Resources" sections and in the **Bibliography**. Some of these links (URLs) may be outdated. In that case, try entering portions of the title or other keywords into a web search.

► PLAN AHEAD TO AVOID THE THREE MOST COMMON MISTAKES

The most common (and costly) errors made by applicants for development approvals with respect to C.3 compliance are:

1. Not planning for C.3 compliance early enough. You should think about your strategy for C.3 compliance before completing a conceptual site design or sketching a layout of subdivision lots (Chapter 1).

2. Assuming underground or proprietary stormwater treatment facilities will be adequate for compliance. A complete Low Impact Development design, typically including bioretention facilities dispersed throughout the development, and integrated with the site plan and landscaping plan, is now required for nearly all projects (Chapter 2).

3. Not planning for periodic inspections and maintenance of treatment and flow-control facilities. Consider who will own and who will maintain the facilities in perpetuity and how they will obtain access, and identify which arrangements are acceptable to your municipality (Chapter 5).

Flood Controls
Implementation of the LID and Hydromodification (Flow Control) requirements in this *Guidebook* is separate from, and in addition to, flood control requirements that may apply to your project.

Chapter
1

Policies and Procedures

Determine if your development project must comply with the Municipal Regional Permit C.3 requirements, and review the steps to compliance.

Thresholds, Effective Dates, and Requirements

Table 1-1 (on the following page) summarizes requirements for development projects. Thresholds are based on the sum of **impervious area created or replaced** in connection with a project. The following may be excluded:

- Interior remodels and routine maintenance or repair such as replacement of a roof or exterior wall surface.
- Pavement resurfacing within the existing footprint. Generally, resurfacing is interpreted to mean work on existing pavement that does not involve changes to grading or drainage; however, municipal staff determines applicability on a case-by-case basis.
- Pervious pavements constructed to the criteria in this *Guidebook*.
- Swimming pools and other features that overflow and drain to the sanitary sewer.

► THE "50% RULE" FOR PROJECTS ON PREVIOUSLY DEVELOPED SITES

Projects on previously developed sites may also need to retrofit drainage to provide **treatment** of runoff from all impervious areas of the entire site. For sites creating or replacing a total amount of impervious area greater than the applicable threshold (Table 1-1):

- If the new project results in an alteration of **more than 50%** of the impervious surface of a previously existing development, and the existing development was not subject to stormwater treatment measures, then the entire project must be included in the treatment measure design.

- If the new project results in an alteration of **less than 50%** of the impervious surface of a previously existing development, and the existing development was not subject to stormwater treatment measures, then only the new and replaced impervious surface must be included in the treatment system design.

Municipal staff will determine case-by-case when and how the "50% rule" applies. Staff may use the original entitlement (discretionary approval) or approved building plans as a guide when calculating the impervious area of the "previously existing development".

TABLE 1-1. THRESHOLDS, EFFECTIVE DATES, AND REQUIREMENTS (in order of increasing threshold).[1]

	Impervious Area Threshold	Effective Date	Requirement
Non-Regulated Projects	All projects requiring municipal approvals or permits (includes single-family residences)	5/1/2010	As encouraged or directed by local staff, preserve or restore open space, riparian areas, and wetlands as project amenities, minimize land disturbance and impervious surfaces (especially parking lots) cluster structures and pavements, include micro-detention in landscaped and other areas, and direct runoff to vegetated areas. Use Bay-friendly landscaping features and techniques. Include Source Controls specified in Appendix D.
Non-Regulated Projects	Projects between 2,500 and 10,000 square feet requiring approvals or permits (includes single-family residences)	12/1/2012	Using the template in Appendix C, prepare and submit a Stormwater Control Plan for a Small Land Development Project. Implement one of four options: (1) Disperse runoff from some amount of roof or paved area to a vegetated area; (2) incorporate some amount of permeable pavement into your project; (3) include a cistern or rain barrel if allowed by your municipality, or (4) incorporate a bioretention facility or planter box.
Regulated Projects	Auto service facilities, gas stations, restaurants, and uncovered parking lots over 5,000 square feet	12/1/2011	Prepare and submit a Stormwater Control Plan as described in Chapter 2, including features and facilities to ensure runoff is treated before leaving the site. Use the LID Design Guide in Chapter 3, including sizing factors and criteria for "treatment only."
Regulated Projects	All projects between 10,000 square feet and one acre[2]	8/15/2006	
Regulated Projects	Projects an acre and larger, unless exempted. See text.[2]	10/14/2006	Where required, design LID features and facilities for hydromodification management (HM, flow-control) as well as stormwater treatment. Prepare and submit a Stormwater Control Plan as described in Chapter 2 and use the LID Design Guide in Chapter 3, including the sizing factors and criteria for "treatment and flow control." See Appendix E for additional information.

[1] Summary only. Requirements for any particular project are determined by your municipality.
[2] Detached single-family homes that are not part of a larger plan of development are specifically excluded. For road widening projects, count only the impervious area associated with new traffic lanes.

Compliance Process

Plan and design your stormwater controls integrally with the site planning and landscaping for your project, and coordinate your submittals at each stage so that your proposed **site plan, landscape plan, and stormwater compliance design are congruent.**

Applicants for development project approval follow these general steps to achieve C.3 compliance:

1. In a **pre-application meeting** with municipal staff, discuss C.3 compliance for your project—including how C.3 compliance review will be coordinated with review of site plans, architectural plans, landscaping plans, and tentative maps. Municipal staff may recommend you prepare and submit a preliminary site design prior to formally applying for planning and zoning approvals. Your preliminary site design should incorporate a conceptual plan for site drainage, including self-treating and self-retaining areas and the locations and footprints of any treatment and flow-control facilities. This additional up-front design effort will save time and avoid delays later in the review process.

2. **Review the instructions** in this *Guidebook* before you prepare your tentative map, preliminary site plan, drainage plan, architectural plan, and landscaping plan.

3. Prepare a **Stormwater Control Plan** and submit it with your application for development approvals (entitlements). Preparation of a complete and detailed Stormwater Control Plan is the key to cost-effective C.3 compliance and expeditious review of your project. Instructions for preparing a Stormwater Control Plan are in Chapters 2 and 3.

4. Following development approval, create your **detailed project design**, incorporating the features described in your Stormwater Control Plan. Follow the design criteria in Chapter 4.

5. In a **table on your construction plans**, list each stormwater control feature and facility and the plan sheet where it appears (see page 19).

6. Prepare a draft Stormwater Facility **Operation and Maintenance Plan** (Chapter 5) and submit it with your application for building permits. Execute legal documents assigning responsibility for operation and maintenance of stormwater facilities. Some municipalities require legal agreements and financial commitments for operation and maintenance be recorded prior to recordation of a final parcel map.

7. **Maintain stormwater facilities during construction** and following construction in accordance with required warranties.

8. During or following construction, submit a final Stormwater Facility Operation and Maintenance Plan and **formally transfer responsibility** for maintenance to the owner or permanent occupant.

9. The occupant or owner must **maintain the facilities in perpetuity**. Municipal staff will periodically verify the facilities are maintained.

C.3 Applicability and Entitlements

Provision C.3 compliance must be demonstrated at the time of application for a development project, including rezoning, tentative map, parcel map, conditional use permit, variance, site development review, design review, development agreement, or building permit.

All Regulated Projects require a Stormwater Control Plan showing the location and footprint of proposed impervious surfaces and of proposed stormwater facilities, and a description of how runoff will flow from impervious surfaces to the facilities. Instructions for preparing a Stormwater Control Plan are in Chapter Two.

► DEFINITION OF A "PROJECT"

When determining which Provision C.3 requirements apply, a "project" should be defined consistent with CEQA definitions of "project." That is, the "project" is the **whole of an action** that has the potential for adding or replacing, or resulting in the addition or replacement, of roofs, pavement, or other impervious surfaces and thereby resulting in increased flows and runoff pollutants. "Whole of an action" means the project may not be segmented or piecemealed into small parts if the effect is to reduce the quantity of impervious area for any part to below the C.3 threshold.

CEQA

See the Governor's Office of Planning and Research Technical Advisory, *CEQA and Low Impact Development Stormwater Design*, for guidance which will help coordinate C.3 and CEQA reviews.

The C.3 project scope includes any impervious surfaces added or replaced within the adjacent public right-of-way in connection with the project.

► GRANDFATHERING

Regulated Projects for which building or grading permits are issued after January 1, 2016 must include LID treatment measures. Criteria in the current edition of this *Guidebook* apply. Regulated Projects approved prior to that date, and which have approved Stormwater Control Plans, may be issued building permits and allowed to proceed. Regulated Projects with vesting tentative maps, regardless of the date of map approval, may be issued building permits to proceed with development in substantial compliance with the ordinance, policies, and standards in effect at the time the vesting tentative map was approved or conditionally approved, in accordance with California law.

This "grandfathering" applies only to the specific discretionary approval that was the subject of the original application. Subsequent applications for further approvals constitute a "project" for the purposes of C.3. If those subsequent approvals or entitlements cover specific locations, modes, or designs for addition or replacement of roofs, pavement, or other impervious surfaces, and if the impervious area created or replaced is in excess of the applicable thresholds, then the C.3 requirements will apply to those areas of the project covered by the subsequent approval or entitlement.

Consider for example an application for a subdivision tentative map which receives final discretionary approval prior to the C.3 start dates. The project may be exempt from Provision C.3; however, if the project proponent later applies for discretionary approval of specific locations, modes, or designs of paving and structures, then C.3 requirements would apply to those improvements.

► PROVISION C.3 COMPLIANCE REQUIREMENTS FOR SUBDIVISION MAPS

In general, it is recommended **stormwater treatment facilities not be located on individual single-family residential lots**, particularly when those facilities manage runoff from other lots, from streets, or from common areas. However, local requirements vary. A better alternative is to locate stormwater facilities on one or more separate, jointly owned parcels.

Applications for tentative maps may be required to include the following:

- Delineation of separate parcels upon which stormwater facilities will be located.
- Dedication of easements and inclusion of provisions related to provision C.3 compliance.
- Execution of, or commitment to execute later, a covenant running with the land and agreement for residents of the subdivision to operate and maintain stormwater facilities.
- Conditions, Covenants, and Restrictions (CC&Rs) recorded against the subdivision to establish reciprocal obligations of the lot owners to maintain stormwater facilities.

If a tentative map approval would potentially entitle future owners of individual parcels to construct new or replaced impervious area which, in aggregate, could exceed the thresholds in Table 1-1, then the applicant must take steps to ensure C.3 requirements can and will be implemented as the subdivision is built out.

If the tentative map application does not include plans for site improvements, the applicant should nevertheless identify the type, size, location, and final ownership of stormwater treatment and flow-control facilities adequate to serve new roadways and any common areas, and to also manage runoff from an expected reasonable estimate of the square footage of future roofs, driveways, and other impervious surfaces on each individual lot. The municipality may condition approval of the map on implementation of stormwater treatment measures in compliance with Provision C.3 when construction occurs on the individual lots. This condition may be enforced by a grant deed of development rights or by a development agreement.

If a municipality deems it necessary, the future impervious area of one or more lots may be limited by a deed restriction. This might be necessary when a project is exempted from one or all C.3 provisions because the total impervious area is below a threshold, or to ensure runoff from impervious areas added after the project is approved does not overload a stormwater treatment and flow-control facility.

Local Requirements

Cities, towns, or the County may have requirements that differ from, or are in addition to, this countywide Guidebook. See Appendix A for local requirements.

Subdivision maps should dedicate an **"open space easement, as defined by Government Code Section 51075,"** to suitably restrict the future building of structures at each stormwater facility location.

See the *Policy for C.3 Compliance for Subdivisions* on the Contra Costa Clean Water Program's C.3 web page. After consulting with local planning staff, applicants for subdivision approvals will propose one of the following four options, depending on project characteristics and local policies:

1. Show the sum of future impervious areas to be created or replaced on all parcels could not exceed the applicable C.3 thresholds shown in Table 1-1.

2. Show that, for each and every lot, the intended use can be achieved with a design which disperses runoff from roofs, driveways, streets, and other impervious areas to self-retaining pervious areas, using the criteria in Chapter 3 of this *Guidebook*.

3. Prepare improvement plans showing drainage to treatment and/or flow-control facilities designed in accordance with this *Guidebook,* and commit to constructing the facilities prior to transferring the lots.

4. Prepare improvement plans showing drainage to treatment and/or flow-control facilities designed in accordance with this *Guidebook*, and provide appropriate legal instruments to ensure the proposed facilities will be constructed and maintained by subsequent owners.

For the option selected, municipal staff will determine the appropriate conditions of approval, easements, deed restrictions, or other legal instruments necessary to assure future compliance. In general, when new streets and common areas are constructed, facilities to treat runoff from those new impervious areas must be constructed concurrently, and agreements for the operation and maintenance of those facilities must be executed timely.

► PHASED PROJECTS

Municipal staff may require, as part of an application for approval of a phased development project, a conceptual or master Stormwater Control Plan which describes and illustrates, in broad outline, how the drainage for the project will comply with the Provision C.3 requirements. The level of detail in the conceptual or master Stormwater Control Plan should be consistent with the scope and level of detail of the development approval being considered. The conceptual or master Stormwater Control Plan should specify that a more detailed Stormwater Control Plan for each later phase or portion of the project will be submitted with subsequent applications for discretionary approvals.

Hydromodification Management Requirements

As shown in Table 1-1, in addition to incorporating treatment controls, projects creating or replacing an acre or more of impervious area—unless exempted—must also provide flow control so post-project runoff does not exceed estimated pre-project rates and durations. Additional information on hydromodification management (HM) is in Appendix E.

► EXEMPTIONS

Projects may be exempted from HM requirements if any of the following apply:

- The post-project impervious area is less than, or the same as, the pre-project impervious area. (At the discretion of municipal staff, on HM projects applicants may provide treatment-only controls for an impervious square footage that is less than or equal to the pre-project impervious square footage. See Appendix E.)
- The project is located in a catchment that drains to pipes or hardened channels, or tidally influenced channels that extend continuously to the Bay, Delta, or a flow-controlled reservoir.
- The project is located in a catchment or subwatershed that is highly developed (that is, 70% or more impervious).

The Contra Costa Clean Water Program is developing maps of exempt catchments. While these maps are being developed (completion is anticipated by 2018), applicants should consult with municipal staff regarding potential exemptions.

► COMPLIANCE WITH HM REQUIREMENTS

Projects subject to the Hydromodification Management (HM) compliance may employ one of the following options:

1. Use the LID Design Guide in Chapter 3 **to meet both treatment and flow-control requirements.**

2. Use a continuous simulation hydrologic computer model to simulate pre-project and post-project runoff. Show that post-project stormwater rates and durations match pre-project discharge rates and durations from 10 percent of the pre-project 2-year peak flow up to the pre-project 10-year peak flow. The post-project flow-duration curve shall not deviate above the pre-project flow duration curve by more than 10 percent over 10 percent of the length of the curve corresponding to this range of flows.

To use the second option, applicants must generally retain a qualified hydrologist experienced in such modeling, and also reimburse the jurisdiction's costs for retaining another qualified hydrologist to review the modeling report.

Offsite Compliance Options for Runoff Treatment

Experience has shown implementation of LID facilities, using the guidance in Chapter 3, is feasible on nearly all development sites. In lieu of incorporating facilities to treat runoff from impervious areas at the development project site, an applicant may propose a secondary project that will treat runoff from an equivalent amount of existing impervious area with LID (i.e., retrofit with LID) at another location within the same watershed.

To be considered, the secondary project must include construction, operation, and maintenance of facilities that meet the criteria in Chapter 3. Those facilities must treat runoff from an amount of impervious surface equivalent to, or greater than, the impervious surface that would be subject to requirements at the project location.

An applicant may propose to combine on-site and off-site facilities to add up to the equivalent amount of impervious area as would be required for only on-site treatment. **Drainage from equivalent existing impervious square footage on an adjacent parcel or public or private street may be used to offset drainage from on-site square footage that would be difficult or expensive to route to treatment.** An applicant may also propose to share in a larger project and be credited for a proportional amount of the impervious area for which runoff is treated by that project.

Consideration or acceptance of such proposals is at the discretion of the local municipality.

Chapter

2

Preparing Your Stormwater Control Plan

Step-by-step documentation of compliance for Regulated Projects

Your Stormwater Control Plan for a Regulated Project will demonstrate your project complies with all applicable requirements in the stormwater NPDES permit to:

- minimize imperviousness and reduce runoff
- slow runoff rates and retain or detain stormwater
- incorporate required source controls
- treat stormwater prior to discharge from the site
- control runoff rates and durations if required
- provide for operation and maintenance of stormwater facilities

The Stormwater Control Plan must be submitted with your application for discretionary approvals and must have sufficient detail to ensure the stormwater design, site plan, and landscaping plan are congruent.

A complete and thorough Stormwater Control Plan will facilitate quicker review and fewer cycles of review. Every Contra Costa municipality requires a Stormwater Control Plan for every applicable project.

Your Stormwater Control Plan will consist of a report and an exhibit.

Municipal staff may use the checklist on the following page to evaluate your Plan.

STORMWATER CONTROL PLAN CHECKLIST

CONTENTS OF EXHIBIT

Show all the following on drawings:

- ❒ Existing natural hydrologic features (depressions, watercourses, relatively undisturbed areas) and significant natural resources.
- ❒ Existing and proposed site drainage network and connections to drainage off-site.
- ❒ Layout of buildings, pavement, and landscaped areas.
- ❒ Impervious areas proposed (roof, plaza/sidewalk, and streets/parking) and area of each.
- ❒ Entire site divided into separate Drainage Management Areas, with each DMA identified as self-treating, self-retaining (zero-discharge), draining to a self-retaining area, or draining to an IMP. Each DMA has one surface type (roof, paving, or landscape), is labeled, and square footage noted.
- ❒ Locations, footprints, and square footage of proposed treatment and flow-control facilities.
- ❒ Potential pollutant source areas, including refuse areas, outdoor work and storage areas, etc. listed in Appendix C and corresponding required source controls.

CONTENTS OF REPORT

Include all the following in a report:

- ❒ Narrative analysis or description of site features and conditions that constrain, or provide opportunities for, stormwater control. Include soil types (including Hydrologic Soil Group), slopes, and depth to groundwater.
- ❒ Narrative description of site design characteristics that protect natural resources.
- ❒ Narrative description and/or tabulation of site design characteristics, building features, and pavement selections that minimize imperviousness of the site.
- ❒ Tabulation of DMAs, including self-treating areas, self-retaining areas, areas draining to self-retaining areas, and areas tributary to Integrated Management Practices (IMPs), in the format shown in Chapter 4. Output from the IMP Sizing Calculator may be used.
- ❒ Sketches and/or descriptions showing there is sufficient hydraulic head to route runoff into, through, and from each IMP to an approved discharge point.
- ❒ A table of identified pollutant sources and for each source, the source control measure(s) used to reduce pollutants to the maximum extent practicable. See Appendix D.
- ❒ General maintenance requirements for infiltration, treatment, and flow-control facilities.
- ❒ Means by which facility maintenance will be financed and implemented in perpetuity.
- ❒ Statement accepting responsibility for interim operation & maintenance of facilities.
- ❒ Identification of any conflicts with codes or requirements or other anticipated obstacles to implementing the Stormwater Control Plan.
- ❒ Construction Plan C.3 Checklist.
- ❒ Certification by a civil engineer, architect, and landscape architect.
- ❒ Appendix: Compliance with flow-control requirements
(if using an HM compliance option other than the design guidance in Chapter 3).

A template for a Stormwater Control Plan, in MS Word format, can be found on at the Contra Costa Clean Water Program's C.3 web pages. Follow the instructions in this *Guidebook* while using the template.

Project Data

The table in the Stormwater Control Plan template is shown below for reference. The table is formatted to facilitate compilation of the municipalities' annual reports.

TABLE 2-1. Format for reporting project data

Project Name/Number	
Application Submittal Date	[to be verified by municipal staff]
Project Location	[Street Address if available, or intersection and/or APN]
Name of Developer	
Project Phase No.	[If project is being constructed in phases, indicate the phase number. If not, enter "NA"]
Project Type and Description	[Example entries: "5-story office building," "Residential with 160 single-family homes with five 4-story buildings to contain 200 condominiums," "100-unit, 2-story shopping mall," "mixed use retail and residential development (apartments)", "Industrial warehouse."]
Project Watershed	[Request from municipal staff]
Total Project Site Area (acres)	
Total Area of Land Disturbed (acres)	
Total New Impervious Surface Area (sq. ft.)	
Total Replaced Impervious Surface Area	
Total Pre-Project Impervious Surface Area	
Total Post-Project Impervious Surface Area	
50% Rule[*]	[Applies or Doesn't Apply]
Project Density	[State DU/Acre and/or Floor Area Ratio]
Applicable Special Project Categories [Complete even if all treatment is LID]	[State A, B, C, or none. If "C", state basis for location credits, density, and parking credits.]
Percent LID and non-LID treatment	[State totals for project and provide details under "Documentation of Drainage Design."]
HMP Compliance [†]	State "applies" or explain reason for exemption.

* 50% rule applies if: Total Replaced Impervious Surface Area > 0.5 × Pre-Project Impervious Surface Area
† HMP applies if: (Total New Impervious Surface Area + Total Replaced Impervious Surface Area) ≥ 1 acre unless exempt. See page 9.

To determine replaced impervious surface area, it is necessary to overlay a drawing of the existing, pre-project impervious areas with the proposed site plan and evaluate the square footage of existing impervious areas that will be covered with new impervious surfaces. See the example in Figure 2-1.

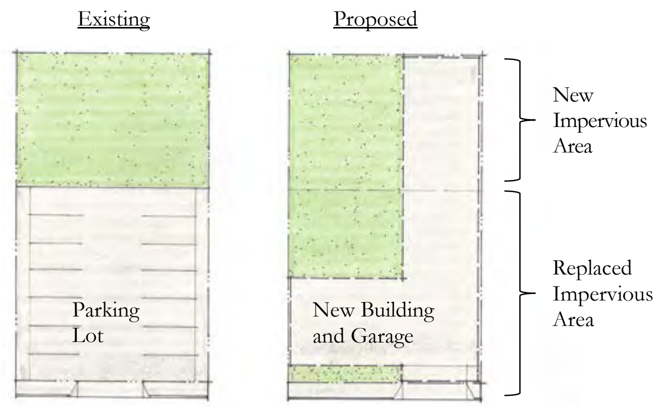

FIGURE 2-1. ILLUSTRATION OF REPLACED Impervious Area. The proposed building replaces impervious area on the existing parking lot. It also creates new impervious area. To complete the Project Data Table, measure, calculate, and enter the total new impervious area, total replaced impervious area, the pre-project impervious area, and the post-project impervious area.

Setting

Prepare a brief narrative placing the project in context. Discuss, as appropriate, the site location, division of parcels, planned land uses, zoning, setback and open space requirements, project phasing, number of residential units or square footage of office or retail, parking requirements, neighborhood character, project design objectives (for example LEED certification), and other notable project characteristics.

Include a vicinity map.

Existing Features and Site Conditions

In a well-organized narrative, describe:

- Project site size, shape, and existing topography, including the general direction of surface drainage, local high or low points or depressions, any outcrops or other significant geologic features, and any contiguous natural areas, wetlands, watercourses, seeps, or springs.
- Existing land use and current or proposed zoning, including requirements for setbacks and open space.
- Soil types (including hydrologic soil groups) and depth to groundwater.
- Existing and proposed site drainage, including connections to the municipal storm drain system. Describe any drainage from adjacent areas that runs on to the project area.
- Existing vegetative cover and impervious areas, if any.

Identify Constraints & Opportunities

Review the information compiled in Step 1. Identify the principal constraints on site design and selection of treatment and flow-control facilities as well as opportunities to reduce imperviousness and incorporate facilities into the site and landscape design. For example, **constraints** might include impermeable soils, high groundwater, groundwater pollution or contaminated soils, steep slopes, geotechnical instability, high-intensity land use, heavy pedestrian or vehicular traffic, utility locations, or safety concerns. **Opportunities** might include existing natural areas, low areas, oddly configured or otherwise unbuildable parcels, easements and landscape amenities including open space and buffers (which can double as locations for bioretention facilities), and differences in elevation (which can provide hydraulic head).

In your narrative, describe site opportunities and constraints. This narrative will help you as you proceed with LID design and explain your design decisions to others.

Low Impact Development Design Strategies

Use the Low Impact Development Design Guide (Chapter 3) to analyze your project for LID, design and document drainage, and specify preliminary design details for integrated management practices.

After analyzing your project for LID (see page 24), prepare a narrative overview of your design and how your design decisions:

- Optimize the site layout
- Use pervious surfaces where appropriate
- Disperse runoff to pervious (self-retaining) areas
- Drain impervious surfaces to bioretention facilities or other Integrated Management Practices (IMPs).

Documentation of Drainage Design

Chapter 3 includes calculation procedures and instructions for using the IMP Sizing Calculator to organize and present your calculations.

As shown in the checklist (page 12), your **Exhibit** must show:

- **The entire site divided into separate Drainage Management Areas (DMAs), with each area identified as self-treating, self-retaining, draining to a self-retaining area, or draining to an IMP.** Each area should be clearly marked with a unique identifier.
- For each drainage area, the types and square footage of impervious area proposed.

- Proposed locations and sizes of treatment and flow-control facilities. Each facility should be clearly marked with a unique identifier.

It's best to use the grading plan (screened) as background for the Exhibit. It may also be appropriate to show portions of the roofing plan (also screened) wherever roof ridges define Drainage Management Areas (DMAs).

Your Stormwater Control Plan **report** must include:

- Tabulation of proposed self-treating areas, self-retaining areas, areas draining to self-retaining areas, and areas draining to IMPs, and the corresponding IMPs identified on the Exhibit.

- Calculations, which can be prepared using the IMP Sizing Calculator, showing the minimum square footage required and proposed square footage for each IMP. If flow-control requirements apply, the required storage volume or volumes, and the diameters of each underdrain orifice, must also be shown.

Your Stormwater Control Plan must also include preliminary design information for each bioretention facility or other IMP. Depending on the complexity of the project and the stage of the design, reviewers may expect to see renderings or details, in plan and/or cross section, showing how the IMPs will be integrated into the site. This may include transitions between the flat, planted surface of bioretention facilities and the adjacent buildings, roadways, sidewalks, or landscapes, and planting plans consistent with the active or inactive uses of the planted bioretention area.

See Chapter 3 for design guidance and design criteria.

Also include in your Stormwater Control Plan report:

- A narrative briefly describing each DMA, its drainage, and where drainage will be directed.

- A narrative briefly describing each IMP. Include any special characteristics or features distinct from the design sheets in Chapter 3.

Group and consolidate descriptions, or provide additional detail, as necessary to help the reviewer understand your drainage design.

Source Control Measures

Some everyday activities – such as trash recycling/disposal and washing vehicles and equipment – generate pollutants that tend to find their way into storm drains. These pollutants can be minimized by applying source control Best Management Practices (BMPs).

Source control BMPs include **permanent**, structural features that may be required in your project plans—such as roofs over and berms around trash and recycling areas—and **operational** BMPs, such as regular sweeping and "housekeeping," that must be implemented by the site's occupant or user.

Use the following procedure to specify source control BMPs for your site:

Identify Pollutant Sources. Review the first column in the Pollutant Sources/Source Control Checklist (Appendix D). Check off the potential sources of pollutants that apply to your site.

Note Locations on Stormwater Control Plan Exhibit. Note the corresponding requirements listed in Column 2 of the Pollutant Sources/Source Control Checklist (Appendix D). Show the location of each pollutant source and each permanent source control BMP in your Stormwater Control Plan Exhibit.

Prepare a Table and Narrative. Check off the corresponding requirements listed in Column 3 in the Pollutant Sources/Source Control Checklist (Appendix D). Now, create a table using the format in Table 2-2. In the left column, list each potential source on your site (from Appendix D, Column 1). In the middle column, list the corresponding permanent, structural BMPs (from Columns 2 and 3, Appendix D) used to prevent pollutants from entering runoff. Accompany this table with a narrative that explains any special features, materials, or methods of construction that will be used to implement these permanent, structural BMPs.

Identify Operational Source Control BMPs. To complete your table, refer once again to the Pollutant Sources/Source Control Checklist (Appendix D, Column 4). List in the right column of your table the operational BMPs that should be implemented as long as the anticipated activities continue at the site. The local stormwater ordinance requires that these BMPs be implemented; the same BMPs may also be required as a condition of a use permit or other revocable discretionary approval for use of the site.

References and Resources

- Appendix D, Stormwater Pollutant Sources/Source Control Checklist
- Municipal Regional Permit Provision C.3.c.
- Bay-Friendly Landscape Guidelines (Stopwaste.org, 2008)
- *Start at the Source*, Section 6.7: Details, Outdoor Work Areas

TABLE 2-2. Format for table of permanent and operational source control measures.

Potential source of runoff pollutants	*Permanent source control BMPs*	*Operational source control BMPs*

Stormwater Facility Maintenance

As required by MRP Provision C.3.h, your local municipality will periodically verify that treatment and flow-control facilities on your site are maintained and continue to operate as designed.

To make this possible, your municipality will require that you include in your Stormwater Control Plan:

1. A means to finance and implement facility maintenance in perpetuity.

2. Acceptance of responsibility for maintenance from the time the facilities are constructed until responsibility for operation and maintenance is legally transferred. A warranty covering a period following construction may also be required.

3. An outline of general maintenance requirements for the treatment and flow-control facilities you have selected.

Your local municipality will also require that you prepare and submit a detailed Stormwater Facilities Operation and Maintenance Plan that sets forth a maintenance schedule for each of the treatment and flow-control facilities built on your site. An agreement assigning responsibility for maintenance and providing for inspections and certification may also be required.

Details of these requirements, and instructions for preparing a Stormwater Facilities Operation and Maintenance Plan, are in Chapter 5.

References and Resources

- *Chapter 5*
- *Model Stormwater Ordinance (CCCWP, 2012)*
- Model Operation and Maintenance Agreements

Construction Plan C.3 Checklist

When you submit construction plans for City review and approval, the plan checker will compare that submittal with your Stormwater Control Plan. By creating a Construction Plan C.3 Checklist for your project, you will facilitate the plan checker's comparison and speed review of your project.

Here's how:

1. Create a table similar to Table 2-3. Number and list each measure or BMP you have specified in your Stormwater Control Plan in Columns

1 and 2 of the table. Leave Column 3 blank. Incorporate the table into your Stormwater Control Plan.

2. When you submit construction plans, **duplicate the table** (by photocopy or electronically). Now fill in Column 3, identifying the plan sheets where the BMPs are shown. List all plan sheets on which the BMP appears. Submit the updated table with your construction plans.

Note that the updated table—or Construction Plan C.3 Checklist—is **only a reference tool** to facilitate comparison of the construction plans to your Stormwater Control Plan. Local municipal staff can advise you regarding the process required to propose changes to the approved Stormwater Control Plan.

See Chapter 3 for details of IMP construction to be included in construction plans.

TABLE 2-3. Format for Construction Plan C.3 Checklist.

Stormwater Control Plan Page #	*BMP Description*	*See Plan Sheet #s*

Certification

Your local municipality may require that your Stormwater Control Plan be certified by an architect, landscape architect, or civil engineer. See Appendix A.

Your certification should state: "The selection, sizing, and preliminary design of stormwater treatment and other control measures in this plan meet the requirements of Regional Water Quality Control Board Order R2-2015-0049."

Stormwater Control Plan Report Sample Outline

I. Project Data (table)

II. Setting

   A. Project Name, Location, Description

   B. Existing Site Features and Conditions

   C. Opportunities and Constraints for Stormwater Control

III. Low Impact Development Design Strategies

   A. Optimization of site layout

      (1) Limitation of development envelope

      (2) Preservation of natural drainage features

      (3) Setbacks from creeks, wetlands, and riparian habitats

      (4) Minimization of imperviousness

      (5) Use of drainage as a design element

   B. Use of Permeable Pavements

   C. Dispersal of Runoff to Pervious (Self-Retaining) Areas

   D. Integrated Management Practices

IV. Documentation of Drainage Design

   A. Description of each Drainage Management Area

   B. Tabulation and Sizing Calculations

V. Source Control Measures

   A. Description of site activities and potential sources of pollutants

   B. Table showing sources, permanent source controls, and operational source controls

   C. Features, Materials, and Construction of Source Control BMPs

VI. Stormwater Facility Maintenance

A. Ownership and responsibility for maintenance in perpetuity.

(1) Commitment to execute any necessary agreements and/or annex into a fee mechanism, per local requirements.

(2) Statement accepting responsibility for operation and maintenance of facilities until that responsibility is formally transferred.

B. Summary of maintenance requirements for each stormwater facility.

VII. Construction Plan C.3 Checklist

VIII. Certifications

Attachment: Stormwater Control Plan Exhibit

Appendix: Compliance with Flow-Control (Hydrograph Modification) requirements (if IMPs are not used to achieve flow control).

Stormwater Control Plan Template

A template with the above format and headings is available on the CCCWP website.

Example Stormwater Control Plans

Example Stormwater Control Plans are available on the CCCWP website.

Chapter
3

Low Impact Development Site Design Guide

Guidance for designing your site to include LID site drainage, stormwater treatment facilities, and flow-control facilities—and for documenting your site's compliance

Your Stormwater Control Plan must include an exhibit and calculations showing the site drainage and proposed treatment and flow-control facilities meet the criteria in this Guidebook.

This will require that you delineate the entire site into discrete Drainage Management Areas (DMAs), and for each DMA, characterize the square footage, surface type, and routing of the drainage. You will also need to show the locations, sizes, and types of proposed stormwater treatment and flow-control facilities.

This may be accomplished in two steps:

1. **Analyze your project** and identify and select options for meeting LID requirements and runoff treatment requirements—and flow-control requirements, if they apply.

2. **Design and document drainage** for the whole site and document how that design meets this Guidebook's stormwater treatment and flow-control criteria.

For most projects, you will need to iterate these two steps to converge on a workable design that complements site conditions and project objectives.

Before beginning your LID design, first determine which requirements apply to your site. See Chapter 1. Determine whether the 50% rule applies, and whether you will need to incorporate hydromodification management (flow control, or HM). The guidance in this chapter will enable you to size stormwater facilities (Integrated Management Practices, or IMPs) for treatment-only or for treatment plus HM.

Analyze Your Project for LID

Conceptually, there are four LID strategies for managing runoff from roofs and paving:

1. **Optimize the site layout** by preserving natural drainage features and designing buildings and circulation to minimize the amount of impervious surface.

2. **Use pervious surfaces** such as turf, gravel, or pervious pavement—or use surfaces that retain rainfall, such as "green roofs."

3. **Disperse runoff** from impervious surfaces on to adjacent pervious surfaces (e.g., direct a roof downspout to disperse runoff onto a lawn).

4. Drain impervious surfaces to engineered **Integrated Management Practices** (IMPs), which are typically bioretention facilities, sometimes augmented with additional storage. Other IMPs include flow-through planters and dry wells, which may be used in specific situations. IMPs evapotranspirate some runoff, infiltrate runoff to groundwater, and/or percolate runoff through engineered soil and allow it to drain away slowly.

With forethought in design, the four LID strategies can provide multiple, complementary benefits to your development. Pervious surfaces reduce heat island effects and temperature extremes. Landscaping improves air quality, creates a better place to live or work, and upgrades value for rental or sale. Retaining natural hydrology helps preserve and enhance the natural character of the area. LID drainage design can also conserve water and reduce the need for drainage infrastructure.

A combination of two or more strategies may work best for your project. Table 3-1 includes ideas for applying LID strategies to site conditions and types of development. It may be useful as a starting point for thinking through application of the four strategies.

► OPTIMIZE THE SITE LAYOUT

To minimize stormwater-related impacts, apply the following design principles to the layout of newly developed and redeveloped sites:

- Define the development envelope and protected areas, identifying areas that are most suitable for development and areas that should be left undisturbed.

- Set back development from creeks, wetlands, and riparian habitats.

- Preserve significant trees.

Where possible, conform the site layout along natural landforms, avoid excessive grading and disturbance of vegetation and soils, and replicate the site's natural drainage patterns.

Concentrate development on portions of the site with less permeable soils, and preserve areas that can promote infiltration.

For all types of development, **limit overall coverage** of paving and roofs. This can be accomplished by designing compact, taller structures, narrower and shorter streets and sidewalks, smaller parking lots (fewer stalls, smaller stalls, and more efficient lanes), and indoor or underground parking. Examine site layout and circulation patterns and identify areas where landscaping can be substituted for pavement.

TABLE 3-1. Ideas for Runoff Management

Site Features/Issues	*Optimize Site Layout*	*Pervious Pavement*	*Green Roof*	*Disperse Runoff to Landscape*	*Bioretention Facility*	*Flow-through Planter*	*Cistern + bioretention*	*Bioretention + Vault*	*Dry Well*
Clayey native soils	✓		✓	✓	✓	✓	✓	✓	
Permeable native soils	✓	✓	✓	✓	✓	✓			✓
Very steep slopes	✓		✓			✓			
Shallow depth to groundwater	✓		✓			✓			
Roof drainage	✓			✓	✓	✓	✓		✓
Parking lots	✓	✓		✓	✓			✓	✓
Extensive landscaping	✓			✓	✓				
Densely developed sites with limited space/landscape		✓	✓			✓	✓	✓	✓

Detain and retain runoff throughout the site. On flatter sites, it typically works best to intersperse landscaped areas and IMPs among the buildings and paving. On hillside sites, drainage from upper areas may be collected in conventional catch basins and piped to landscaped areas and IMPs in lower areas. Or use low retaining walls to create terraces that can accommodate IMPs. Wherever possible, direct drainage from landscaped slopes offsite and not to IMPs.

Use drainage as a design element. Use depressed landscape areas, vegetated buffers, and bioretention facilities as amenities and focal points within the site and landscape design. Bioretention facilities can be almost any shape and should be located at low points.

► USE PERVIOUS SURFACES

Consider a green roof. Green roofs are growing (in popularity), and many have been built in the Bay Area in the last few years. Benefits include longer roof life, lower heating and cooling costs, and better sound insulation, in addition to air quality and water quality benefits.

However, initial costs are higher than for conventional roofs, and green roofs may add to the complexity of permitting, financing, and insuring new buildings. For C.3 compliance purposes, green roofs are considered not to produce increased runoff or runoff pollutants (that is, any runoff from a green roof requires no further treatment or detention) if the media is sufficiently deep to store an inch of rainfall (typically, a 3-inch media depth is sufficient) and also supports long-term health of vegetation.

Consider permeable pavements and surface treatments. Inventory paved areas on your preliminary site plan. Identify where permeable pavements, such as crushed aggregate, turf block, unit pavers, pervious concrete, or pervious asphalt could be substituted for impervious concrete or asphalt paving. Pervious pavement generally costs more and requires a deep base course for structural stability, especially in clay soils. Installation on slopes requires special design features. Depending on the site, the additional costs may be partially offset by reduced needs for drainage structures and for stormwater treatment and flow control. For C.3 compliance purposes, pervious pavements, when designed and constructed according to the criteria in Chapter 4, are considered to not produce increased runoff or runoff pollutants.

► DISPERSE RUNOFF TO ADJACENT PERVIOUS AREAS

Look for opportunities to direct runoff from impervious areas to adjacent landscaping ("self-retaining" or "zero-runoff" areas). The design, including slopes and soils, must reflect a reasonable expectation that an inch of rainfall will soak into the soil and produce no runoff. For example, a lawn or garden depressed 3-4" below surrounding walkways or driveways provides a simple but functional landscape design element.

For sites subject to stormwater treatment requirements only, a 2:1 maximum ratio of impervious to pervious area is acceptable. If flow-control requirements apply, the impervious-to-pervious ratio must be limited to 1:1. Be sure soils will drain adequately.

Under some circumstances, it may be allowable to direct runoff from impervious areas to pervious pavement (for example, from roof downspouts to a parking lot paved with crushed aggregate or turf block). The pore volume of pavement and base course must be enough to retain an inch of rainfall, including runoff from the tributary impervious area. The slopes and soils must be compatible with infiltrating that volume without producing runoff. This solution is most practical on flat sites with permeable soils.

References and Resources

- *Green Roofs for Stormwater Runoff Control* (USEPA, 2009a)
- *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act.* (USEPA, 2009b)
- *Porous Pavements* (Ferguson, 2005)
- *Green Roof Minimum Specifications* (BASMAA, 2011b)

► DIRECT RUNOFF TO BIORETENTION OR OTHER IMPS

The CCCWP has developed design criteria (See Chapter 4) for the following IMPs:

- **Bioretention facilities**, which can be configured to integrate with your landscape design.
- **Flow-through planters**, which can be used on elevated plazas or other circumstances where infiltration to native soils is not possible.
- **Cistern + bioretention** facilities, which use an upstream storage volume and metered flow to reduce the required square footage of a bioretention facility or flow-through planter.
- **Bioretention + vault** facilities, which capture a volume downstream of bioretention and meter outflows.
- **Dry wells** and other infiltration facilities, which can be used only where soils are permeable. See other restrictions in Appendix E.

Table 3-4 on page 36 shows the conditions under which each IMP may be used.

Finding the right location for bioretention or other facilities on your site involves a careful and creative integration of several factors:

- Put bioretention facilities in **high-visibility, well-trafficked areas** and make them a focal point in the landscape.

- Where possible, design site drainage so **only impervious roofs and pavement** drain to IMPs. This yields a simpler, more efficient design and also helps protect IMPs from becoming clogged by sediment.

- Place bioretention inlet elevations, and the top of the engineered soil layer, as high as possible (typically 6" to 12" below the surrounding ground surface elevation). Avoid walls and steep slopes adjacent to the bioretention soil surface. On flatter sites, **keep drainage runs short and use surface drainage**—sheet flow, valley gutters, or trench drains—to convey runoff from paved areas to the bioretention facility. It may be necessary, or helpful, to pipe runoff from roof gutters all the way to the facility.

- To make the most efficient use of the site and to maximize aesthetic value, **integrate IMPs with site landscaping**. Many local zoning codes may require landscape setbacks or buffers, or may specify that a minimum portion of the site be landscaped. It may be possible to locate some or all of your site's treatment and flow-control facilities within this same area, or within utility easements or other non-buildable areas.

- Bioretention facilities must be **level or nearly level** all the way around, so that the entire soil surface is wetted. Linear bioretention facilities (swales) must be designed with their opposite sides at the same elevation. In the linear direction, slopes must be terraced or provided with check dams.

- For effective, low-maintenance operation, **locate facilities so drainage into and out of the device is by gravity flow.** Pumped systems are feasible, but are expensive, require more maintenance, are prone to untimely failure, and can cause mosquito control problems. Most IMPs require 2 feet or more of **head**.

- Bioretention facilities and other IMPs require excavations three or more feet deep, which can **conflict with underground utilities**.

- If the property is being subdivided now or in the future, the facility should be in a **common, accessible area.** In particular, avoid locating facilities on private residential lots. Even if the facility will serve only one site owner or operator, make sure the facility is located for ready access by inspectors from the local municipality and the Contra Costa Mosquito and Vector Control District.

- The facility must be accessible to equipment needed for its maintenance. Bioretention facilities will typically need access for the same types of equipment used for landscape maintenance.

To complete your analysis, include in your Stormwater Control Plan a brief **narrative** documenting the site layout and site design decisions you made. This will provide background and context for how your design meets the quantitative LID criteria.

References and Resources

- *Central Coast Low Impact Development Center*
- *Start at the Source* (BASMAA, 1999)
- *Model Low Impact Development Strategies for Big Box Retail Stores* (King County, WA, 2007)
- *Urban Street Stormwater Guide* (National Association of City Transportation Officials, 2017)

Develop and Document Your LID Drainage Design

The CCCWP's **design documentation procedure** begins with careful delineation of pervious areas and impervious areas (including roofs) throughout the site. The procedure accounts for how runoff from each delineated area is managed. For areas draining to IMPs, the procedure ensures each IMP is appropriately sized.

The procedure results in a space-efficient, cost-efficient LID design for meeting C.3 requirements on most residential and commercial/industrial developments. The procedure arranges documentation of drainage design and IMP sizing in a consistent format for presentation and review.

This procedure is intended to facilitate, not substitute for, creative interplay among site design, landscape design, and drainage design. **Several iterations may be needed** to optimize your drainage design as well as aesthetics, circulation, and use of available area for your site.

You should be able to complete the needed calculations using only the project's site development plan. If your project requires hydromodification management (flow control or HM), you will also need to know the hydrologic soil group (A, B, C, or D) of site soils, and mean annual precipitation at the project location. Mean annual precipitation at locations in Contra Costa County can be determined using isohyetal maps accessible from the CCCWP's C.3 web page.

The CCCWP has created an **IMP Sizing Calculator** to facilitate the iterative calculations needed to create an optimal site design. The calculator is a stand-alone application and is available, along with instructions for its use, on the CCCWP's C.3 web pages. In addition to performing calculations, the IMP Sizing Calculator formats calculation results into a summary report. The summary report should be attached to your Stormwater Control Plan submittal.

When using the calculator, **be sure to read through the following instructions**, as they include key information you will need for design. These procedures and formulas can be used to **investigate, check, and verify** calculations made with the IMP Sizing Calculator.

► STEP 1: DELINEATE DRAINAGE MANAGEMENT AREAS

This is the key first step. You must divide the **entire project area** into individual, discrete Drainage Management Areas (DMAs). Typically, lines delineating DMAs follow grade breaks and roof ridge lines. The Exhibit, tables, text, and calculations in your Stormwater Control Plan will illustrate, describe, and account for runoff from each of these areas.

Use separate DMAs for each surface type (e.g., landscaping, pervious paving, or roofs). Each DMA must be assigned a single hydrologic soil group. Assign each DMA an identification number and determine its size in square feet.

► STEP 2: CLASSIFY DMAS AND DETERMINE RUNOFF FACTORS

Next, determine how drainage from each DMA will be handled. Each DMA will be one of the following four types—based on the DMA's drainage characteristics.

1. Self-treating areas.
2. Self-retaining areas (also called "zero-discharge" areas).
3. Areas that drain to self-retaining areas.
4. Areas that drain to IMPs.

Runoff from self-treating areas, self-retaining areas, and areas draining to self-retaining areas does not require any further treatment or flow control. Except for pervious pavement installations greater than 3,000 SF in area, there is no requirement for operation and maintenance inspections.

#1. Self-treating areas are landscaped or turf areas that do not drain to IMPs, but rather drain directly off site or to the storm drain system. Examples include upslope undeveloped areas which are ditched and drained around a development and grassed slopes that drain off-site to an existing public street or storm drain. See Figure 3-1. In general, self-treating areas include no impervious areas, unless the impervious area is very small (5% or less) in relationship to the receiving pervious area, and slopes are gentle enough to ensure runoff from impervious areas will be absorbed into the vegetation and soil.

Rationale

Pollutants in rainfall and windblown dust will tend to become entrained in the vegetation and soils of landscaped areas, so no additional treatment is needed. It is assumed the self-treating landscaped areas will produce runoff less than or equal to the pre-project site condition.

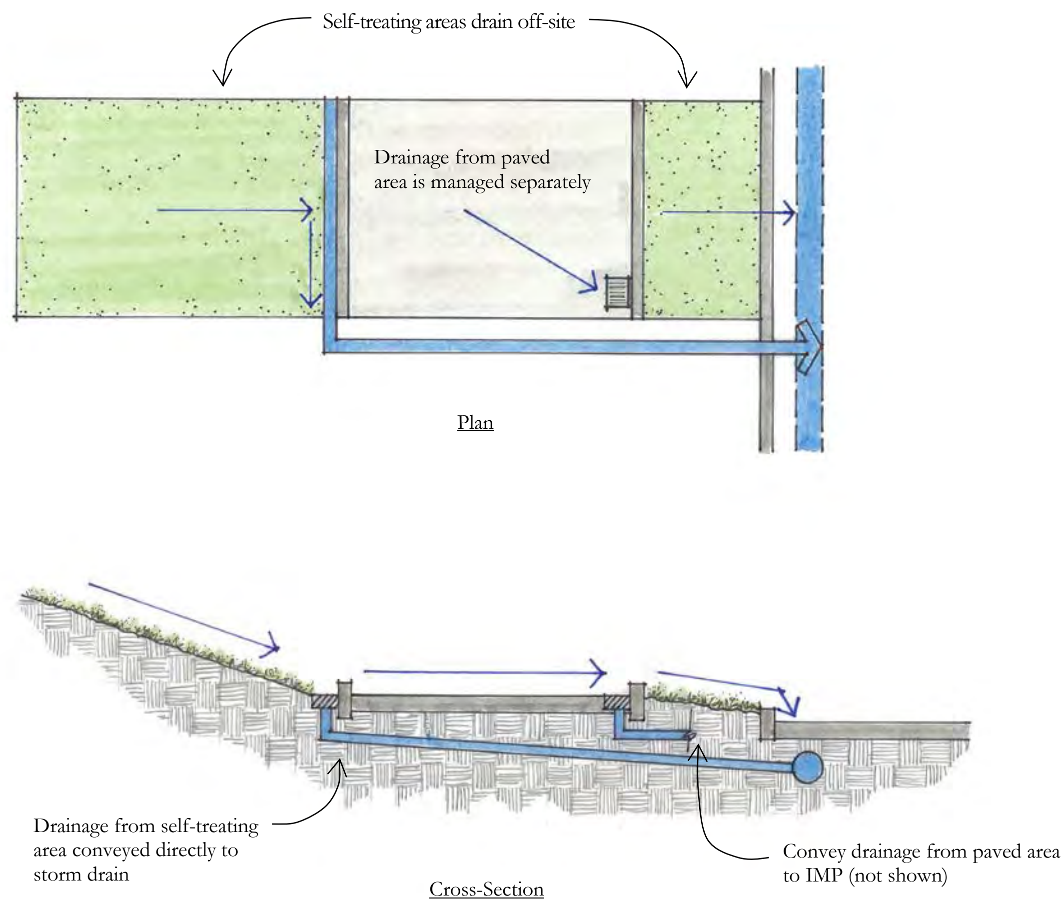

FIGURE 3-1. SELF-TREATING AREAS are landscaped or turf areas that drain directly off-site or to the storm drain system.

#2. Self-retaining areas are designed to retain the first one inch of rainfall without producing any runoff. The technique works best on flat, heavily landscaped sites. It may be used on mild slopes if there is a reasonable expectation that a one-inch rainfall event would produce no runoff. See Figure 3-2.

To create self-retaining turf and landscape areas in flat areas or on terraced slopes, berm the area or depress the grade into a concave cross-section so that these areas will retain the first inch of rainfall. Grade slopes, if any, toward the center of the pervious area. Inlets of area drains, if any, should be set 3 inches above the low point to allow ponding.

Green roofs are considered self-retaining areas.

Pervious pavement (e.g., crushed stone, pervious asphalt, or pervious concrete) can be self-retaining if designed and constructed according to the criteria in Chapter 4.

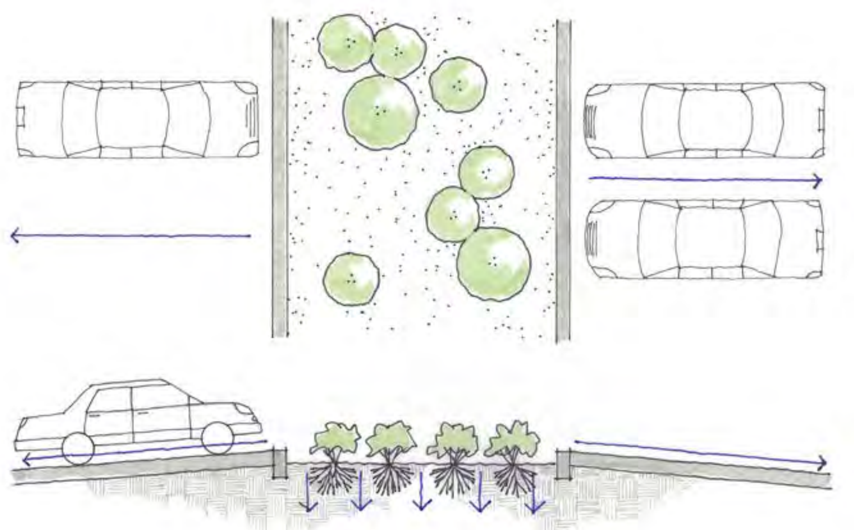

FIGURE 3-2. SELF-RETAINING AREAS are depressed pervious areas that produce no runoff.

#3. Areas draining to self-retaining areas. Runoff from impervious or partially pervious areas can be managed by routing it to self-retaining pervious areas. For example, roof downspouts can be directed to lawns, and driveways can be sloped toward landscaped areas. The maximum ratio is 2 parts impervious area for every 1 part pervious area if only treatment requirements apply to the development project. If flow-control requirements also apply, the maximum ratio is 1 part impervious area for every 1 part pervious area. The drainage from the impervious area must be directed to and dispersed within the pervious area, and the entire area must be designed to retain an inch of rainfall without flowing off-site. For example, if the maximum ratio of 2 parts impervious area into 1 part pervious area is used, then the pervious area must absorb 3 inches of water over its surface before overflowing to an off-site drain.

Derivation of Criteria

A computer model was used to continuously simulate rainfall, infiltration, and runoff at an hourly time-step over 30 years. Results indicate drainage areas using the 1:1 ratio will not exceed pre-project peaks and durations.

Prolonged ponding is a potential problem at higher impervious/pervious ratios. In your design, ensure that the pervious area soils can handle the additional run-on and are sufficiently well-drained.

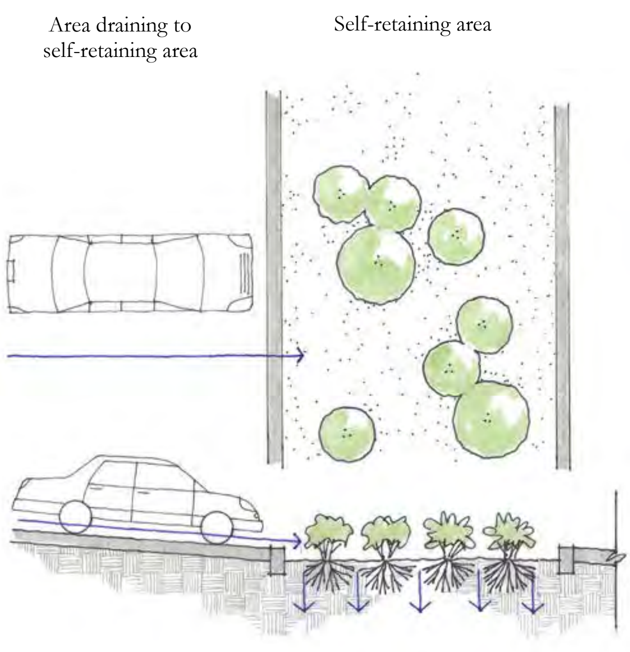

FIGURE 3-3. AREAS DRAINING TO SELF-RETAINING AREAS.
The maximum ratio is two parts impervious to one part impervious, or one-to-one if HM requirements apply.

If pervious pavement is designed and constructed to be self-retaining—that is, according to the criteria in Chapter 4—adjacent roofs or impervious pavement may drain on to the pervious pavement with the same maximum ratios. A gravel base course four or more inches deep will ensure an adequate proportion of rainfall is infiltrated into native soils (including clay soils) rather than producing runoff. Consult with a qualified engineer regarding infiltration rates, pavement stability, and suitability for the intended traffic, especially when considering draining impervious areas on to pervious pavement.

A partially pervious area may be drained to a self-retaining area. For example, a driveway composed of unit pavers may drain to an adjacent lawn. In this case, the maximum ratios are, for treatment-only sites:

(Runoff factor) x (tributary area) ≤ 2 x (self-retaining area) *Equation 3-1*

For sites subject to flow-control requirements:

(Runoff factor) x (tributary area) ≤ 1 x (self-retaining area) *Equation 3-2*

Use the runoff factors in Table 3-2.

TABLE 3-2. RUNOFF FACTORS for evaluating drainage to self-retaining areas and for sizing IMPs.

Surface	Treatment and Flow Control	Treatment only
Roofs	1.0	1.0
Concrete or Asphalt	1.0	1.0
Pervious Concrete	0.1	0.1
Porous Asphalt	0.1	0.1
Grouted Unit Pavers	1.0	1.0
Solid Unit Pavers Set in Sand	0.5	0.2
Open and Porous Pavers	0.1	0.1
Crushed Aggregate	0.1	0.1
Decomposed Granite*	0.1	0.1
Turfblock	0.1	0.1
Landscape, Group A Soil	0.1	0.1
Landscape, Group B Soil	0.3	0.1
Landscape, Group C Soil	0.5	0.1
Landscape, Group D Soil	0.7	0.1

* with no binder, uncompacted

#4. Areas draining to IMPs are used to calculate the required size of the bioretention facility or other IMP. On densely developed sites—such as commercial and mixed-use developments and small-lot residential subdivisions—most DMAs will drain to IMPs.

The CCCWP has developed sizing factors (ratios of IMP area to impervious DMA area). For each IMP design, factors are provided for:

- Treatment-only.
- Treatment-plus-flow-control.

Treatment-only IMPs are smaller and in some cases, are simpler in design.

More than one drainage management area can drain to the same IMP. However, because the minimum IMP sizes are determined by ratio to drainage area size, one drainage area may not drain to more than one IMP. See Figure 3-4.

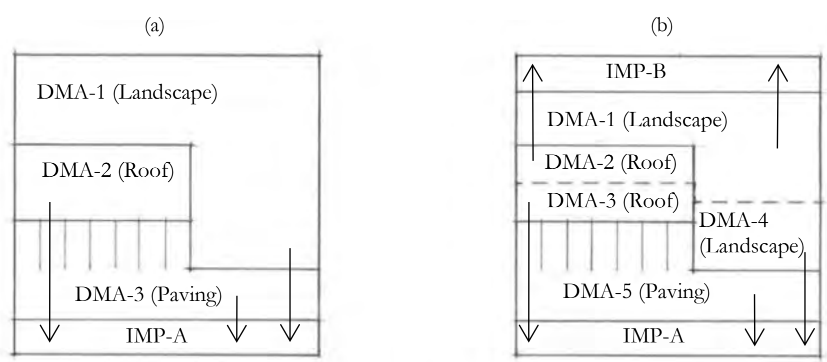

FIGURE 3-4. DELINEATE EACH SURFACE AS A SEPARATE DMA.
(a) More than one DMA can drain to an IMP. (b) If another IMP is added, divide the DMAs as necessary so that each DMA drains to only one IMP.

If it is necessary to include turf, landscaping, or pervious pavements within the area draining to an IMP, list each surface as a separate DMA. A runoff factor (similar to a "C" factor used in the rational method) is applied to account for the reduction in the quantity of runoff. For example, when a turf or landscaped drainage management area drains to an IMP, the resulting increment in IMP size is:

(pervious area) × (runoff factor) × (sizing factor).

Use the runoff factors in Table 3-2.

► STEP 3: TABULATE DRAINAGE MANAGEMENT AREAS

Prepare a table of DMAs, using the format in Table 3-3, and include it in your Stormwater Control Plan. Proceed to Step 4 to check that the IMPs can be sized to fit your preliminary site plan.

TABLE 3-3. Format for Tabulation of Drainage Management Areas

DMA Name	*DMA Type*	*Description*	*Area (square feet)*

► STEP 4: SELECT AND LAY OUT IMPS ON SITE PLAN

Select from the IMPs in Table 3-4. Note that flow-through planters may be used only on elevated plazas and other locations where it is not feasible to allow the facility to infiltrate to underlying soil.

TABLE 3-4. IMP SELECTION

	Treatment Only				Treatment + Flow Control			
Hydrologic Soil Group	A	B	C	D	A	B	C	D
Bioretention	✓	✓	✓	✓	✓	✓	✓	✓
Flow-through Planter	✓	✓	✓	✓			✓	✓
Dry Well	✓	✓			✓	✓		
Cistern + Bioretention					✓	✓	✓	✓
Bioretention + Vault					✓	✓	✓	✓

Descriptions, illustrations, designs, and design criteria for the IMPs are in Chapter 4. Once you have laid out the IMPs, calculate the square footage you have set aside on your site plan for each IMP.

► STEP 5: CALCULATE MINIMUM IMP AREA AND VOLUMES

For **treatment only**, the minimum IMP areas and volumes are determined by summing up the contributions of each tributary DMA and multiplying times the factors shown in Table 3-5.

Note that the minimum areas are the wetted area and do not include side slopes.

TABLE 3-5. MINIMUM IMP AREAS AND VOLUMES for treatment only

Hydrologic Soil Group	A	B	C	D
Bioretention Facility A	 0.04	 0.04	 0.04	 0.04
Flow-through Planter A	 0.04	 0.04	 0.04	 0.04
Dry Well (treatment only) A V	 0.02 0.068	 0.04 0.136	 N/A N/A	 N/A N/A
A = ft^2 of IMP footprint per ft^2 of impervious tributary area (unitless) V = ft^3 per ft^2 of tributary area (ft.) Apply runoff factors from Table 3-2 for landscape or other pervious surfaces.				

For **treatment-and-flow-control**, the minimum area and minimum storage volumes are found by summing up the contributions of each tributary DMA and applying sizing factors and equations. The configuration of area (A), surface reservoir volume (V_1) and subsurface reservoir volume (V_2) for bioretention facilities and flow-through planters is shown in Figure 3-5.

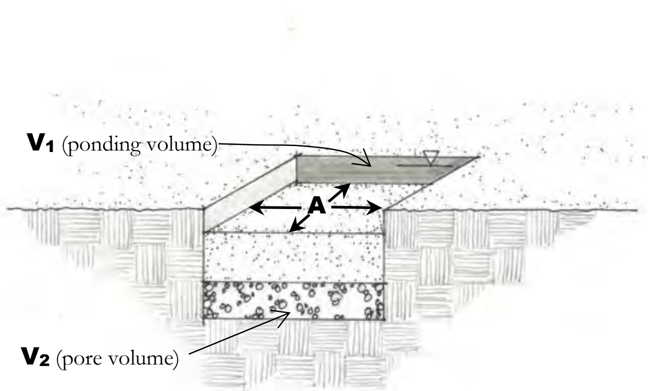

FIGURE 3-5. A, V_1, and V_2.

V_2 is the free pore volume. For gravel, use an assumed porosity of 0.4.

V_1 is the floodable volume above the soil layer (that is, the total volume of surface storage when the facility just begins to overflow). V_2 is the storage volume below the soil layer. If gravel fill is used, **multiply the volume of gravel by an assumed porosity of 0.4** to obtain the subsurface volume.

Sizing factors for treatment-only IMPs do not require any adjustment for differing rainfall patterns. Area (A) and volume (V_1, V_2) sizing factors for treatment-plus-flow-control IMPs, however, must be adjusted to account for the effects of differing rainfall patterns on pre-project and post-project runoff. Cisterns and dry wells have a single storage volume V.

Note these volumes can be configured in a variety of practical combinations of depth and area to best fit into your landscape design. For example, if a bioretention facility were designed with double the minimum value of A, then the depth of the surface reservoir and the depth of the subsurface reservoir could both be halved. Some other strategies to achieve the required minimum values of V1 and V2 are described in the design sheets in this chapter.

The minimum values of A, V_1, and V_2 are calculated by Equation 3-3. **These calculations are incorporated into the IMP Sizing Calculator** and are provided here for purposes of investigating and validating calculator results.

Equation 3-3

$$Min. IMP\ Area\ or\ Volume = \sum \begin{pmatrix} DMA & & DMA \\ Square & \times & Runoff \\ Footage & & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

IMP Sizing Factors and equations for calculating Rain Adjustment Factors are in Tables 3-6 and 3-7.

TABLE 3-6. FACTORS FOR CALCULATING IMP Area and Storage Volumes (Treatment-and-flow-control)

Facility Design	Soil Group	Area (ft^2/ft^2)	Volume V_1 (ft^3/ft^2)	Volume V_2 (ft^3/ft^2)	Rainfall Adjustment for Surface Area	Rainfall Adjustment for Storage Volume	Maximum Release Rate
Bioretention Facility	A	0.07	0.058	No min.	Eq. 3-6	Eq. 3-6	No orifice
	B	0.11	0.092	No min.	Eq. 3-7	Eq. 3-7	No orifice
	C	0.06	0.050	0.066	Eq. 3-8	Eq. 3-8	Eq. 3-10
	D	0.05	0.042	0.055	Eq. 3-9*	Eq. 3-9	Eq. 3-11
Flow-through Planter	A	Not permitted in "A" soils					
	B	Not permitted in "B" soils					
	C	0.06	0.050	0.066	Eq. 3-8	Eq. 3-8	Eq. 3-10
	D	0.05	0.042	0.055	Eq. 3-9*	Eq. 3-9	Eq. 3-11
Dry Well	A	0.05	0.130	N/A	Eq. 3-6	Eq. 3-6	No release
	B	0.06	0.204	N/A	Eq. 3-7	Eq. 3-7	No release
	C	Not permitted in "C" soils					
	D	Not permitted in "D" soils					
Cistern + Bioretention	A	0.020	0.193	N/A	Eq. 3-13	Eq. 3-6	Eq. 3-17
	B	0.009	0.210	N/A	Eq. 3-14	Eq. 3-7	Eq. 3-12
	C	0.013	0.105	N/A	Eq. 3-15	Eq. 3-8	Eq. 3-10
	D	0.017	0.063	N/A	Eq. 3-16	Eq. 3-9	Eq. 3-11
Bioretention + Vault	A	0.04	N/A	0.096	N/A	Eq. 3-6	No release
	B	0.04	N/A	0.220	N/A	Eq. 3-7	Eq. 3-12
	C	0.04	N/A	0.152	N/A	Eq. 3-8	Eq. 3-10
	D	0.04	N/A	0.064	N/A	Eq. 3-9	Eq. 3-11

A = ft^2 of IMP footprint per ft^2 of tributary impervious area (unitless)
V_1, V_2 = ft^3 per ft^2 of equivalent tributary impervious area (ft.) Cisterns, dry wells, and vaults have only one volume.
*If MAP is 25 inches or greater, this equation will yield a rainfall adjustment less than 0.8 and a bioretention facility area less than 0.04 times the tributary area. In that case, use 0.04 times the tributary area to calculate the minimum allowable bioretention facility area. Equation 3-9 may still be used to adjust minimum required storage volumes.

TABLE 3-7. EQUATIONS TO BE USED in calculating IMP sizes and outflow rates.*

Equation 3-6	$Rain\ \ Adjustment = \dfrac{0.0009 \times \left(MAP_{project\ \ site} - 20.2\right) + 0.07}{0.07}$
Equation 3-7	$Rain\ \ Adjustment = \dfrac{-0.0005 \times \left(MAP_{project\ \ site} - 20.2\right) + 0.11}{0.11}$
Equation 3-8	$Rain\ \ Adjustment = \dfrac{-0.0022 \times \left(MAP_{project\ \ site} - 20.2\right) + 0.06}{0.06}$
Equation 3-9	$Rain\ \ Adjustment = \dfrac{-0.0022 \times \left(MAP_{project\ \ site} - 20.2\right) + 0.05}{0.05}$
Equation 3-10	$Flow\ \ (cfs\ \ per\ \ ft^2) = \dfrac{0.093 \times \left(MAP_{project\ \ site} - 20.2\right) + 1.42}{10^6}$
Equation 3-11	$Flow\ \ (cfs\ \ per\ \ ft^2) = \dfrac{0.122 \times \left(MAP_{project\ \ site} - 20.2\right) + 1.85}{10^6}$
Equation 3-12	$Flow\ \ (cfs\ \ per\ \ ft^2) = \dfrac{0.071 \times \left(MAP_{project\ \ site} - 20.2\right) + 0.91}{10^6}$
Equation 3-13	$Area\ \ Ratio = \dfrac{0.151 \times \left(MAP_{project\ \ site} - 20.2\right) + 2.30}{2.30}$
Equation 3-14	$Area\ \ Ratio = \dfrac{0.071 \times \left(MAP_{project\ \ site} - 20.2\right) + 0.91}{0.91}$
Equation 3-15	$Area\ \ Ratio = \dfrac{0.093 \times \left(MAP_{project\ \ site} - 20.2\right) + 1.42}{1.42}$
Equation 3-16	$Area\ \ Ratio = \dfrac{0.122 \times \left(MAP_{project\ \ site} - 20.2\right) + 1.85}{1.85}$
Equation 3-17	$Flow\ \ (cfs\ \ per\ \ ft^2) = \dfrac{0.151 \times \left(MAP_{project\ \ site} - 20.2\right) + 2.30}{10^6}$

MAP = Mean Annual Precipitations, determined from Contra Costa County Public Works Figure B-166.
*There are no Equations 3-4 or 3-5 in this edition; this was done to preserve equation numbering from a previous edition.

► STEP 6: DETERMINE IF IMP AREA AND VOLUME ARE ADEQUATE

Sizing and configuring IMPs may be an iterative process. After computing the minimum IMP area using Steps 1–5, review the site plan to determine if the reserved IMP area is sufficient.

If so, the planned IMPs will meet the Provision C.3 sizing requirements. If not, revise the plan accordingly. Revisions may include:

- Reducing the overall imperviousness of the project site.
- Changing the grading and drainage to redirect some runoff toward other IMPs which may have excess capacity.
- Making tributary landscaped DMAs self-treating or self-retaining (may require changes to grading).
- Expanding IMP surface area.
- Using a different IMP. The cistern + bioretention and bioretention + vault options were created to achieve **flow control** in a smaller footprint than bioretention alone. Note these options are more costly and complex to build and operate.

Note revisions to square footage of an IMP typically require a corresponding revision to the square footage of the surrounding or adjacent DMA area.

Once a design with adequate area is achieved, review the IMP configuration to confirm the required minimum volumes are met. If not, revisions to V_1 may include adjusting depth or side slopes and extending the floodable storage area to include adjacent paved or landscaped areas. Revisions to V_2 may include adjusting width or depth, or incorporating buried pipes or arches in the gravel layer.

► STEP 7: COMPUTE MAXIMUM ORIFICE FLOW RATE

This step applies only to:

- **treatment-and-flow-control** bioretention facilities and flow-through planters built on native Group C and Group D soils.
- cistern + bioretention-facilities built in all soils.
- bioretention + vault facilities built on Group B, Group C, and Group D native soils.

See Table 3-4. The IMP Sizing Calculator performs this calculation.

Treatment-only bioretention facilities and flow-through planters are equipped with underdrains, but there is no restriction on the rate of outflow. For the **treatment-and-flow-control** IMPs, listed above, the underdrain has a flow control orifice sized to ensure rates and durations of flows do not exceed pre-project conditions.

For a cistern + bioretention-facility, the flow-control orifice is placed on the outlet from the cistern where it discharges to the bioretention facility. The bioretention facility must have an underdrain in B, C, and D soils, but no flow-control orifice is required on the underdrain.

For a bioretention + vault facility, the flow-control orifice is placed on the discharge from the vault.

Find the appropriate equation in Tables 3-6 and 3-7 to determine the maximum underdrain flow. Sum the total area draining to an IMP (including all tributary DMAs; **do not use runoff factors**. Compute the maximum orifice release rate, and then apply the orifice equation (Eq. 3-18) to determine the required orifice area. Then use Eq. 3-19 to determine the diameter of the flow control orifice.

Equation 3-18

$$Orifice\ Area\ (in\ \ feet) = \frac{UnderdrainMaxFlow}{c \times \sqrt{64.4 \times H}}$$

where c is the orifice coefficient, which may be approximated as 0.6. H is the height of the storage above the orifice.

Equation 3-19

$$Orifice\ Diameter\ (in\ inches) = 12 \times \sqrt{\frac{4 \times Orifice\ Area}{\pi}}$$

► STEP 8: PRESENT IMP SIZING CALCULATIONS

Review the output from the IMP Sizing Calculator. Coordinate and cross-check your presentation of DMAs and calculation of minimum IMP sizes with the Stormwater Control Plan Exhibit (labeled to show delineation of DMAs and locations of IMPs) and with your Stormwater Control Plan report, which should incorporate a brief description of each DMA and each IMP.

Tabulate and sum the total area of all DMAs and IMPs listed and show it is equal to the total project area. This step will include adjusting the square footage of some DMAs to account for area used for IMPs. **Note the minimum square footage for IMPs does not include the area of transitions or slopes adjacent to the IMP.**

Integrating Your LID Design into Your Project

Before completing your Stormwater Control Plan exhibit and report, perform another check to ensure your stormwater control design is fully coordinated with the site plan, grading plan, and landscaping plan being proposed for the site.

Information submitted and presentations to design review committees, planning commissions, and other decision-making bodies must incorporate relevant aspects of the stormwater design. In particular, ensure:

- Curb elevations, elevations, grade breaks, and other features of the drainage design are consistent with the delineation of DMAs.
- The top edge of each bioretention facility is level all around its perimeter—this is particularly important in parking lot medians.
- The resulting grading and drainage design is consistent with the design for parking and circulation.
- Bioretention facilities and other IMPs do not create conflicts with pedestrian access between parking and building entrances.
- Vaults and utility boxes will be accommodated outside bioretention facilities and will not be placed within bioretention facilities.
- The visual impact of stormwater facilities, including planter boxes at building foundations and any terracing or retaining walls required for the stormwater control design, is shown in renderings and other architectural drawings.
- Landscaping plans, including planting plans, show locations of bioretention facilities, and the plant requirements are consistent with the engineered soils and conditions in the bioretention facilities.
- Renderings and representation of street views incorporate any stormwater facilities located in street-side buffers and setbacks.
- Any potential conflicts with local development standards have been identified and resolved.

Review Chapter 4 to anticipate additional requirements for design and construction of IMPs.

Use of Non-LID Treatment Facilities

LID has been found to be feasible for nearly all development sites. If you believe LID design may be infeasible for part of or your entire development site, you should consult with municipal staff and seek additional technical assistance for incorporating LID into your site before considering non-LID options.

► SPECIAL PROJECTS

"Special Projects" that meet the criteria in Table 3-8 (page 46) may, subject to local staff review and approval—and subject to a demonstration that it is infeasible to use the LID to treat 100% of runoff—use the following non-LID treatment systems for up to the specified proportion of the total impervious area on the site:

- Tree-box-type high-flowrate biofilters.
- Vault-based high-flowrate media filters.

► TECHNICAL CRITERIA FOR NON-LID FACILITIES

Minimum design criteria for tree-box type high-flowrate biofilters and for vault-based high-flowrate media filters are in Appendix E.

If flow-control (HM) requirements apply, also review the options for compliance in Chapter One. Then consult with municipal staff before preparing an alternative design for stormwater treatment and HM.

► DEMONSTRATION OF INFEASIBILITY IS REQUIRED

For all non-LID designs, the applicant must submit a complete Stormwater Control Plan, including an exhibit showing the entire site divided into discrete Drainage Management Areas, and text and tables showing how drainage is routed from each DMA to a treatment facility.

In addition, to establish the **infeasibility of implementing LID on the entire site**, include in the Stormwater Control Plan an explanation of how routing of drainage has been optimized so that as much runoff as possible goes to LID features and facilities (if any). For DMAs draining to tree-box-type high-flow-rate biofilters and/or high-flow-rate media filters, briefly describe all areas not covered by buildings. Note the uses of all impervious paved areas and why LID treatment is precluded for these areas.

For any landscaped areas, note and briefly describe the following technical constraints as applicable:

- Inadequate size to accommodate bioretention facilities that meet sizing requirements for the tributary area

- Slopes too steep to terrace
- Environmental constraints (for example, landscaped area is within a riparian corridor and applicable regulations prohibit bioretention facilities within that corridor)
- High groundwater (within 2 feet of ground surface) or shallow bedrock
- Conflict with subsurface utilities
- Cap over polluted soil or groundwater
- Lack of head or routing path to route runoff to the landscaped area or from a bioretention underdrain to the municipal storm drain.
- Other conflicts, including required uses that preclude use for stormwater treatment (describe in detail)

Also include in your Stormwater Control Plan a narrative discussion of **infeasibility of offsite treatment**:

- Describe whether the project proponent owns or otherwise controls land within the same watershed of the project that can accommodate in perpetuity off-site bioretention facilities adequately sized to treat the runoff volume of the primary project.
- Identify any regional Low Impact Development stormwater mitigation programs available to the project for in-lieu C.3 compliance.

References and Resources

- *Municipal Regional Permit* Provision C.3.e.
- *Special Projects Proposal* (BASMAA, 2010)

TABLE 3-8. NON-LID TREATMENT SYSTEMS may be allowed in these "Special Projects," subject to a demonstration of the infeasibility of using 100% LID and local staff review and approval.
Note: This table is a summary only. Consult with local staff regarding applicability to your project.

Category	*Impervious Area*	*Project Characteristics*	*Criteria (Acreage refers to total site acreage)*	*LID Credit*	*Comments*
A Lot Line to Lot Line	X ≤ ½ Ac	Urban/Pedestrian design[1] in Business/ Downtown Districts[1]	No density criterion	100%	Zero surface parking[1] ≥ 85% Site Coverage[1]
B High Density	½ Ac ≤ X ≤ 2 Ac	Urban/Pedestrian design[1] in Business/ Downtown Districts[2]	Floor Area Ratio[1] (FAR) ≥ 2:1; OR for Residential (Res) projects, ≥ 50 Dwelling Units (DU)/Acre[1]; OR either for mixed-use projects.	50%	Zero surface parking[3] ≥ 85% Site Coverage[4]
			FAR ≥ 3:1; OR Res ≥ 75 DU/Acre	75%	
			FAR ≥ 4:1; OR Res ≥ 100 DU/Acre	100%	
C Transit Oriented	No limit	TOD characteristics Non-auto-use project FAR ≥ 2:1 OR Res ≥ 25 DU/Ac	*Location Credits (count only one)*		
			within ¼ mi of transit hub[1]	50%	50%+ of site w/in distance
			within ½ mi of transit hub[7]	25%	
			within a Priority Development Area	25%	100% of site w/in PDA
			Density/FAR Credits		
			FAR ≥ 2:1; OR Res ≥ 30 DU/Acre	10%	
			FAR ≥ 4:1; OR Res ≥ 60 DU/Acre	20%	
			FAR ≥ 6:1; OR Res ≥ 100 DU/Acre	30%	
			Minimized Parking Credits		
			≤ 10% at-grade surface parking	10%	Surface parking uses LID
			Zero surface parking[3]	20%	

[1] Built as part of a municipality's stated objective to preserve or enhance a pedestrian-oriented type of urban design.

[2] Located in a municipality's designated central business district, downtown core area or downtown core zoning district, neighborhood business district or comparable pedestrian-oriented commercial district, or historic preservation site and/or district.

[3] Incidental parking allowed: surface parking required for emergency vehicle access, ADA accessibility, and passenger and freight loading zones.

[4] Remaining portion to be used for safety access, parking structure entrances, trash and recycling service, utility access, pedestrian connections and public uses.

[5] Floor Area Ratio (FAR) is the ratio of total floor areas on all floors of all buildings at a project site (except structures, floors, or floor areas dedicated to parking) to the total project site area.

[6] Gross Density (DU/Acre) is the total number of residential units divided by the acreage of the entire site area, including land occupied by public ROW, recreational, civic, commercial, and other non-residential uses.

[7] Transit hub is a rail, light rail, or commuter rail station, or bus transfer station served by 3 or more bus routes. A bus stop with no supporting services does not qualify. A planned transit hub is a station on the Metropolitan Transportation Commission's Regional Transit Expansion Program's list.

Chapter 4

Design and Construction of Bioretention Facilities and Other Integrated Management Practices

Guidance for preparing construction documents and overseeing construction of Integrated Management Practices

Details of construction are critical to ensuring stormwater facilities work properly. A misplaced inlet, an overflow at the wrong elevation, or the wrong soil mix can make a bioretention facility useless or ineffective even before it comes on-line, and could result in delays to project approvals—and additional expense.

Your Stormwater Control Plan is intended for the planning phase and must contain, at minimum, enough detail to demonstrate your planned LID features and facilities are feasible and are coordinated with the project site plan, architectural renderings, landscape design, grading and drainage plan, and other information submitted with your application for development approvals.

At plan check, reviewers will examine the construction documents to ensure the site design features, and especially the construction of bioretention facilities and other IMPs, will meet the criteria in this chapter and throughout the *Guidebook*.

Following are design sheets for:

- Self-treating and self-retaining areas
- Pervious pavements
- Bioretention facilities

- Flow-through planters
- Dry wells
- Cisterns + bioretention
- Bioretention + vaults

These design sheets include recommended configurations and details, and example applications, for these features and facilities. **The information in these design sheets must be adapted and applied to the conditions specific to the development project.** Local planning, building, and public works officials have final review and approval authority over the project design.

Keep in mind that proper and functional design of features and facilities is the responsibility of the applicant. Effective operation of facilities throughout the project's lifetime will be the responsibility of the property owner.

What to Show on Construction Plans

With few exceptions, the plan set should include separate sheets specifically incorporating the features and facilities described in the Stormwater Control Plan. The information on these sheets must be carefully coordinated and made consistent with grading plans, utility plans, landscaping plans, and (in many cases) architectural plans.

On the grading and drainage plan, or on a separate stormwater control plan sheet showing the grading and drainage plan (and possibly the roof plan) screened as background, show how DMAs follow grade breaks, consistent with the grading plan and the Stormwater Control Plan.

► SHOW KEY ELEVATIONS

On the grading and drainage plan, or in a detailed plan view, call out the following elevations:

- Bottom of gravel layer (BGL, or the bottom of the excavation), top of gravel layer (TGL), and top of soil layer (TSL). Note that each of these is consistent (flat) throughout the facility.
- The top of curbs or walls surrounding the facility, and spot elevations of adjacent pavement.
- At curb cut inlets, show the top of paving, top of curb, and top of the bioretention soil layer (TSL).

- At overflow grates, show the grate elevation and the adjacent top of soil elevation (TSL).
- Call out elevations of piped inlets.

For treatment-and-flow-control IMPs, demonstrate how the minimum surface volume V_1 is attained by the design.

► SHOW HOW RUNOFF MOVES

As needed for clarity, show the direction of runoff flow across roofs and pavement and into IMPs. For runoff conveyed via pipes or channels, show locations, slopes, and elevations at the beginning and end of each run.

For roof drainage, show the routing of roof leaders. Use drawings or notes to make clear how drainage from leaders is routed under walkways, across pavement, through drainage pipes, or by other means to reach the IMP.

Show pipes or channels connecting the IMP underdrain and overflow to the site drainage system, municipal storm drain system, or other approved discharge point. Call out slopes and key elevations.

► SHOW IMPS IN CROSS-SECTION

For many installations, a not-to-scale cross section view can be used to illustrate the dimensions and placement of the soil and gravel layers, surrounding walls, and overflow structures. Where needed, use detailed, specific cross-section drawings to show edge treatments, inlet elevations, overflow grates, rock for energy dissipation, moisture barriers, and other information.

Call out references for the gravel (Class 2 perm) and specified soil mix layers.

The details in the design sheets may be used as a general guide.

► COORDINATE WITH THE LANDSCAPING PLAN

The landscaping plan must show the footprints of the IMPs precisely and should incorporate plants and irrigation appropriate to the facilities. See Appendix B.

Landscape plans should call out that no soil or amendments other than the specified soil mix are to be used within the boundaries of the IMPs and that the specified top of soil elevation is to be maintained following plant installation.

References and Resources

- San Francisco *Stormwater Management Requirements and Design Guidelines*
- Central Coast Low Impact Development Center *Bioretention Standard Details and Specifications*

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Runoff Reduction Measures

1. **Self-Treating Areas**
2. **Self-Retaining Areas**
3. **Areas Draining to Self-Retaining Areas**

Runoff-reduction site-design measures are the most effective and least expensive way to implement LID.

- Manage drainage from pervious landscaped areas separately, so that it doesn't run on to adjacent pavement.
- Further reduce runoff by dispersing runoff from impervious roofs and pavement to landscaped areas.

To incorporate these features into your project, **delineate and classify the Drainage Management Areas** (DMAs) appropriately on your Stormwater Control Plan Exhibit. See page 30.

Follow the criteria below in your Exhibit and grading and drainage plan.

Note: Runoff from drainage management areas that do not meet the criteria for self-treating areas, self-retaining areas, or areas draining to self-retaining areas must be directed to bioretention facilities or other IMPs.

Best Uses

- Sites with extensive landscaping

Advantages

- Low cost
- No maintenance verification requirement
- Complements site landscaping

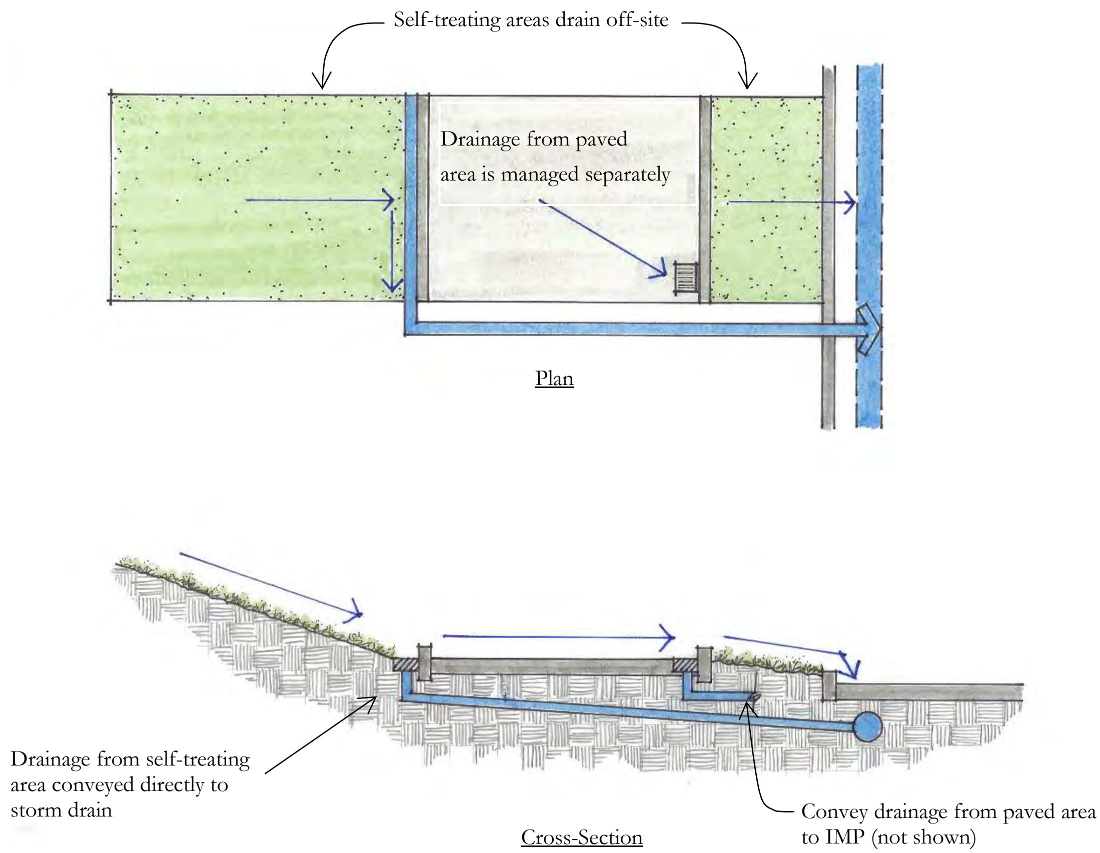
Limitations

- Requires substantial square footage
- Grading requirements must be coordinated with landscape design

1. Self-Treating Areas

Self-treating drainage management areas are natural, landscaped, or turf areas that drain directly off site or to the storm drain system. Examples include upslope undeveloped areas from which runoff is piped or ditched and drained around a development and grassed slopes that drain offsite to a street gutter. Self-treating areas must not drain on to adjacent paved areas within the project.

Drainage from self-treating areas must flow to off-site streets or storm drains without flowing on to paved areas within the project. Lawn or landscaped areas adjacent to streets can be considered self-treating areas. Pavement within a self-treating area must not exceed 5% of the total area.

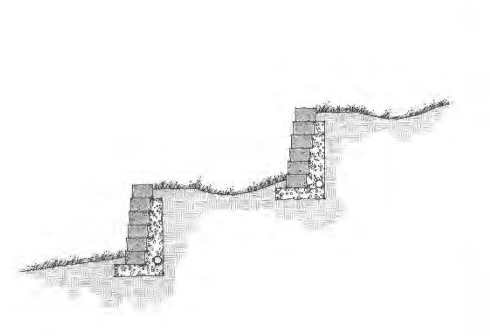


► CRITERIA FOR SELF-TREATING AREAS

- ❒ Runoff from the self-treating area does not enter an IMP or another drainage management area, but goes directly offsite or to the storm drain system.
- ❒ The self-treating area is at least 95% lawn or landscaping (not more than 5% impervious).
- ❒ Re-graded or re-landscaped areas have amended soils, vegetation, and irrigation as may be required to maintain soil stability and permeability.

2. Self-Retaining Areas

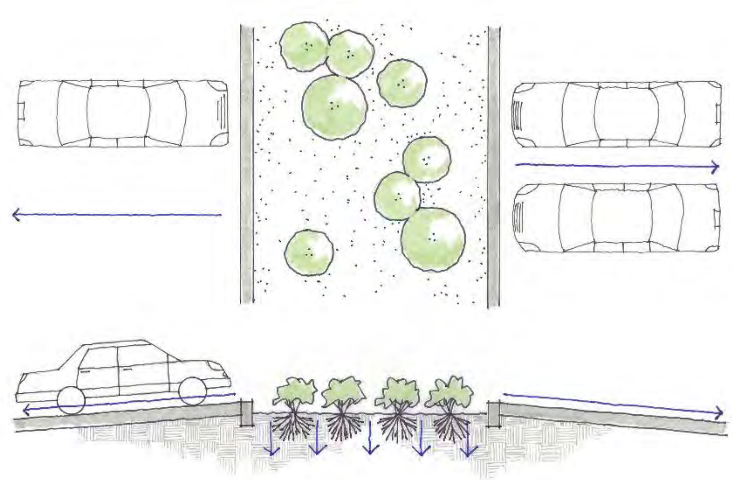
Where a landscaped area is upslope from or surrounded by paved areas, a self-retaining drajnage management area (also called a zero-discharge area) may be created. Self-retaining areas are designed to retain the first one inch of rainfall without producing any runoff. The technique works best on flat, heavily landscaped sites. It may be used on mild slopes if there is a reasonable expectation that the first inch of rainfall would produce no runoff.



Slope terraced to create a self-retaining area

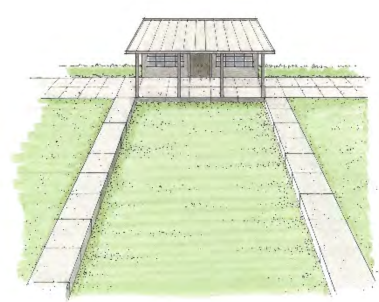
To create self-retaining turf and landscape areas in flat areas or on terraced slopes, berm the area or depress the grade into a concave cross-section so that these areas will retain the first inch of rainfall.

Self-retaining areas can also be created by depressing lawn and landscape below surrounding sidewalks and plazas. Leave enough reveal (elevation difference) to accommodate buildup of turf or mulch.



► CRITERIA FOR SELF-RETAINING AREAS

- ❒ Area is bermed all the way around or graded concave.
- ❒ Slopes do not exceed 4%.
- ❒ Entire area is lawn, landscaping, or pervious pavement (see criteria for pervious pavement).
- ❒ Area has amended soils, vegetation, and irrigation as may be required to maintain soil stability and permeability.
- ❒ Any area drain inlets are at least 3 inches above surrounding grade.
- ❒ Overflow (which may occur during high-intensity events) is conveyed safely.

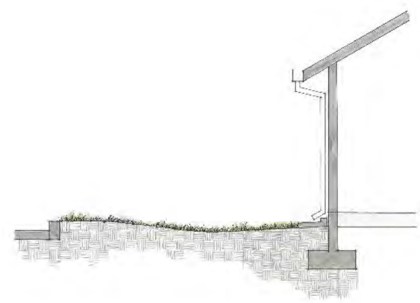


Lawn depressed to create a self-retaining area

3. Areas draining to self-retaining areas

Drainage from roofs and paving can be directed to self-retaining drainage management areas and allowed to infiltrate into the soil. The maximum ratios are:

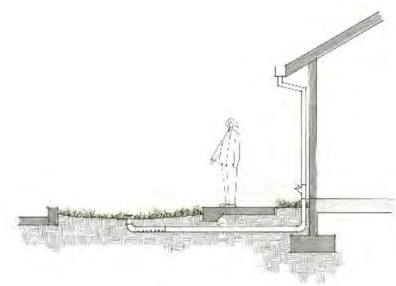
Site requirement	Maximum allowable ratio
Treatment only	2 parts impervious: 1 pervious
Treatment and flow-control	1 part impervious: 1 pervious



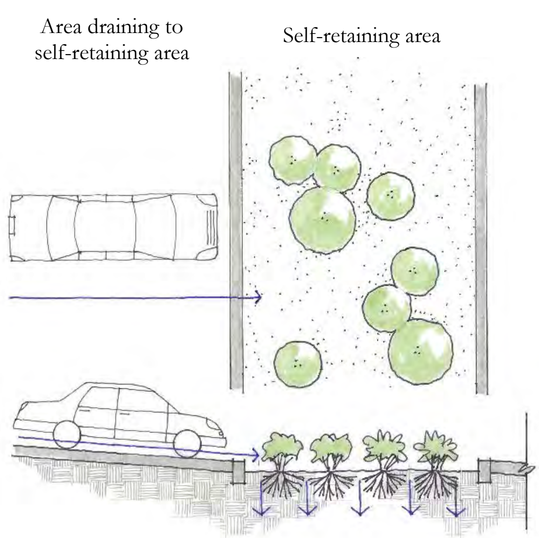
Roof runoff is directed to an adjacent self-retaining landscaped area.

The self-retaining area must be bermed or depressed to retain an inch of rainfall including the flow from the tributary impervious area. Inlets of area drains, if any, should be set 3 inches above the low point to allow ponding. Self-retaining areas should be designed to promote even distribution of ponded runoff over the area.

Runoff from walkways or driveways in parks and park-like areas can sheet-flow to self-retaining areas. Roof leaders can be connected to self-retaining areas by piping beneath plazas and walkways. If necessary, a "bubble-up" can be used.



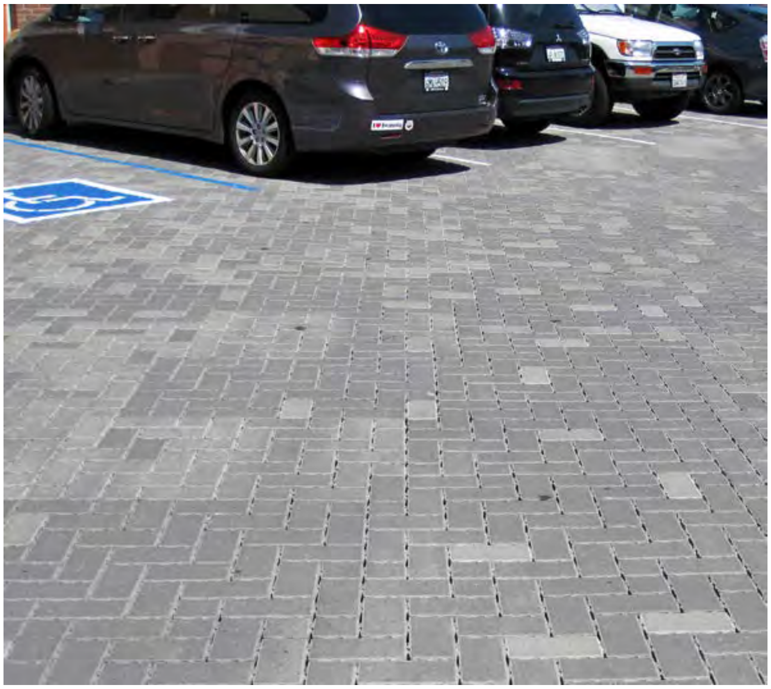
A roof leader extends to a bubble-up to convey roof runoff to a self-retaining area.



► CRITERIA FOR AREAS DRAINING TO SELF-RETAINING AREAS

- ❒ Ratio of tributary impervious area to self-retaining area is not greater than 2:1 (1:1 if flow-control requirements apply).
- ❒ Roof leaders collect runoff and route it to the self-retaining area.
- ❒ Paved areas are sloped so drainage is routed to the self-retaining area.
- ❒ If runoff is concentrated where it enters the self-retaining area, there are appropriate measures to protect against erosion and promote flow across the self-retaining area.

Pervious Pavements



Impervious roadways, driveways, and parking lots account for much of the hydrologic impact of land development. Pervious pavements allow rainfall to collect in a gravel or sand base course and infiltrate into native soil instead of creating runoff.

Pervious pavements are often costly to build and maintain when compared to conventional pavement draining to bioretention facilities. However, in some applications the aesthetic or practical benefits of a flat surface unbroken by drainage structures may be worth the additional cost.

Best Uses

- Flat areas (< 2% slope)
- Areas with competent, permeable native soils
- Low-traffic areas
- Where aesthetic quality can justify higher cost

Advantages

- No maintenance verification requirement for installations < 3000 SF
- Surface treatments can complement landscape design

Limitations

- Initial cost
- Placement requires specially trained crews
- Geotechnical concerns, especially in clay soils
- Concerns about pavement strength and surface integrity

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Pervious pavements are not treatment facilities. However, they may be configured as self-retaining areas. In specific, limited circumstances, pervious pavements configured as self-retaining areas may receive some runoff from roofs or conventional pavement—if it can be shown that the required amount of runoff, as well as rain falling on the pervious pavement, will infiltrate into the underlying soil.

Solid unit pavers—such as bricks, stone blocks, or precast concrete shapes—are considered to reduce runoff compared to impervious pavement, when the unit pavers are set in sand or gravel with $\frac{3}{8}$" gaps between the pavers. Joints must be filled with an open-graded aggregate free of fines.

If pervious pavement areas drain to IMPs, use the runoff factors in Table 3-2 when sizing the IMPs.

► DETAILS

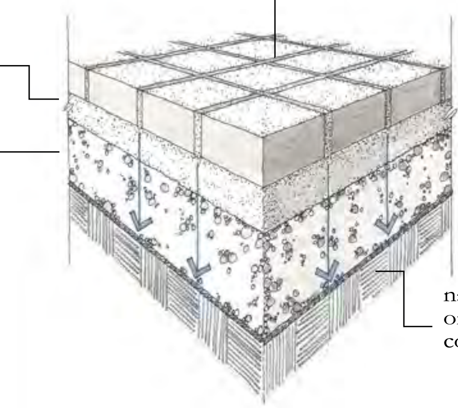
Permeable pavements can be used in clay soils; however, special design considerations, including an increased depth of base course, typically apply and will increase the cost of this option. Geotechnical fabric between the base course and underlying clay soil is recommended.

Permeable pavements are best used on grades from flat to approximately 2%. Installations on steeper grades, particularly on clay soils, require cut-off trenches lateral to the slope—to intercept, store, and infiltrate drainage from the base course.

Pavement strength and durability typically determines the required depth of base course. If underdrains are used, the outlet elevation must be a minimum of 3 inches above the bottom elevation of the base course.

Pervious concrete and porous asphalt must be installed by crews with special training and tools. Industry associations maintain lists of qualified contractors.

Parking lots with crushed aggregate or unit pavers may require signs or bollards to organize parking.



TYPICAL CONFIGURATION for a pervious pavement. The base course is a minimum 3" depth for runoff retention. A deeper base course is typically required for pavement stability.

▶ CRITERIA FOR PERVIOUS PAVEMENTS

- ❒ Installation is flat or < 2% grade.
- ❒ No erodible areas drain on to pavement.
- ❒ Subgrade is uniform and slopes are not so steep that subgrade is prone to erosion. Compaction is minimal.
- ❒ Reservoir base course is of open-graded crushed stone. Base depth is adequate to retain rainfall and support design loads.
- ❒ If a subdrain is provided, outlet elevation is a minimum of 3 inches above highest point of bottom of base course.
- ❒ Rigid edge is provided to retain granular pavements and unit pavers.
- ❒ Solid unit pavers, if used, are set in sand or gravel with minimum $\frac{3}{8}$" gaps between the pavers. Joints are filled with an open-graded aggregate free of fines.
- ❒ **Permeable concrete and porous asphalt, if used, are installed by qualified professionals according to vendor's recommendations.**
- ❒ Selection and location of pavements incorporates Americans with Disabilities Act requirements, site aesthetics, and uses.
- ❒ Pavement design and/or grading design incorporates management of design flows to avoid local flooding (typically a 10-year storm).

▶ RESOURCES

National Ready Mix Concrete Association
http://www.perviouspavement.org/

National Asphalt Pavement Association
www.asphaltpavement.org

Interlocking Concrete Pavement Institute
http://www.icpi.org/

Start at the Source Design Manual for Water Quality Protection, pp. 47-53. http://www.cccleanwater.org/c3-resources.html

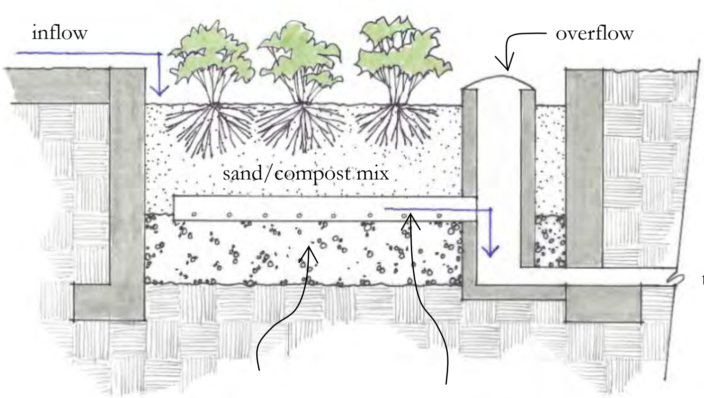
Porous Pavements, by Bruce K. Ferguson. 2005. ISBN 0-8493-2670-2.

Caltrans. 2014. *Pervious Pavement Design Guidance.* http://www.dot.ca.gov/hq/oppd/stormwtr/bmp/DG-Pervious-Pvm_082114.pdf

Bioretention Facilities

Bioretention facilities can be rectangular, linear, or nearly any shape.
Photo by Scott Wikstrom

Bioretention facilities capture runoff in a shallow reservoir on the soil surface, then filter the runoff through plant roots and a biologically active soil mix. The treated runoff then trickles into a subsurface gravel layer. Runoff is held in the gravel layer until it infiltrates it into the ground. If the entire gravel layer becomes saturated, an underdrain conveys excess treated runoff to a storm drain or to surface drainage.



Best Uses

- Commercial areas
- Residential subdivisions
- Industrial facilities
- Roadways
- Parking lots
- Fit in setbacks, medians, and other landscaped areas

Advantages

- Can be any shape
- Low maintenance

Limitations

- Require 4%-15% of tributary impervious square footage
- Typically require 3-4 feet of head
- Irrigation may be required

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LAYOUT AND SITE DRAINAGE

See the guidance on page 28 regarding how to incorporate bioretention facilities into your site. Also see "Integrating Your LID Design into Your Project" on page 42.

- Place bioretention facilities in visible, well-trafficked areas and make them a focal point in the landscape.

- On flatter sites, use surface drainage, rather than underground pipes, to convey runoff to the bioretention facility inlets. The top of soil elevation should be as high as possible—typically 6 to 12 inches below surrounding grade.

- Where possible, design site drainage so only impervious roofs and pavement drain to the bioretention facility. Avoid high walls or steep slopes adjacent to bioretention facilities. Avoid side slopes within bioretention areas as much as possible. The bioretention soil mix will tend to rill even on very mild slopes (>8:1).

- Integrate bioretention facilities with the landscape design.

- Make the bioretention facilities level around their perimeter.

- Where possible, grade tributary paved areas to sheet flow runoff and disperse it among curb cuts, rather than concentrating flow at one inlet location.

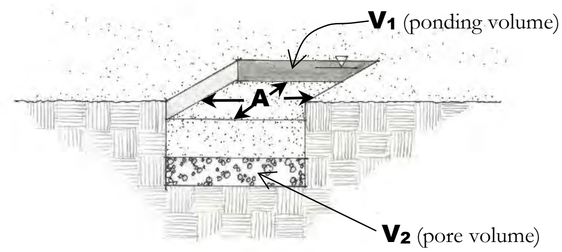
- Place each facility in a common, accessible area. Avoid locating facilities on private residential lots.

► DIMENSIONS AND MATERIALS

For development projects subject only to **runoff treatment requirements**, the following minimum dimensions apply.

Parameter	Criterion
Surface reservoir mean depth	6" minimum
Soil mix surface area	0.04 times tributary impervious area (or equivalent)
Soil mix depth	18" minimum
Gravel layer	12" min. Class 2 permeable
Underdrain discharge	At top of gravel layer

Where **flow-control requirements** also apply, the bioretention facility must be designed to meet the minimum surface area (A), surface volume (V_1), and subsurface volume (V_2) using Equation 3-3 and the sizing factors and equations in Tables 3-6 and 3-7. The IMP Sizing Calculator should be used.



Minimum subsurface volume. For treatment-and-flow-control facilities the minimum subsurface volume V_2 specified in Table 3-6 is the void space, not the entire volume of gravel. Where the native soils are Hydrologic Soil Group C or D, V_2 may be achieved by a 30" deep layer of gravel **of 40% porosity,** extending under the minimum footprint "A". Note that if the facility area is increased, the required depth to achieve the same volume is correspondingly decreased.

Gravel. "Class 2 permeable," Caltrans specification 68-2.02(F)(3), is preferred. Open-graded crushed rock, washed, may be used, but requires 4"-6" washed pea gravel be substituted at the top of the crushed rock layer. **Do not use filter fabric** to separate the soil mix from the gravel drainage layer or the gravel drainage layer from the native soil.

If desired, voids created by buried structures such as pipes or arches, may be substituted, as long as the voids are hydraulically interconnected and the minimum subsurface volume calculated by Equation 3-3 is achieved.

Soil mix. Criteria for the required mix of sand and compost are in Appendix B. It is similar to a loamy sand and must maintain a minimum percolation rate of 5" per hour throughout the life of the facility. It must be suitable for maintaining plant life with a minimum of fertilizer use. A list of suppliers is on the C.3 web pages.

► **FACILITY DETAILS**

Inlets. Curb cuts should be wide (12" is recommended) to avoid clogging with leaves or debris. Allow for a minimum reveal of 6" between the inlet and soil mix elevations to ensure turf or mulch buildup does not block the inlet. In addition, place an apron of stone or concrete, a foot square or larger, inside each inlet to prevent vegetation from growing up and blocking the inlet.

If the linear slope along the curb is greater than the orthogonal slope of the gutter pan, runoff flows will not enter the inlet efficiently. Use a drop inlet with a grate instead.

Where runoff is concentrated and conveyed to the facility in pipes or swales, protect the landscaping from high-velocity flows with energy-dissipating cobble of appropriate size. In larger installations, provide cobble-lined channels to better distribute flows throughout the facility.

"Bubble ups" can be used to dissipate energy when runoff is piped from roofs and up-gradient paved areas.

Surface storage and overflow. For treatment-only facilities, the surface reservoir should be a minimum 6" deep. In treatment-and-flow-control facilities, the overflow elevation must be set to achieve the minimum surface storage volume calculated using Equation 3-3 and the V_1 sizing factor.

Ensure the soil mix is installed level and at the specified elevation, and that the elevation does not change when plants are installed.

Overflow structure. A precast concrete catch basin or manhole is best. The overflow elevation is critical and must be designed to achieve the surface reservoir requirements. The outlet should be designed to exclude floating mulch and debris. Design in **freeboard** if needed to prevent flooding or protect adjacent structures.

Underdrains. Underdrains must have their discharge elevation set at the top of gravel layer elevation. Perforated pipe can be laid in a shallow groove dug across the top of the gravel layer, holes facing down, and connected to the overflow structure. Underdrains must be constructed of rigid pipe (SDR 35 or equivalent) and provided with a cleanout.

Flow-control orifice. For treatment-and-flow-control facilities, the underdrain must be routed through a device designed to limit flows to that specified in Equation 3-10 or 3-11 (page 40). Typically, a section of solid pipe is designed to protrude slightly into the overflow structure. The pipe is threaded and fitted with a standard cap; a hole of the specified diameter is drilled into the cap. The cap can then be easily removed for cleaning or adjustment and reinstalled.

Multi-purpose landscaped areas. Bioretention facilities are easily adapted to serve multiple purposes. The loamy sand soil mix will support either turf or a plant palette suitable to the location and a well-drained soil. See Appendix B for additional guidance on soil, plant selection, and irrigation.

Bioretention facility in El Cerrito with active and passive recreational uses.

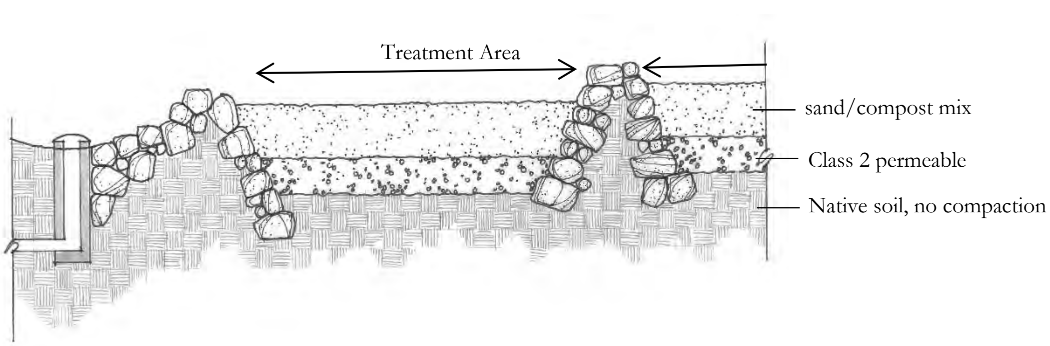
Residential subdivisions. In the design of many subdivisions, it has proven easiest and most effective to drain roofs and driveways to the streets (in the conventional manner) and then drain the streets to bioretention areas, with one bioretention area for each 1 to 10 lots, depending on subdivision layout and topography.

Bioretention areas can be placed on one or more separate, dedicated parcels with joint ownership.

Sloped sites. Bioretention facilities must be constructed as a basin or as a series of basins, with the circumference of each basin level.

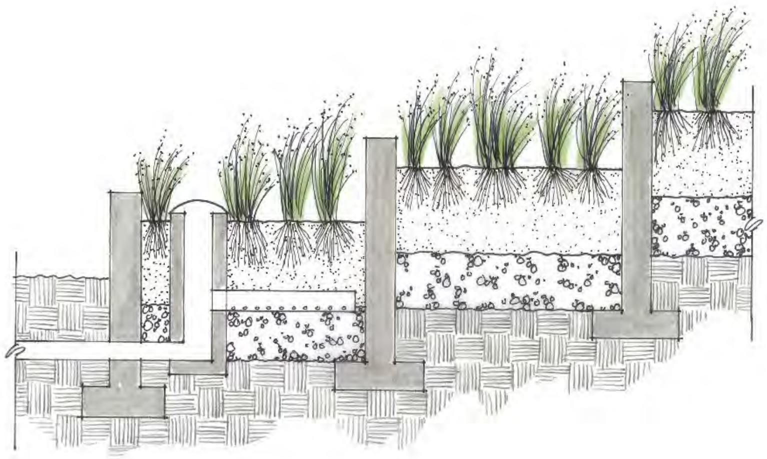
On the surface, a bioretention facility should be one level, shallow basin—or a series of basins. As runoff enters each basin, it should flood and fill throughout before runoff overflows to the outlet or to the next downstream basin. This helps prevent movement of surface mulch and soil mix.

Swales can be used on mild slopes. Check dams should be placed every 4 to 6 inches of elevation change and so that the lip of each dam is at least as high as the toe of the next upstream dam.

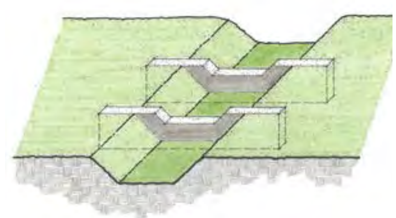


Swale with check dams. Not suitable for steeper slopes. Movement of soil can be a problem even at mild slopes. Design must ensure ponding behind each check dam.

A series of planters is a more robust solution and is required for steeper slopes.



Concrete check dams are a better solution on steeper slopes.



Key check dams into bottom and side slopes.

Solutions for surface storage. Placing a steep-sided depression in an urban landscape poses aesthetic challenges as well as practical challenges. First, use sheet flow, valley gutters, and trench drains, instead of pipes, to move runoff to the bioretention facility, so that inlets can be at or near ground level.

To further avoid the effects of high and steep drop offs, consider:

- Increasing the facility area and reducing the surface depth accordingly.
- Incorporating steps down into the facility.
- Specifying taller, woody plants to block or discourage entry.

Mulch can be mounded a few inches deeper at walkway edges to transition to the top of soil elevation.

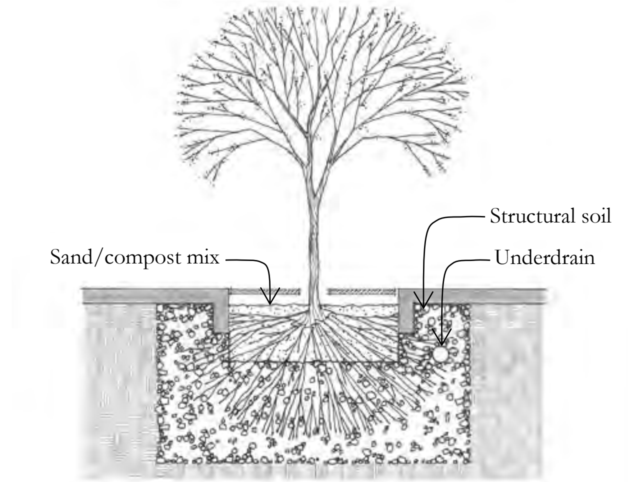
Vaults, utility boxes, backflow preventers, and light standards. Utility features and structures must be located outside the bioretention facility—in adjacent walkways or in a separate area set aside for this purpose.

Emergency overflow. The site grading plan should anticipate extreme events and potential clogging of the overflow, and should route emergency overflows safely.

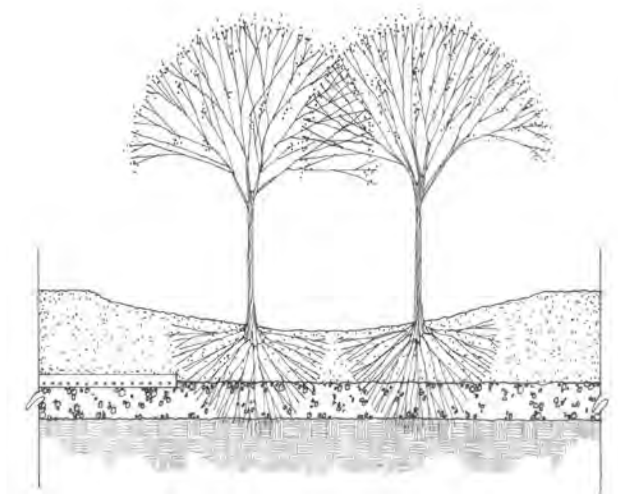
Trees. Bioretention areas can accommodate small or large trees within the minimum areas and volumes calculated by Equation 3-3. Tree canopies intercept rain, and tree roots maintain soil permeability and help retain runoff. Normal maintenance of a bioretention facility should not affect tree lifespan.

Consider the following when designing bioretention facilities to accommodate trees, especially large trees:

- The bioretention facility requires 18" of soil mix over the minimum surface area. Trees can be planted in this soil mix; the area occupied by the tree counts toward the minimum area requirement.
- Trees require sufficient rooting volume to thrive. Structural soils can be used below or around the soil mix.
- Most tree roots extend horizontally near the soil surface.
- The bioretention soil mix has low moisture-holding capacity. Consider planning for tree roots to access native clay soils through the side walls as the tree grows. However, where needed, adjacent paving or structures can be protected with a root barrier.
- A podium of native soil is sometimes constructed so that the root ball can be installed at the correct elevation (so that bioretention soil mix and mulch do not cover the tree's root collar).
- Large trees should be spaced appropriately for their size at maturity.
- Trees may need to be staked for longer because the bioretention soil mix provides little structural support against trees being toppled by wind.



Bioretention facility configured as a tree well.


Larger bioretention facility with trees.

Criteria for Bioretention

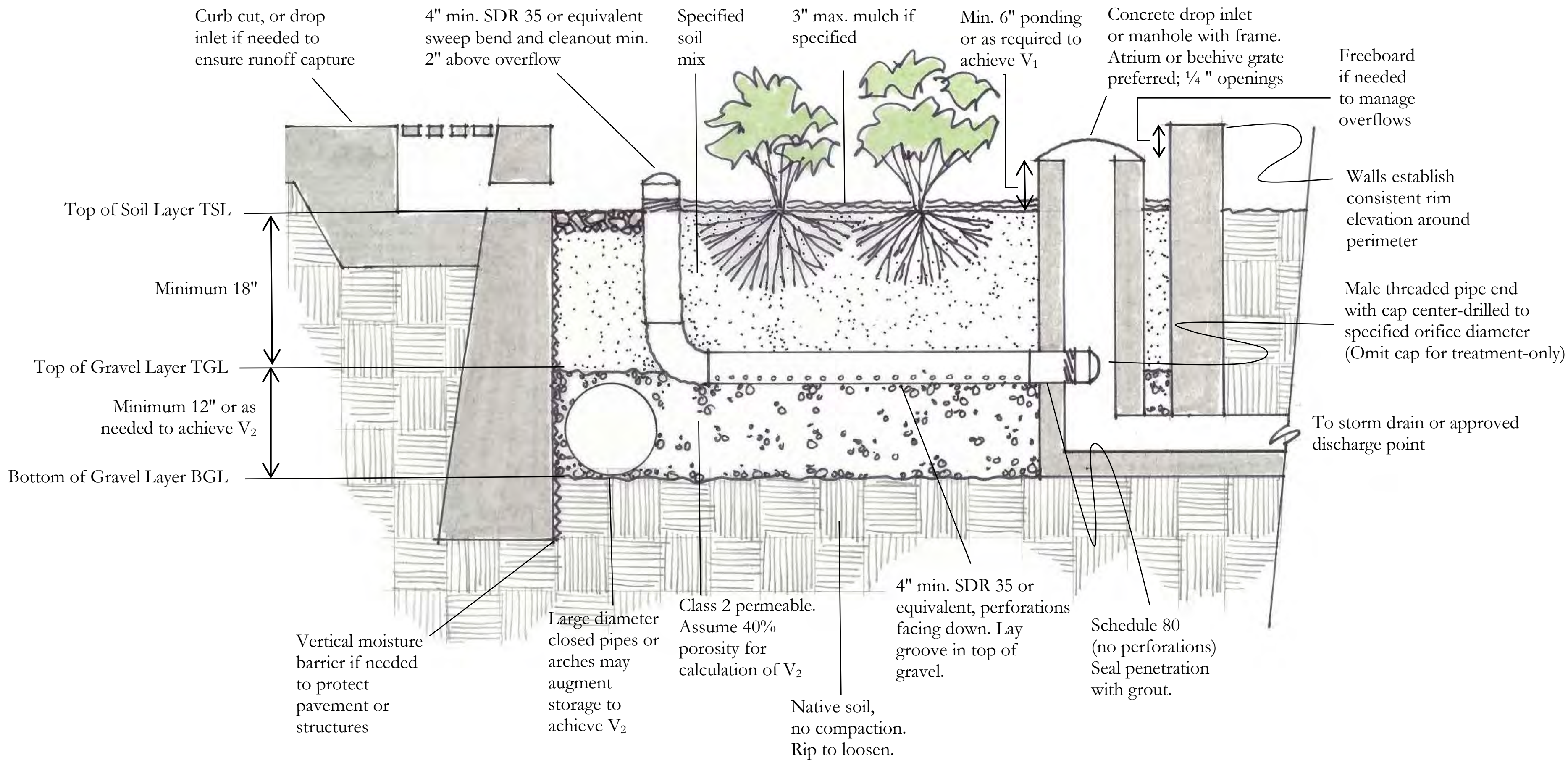
- ❒ Bioretention facilities are located in a visible, well-trafficked area where possible.
- ❒ Top of soil elevation is as high as possible. High walls and steep slopes adjacent to the facility are avoided.
- ❒ Location and footprint of facility are congruent on site plan, landscaping plan, and grading plan.
- ❒ Bioretention area is designed as a basin (level edges) or a series of basins, and grading plan is consistent with these elevations. Check dams, if any, are set so the lip or weir of each dam is at least as high as the toe of the next upstream dam.
- ❒ Volume or depth of surface reservoir meets or exceeds minimum. Freeboard above overflow (1"-2" recommended) is not included in surface reservoir volume.
- ❒ 18" depth specified soil mix (reference *Guidebook* Appendix B).
- ❒ Area of soil mix meets or exceeds minimum.
- ❒ Perforated pipe (PVC SDR 35 or approved equivalent) underdrain with discharge elevation **at the top** of the "Class 2 perm" layer. Holes facing downward. Connection and sufficient head to storm drain or approved discharge point.
- ❒ No filter fabric.
- ❒ Underdrain has a clean-out port consisting of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4 inches and a watertight cap.
- ❒ Curb inlets are 12" wide, have 4"-6" reveal and an apron or other provision to prevent blockage when vegetation grows in, and energy dissipation as needed.
- ❒ Overflow catch basin or manhole connected to a downstream storm drain or approved discharge point.
- ❒ Emergency spillage will be safely conveyed overland.
- ❒ Plantings are suitable to the climate, exposure, and a well-drained soil, and occasional inundation during large storm events.
- ❒ Irrigation system with connection to water supply, on a separate zone. See Appendix B.
- ❒ Vaults, utility boxes, backflow preventers, and light standards are located outside the minimum soil mix surface area.

For treatment-and-flow-control facilities only

- ❒ Volume of surface storage meets or exceeds minimum (V_1).
- ❒ Volume of subsurface storage meets or exceeds minimum (V_2).
- ❒ In "C" and "D" native soils, underdrain is connected to discharge through an appropriately sized orifice or other flow-limiting device.

Bioretention Facility

Cross-section
Not to Scale

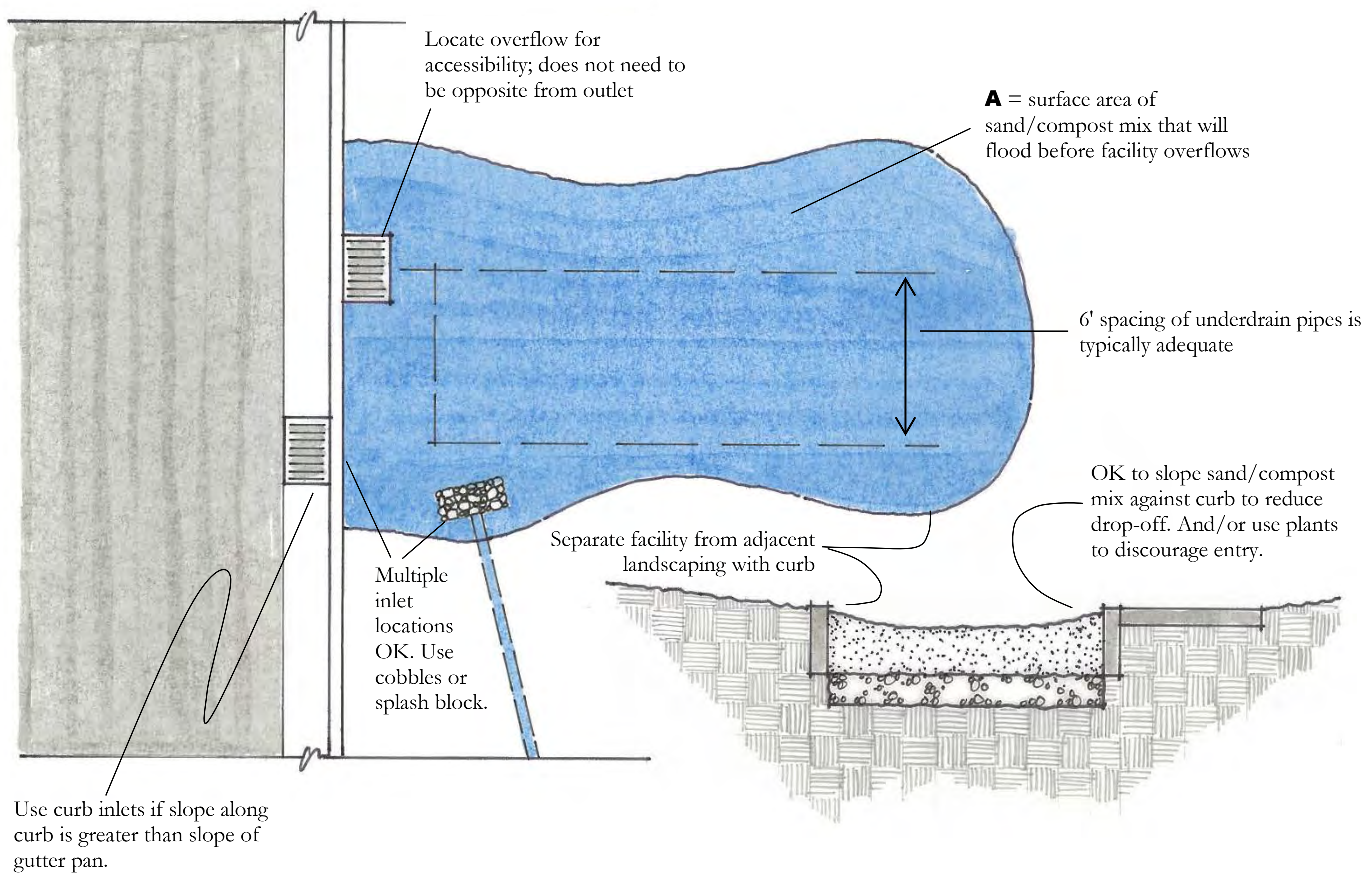


Notes:
- No liner, no filter fabric, no landscape cloth.
- Maintain BGL. TGL, TSL throughout facility area at elevations to be specified on drawing.
- Class 2 perm layer may extend below and underneath drop inlet.
- Elevation of perforated pipe underdrain is atop gravel layer.
- See Appendix B for soil mix specification, planting and irrigation guidance.
- See Chapter 3 for factors and equations used to calculate V_1 V_2 and orifice diameter.

Bioretention Facility

Plan

Not to Scale



Flow-through Planter

Unlike bioretention facilities, flow-through planters are designed to discharge all influent runoff following treatment, rather than infiltrating some treated runoff into the underlying soil.

Flow-through planters are contained within a concrete box, or plastic liners may be used on the sides and bottom. An underdrain is constructed with the discharge elevation near the bottom of the gravel layer (that is, there is no "dead" storage)."

Flow-through planters may be used as an alternative to bioretention under certain conditions:

- Upper-story plazas
- Where bioretention facilities could cause mobilization of pollutants in soil or groundwater.
- Other situations where infiltration is a concern, such as locations with potential geotechnical hazards that cannot be mitigated except by preventing infiltration.

Best Uses

- Management of roof runoff
- Podium-style developments
- On building plazas

Advantages

- Versatile
- Can be any shape
- Low maintenance

Limitations

- Can only be used where infiltration is not possible
- May not be used for flow control (HM) where underlying soils are Hydrologic Soil Group "A" or "B"
- Requires underdrain
- Requires 3-4 feet of head

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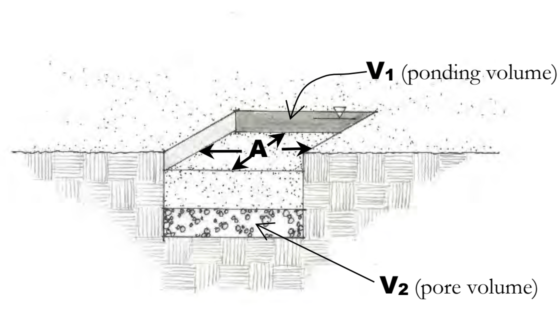
► **DIMENSIONS AND MATERIALS**

Treatment only. For development projects subject only to runoff treatment requirements, the following criteria apply:

Parameter	Criterion
Surface reservoir depth	6" minimum
Soil mix surface area	0.04 × tributary impervious area
Soil mix depth	18" minimum
Gravel layer	12" min. Class 2 permeable
Underdrain	At bottom of gravel layer

Where **flow-control requirements** also apply, the flow-through planter must be designed to meet the minimum surface area (A), surface volume (V_1), and subsurface volume (V_2) using Equation 3-3 and the sizing factors and equations in Tables 3-6 and 3-7. The IMP Sizing Calculator should be used.

Minimum surface and subsurface volume. In a vertical-sided box-like planter for treatment-and-flow-control with the minimum surface area A, the minimum surface volume V_1 can be achieved with an overflow height of 10" (12" total height of walls with 2" of freeboard).



For treatment-and-flow-control facilities the minimum subsurface volume V_2 specified in Table 3-8 is the void space, not the entire volume of gravel. The minimum subsurface volume V_2 can be achieved with a gravel (Class 2 permeable) depth of 30". This combination results in a planter approximately 5' high. The planter height can be reduced by incorporating void-creating underdrain pipes, other pipes, or arches, or by increasing the planter area so that the minimum V_2 is achieved.

Gravel. "Class 2 permeable," Caltrans specification 68-2.02(F)(3), is preferred. Open-graded crushed rock, washed, may be used, but requires 4"-6" washed pea gravel be substituted at the top of the crushed rock layer. **Do not use filter fabric** to separate the soil mix from the gravel drainage layer or the gravel drainage layer from the native soil.

If desired, voids created by buried structures such as pipes or arches may be substituted, as long as the voids are hydraulically interconnected and the minimum subsurface volume calculated by Equation 3-3 is achieved.

Soil mix. Criteria for the required mix of sand and compost are in Appendix B. It is similar to a loamy sand and must maintain a minimum percolation rate of 5" per hour throughout the life of the facility, and it must be suitable for maintaining plant life with a minimum of fertilizer use. A list of suppliers is on the C.3 web pages.

Underdrains. Underdrains must have their discharge elevation set as flush with the planter bottom as possible. Underdrains must be constructed of rigid pipe (SDR 35 or equivalent) and provided with a cleanout.

Flow-control orifice. For treatment-and-flow-control facilities, the underdrain must be routed through a device designed to limit flows to that specified in Equation 3-10 or 3-11 (page 38). Typically a section of solid pipe is designed to protrude slightly into the overflow structure. The pipe is threaded and fitted with a standard cap; a hole of the specified diameter is drilled into the cap. The cap can then be easily removed for cleaning or adjustment and reinstalled.

Flow-through planters on the plaza level of a podium-style development.

► APPLICATIONS

At plaza level. Flow-through planters have been successfully incorporated into podium-style developments, with the planters placed on the plaza level and receiving runoff from the tower roofs above. Runoff from the plaza level is typically managed separately by additional flow-through planters or bioretention facilities located at street level.

Bioretention facility adjacent to building. An impermeable cutoff wall between the facility and the building may be incorporated.

Adjacent to buildings. Designers should aim to use bioretention facilities (that is, facilities open at the bottom to allow infiltration) adjacent to buildings. An impermeable vertical cutoff wall between the facility and the building may be incorporated. Where it is not feasible to adjust the building and foundation design, flow-through planters may be used. Planter vegetation can soften the visual effect of the building wall. A setback with a raised planter box may be appropriate even in some neo-traditional pedestrian-oriented urban streetscapes.

Steep slopes. Flow-through planters provide a means to detain and treat runoff on very steep slopes that cannot accept infiltration from a bioretention facility. The planter can be built into the slope similar to a retaining wall. The design should consider the need to access the planter for maintenance. Flows from the planter underdrain and overflow must be directed in accordance with local requirements. It is sometimes possible to disperse these flows to the downgradient hillside.

Flow-through planter built into a hillside. Flows from the underdrain and overflow must be directed in accordance with local requirements.

Design Checklist for Flow-through Planter

- ❒ Location and footprint of facility are shown on site plan and landscaping plan.
- ❒ Planter is set level.
- ❒ Location is on an upper-story plaza, adjacent to a building foundation, where mobilization of pollutants in soil or groundwater is a concern, or where potential geotechnical hazards are associated with infiltration
- ❒ Volume or depth of surface reservoir meets or exceeds minimum.
- ❒ 18" depth specified soil mix (reference *Guidebook* Appendix B).
- ❒ Area of soil mix meets or exceeds minimum.
- ❒ "Class 2 perm" drainage layer.
- ❒ No filter fabric.
- ❒ Perforated pipe (PVC SDR 35 or approved equivalent) underdrain with outlet located flush or nearly flush with planter bottom.
- ❒ Connection with sufficient head to storm drain or discharge point.
- ❒ Underdrain has a clean-out port consisting of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4" and a watertight cap.
- ❒ Overflow outlet connected to a downstream storm drain or approved discharge point.
- ❒ Emergency spillage will be safely conveyed overland.
- ❒ Plantings are suitable to the climate, exposure, and a well-drained soil.
- ❒ Irrigation system with connection to water supply, on a separate zone. See Appendix B.

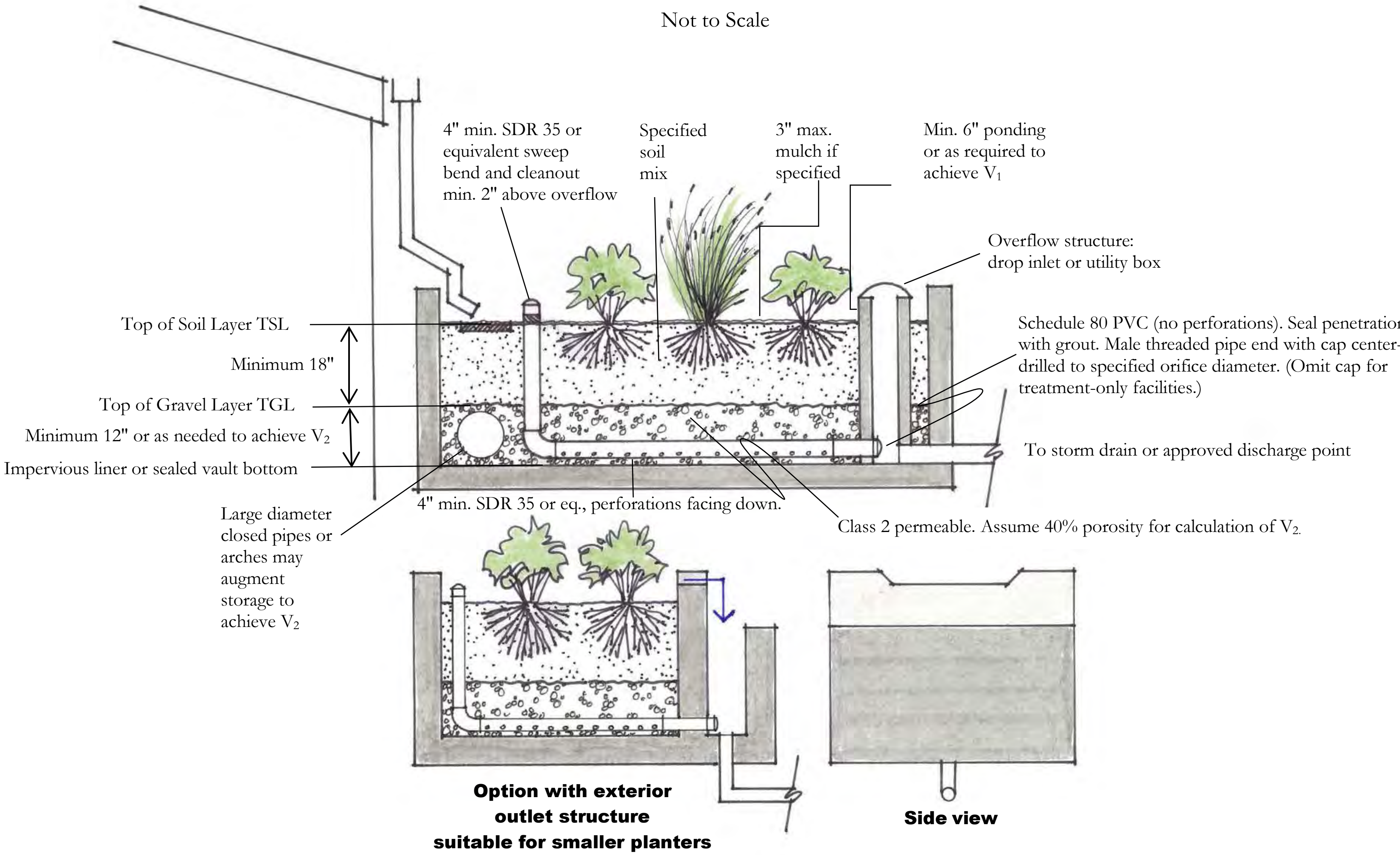
For treatment-and-flow-control flow-through planters only

- ❒ Volume of surface storage meets or exceeds minimum.
- ❒ Volume of subsurface storage meets or exceeds minimum.
- ❒ Underdrain is connected via an appropriately sized orifice or other flow-limiting device.

Flow-through Planter

Cross-section

Not to Scale



Notes:

- Underdrain to be min. 4" PVC SDR 35 or equiv. with holes facing down.
- Locate undedrain as close as possible to bottom.
- No filter fabric, no landscape cloth.
- See Appendix B for soil mix specification, planting and irrigation guidance.
- See Chapter 3 for factors and equations used to calculate V_1 V_2 and orifice diameter.

Dry Wells and Infiltration Basins

The typical dry well is a prefabricated structure, such as an open-bottomed vault or box, placed in an excavation or boring. The vault may be empty, which provides maximum space efficiency, or may be filled with rock.

An infiltration basin has the same functional components—a volume to store runoff and sufficient area to infiltrate that volume into the native soil—but is open rather than covered.

► CRITERIA

Dry wells and infiltration basins must be designed with the minimum volume and infiltrative area calculated by Equation 3-3 using the sizing factors in Table 3-6.

Consult with the local municipal engineer regarding the need to verify soil permeability and other site conditions are suitable for dry wells and infiltration basins. Some proposed criteria are on Page 5-12 of Caltrans' 2004 *BMP Retrofit Pilot Study Final Report* (CTSW-RT-01-050).

► DETAILS

Dry wells should be sited to facilitate maintenance and allow for the potential future need for removal and replacement.

In locations where native soils are coarser than a medium sand, the area directly beneath the facility should be over-excavated by two feet and backfilled with sand as a groundwater protection measure.

Best Uses

- Projects on sites with permeable soils

Advantages

- Compact footprint
- Can be installed in paved areas

Limitations

- Can be used only on sites with Group "A" or Group "B" soils
- Requires minimum of 10' from bottom of facility to seasonal high groundwater
- Not suitable for drainage from some industrial areas or arterial roads
- Must be maintained to prevent clogging.
- Typically not as aesthetically pleasing as bioretention facilities

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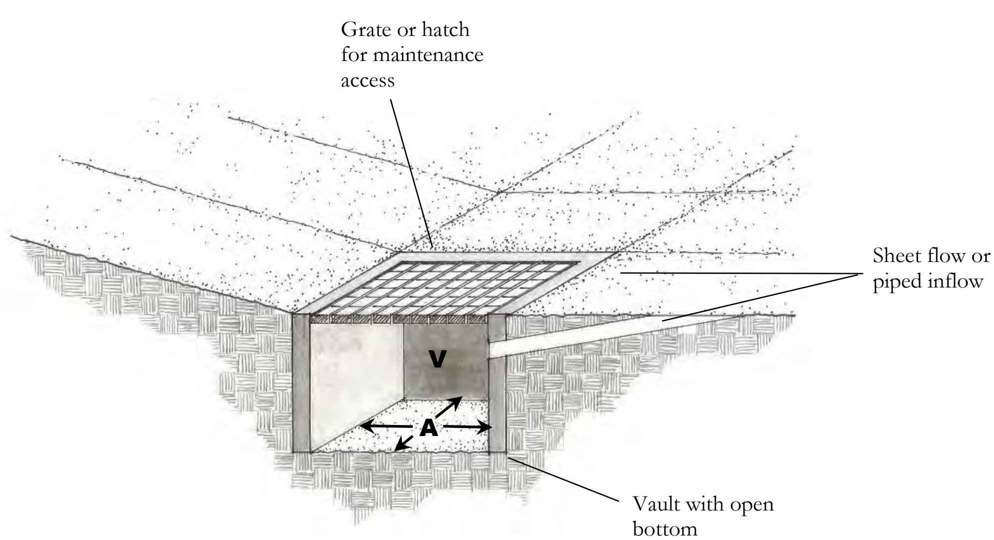
Criteria for Dry Wells and Infiltration Basins

- ❐ Volume (V) and infiltrative area (A) meet or exceed minimum.
- ❐ Emergency spillage will be safely conveyed overland.
- ❐ Depth from bottom of the facility to seasonally high groundwater elevation is ≥10'.
- ❐ Areas tributary to the facility do not include automotive repair shops; areas subject to high vehicular traffic (25,000 or greater average daily traffic on main roadway or 15,000 or more average daily traffic on intersecting roadway), car washes; fleet storage areas (bus, truck, etc.); nurseries, or other uses that may present an exceptional threat to groundwater quality.
- ❐ Underlying soils are in Hydrologic Soil Group A or B. Infiltration rate is sufficient to ensure a full basin will drain completely within 72 hours. Soil infiltration rate has been confirmed.
- ❐ 10' setback from structures or as recommended by structural or geotechnical engineer



Cistern + Bioretention Facility

A cistern in series with a bioretention facility or flow-through planter can meet treatment and flow-control requirements where space is limited. The cistern includes an orifice for flow control. The downstream bioretention facility or flow-through planter is sized to accommodate the maximum flow from the cistern orifice.

► CRITERIA

Cistern. Size the cistern using Equation 3-3 (page 38) and the factors and rainfall adjustment equations in Tables 3-6 and 3-7. The cistern must also include an orifice or other device to limit outflow to the calculated maximum release rate.

Bioretention facility. Size the bioretention facility or flow-through planter based on the cistern maximum release rate and a maximum surface loading rate of 5" per hour.

► DETAILS

Preventing mosquito harborage. Cisterns should be designed to drain completely, leaving no standing water. Drains should be located flush with the bottom of the cistern. Alternatively—or in addition—all entry and exit points should be provided with traps or sealed or screened to prevent mosquito entry. Note mosquitoes can enter through openings $\frac{1}{16}$" or larger and will fly for many feet through pipes as small as ¼".

Exclude debris. Provide leaf guards and/or screens to prevent debris from accumulating in the cistern.

Ensure access for maintenance. Design the cistern to allow for cleanout. Avoid creating the need for maintenance workers to enter a confined space. Ensure the outlet orifice can be easily accessed for cleaning and maintenance.

► APPLICATIONS

Shallow ponding on a flat roof. The "cistern" storage volume can be designed in any configuration, including simply storing rainfall on the roof where it falls and draining it away slowly. In sites with Group "D" soils, the required average depth amounts to about ¾".

Best Uses

- To meet flow-control requirements in limited space.
- Management of roof runoff
- Dense urban areas

Advantages

- Storage volume can be in any configuration
- Small footprint

Limitations

- Somewhat complex to design, build, and operate
- Requires head for both cistern and bioretention facility

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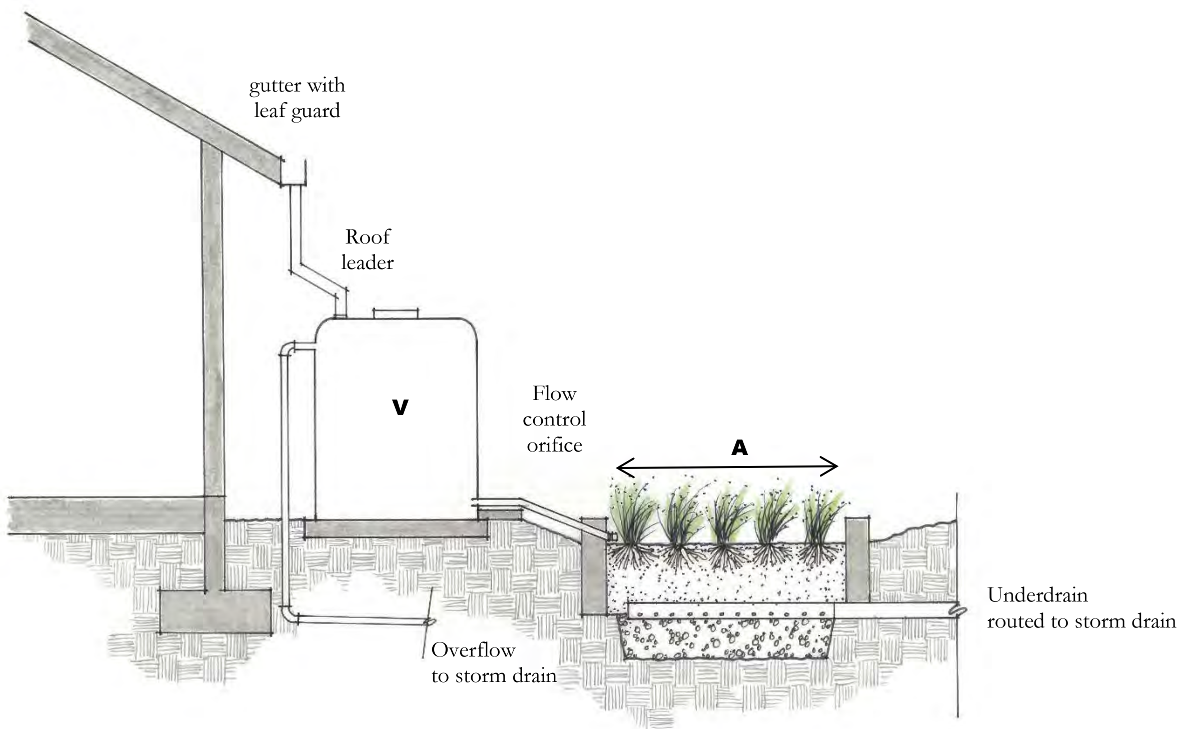
Cistern attached to a building and draining to a planter. This system for treatment-and-flow-control can be constructed with a flow-through planter at a height as low as 30".

Criteria for Cistern + Bioretention

- ❒ Cistern volume meets or exceeds calculated minimum V (Eq. 3-3).
- ❒ Cistern outlet with orifice or other flow-control device restricts flow to calculated maximum. A drilled, threaded cap is suggested for easy maintenance.
- ❒ Cistern outlet is piped to bioretention area or flow-through planter.
- ❒ Bioretention surface area meets or exceeds the calculated minimum.
- ❒ Except for surface area, bioretention facility is designed to the criteria for "treatment only" in the "Bioretention Facility" design sheet (p. 59) or "Flow-through Planter" design sheet (p. 69).
- ❒ Cistern is designed to drain completely and/or sealed to prevent mosquito harborage.
- ❒ Design provides for exclusion of debris and accessibility for maintenance.
- ❒ Overflow connected to a downstream storm drain or approved discharge point.
- ❒ Emergency spillage will be safely conveyed overland.



Bioretention + Vault

A bioretention facility in series with a vault can meet treatment and flow-control requirements where space is limited. In this configuration, the bioretention facility is sized to a minimum of 4% of the tributary impervious area. The underdrain and overflow from the bioretention facility are routed to a storage vault, which can be located beneath a plaza, sidewalk, or parking area. An orifice limits the rate of discharge from the vault to the storm drain system.

▶ CRITERIA

Bioretention facility. Size and design the bioretention facility to the treatment-only criteria (see Bioretention Facility design sheet, p. 69.)

Vault. Size the vault using Equation 3-3 (page 52) and the factors and rainfall adjustment equations in Tables 3-6 and 3-7. The vault must include an orifice or other device to limit outflow.

Dead storage in the bioretention facility (volume of the gravel pore space or other free volume below the elevation of the underdrain discharge) may be credited toward the required V_2.

▶ DETAILS

Preventing mosquito harborage. Vaults must be designed to drain completely, leaving no standing water, and have an open bottom to allow infiltration into the native soil.

Ensure access for maintenance. Design the vault to allow for cleanout. Avoid creating the need for maintenance workers to enter a confined space. Ensure the outlet orifice can be easily accessed for cleaning and maintenance.

▶ APPLICATIONS

Parking lot. Because the required landscaped bioretention facilities is only 4% of the tributary impervious area, the bioretention component can in many cases be integrated into parking lot medians and islands. The vault component can be located beneath aisles or driveways.

Best Uses

- To meet flow-control requirements in limited space
- Parking lots
- Dense urban areas

Advantages

- Smaller footprint than bioretention facility sized for flow control

Limitations

- Somewhat complex to design, build, and operate
- Requires head for both bioretention facility and vault

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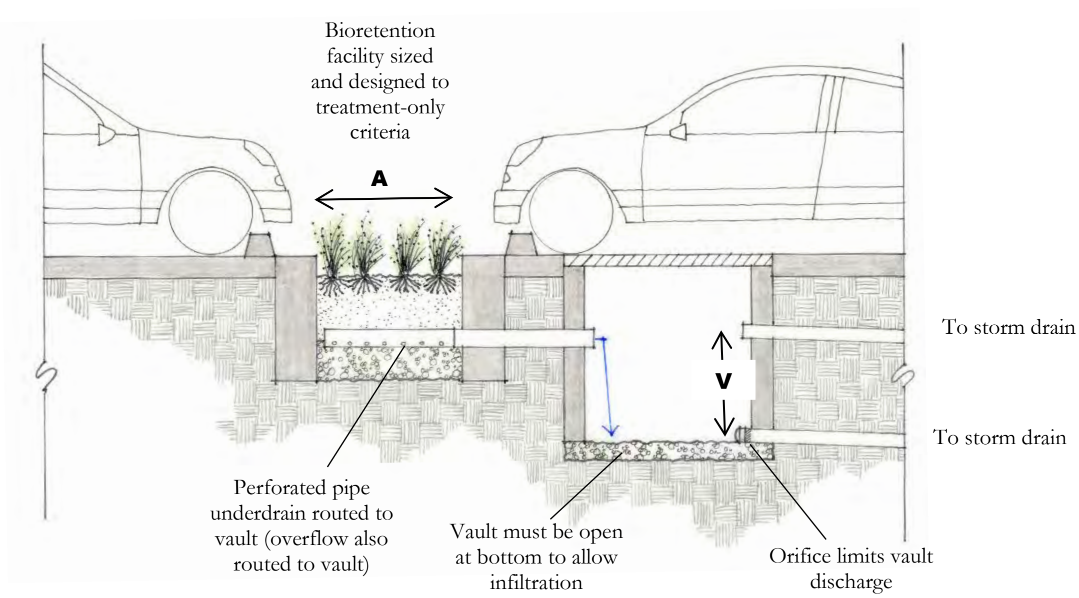
Multiple bioretention facilities draining to a single vault. Two or more bioretention areas can be connected to a single vault. The vault minimum volume and outlet maximum flow rate are the sum of those calculated for each individual bioretention facility.

Vault with pumped discharge. Where insufficient head exists, vaults may be equipped with pumps to discharge (at a rate no greater than the calculated maximum) to a storm drain or approved discharge point.

Design Checklist for Bioretention + Vault

- ❒ Bioretention facility is designed to the treatment-only criteria in the "Bioretention Facility" design sheet (pp. 59-68).
- ❒ Vault retention volume meets or exceeds calculated minimum.
- ❒ Vault outlet with orifice or other flow-control device restricts flow to calculated maximum.
- ❒ Bioretention facility underdrain is routed to the vault.
- ❒ Bioretention facility overflow is routed to the vault.
- ❒ Sufficient head exists to convey flow from the underdrain to the vault and from the vault to the discharge point.
- ❒ Bottom of vault is open to allow infiltration.
- ❒ Vault design provides for exclusion of debris and accessibility for maintenance.
- ❒ Vault outlet and overflow are connected to a downstream storm drain or approved discharge point.
- ❒ Emergency spillage will be safely conveyed overland.



Items to Be Inspected During Construction

Successful construction of IMPs requires attention to detail during **every stage** of the construction process, from initial layout to rough grading, installation of utilities, construction of buildings, paving, landscaping, and final clean-up and inspection.

Construction project managers need to understand the purpose and function of IMPs and know how to avoid common missteps that can occur during construction. For bioretention facilities, the following operating principles should be noted at a pre-construction meeting.

- Runoff flow from the intended tributary drainage management area must flow into the facility.
- The surface reservoir must fill to its intended volume during high inflows.
- Runoff must filter rapidly through the layer of imported soil mix.
- Filtered runoff must infiltrate into the native soil to the extent possible (or allowable).
- Remaining runoff must be captured and drained to a storm drain or other approved location.

See the model construction inspection checklist on the following pages.

IMP CONSTRUCTION CHECKLIST

LAYOUT (to be confirmed prior to beginning excavation)

- ❐ Square footage of the facility meets or exceeds minimum shown in Stormwater Control Plan
- ❐ Site grading and grade breaks are consistent with the boundaries of the tributary Drainage Management Area(s) (DMAs) shown in the Stormwater Control Plan
- ❐ Inlet elevation of the facility is low enough to receive drainage from the entire tributary DMA
- ❐ Locations and elevations of overland flow or piping, including roof leaders, from impervious areas to the facility have been laid out and any conflicts resolved
- ❐ Rim elevation of the facility is laid out to be level all the way around, or elevations are consistent with a detailed cross-section showing location and height of interior dams
- ❐ Locations for vaults, utility boxes, and light standards have been identified so that they will not conflict with the facility
- ❐ Facility is protected as needed from construction-phase runoff and sediment

EXCAVATION (to be confirmed prior to backfilling or pipe installation)

- ❐ Excavation conducted with materials and techniques to minimize compaction of soils within the facility area
- ❐ Excavation is to accurate area and depth
- ❐ Slopes or side walls protect from sloughing of native soils into the facility
- ❐ Moisture barrier, if specified, has been added to protect adjacent pavement or structures.
- ❐ Native soils at bottom of excavation are ripped or loosened to promote infiltration

OVERFLOW OR SURFACE CONNECTION TO STORM DRAINAGE
(to be confirmed prior to backfilling with any materials)

- ❐ Overflow is at specified elevation (typically no lower than two inches below facility rim)
- ❐ No knockouts or side inlets are in overflow riser
- ❐ Overflow location selected to minimize surface flow velocity (near, but offset from, inlet recommended)
- ❐ Grating excludes mulch and litter (beehive or atrium-style grates with ¼" openings recommended)
- ❐ Overflow is connected to storm drain via appropriately sized piping

UNDERGROUND CONNECTION TO STORM DRAIN/OUTLET ORIFICE
(to be confirmed prior to backfilling IMP with any materials)

- ❐ Perforated pipe underdrain (PVC SDR 35 or approved equivalent) is installed with holes facing down
- ❐ Perforated pipe is connected to storm drain (treatment only) or orifice (treatment-and-flow-control)
- ❐ Underdrain pipe is at elevation shown in plans. In facilities allowing infiltration, preferred elevation is above native soil but low enough to be covered by at least 2 inches of Class 2 perm; in sealed planter boxes or bioretention facilities with liners, preferred elevation is as near bottom as possible
- ❐ Cleanouts are in accessible locations and connected via sweeps
- ❐ Structures (arches or large diameter pipes) for additional surface storage are installed as shown in plans and specifications and have the specified volume

(continued)

IMP CONSTRUCTION CHECKLIST (CONTINUED)

DRAIN ROCK/SUBDRAIN (to be confirmed prior to installation of soil mix)

- ❒ Rock is installed as specified. Class 2 permeable, Caltrans specification 68-1.025 recommended, or 4"-6" pea gravel is installed at the top of the crushed rock layer
- ❒ Rock is smoothed to a consistent top elevation. Depth and top elevation are as shown in plans
- ❒ Slopes or side walls protect from sloughing of native soils into the facility
- ❒ No filter fabric is placed between the subdrain and soil mix layers

SOIL MIX

- ❒ Soil mix is as specified. Quality of mix is confirmed by delivery ticket or on-site testing as appropriate to the size and complexity of the facility
- ❒ Mix installed in lifts not exceeding 12"
- ❒ Mix is not compacted during installation but may be thoroughly wetted to encourage consolidation
- ❒ Mix is smoothed to a consistent top elevation. Depth of mix (18" min.) and top elevation are as shown in plans, accounting for depth of mulch to follow and required reservoir depth

IRRIGATION

- ❒ Irrigation system is installed so it can be controlled separately from other landscaped areas. Smart irrigation controllers and drip emitters are recommended
- ❒ Spray heads, if any, are positioned to avoid direct spray into outlet structures

PLANTING

- ❒ Plants are installed consistent with approved planting plan
- ❒ Any trees and large shrubs are staked securely
- ❒ No fertilizer is added; compost tea may be used
- ❒ No native soil or clayey material are imported into the facility with plantings
- ❒ 1"-2" mulch may be applied following planting; mulch selected to avoid floating
- ❒ Final elevation of soil mix maintained following planting
- ❒ Curb openings are free of obstructions

FINAL ENGINEERING INSPECTION

- ❒ Drainage Management Area(s) are free of construction sediment and landscaped areas are stabilized
- ❒ Inlets are installed to provide smooth entry of runoff from adjoining pavement, have sufficient reveal (drop from the adjoining pavement to the top of the mulch or soil mix, and are not blocked
- ❒ Inflows from roof leaders and pipes are connected and operable
- ❒ Temporary flow diversions are removed
- ❒ Rock or other energy dissipation at piped or surface inlets is adequate
- ❒ Overflow outlets are configured to allow the facility to flood and fill to near rim before overflow
- ❒ Plantings are healthy and becoming established
- ❒ Irrigation is operable
- ❒ Facility drains rapidly; no surface ponding is evident
- ❒ Any accumulated construction debris, trash, or sediment is removed from facility

Chapter 5

Operation & Maintenance of Stormwater Facilities

How to prepare a customized Stormwater Facilities Operation & Maintenance Plan for the treatment BMPs on your site.

Stormwater NPDES Permit Provision C.3.e requires each municipality verify stormwater treatment and flow-control facilities, and impervious pavement installations 3000 SF and greater in area, are adequately maintained. Municipalities must report the results of inspections to the Water Boards annually.

Facilities you install as part of your project will be incorporated into the local municipality's verification program. This is a six-stage process:

1. Determine **who will own** the facility and be responsible for its maintenance in perpetuity and document this in your Stormwater Control Plan. The Stormwater Control Plan must also identify the means by which ongoing maintenance will be assured (for example, a maintenance agreement that runs with the land).

2. Identify typical maintenance requirements, allow for these requirements in your project planning and preliminary design, and document the typical maintenance requirements in your Stormwater Control Plan.

3. Prepare an **Operation and Maintenance Plan** (O&M Plan) for the site incorporating detailed requirements for **each treatment and flow-control facility**. Typically, a draft O&M Plan must be submitted with the building permit application, and a final O&M Plan must be submitted for review and approved by the municipality prior to building permit final and issuance of a certificate of occupancy. **Local requirements vary as to schedule. Check with municipal staff.**

4. **Maintain** the facilities from the time they are constructed until ownership and maintenance responsibility is formally transferred.

5. **Formally transfer** operation and maintenance **responsibility** to the site owner or occupant. A warranty, secured by a bond, or other financial instrument, may be required to secure against lack of performance due to flaws in design or construction. A typical warranty period will cover two rainy seasons.

6. Maintain the facilities in perpetuity and comply with your municipality's self-inspection, reporting, and verification requirements.

See the schedule for these stages in Table 6-1. **Again, local requirements will vary.**

TABLE 5-1. SCHEDULE FOR PLANNING operation and maintenance of stormwater treatment and flow-control faciliites

Stage	*Description*	*Where documented*	*Schedule*
1	Determine facility ownership and maintenance responsibility	Stormwater Control Plan	Discuss with planning staff at pre-application meeting
2	Identify typical maintenance requirements	Stormwater Control Plan	Submit with planning & zoning application
3	Develop detailed operation and maintenance plan	O&M Plan	Submit draft with Building Permit application; final due before building permit final and applying for a Certificate of Occupancy
4	Interim operation and maintenance of facilities	As required by municipal O&M verification program	During and following construction including warranty period
5	Formal transfer of operation & maintenance responsibility	As required by municipal O&M verification program	On sale and transfer of property or permanent occupancy
6	Ongoing maintenance and compliance with inspection & reporting requirements	As required by municipal O&M verification program	In perpetuity

Stage 1: Ownership and Responsibility

Your Stormwater Control Plan must specify a means to **finance and implement maintenance** of treatment and flow-control facilities **in perpetuity.**

Depending on the intended use of your site and the policies of the local municipality, this may require one or more of the following:

- Execution of a maintenance agreement that "runs with the land."
- Creation of a homeowners association (HOA) and execution of an agreement by the HOA to maintain the facilities as well as an annual inspection fee.
- Formation of a new community facilities district or other special district, or addition of the properties to an existing special district.
- Dedication of fee title or easement transferring ownership of the facility (and the land under it) to the municipality.

Ownership and maintenance responsibility for treatment and flow-control facilities should be discussed at the **beginning of project planning**, typically at the pre-application meeting for planning and zoning review. Experience has shown provisions to finance and implement maintenance of treatment and flow-control facilities can be a major stumbling block to project approval, particularly for **small residential subdivisions**. (See "Applying C.3 to New Subdivisions" in Chapter 1.)

► PRIVATE OWNERSHIP AND MAINTENANCE

The municipality may require—as a condition of project approval—that a maintenance agreement be executed.

The CCCWP has prepared the following model agreements:

- Operation and Maintenance Agreement for a Single Parcel with a Stormwater Management Facility
- Operation and Maintenance Agreement for Subdivisions with Stormwater Management Facilities
- Operation and Maintenance Agreement for Subdivisions with Stormwater Management Facilities and a Homeowners Association
- CC&R and Subdivision Map Provisions for Subdivisions with Stormwater Management Facilities
- CC&R Provisions for Subdivisions with Stormwater Management Facilities and a Homeowners Association

The model agreements "run with the land," so the agreement executed by a developer is binding on the owners of the subdivided lots. The agreement must be recorded prior to conveyance of the subdivided property.

The model agreements provide the municipality may collect a management and/or inspection fee established by the standard fee schedule. In addition, the agreements provide that, if the property owner fails to maintain the stormwater facility, the municipality may enter the property, restore the stormwater facility to good working order and obtain reimbursement, including administrative costs, from the property owner.

To augment and enforce maintenance requirements, the County established a two-tiered Community Facilities District (Mello-Roos) throughout the unincorporated area to cover the costs of inspections, reporting to the Water Board and, if necessary, code enforcement and maintenance and repair of individual facilities. Some cities and towns may have similar districts.

► TRANSFER TO PUBLIC OWNERSHIP

Municipalities may sometimes choose to have a treatment and flow-control facility deeded to the public in fee or as an easement and maintain the facility as part of the municipal storm drain system. The municipality may recoup the costs of maintenance through a special tax, assessment district, or similar mechanism.

Locating an IMP in a public right-of-way or easement creates an additional design constraint—along with hydraulic grade, aesthetics, landscaping, and circulation. However, because sites typically drain to the street, it may be possible to locate a bioretention swale parallel with the edge of the parcel. The facility may complement, or substitute for, an underground storm drain system.

Local Requirements

Cities, towns, or the County may have requirements that differ from, or are in addition to, this countywide Guidebook. See Appendix A and check with local planning and community development staff.

Even if the facility is to be deeded or transferred to the municipality after construction is complete, it is still the responsibility of the builder to identify general operation and maintenance requirements, prepare a detailed operation and maintenance plan, and to maintain the facility until that responsibility is formally transferred.

Stage 2: General Maintenance Requirements

Include in your Stormwater Control Plan a general description of anticipated facility maintenance requirements. This will help ensure that:

- Ongoing costs of maintenance have been considered in your facility selection and design.
- Site and landscaping plans provide for access for inspections and by maintenance equipment.

- Landscaping plans incorporate irrigation requirements for facility plantings.
- Initial maintenance and replacement of facility plantings is incorporated into landscaping contracts and guarantees.

Fact sheets available on the CCCWP C.3 web page describe general maintenance requirements for the types of stormwater facilities featured in the LID Design Guide (Chapter 4). You can use this information to specify general maintenance requirements in your Stormwater Control Plan.

Maintenance fact sheets for conventional stormwater facilities are available in the California Stormwater BMP Handbooks.

Stage 3: Stormwater Facilities O&M Plan

Submit a **draft** O&M Plan with construction documents when you apply for permits to begin grading or construction on the site. **Revise** your draft O&M plan in response to any comments from your municipality, and incorporate new information and changes developed during project construction. Submit a revised, **final** O&M plan before construction is complete.

Your Final Stormwater Control O&M Plan must be submitted to and approved by your municipality before your building permit can be made final and a certificate of occupancy issued.

Your O&M Plan must be kept on-site for use by maintenance personnel and during site inspections. It is also recommended that a copy of the Stormwater Control Plan be kept onsite as a reference.

Municipal Regional Permit Provision C.3.h requires Contra Costa municipalities periodically verify operation and maintenance (O&M) of facilities installed in their jurisdiction. Each year, they must report to the Water Board the facilities inspected that year and the status of each.

The final O&M plan should incorporate solutions to any problems noted or changes that occurred during construction. For this reason, the final O&M plan may be submitted at the end of the construction period, before the application for final building permit and Certificate of Occupancy.

► TOOLS AND ASSISTANCE

The following step-by-step instructions—and forms available on the CCCWP website—will help you prepare your Stormwater Control Operation and Maintenance Plan. You may use, adapt, and assemble these documents to prepare your own Plan, which will be customized to the specific needs of your site.

These include:

- A form for stating or updating key contact information.
- An example Inspection and Maintenance Log.
- A format for an independent inspector's annual inspection report.
- An example maintenance matrix including necessary maintenance activities, recommended frequency of inspections of maintenance, and indications that maintenance is necessary.

Additional useful references, including links to additional documents, are available in "References and Resources" at the end of this chapter.

► YOUR O&M PLAN: STEP BY STEP

The following step-by-step guidance will help you prepare each required section of your Stormwater Control Operation and Maintenance Plan.

Preparation of the plan will require familiarity with your stormwater facilities as they have been constructed and a fair amount of "thinking through" plans for their operation and maintenance. The text and forms provided here will assist you, but are no substitute for thoughtful planning.

► STEP 1: DESIGNATE RESPONSIBLE INDIVIDUALS

To begin creating your O&M Plan, your organization must designate and identify:

- The individual who will have direct responsibility for the maintenance of stormwater controls. This individual should be the designated contact with municipal inspectors and should sign self-inspection reports and any correspondence with the municipality regarding verification inspections.
- Employees or contractors who will report to the designated contact and are responsible for carrying out BMP operation and maintenance.
- The corporate officer authorized to negotiate and execute any contracts that might be necessary for future changes to operation and maintenance or to implement remedial measures if problems occur.
- Your designated respondent to problems, such as clogged drains or broken irrigation mains, that would require immediate response should they occur during off-hours.

It is recommended to use the form available on the CCCWP website to list this information. **Updated contact information must be provided to the municipality immediately whenever a property is sold and whenever designated individuals or contractors change.** Complete a new form—and mail or fax a copy to the municipality—whenever this occurs.

Draw or sketch an **organization chart** to show the relationships of authority and responsibility between the individuals responsible for O&M. This need not be elaborate, particularly for smaller organizations.

Describe how **funding for BMP operation and maintenance** will be assured, including sources of funds, budget category for expenditures, process for establishing the annual maintenance budget, and process for obtaining authority should unexpected expenditures for major corrective maintenance be required.

Describe how your organization will accommodate initial **training** of staff or contractors regarding the purpose, mode of operation, and maintenance requirements for the stormwater facilities on your site. Also, describe how your organization will ensure ongoing training as needed and in response to staff changes.

► STEP 2: SUMMARIZE DRAINAGE AND BMPS

Incorporate the following information from your Stormwater Control Plan into your O&M Plan:

- Figures delineating and designating pervious and impervious areas.
- Figures showing locations of stormwater facilities on the site.
- Tables of pervious and impervious areas served by each facility.

Review the Stormwater Control Plan narrative that describes each facility and its tributary drainage area and update the text to incorporate any changes that may have occurred during planning and zoning review, building permit review, or construction. Incorporate the updated text into your O&M Plan.

► STEP 3: DOCUMENT FACILITIES “AS BUILT”

Include the following information from final construction drawings:

- Plans, elevations, and details of all facilities. Annotate if necessary with designations used in the Stormwater Control Plan.
- Design information or calculations submitted in the detailed design phase (i.e., not included in the Stormwater Control Plan)

- Specifications of construction for facilities, including sand or soil, compaction, pipe materials and bedding.

In the final O&M Plan, incorporate field changes to design drawings, including changes to any of the following:

- Location and layouts of inflow piping, flow splitter boxes, and piping to off-site discharge
- Depths and layering of soil, sand, or gravel
- Placement of filter fabric or geotextiles (not recommended between soil and gravel layers of bioretention facilities)
- Changes or substitutions in soil or other materials.
- Natural soils encountered (e.g. sand or clay lenses)

► STEP 4: PREPARE CUSTOMIZED MAINTENANCE PLANS

Prepare a maintenance plan, schedule, and inspection checklists (routine, annual, and after major storms) for each facility. Plans and schedules for two or more similar facilities on the same site may be combined.

Use the following resources to prepare your customized maintenance plan, schedule, and checklists.

- Specific information noted in Steps 2 and 3, above.
- Other input from the facility designer, municipal staff, or other sources.
- BMP Operation and Maintenance Fact Sheets (available on the CCCWP C.3 web page).

Note any particular characteristics or circumstances that could require attention in the future, and include any troubleshooting advice.

Also include manufacturer's data, operating manuals, and maintenance requirements for any:

- Pumps or other mechanical equipment.
- Proprietary devices used as or in conjunction with BMPs.

Manufacturers' publications should be referenced in the text (including models and serial numbers where available). Copies of the manufacturers' publications should be included as an attachment in the back of your O&M Plan or as a separate document.

To better organize your maintenance plan, consider using the "O&M Maintenance Matrix" available on the Program's C.3 web page to present inspection frequencies, observations, and appropriate maintenance response.

► STEP 5: COMPILE O&M PLAN

Your O&M Plan should follow this general outline:

I. Inspection and Maintenance Log

II. Updates, Revisions and Errata

III. Introduction

A. Narrative overview describing the site; drainage areas, routing, and discharge points; and treatment and flow control facilities

IV. Responsibility for Maintenance

A. General

(1) Name and contact information for responsible individual(s).

(2) Organization chart or charts showing organization of the maintenance function and location within the overall organization.

(3) Reference to Operation and Maintenance Agreement (if any). A copy of the agreement should be attached.

(4) Maintenance Funding

(a) Sources of funds for maintenance

(b) Budget category or line item

(c) Description of procedure and process for ensuring adequate funding for maintenance

B. Staff Training Program

C. Records

D. Safety

V. Summary of Drainage Areas and Stormwater Facilities

A. Drainage Areas

(1) Drawings showing pervious and impervious areas (copied or adapted from Stormwater Control Plan)

(2) Designation and description of each drainage area and how flow is routed to the corresponding facility.

B. Treatment and Flow Control Facilities

(1) Drawings showing location and type of each facility

(2) General description of each facility (Consider a table if more than two facilities)

(a) Area drained and routing of discharge.

(b) Facility type and size

VI. BMP Design Documentation

A. "As-built" drawings of each facility (design drawings in the draft Plan)

B. Manufacturer's data, manuals, and maintenance requirements for pumps, mechanical or electrical equipment, and proprietary facilities (include a "placeholder" in the draft plan for information not yet available).

C. Specific operation and maintenance concerns and troubleshooting

VII. Maintenance Schedule or Matrix

A. Maintenance Schedule for each facility with specific requirements for:

(1) Routine inspection and maintenance

(2) Annual inspection and maintenance

(3) Inspection and maintenance after major storms

B. Service Agreement Information

Assemble and make copies of your O&M Plan. One or more copies must be submitted to the municipality, and at least one copy kept on-site. Here are some suggestions for formatting the O&M Plan:

- Format plans to 8½" x 11" to facilitate duplication, filing, and handling.

- Include the revision date in the footer on each page.
- Scan graphics and incorporate with text into a single electronic file. Keep the electronic file backed-up so that copies of the O&M Plan can be made if the hard copy is lost or damaged.

► **STEP 6: UPDATES**

Your Stormwater Control Operation and Maintenance Plan will be **a living document**.

Operation and maintenance personnel may change; mechanical equipment may be replaced, and additional maintenance procedures may be needed. Throughout these changes, the O&M Plan must be kept up-to-date.

Updates may be transmitted to your municipality at any time. However, at a minimum, updates to the O&M Plan must accompany the annual inspection report. These updates should reference the sections of the Plan being changed and should be placed in reverse chronological order (most recent at the top) in Section II of the binder. If the entire O&M Plan is updated, as it should be from time to time, these updates should be removed from the first section, but may be filed (perhaps in the back of the binder) for possible future reference.

Stage 4: Interim Operation & Maintenance

In accordance with NPDES Permit Provision C.3.e.ii, include the following statement in your Stormwater Control Plan:

> The property owner accepts responsibility for interim operation and maintenance of stormwater treatment and flow-control facilities until such time as this responsibility is formally transferred to a subsequent owner.

Applicants will typically be required to warranty stormwater facilities against lack of performance due to flaws in design or construction for a minimum of two rainy seasons following completion of construction. The warranty may need to be secured by a bond or other financial instrument.

Stage 5: Transfer Responsibility

As part of the final O&M plan, note the expected date when responsibility for operation and maintenance will be transferred. Notify your municipality when this transfer of responsibility takes place.

Stage 6: Operation & Maintenance Verification

Each Contra Costa municipality will implement a Stormwater Treatment Measures Operation and Maintenance Verification Program, including periodic site inspections.

Local stormwater ordinances state municipalities may require an annual certificate of compliance certifying operation and maintenance of treatment and flow-control facilities. To obtain a certificate of compliance, the responsible party must request and pay for an inspection from the municipality each year. Alternatively, owners or lessees may arrange for inspection by a private company authorized by the municipality. Based on the results of the inspection, the municipality may issue a certificate, issue a conditional certificate requiring correction of noted deficiencies by a specific date, or deny the certificate.

Some municipalities have established alternative procedures. Check with local staff for requirements.

References and Resources

- *Model Stormwater Ordinance (CCCWP, 2005)*
- *Start at the Source* (BASMAA, 1999) pp. 139-145.
- *Urban Runoff Quality Management* (WEF/ASCE, 1998). pp 186-189.
- Contra Costa Clean Water Program *Vector Control Plan*

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RWQCB. 2015. California Regional Water Quality Control Board for the San Francisco Bay Region. Municipal Regional Stormwater NPDES Permit. Order R2-2015-0074.

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USEPA. 2009b. *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act.* EPA 841-B-09-001

WEF/ASCE. 1998. Water Environment Foundation/American Society of Civil Engineers. Urban Runoff Quality Management. WEF Manual of Practice No. 23, ASCE Manual and Report on Engineering Practice No. 87. ISBN 1-57278-039-8 ISBN 0-7844-0174-8. 259 pp.

Appendix

A

Local Exceptions & Requirements

Municipality-specific procedures, policies, and submittal requirements.
Obtain from your municipal planning and community development department.

The Contra Costa Clean Water Program C.3 web page includes links to each Contra Costa municipality's C.3 information.

Appendix B

Soils, Plantings, and Irrigation for Bioretention Facilities

Additional guidance for design and construction of bioretention facilities and flow-through planters

Bioretention facility owners are responsible for ensuring the following standards of performance are achieved throughout the life of the facility:

- Runoff must percolate through the imported bioretention soil mix at a minimum rate of 5" per hour.
- Plantings must be maintained in a healthy condition without use of conventional fertilizers or pesticides.
- Irrigation systems must minimize water use and be controlled to prevent overwatering and underdrain flow during dry weather.

As described in Chapter 5, municipalities will periodically verify these standards continue to be achieved. Operation and maintenance verification is required by the municipalities' stormwater NPDES permit issued by the Regional Water Quality Control Board.

The design criteria and checklists and other guidance in Chapter 3—including the design sheets—aim to ensure new bioretention facilities and planter boxes can reliably meet these standards of performance.

The additional guidance in this Appendix will assist applicants and their designers as they proceed from initial planning through design and construction.

Appendix B Contents

Responsibility for design, construction, maintenance, and performance of stormwater treatment and flow-control facilities and their components rests with the applicant or property owner.

Soils

Soils for bioretention facilities must meet the specifications proposed by BASMAA and accepted by Water Board staff. The current specifications were approved April 18, 2016. These specifications were adapted from specifications in the 5th Edition of this *Guidebook* (2010). The substantive change is the addition of particle size distribution for compost as well as for sand.

Use of the standard (rather than "alternative") soil mix is strongly encouraged. See the CCCWP C.3 web pages for a list of suppliers. These suppliers have submitted sample testing data to CCCWP. At their sole discretion, municipal construction inspectors may choose to accept test results and certification for a "brand-name" mix from a soil supplier.

► SUBMITTAL REQUIREMENTS AND PROCESS

It is recommended that permittees request applicants and soil suppliers to submit only the information specified in Attachment L when seeking approval to use a particular mix.

For the "specified" mix, the submittal requirements are:

- A sample of mixed bioretention soil.
- Certification that the mix meets the specification.
- Grain size analysis of the sand component.
- Quality analysis results for compost based on the US Composting Council's Seal of Testing Assurance standards
- Grain size analysis of the compost component
- Description of equipment and methods used to mix the sand and compost.
- Contact information for the testing laboratory, including qualifications and dates of current certifications

Attachment L explicitly allows municipalities to accept test results and certification for a "brand name" mix from a supplier in lieu of test results and certification specific to the development project.

For the specified mix, no infiltration rate testing is required. It is recommended this information not be included in submittals for the "specified" mix. (Infiltration rate tests are required with requests to approve "alternative" soil mixes.)

It is also common for the testing laboratory to provide information regarding soil fertility and recommended soil fertilizers or amendments. As fertilizers and amendments are not to be used in bioretention facilities, this information is potentially misleading to contractors and maintenance personnel and and should also be omitted from the submittal.

► PLACEMENT AND COMPACTION OF BIORETENTION SOILS

Place the bioretention soil in 8" to 12" lifts. Lifts are **not to be compacted** but are placed to reduce the possibility of excessive settlement. Allow time for natural compaction and settlement prior to planting. Bioretention soil may be watered to encourage compaction.

Plantings

► PLANT SELECTION GUIDELINES

The plants tabulated in Attachment B-1 were selected for the following characteristics:

- Adaptation to Contra Costa's climate
- Drought tolerance
- Adaptation to well-drained soils
- Adaptation to low soil fertility
- Allow infiltration
- Are not invasive weeds
- Do not have aggressive roots

Characteristics noted in the table, including irrigation preferences and ability to tolerate heat, coastal conditions, flooding, and wind should be considered when selecting plants.

This list is not comprehensive, nor will all these species succeed at every site. Selection for a particular site should be done by experienced professionals familiar with the plants and site conditions. Avoid planting species on the California Invasive Plant Council's invasive plant inventory list.

► PLANT INSTALLATION

Trees and large shrubs installed in bioretention facilities are susceptible to blowing over before roots are established. They should be staked securely. Three stakes per tree are recommended at windy sites. Straps should be inspected once or twice a year and removed once trees are established to prevent girdling.

► FERTILIZATION

Due to the potential for conveying nutrients to storm drains, no fertilizer should be added to bioretention facilities or planter boxes. **Compost tea**, available from various nurseries and garden supply retailers, may be applied at a recommended rate of 5 gallons mixed with 15 gallons of water per acre.

Compost tea can be applied up to two weeks prior to planting and once per year between March and June. Application is not recommended when temperatures are below 50°F or above 90°F or when rain is forecast in the next 48 hours. Additional applications may be made as needed to correct nutrient deficiencies.

► MULCH

Mulch is not required but is recommended for the purpose of retaining moisture, preventing erosion and minimizing weed growth. Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. Aged mulch can be obtained through soil suppliers or directly from commercial recycling yards. Apply 1" to 2" of composted mulch, once a year, preferably in June following weeding.

Compared to bark mulch, aged mulch has somewhat less of a tendency to float into overflow inlets during intense storms. To reduce mulch entering overflow inlets, it is recommended to use atrium or beehive grates with ¼" openings over overflow inlets.

► WEED CONTROL

Weeds should be controlled primarily by manual methods and soil amendment. In response to problem areas or threatening invasions, corn gluten, white vinegar, vinegar-based products such as Burn-out, or non-selective natural herbicides such as Safer's Sharpshooter may be used.

► PEST AND DISEASE CONTROL

Synthetic pesticides should not be used on bioretention facilities. Beneficial nematodes and non-toxic controls may be used. Acceptable natural pesticides include Safer® Aphid, Whitefly, and Mealybug Killer, Safer® Tree and Shrub Insect Attach, Safer® for Evergreens, and Neem oil.

Irrigation

Bioretention soils have a high infiltration rate and require a different irrigation system design than what is typically used for heavy clay soils in Contra Costa

County. Irrigation systems must be designed to minimize water use, avoid overwatering, and prevent the underdrain discharges during dry weather.

Bioretention facilities and planter boxes may need to be irrigated more than once a day. Irrigation controls should allow **separate control** of times and durations of irrigation for bioretention facilities and planter boxes vs. other landscape areas.

Smart irrigation controllers are strongly encouraged. Available controllers may access weather stations, use sensors to measure soil temperature and moisture, and allow input of soil types, plant types, root depth, light conditions, slope, and usable rainfall.

Drip emitters are strongly recommended over spray irrigation. Use multiple, lower-flow (one-half to two gallons per hour) emitters in fast-draining bioretention soils. Use two or more emitters for perennials, ground covers, and bunchgrasses. Four to six emitters may be needed for larger shrubs and trees. Some types of emitters encourage horizontal distribution of water.

Spray heads must be positioned to **avoid direct spray** into bioretention facility or planter box outlet structures.

References and Resources

- Model Biotreatment Soil Media Specifications—MRP 2.0 Provision C.3.c.i.(2)(c)(ii)
- *Recommendations for Soils Specification, Planting, and Irrigation of Bioretention Facilities*, WRA Environmental Consultants, November 5, 2008.
- US Composting Council
- ASTM International
- *Plant List and Planting Guidance for Landscape-Based Stormwater Measures*. Appendix B in the *Alameda County Clean Water Program C.3 Technical Guidance* (2016).
- *Plants and Landscapes for Summer Dry Climates.* Nora Harlow, Ed. East Bay Municipal Utility District, Oakland
- *California Native Plants for Your Garden and Wildlife*, Las Pilitas Nursery, 2008.
- *Native Treasures: Gardening with the Plants of California.* M. Nevin Smith, 2016. University of California Press.
- *The Calflora Database, 2008.*
- California Invasive Plant Council
- *A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California*, University of California Cooperative Extension and California Department of Water Resources
- Our Water Our World, website to developed to assist consumers in managing home and garden pests in a way that helps protect water.
- Bay-Friendly Best Practices for Landscape Professionals, a whole systems approach to the design, construction, and maintenance of the landscape to support the integrity of the San Francisco Bay watershed.
- University of California Statewide Integrated Pest Management (IPM) Program

Plant Recommendations for Bioretention Facilities and Planter Boxes

Grasses and Grass-like Plants

Scientific name Common name	Light Preference			Size (feet)		Watering				Tolerates				CA Native	Other Notes
	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind		
Bromus carinatus California brome	✓			2	1	✓			ok	✓		✓	✓	✓	
Bouteloua gracilis blue grama	✓			1.5	1	✓				✓		✓	✓		Tolerates no summer water, good for non-irrigated remote sites
Carex densa dense sedge	✓			1	1		✓	✓	✓	✓		✓		✓	
Carex obnupta slough sedge	✓			2	1		✓	✓	✓	✓	✓	✓	✓	✓	
Carex praegracilis clustered field sedge	✓	✓		1.5	1.5		✓	✓	✓	✓	✓	✓	✓	✓	
Carex subfusca rusty sedge	✓	✓		1	1		✓		ok	✓	✓	✓	✓	✓	Great for swales
Carex divulsa Berkeley sedge		✓	✓	1	1		✓		ok		✓	✓	✓	✓	AKA *Carex tumulicola*,. Full sun along coast.
Deschampsia cespitosa tufted hairgrass	✓			2	1		✓		ok			✓	✓	✓	Can look weedy
Distichlis spicata salt grass	✓			0.3	3		✓	✓	✓	✓	✓	✓	✓	✓	Looks like bermuda grass, withstands foot traffic, for soils with high salt
Eleocharis palustris creeping spikerush	✓			1	1		✓	✓	ok	✓	✓	✓	✓	✓	
Elymus glaucus blue wildrye	✓			1.5	2		✓	✓	ok	✓	✓	✓	✓	✓	good for grazing, difficult to mow, messy looking lawn
Festuca californica California fescue	✓	✓	✓	2	2	✓			ok	✓	✓		✓	✓	
Festuca idahoensis Idaho fescue	✓	✓		1	1	✓	✓		ok	✓	✓		✓	✓	Can mow. Needs light summer water at hot sites
Festuca rubra red fescue	✓	✓		1	1.5	✓	✓		ok	✓	✓	✓	✓	✓	Can mow. Lawn alternative
Festuca rubra 'molate' molate fescue	✓	✓		1	1.5	✓	✓		ok	✓	✓		✓	c	Can mow. Lawn alternative

Plant Recommendations for Bioretention Facilities and Planter Boxes

Hordeum brachyantherum meadow barley	✓	✓		1.5	1		✓	✓	ok	✓	✓		✓	✓	
Juncus patens blue rush	✓			2	1		✓	✓	✓	✓		✓		✓	
Leymus triticoides creeping wildrye	✓	✓		3	1	✓	✓		ok	✓	✓	✓	✓	✓	Can mow. Recommended for swales.
Melica californica California melica	✓	✓		1	1	✓				✓			✓	✓	
Melica imperfect melic	✓	✓		1	1	✓			ok		✓	✓		✓	Part shade inland, light water in Summer to keep green or goes dormant
Muhlenbergia rigens deergrass	✓			3	3	✓	✓		ok	✓		✓		✓	
Nasella pulchra purple needlegrass	✓	✓		2	1	✓	✓		ok	✓		✓	✓	✓	
Nassella lepida foothill needlegrass	✓	✓	✓	1.5	1	✓	✓		ok	✓	✓		✓	✓	
Phalaris californica California canarygrass		✓	✓	1.5	1		✓	✓	ok		✓	✓	✓	✓	Can be aggressive spreader

Plant Recommendations for Bioretention Facilities and Planter Boxes

Herbaceous Perennials and Groundcovers

Scientific name Common name	Light Preference			Size (feet)		Watering				Tolerates				CA Native	Other Notes
	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind		
Achillea filipendulina fernleaf yarrow	✓			3	3	✓			✓	✓					
Achillea millefolium common yarrow	✓			1.5	1	✓			ok	✓				✓	Good for hot sites
Achillea tomentosa woolly yarrow	✓	✓		1	1.5	✓	✓		ok	✓			✓		
Aloe striata coral aloe	✓	✓		2	2	✓			ok						Sun along coast, afternoon shade inland
Arctostaphylos hookeri Monterey manzanita	✓	✓		1	4	✓	✓		ok		✓		✓	✓	Better in part shade in hot sites
Arctostaphylos uva-ursi kinnick-kinnick	✓	✓		1	15	✓	✓		ok		✓		✓	✓	Full sun at coast, part shade inland. Cultivars to try include 'emerald carpet,' 'Point Reyes,' 'San Bruno Mountain' depending on site
Ceratostigma plumbaginoides dwarf plumbago		✓		0.75	5	✓	✓		✓	✓					
Epilobium canum California fuchsia	✓	✓		1	4	✓			ok					✓	
Eriogonum fasciculatum flattop buckwheat	✓			3	4	✓				✓				✓	
Eschscholzia californica California poppy	✓			1	1	✓			ok	✓	✓	✓	✓	✓	
Fragaria chiloensis beach strawberries	✓	✓	✓	0.3	2	✓			ok		✓			✓	
Gazania spp. treasure flower	✓			0.5	2	✓	✓		✓	✓			✓		
Iris douglasiana Douglas iris	✓	✓		1.5	2	✓	✓		ok	✓			✓	✓	Also, Iris hybrids
Scientific name	Light Preference			Size (feet)		Watering				Tolerates					Other Notes

Plant Recommendations for Bioretention Facilities and Planter Boxes

Common name	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind	CA Native	
Lotus scoparius deerweed	✓			4	3	✓				✓		✓		✓	
Lupinus bicolor miniature lupine	✓			1	1	✓					✓	✓		✓	Adds nitrogen
Mimulus aurantiacus common monkeyflower	✓	✓		3	3	✓			ok			✓		✓	
Mimulus cardinalis scarlet monkeyflower	✓	✓	✓	3	3	▯	✓	✓	✓			✓		✓	Aggressive seeder
Polygonum capitatum pink knotweed	✓	✓		0.5	4	✓			✓	✓	✓		✓		
Prunella vulgaris self heal	✓	✓				✓	✓		ok		✓	✓	✓	✓	
Rudebeckia californica California coneflower	✓			3	2	✓	✓		ok	✓		✓		✓	
Salvia clevelandii Cleveland sage						✓									
Scaevola 'mauve clusters' fan flower	✓	✓		1	4	✓				✓			✓		
Sedum spathulifolium stone crop	✓					✓			ok	✓			✓	varies	For above the high water line
Sisyrinchium bellum blue eyed grass				1	1	✓			ok	✓	✓	✓	✓	✓	
Sisyrinchium californicum yellow eyed grass	✓	✓		1	1		✓		✓	✓	✓	✓	✓	✓	
Solidago californica California goldenrod		✓		3	2	✓	✓		ok	✓		✓		✓	
Stachys byzantine lamb's ears	✓	✓		1	3	✓			ok	✓	✓		✓		
Verbena tenuisecta moss verbena	✓			0.5	5	✓			ok	✓	✓		✓		

Plant Recommendations for Bioretention Facilities and Planter Boxes

Small Shrubs

Scientific name	Light Preference			Size (feet)		Watering				Tolerates				CA	
Common name	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind	Native	Other Notes
Artemisia californica California sagebrush	✓			2-5	4-5	✓				✓	✓		✓	✓	Will not tolerate sprinklers
Baccharis pilularis 'Twin Peaks' or Pigeon Point' dwarf coyote brush	✓			2	6	✓	✓		ok	✓	✓	✓	✓	c	
Cistus skanbergii hybrid rockrose	✓			3	5	✓	✓		✓	✓	✓	✓	✓		Best with annual shearing
Correa 'Carmine Bells' or 'ivory bells' Australian fuchsia	✓	✓		3	6	✓	✓		✓	✓			✓		Ivory bells does not tolerate wind. Attracts hummingbirds. Sunset Zones 16-17 (not recommended for E. Contra Costa)
Erigeron glaucus seaside daisy	✓			1	1.5				ok		✓			✓	
Eriogonum crocatum saffron buckwheat	✓			1.5	1.5	✓				✓	✓		✓	✓	
Eriogonum umbellatum sulfur buckwheat	✓			0.7	3	✓			ok	✓			✓	✓	
Grevillea lanigera woolly grevillea	✓			4	6	✓				✓			✓		Sunset Zones 15-24 (not recommended for E. Contra Costa)
Lavendula spp. lavender	✓			1.5	1.5	✓			ok	✓	✓				
Mahonia pinnata California holly grape	✓	✓	✓	4	4	✓	✓			✓		✓	✓	✓	
Mahonia repens creeping Oregon grape	✓	✓		2	3	✓	✓		ok		✓	✓		✓	
Rosmarinus officinalis rosemary	✓			2.5	5	✓			✓	✓	✓		✓		
Rubus ursinus California blackberry		✓	✓	3	5		✓	✓	ok	✓	✓	✓	✓	✓	Thorns. Harbors beneficial insects

Plant Recommendations for Bioretention Facilities and Planter Boxes

Scientific name / Common name	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind	CA Native	Other Notes
Symphorocarpos albus common snowberry	✓	✓	✓	4	4	✓	✓	✓	ok	✓				✓	Adaptable to many conditions
Westringia fruticosa coast rosemary	✓			4	8	✓				✓	✓		✓		
Whipplea modesta whipplevine		✓	✓	0.5	3		✓	✓	✓		✓	✓		✓	Sunset zones 16-17, 19-24 only (not recommended E. Contra Costa), best for moist shady spots
Large Shrubs															
	Light Preference			Size (feet)		Watering				Tolerates					
Scientific name Common name	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind	CA Native	Other Notes
Alyogyne huegelil blue hibiscus	✓			6	5	✓				✓					Very low water after second year, Sunset zones 15-17 & 20-24 (not recommended E. Contra Costa)
Arctostaphylos densiflora 'Howard Mcminn' McMinn manzanita	✓	✓		3	7	✓				✓			✓	c	
Baccharis pilularis coyote brush	✓			6	7	✓	✓		ok	✓	✓	✓	✓		Fast-growing, short-lived
Berberis darwinii Darwin's barberry	✓	✓		6	6	✓				✓		✓	✓		Sprinklers will kill foliage
Carpenteria californica Bush anemone	✓	✓		6	4	✓	✓		✓	✓				✓	Interior climate with occasional water otherwise low water needs
Ceanothus spp. Various ceanothus	✓	✓		varies	varies	✓			▯	✓			✓	✓	fast-growing but short-lived
Cercis occidentalis western redbud	✓			12	8	✓			▯	✓		✓	✓	✓	Prune low branches for small tree form, susceptible to disease if overwatered
Cotinus coggygia smoke bush	✓			15	15	✓			▯			✓	✓		No water after second year
Eriogonum arborescens Santa Cruz Island buckwheat	✓			3	5	✓			✓	✓	✓	✓	✓	✓	Low water after second year

Plant Recommendations for Bioretention Facilities and Planter Boxes

Scientific name Common name	Light Preference			Size (feet)		Watering				Tolerates				CA Native	Other Notes
	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind		
Eriogonum giganteum St. Catherines lace	✓			5	6	✓			▯		✓	✓	✓	✓	best at coast, tolerant of unwatered inland garden
Fremontodendron californicum flannel bush	✓			20	14	✓			▯	✓		✓		✓	Fast-growing, short-lived
Garrya elliptica Coast silktassel	✓	✓		8	8	✓	✓		✓	✓		✓	✓	✓	'Evie' is compact variety
Heteromeles arbutifolia toyon	✓	✓	✓	7	5	✓	✓		✓	✓	✓	✓		✓	Doesn't respond well to pruning low branches
Juniperus chinensis 'Mint Julep" mint julep juniper	✓	✓		3	6	✓	✓		✓	✓	✓	✓	✓		
Lonicera hispidula California honeysuckle	✓	✓	✓	4	2		✓	✓	✓		✓	✓		✓	Climbing vine-like. Best in part shade. Attracts birds
Lonicera involucrate twinberry honeysuckle	✓	✓	✓	6	3		✓	✓	✓		✓	✓		✓	Best in part shade. Attracts birds
Nandina domestica heavenly bamboo	✓	✓		4	3	✓	✓		✓	✓		✓			
Philadelphus coronaries sweet mock orange	✓	✓		10	10		✓		✓				✓		Best with annual pruning
Physocarpus capitatus Pacific ninebark	✓	✓		5	5	✓	✓	✓	ok		✓	✓		✓	Part shade and summer water required in hot locations
Pittosporum eugeniodes Pittosporum	✓	✓		40	15	✓	✓		✓	✓		✓	✓		shear to control height
Pittosporum tenuifolium Pittosporum	✓	✓		40	15	✓	✓		✓	✓		✓	✓		shear to control height
Prunus illicifolia holly leaf cherry	✓	✓		15	15	✓	✓			✓	✓	✓	✓	✓	
Prunus lyonii Catalina cherry	✓	✓		15	15	✓	✓			✓	✓	✓	✓	✓	
Rhamnus californica California coffeeberry	✓	✓		3-15	6	✓			✓	✓		✓	✓	✓	'Eve Case' is compact with broad foliage

Rhus integrifolia lemonade berry	✓	✓		8	6	✓			✓	✓			✓	✓	Shear to hedge if desired
Ribes malvaceum chaparral currant	✓	✓		5	5	✓	✓		ok	✓				✓	
Ribes sanguineum flowering currant		✓	✓	5-12	5-12	✓	✓		✓	✓	✓	✓		✓	Needs good air movement to avoid white fly
Ribes speciosum fuchsia-flowered gooseberry	✓	✓	✓	3-6	3-6	✓	✓		✓	✓	✓	✓		✓	
Rosa californica California wild rose	✓	✓		3	3-6		✓	✓	ok	✓	✓	✓	✓	✓	hooked thorns not compatible with foot traffic
Rosa gymnocarpa wood rose	✓	✓		2	3		✓		ok	✓	✓	✓		✓	
Vitis californica California grape	✓	✓		10	2-10	✓	✓		✓	✓	✓	✓	✓	✓	Climbing vine. Best in full sun. Can be aggressive in moist area.
Vitis girdiana desert grape	✓			8	2-11	✓	✓		✓	✓		✓	✓	✓	Climbing vine. May be more suited to biofilter soils than californica.

Small Trees

Scientific name Common name	Light Preference			Size (feet)		Watering				Tolerates				CA Native	Other Notes
	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind		
Acer Negundo box elder	✓	✓	✓	30	30	✓	✓		ok	✓	✓	✓	✓	✓	Tough shade tree, deciduous
Arbetus unedo strawberry tree	✓	✓				✓	✓		✓	✓	✓	✓			'Elfin King' is dwarf from 6' tall
Arctostaphylos manzanita common manzanita	✓			6-15	8-12	✓				✓			✓	✓	Prune to be small tree. "Dr. Hurd" is more tolerant of summer water.
Cercis occidentalis western redbud	✓	✓		12	8	✓				✓			✓	✓	Prune low branches for small tree form; susceptible to disease if overwatered.
Eriobotrya deflexa bronze loquat	✓	✓		18	25	✓	✓		✓	✓		✓			Monthly deep watering
Eriobotrya japonica Japanese loquat	✓	✓		25	20	✓	✓		✓	✓		✓			Susceptible to blight under stress
Fraxinus angustfolia Raywood ash	✓			30	30		✓		✓	✓					Fall color
Fraxinus dipetala California ash	✓	✓		20	20				ok	✓		✓		✓	

Plant Recommendations for Bioretention Facilities and Planter Boxes

Scientific name	Light Preference			Size (feet)		Watering				Tolerates				CA	
Common name	Sun	Part	Shade	Ht.	Width	L	M	H	Summer	Heat	Coast	Flood	Wind	Native	Other Notes
Fraxinus latifolia Oregon ash	✓	✓	✓	30	25	✓			✓	✓	✓	✓		✓	
Fraxinus velutina velvet ash	✓			25	15	✓	✓		ok	✓		✓	✓		
Garrya elleptica coast silk tassel	✓	✓		20	20	✓	✓		ok		✓				Afternoon shade inland, responds well to pruning
Laurus 'Saratoga' hybrid laurel	✓	✓		12-40	12-40	✓				✓		✓	✓		prune for tree form
Myrica californica Pacific wax myrtle	✓	✓	✓	10-30	10-30	✓	✓				✓				best at coast
Pinus thumbergiana Japanese black pine	✓	✓		25	20	✓			✓	✓	✓			✓	Asymmetrical, often leaning habit
Pittosporum undulatum victorian box	✓	✓		15	15	✓	✓		✓	✓					Sunset zones 16-17, 21-24 only (not recommended E. Contra Costa. Prune low branches for tree form.
Prunus ilicifolia holly leaf cherry	✓	✓		15	15	✓	✓			✓	✓		✓	✓	
Prunus lyonii Catalina cherry	✓	✓		15	15	✓	✓			✓	✓		✓	✓	
Prunus serrulata "shirofugen' cherry	✓			25	25		✓				✓	✓	✓		Additional cultivars

Plant Recommendations for Bioretention Facilities and Planter Boxes

Key

Water Preference-Low/Moderate/High	We have provided recommendations for irrigation. All plants should be watered with more frequency during the first two years after planting. After this establishment period, Low water use plants will only need supplemental irrigation at the hottest and driest sites. Plants with Moderate irrigation needs will be best with occasional supplemental water (once per week to once per month) and plants with High irrigation needs will be best with more frequent watering especially during periods of drought in the cooler seasons.
Water Preference-Summer Irrigation	Plants with a check in this column will not withstand a long period of summer drought without irrigation. Plants with an 'ok' in this column are tolerant of, but do not require, frequent summer irrigation. Plants with nothing in this column may not tolerate summer irrigation.
Tolerates Heat	A check in the heat column indicates that the plant will tolerate hot sites. It should not be confused with a plants preference for sun. Absence of the check indicates it should only be used in areas close to the Bay or other cool sites.
Tolerates Coast	The coast column indicates plants that perform well within 1,000 feet of the ocean or bay. Most of these plants tolerate some amount of salt air, fog, and wind.
Tolerates Flooding	
Tolerates Wind	A check in the wind column means that the plant will tolerate winds of ten miles per hour or more.
CA Native - c	Cultivar of California native. Cultivars offer habitat benefits to native wildlife and are adapted to the local climate but have reduced genetic diversity.
Other Notes - Sunset Climate Zones	Under the Other Notes category, we have indicated appropriate Sunset Climate Zones only for plants that will not do well across all of Contra Costa County. Please refer to the *Sunset Western Garden Book* which defines climate zones in the Bay Area based on elevation, influence of the Pacific Ocean, presence of hills and other factors.

Appendix

C

Preparing a Stormwater Control Plan for a Small Land Development Project

Instructions and Template for Preparing a Submittal for a Project Creating or Replacing More than 2,500 Square Feet but less than 10,000 Square Feet of Impervious Area

The template is available in Word format on the Contra Costa Clean Water Program website.

CONTRA COSTA
CLEAN WATER
PROGRAM

Preparing a Stormwater Control Plan for a Small Land Development Project

Introduction

As of December 1, 2012, development projects that create or replace 2,500 square feet* or more of impervious surface (roofs or pavement) must incorporate one or more specified measures to reduce runoff. This requirement is part of municipalities' comprehensive effort to reduce runoff pollution. The requirement is mandated by Provision C.3.i. in the Municipal Regional Stormwater Permit issued by the California Regional Water Quality Control Boards for the San Francisco Bay Region and Central Valley Region.

It is fairly easy to achieve compliance with the stormwater requirements for small land development projects. Compliance for each project must be carefully documented. Please complete the following form and submit it as directed by municipal staff.

*All projects that create or replace 10,000 square feet or more of impervious surface—and auto service facilities, gas stations, restaurants, and uncovered parking lots that create or replace 5,000 square feet or more of impervious surface—are "Regulated Projects," and require a more comprehensive Stormwater Control Plan. See the Contra Costa Clean Water Program *Stormwater C.3 Guidebook*.

Step-by-Step Instructions

The steps are:

1. Fill out the Project Data Form (below) and select one or more runoff reduction measures.
2. Prepare a site plan or sketch. Specify and design the runoff reduction measure you will use to meet the stated minimum requirements.
3. Complete your submittal, which will include:
    - Project Data Form
    - Site Plan or Sketch
    - Completed checklist for each Runoff Reduction Measure selected

► STEP 1: PROJECT DATA FORM AND RUNOFF REDUCTION MEASURE SELECTION

Complete all fields.

Project Name/Number	
Application Submittal Date [to be verified by municipal staff]	
Project Location [Street Address if available, or intersection and/or APN]	
Name of Owner or Developer	
Project Type and Description [Examples: "Single Family Residence," "Parking Lot Addition," "Retail and Parking"]	
Total Project Site Area (acres)	
Total New Impervious Surface Area (square feet) [Sum of currently pervious areas that will be covered with new impervious surfaces]	
Total Replaced Impervious Surface Area [Sum of currently impervious areas that will be covered with new impervious surfaces.]	
Total Pre-Project Impervious Surface Area	
Total Post-Project Impervious Surface Area	
Runoff Reduction Measures Selected (Check one or more)	❑ 1. Disperse runoff to vegetated area ❑ 2. Pervious pavement ❑ 3. Cisterns or Rain Barrels ❑ 4. Bioretention Facility or Planter Box

► STEP 2: DELINEATE IMPERVIOUS AREAS AND LOCATIONS OF RUNOFF REDUCTION MEASURES

Delineate the impervious area. On a site plan or sketch, show the impervious area—for example, a roof, or portion of a roof, or a paved area—that will drain to your runoff reduction measure. Typically these delineations follow roof ridge lines or grade breaks. Alternatively, show the type and extent of pervious paving. An example sketch is attached.

Indicate the location and kind of runoff reduction measure you've selected. At least one option, designed to manage runoff from some amount of impervious area—or to avoid creating runoff—is required.

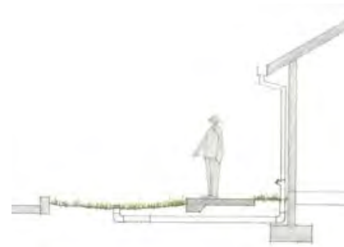
For each option selected, there is a brief checklist to confirm your design and your submittal meet minimum requirements.

► STEP 3: COMPLETE AND SUBMIT YOUR PLAN

Consult with municipal staff about when and how to submit your Stormwater Control Plan for Small Projects.

Option 1: Disperse runoff from roofs or pavement to vegetated areas.

This is the simplest option. Downspouts can be directed to vegetated areas adjacent to buildings, or extended via pipes to reach vegetated areas further away. Paved areas can be designed with curb cuts, or without curbs, to direct flow into surrounding vegetation.



Connecting a roof leader to a vegetated area. The head from the eave height makes it possible to route roof drainage some distance away from the building.

On the site plan, show:

- ❑ Each impervious area from which runoff will be directed, and its square footage.
- ❑ The vegetated areas that will receive runoff, and the approximate square footage of each.
- ❑ If necessary, explain in notes on the plan how runoff will be routed from impervious surfaces to vegetated areas.

Confirm the following standard specifications are met:

- ❑ Tributary impervious square footage in no instance exceeds twice the square footage of the receiving pervious area.
- ❑ Roof areas collect runoff and route it to the receiving pervious area via gutters and downspouts.
- ❑ Paved areas are sloped so drainage is routed to the receiving pervious area.
- ❑ Runoff is dispersed across the vegetated area (for example, with a splash block) to avoid erosion and promote infiltration.
- ❑ Vegetated area has amended soils, vegetation, and irrigation as required to maintain soil stability and permeability.
- ❑ Any drain inlets within the vegetated area are at least 3 inches above surrounding grade.

Option 2: Permeable Pavement

This option can be easy to install and maintain, cost-effective, and can add aesthetic value to your project. Permeable pavements may include pervious concrete, pervious asphalt, porous pavers, crushed aggregate, open pavers with grass or plantings, open pavers with gravel, or solid pavers.

Show on your site plan:

- ❑ Location, extent and types of pervious pavements.

Confirm the following standard specifications are met:

- ❑ No erodible areas drain on to permeable pavement.
- ❑ Subgrade compaction is minimal.
- ❑ Reservoir base course is of open-graded crushed stone. Base depth is adequate to retain rainfall (3 inches is adequate) and support design loads (more depth may be required).
- ❑ No subdrain is included or, if a subdrain is included, outlet elevation is a minimum of 3 inches above bottom of base course.
- ❑ Subgrade is uniform and slopes are not so steep that subgrade is prone to erosion.
- ❑ Rigid edge is provided to retain granular pavements and unit pavers.
- ❑ Solid unit pavers, if used, are set in sand or gravel with minimum 3/8 inch gaps between the pavers. Joints are filled with an open-graded aggregate free of fines.
- ❑ Permeable concrete or porous asphalt, if used, are installed by industry-certified professionals according to the vendor's recommendations.
- ❑ Selection and location of pavements incorporates Americans with Disabilities Act requirements (if applicable), site aesthetics, and uses.

Option 3: Cisterns or Rain Barrels

Use of cisterns or rain barrels to comply with this requirement is subject to municipality approval. Planning and Building Permits may be required for larger systems.

Show on your site plan:

- ❑ Impervious areas tributary to each cistern or rain barrel.
- ❑ Location of each cistern or rain barrel.

Confirm the following standard specifications are met:

- ❑ Rain barrels are sited at grade on a sound and level surface at or near gutter downspouts.
- ❑ Gutters tributary to rain barrels are screened with a leaf guard or maximum ½-inch to ¼-inch-minimum corrosion-resistant metallic hardware fabric.
- ❑ Water collected will be used for irrigation only.
- ❑ Openings are screened with a corrosion-resistant metallic fine mesh (1/16 inch or smaller) to prevent mosquito harborage.
- ❑ Large openings are secured to prevent entry by children.
- ❑ Rain barrels and gutters are to be cleaned annually.
- ❑ The Contra Costa Mosquito and Vector Control District is informed of the installation. The District will be provided additional information and/or rights of entry if they request.

Option 4: Bioretention Facility or Planter Box

An above-ground planter box may be appropriate if the development site lacks level landscaped areas for dispersion and pervious pavements are not practical. Planter boxes and bioretention facilities can treat runoff from impervious surfaces 25 times their area (sizing factor of 0.04).

Flow-through planter built into a hillside. Flows from the underdrain and overflow must be directed in accordance with local requirements.

Detailed design guidance for planter boxes and bioretention areas is in the *Contra Costa Clean Water Program Stormwater C.3 Guidebook*.

Show on your site plan:

- ❑ Impervious areas tributary to the planter box.
- ❑ Location and footprint of planter box.

Confirm the following standard specifications are met:

- ❑ Reservoir depth is 4"-6" minimum.
- ❑ 18" depth soil mix with minimum long-term infiltration rate of 5"/hour. See http://www.cccleanwater.org/c3-guidebook.html for a list of soil mix suppliers.
- ❑ Surface area of soil mix is a minimum 0.04 times the tributary impervious area.
- ❑ "Class 2 perm" drainage layer 12" deep.
- ❑ No filter fabric.
- ❑ Perforated pipe (PVC SDR 35 or approved equivalent) underdrain with outlet located flush or nearly flush with planter bottom.
- ❑ Connection with sufficient head to storm drain or discharge point.
- ❑ Underdrain has a clean-out port consisting of a vertical, rigid, non-perforated PVC pipe, connected to the underdrain via a sweep bend, with a minimum diameter of 4" and a watertight cap.
- ❑ Overflow outlet connected to a downstream storm drain or approved discharge point.
- ❑ Planter is set level.
- ❑ Emergency spillage will be safely conveyed overland.
- ❑ Plantings are suitable to the climate, exposure, and a well-drained soil.
- ❑ Irrigation system with connection to water supply, on a separate zone.

Useful Resources

The following references may be useful for design. Designs must meet the minimum standard specifications in this supplement to the *Stormwater C.3 Guidebook*.

Contra Costa Clean Water Program Stormwater C.3 Guidebook. Available at http://www.cccleanwater.org/c3-guidebook.html

Start At the Source: Design Guidance Manual for Stormwater Quality. Bay Area Stormwater Management Agencies Association, 1999. Available at http://www.cccleanwater.org/c3-resources.html

Stormwater Control for Small Projects Fact Sheets. Bay Area Stormwater Management Agencies Association, 2012. Available at http://www.cccleanwater.org/c3-resources.html

National Ready Mix Concrete Association
http://www.perviouspavement.org/

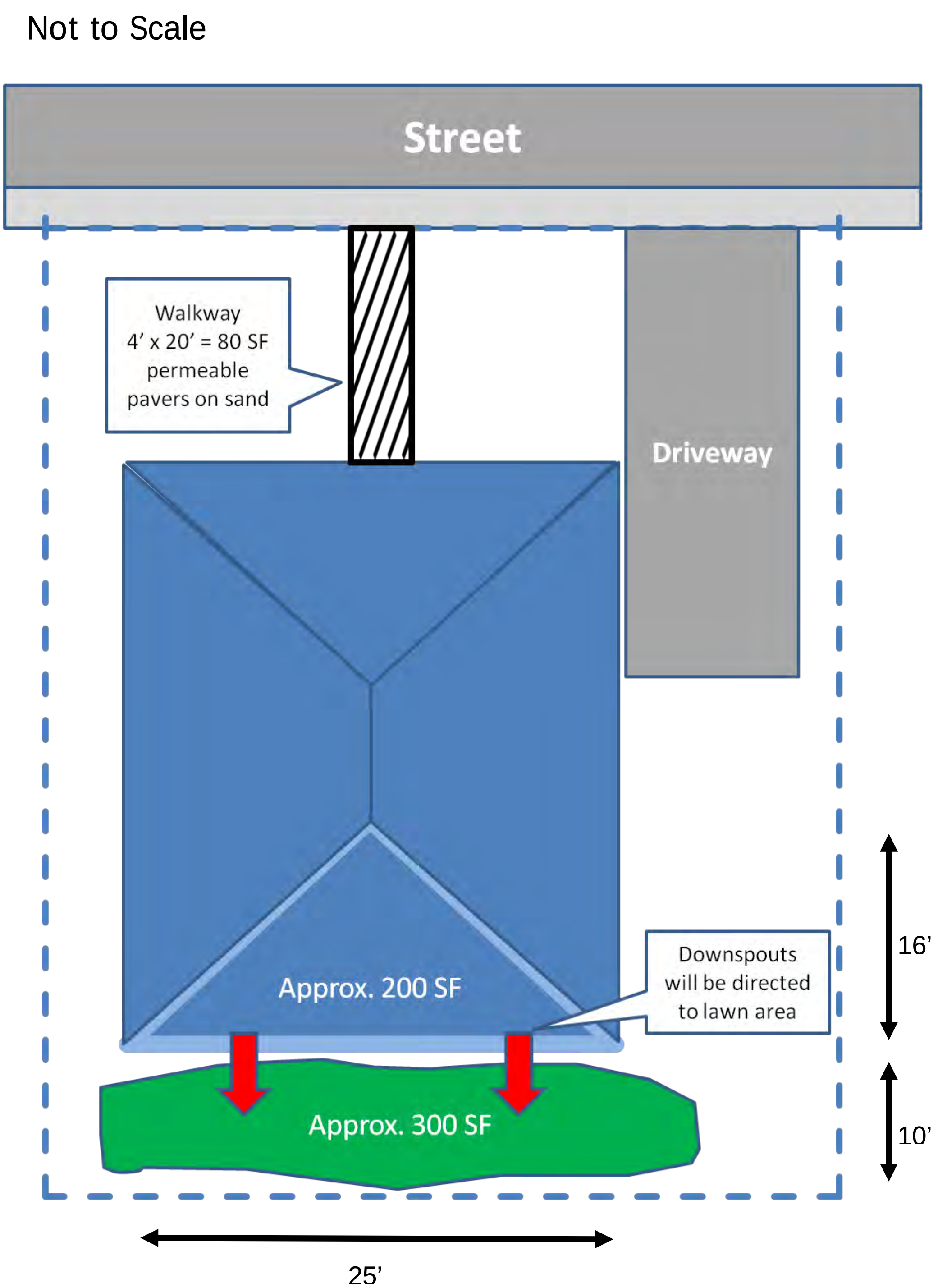
California Asphalt Pavement Association
http://www.californiapavements.org/stormwater.html

Interlocking Concrete Pavement Institute
http://www.icpi.org/

Porous Pavements, by Bruce K. Ferguson. 2005. ISBN 0-8493-2670-2

Example Sketch

The example below illustrates the level of detail required.



APPENDIX D—STORMWATER POLLUTANT SOURCES/SOURCE CONTROL CHECKLIST

How to use this worksheet (also see instructions on page 16 of the *Stormwater C.3 Guidebook*):

1. Review Column 1 and identify which of these potential sources of stormwater pollutants apply to your site. Check each box that applies.
2. Review Column 2 and incorporate all of the corresponding applicable BMPs in your Stormwater Control Plan drawings.
3. Review Columns 3 and 4 and incorporate all of the corresponding applicable permanent controls and operational BMPs in a table in your Stormwater Control Plan. Use the format shown in Table 3-1 on page 17 of the *Guidebook*. Describe your specific BMPs in an accompanying narrative, and explain any special conditions or situations that required omitting BMPs or substituting alternative BMPs for those shown here.

IF THESE SOURCES WILL BE ON THE PROJECT SITE …	… THEN YOUR STORMWATER CONTROL PLAN SHOULD INCLUDE THESE SOURCE CONTROL BMPs		
1 **Potential Sources of Runoff Pollutants**	**2** **Permanent Controls—Show on Stormwater Control Plan Drawings**	**3** **Permanent Controls—List in Stormwater Control Plan Table and Narrative**	**4** **Operational BMPs—Include in Stormwater Control Plan Table and Narrative**
❑ **A.** On-site storm drain inlets	❑ Locations of inlets.	❑ Mark all inlets with the words "No Dumping! Flows to Bay" or similar.	❑ Maintain and periodically repaint or replace inlet markings. ❑ Provide stormwater pollution prevention information to new site owners, lessees, or operators. ❑ See applicable operational BMPs in Fact Sheet SC-74, "Drainage System Maintenance," in the CASQA Stormwater Quality Handbooks ❑ Include the following in lease agreements: "Tenant shall not allow anyone to discharge anything to storm drains or to store or deposit materials so as to create a potential discharge to storm drains."
❑ **B.** Interior floor drains and elevator shaft sump pumps		❑ State that interior floor drains and elevator shaft sump pumps will be plumbed to sanitary sewer.	❑ Inspect and maintain drains to prevent blockages and overflow.

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❑ **C.** Interior parking garages		❑ State that parking garage floor drains will be plumbed to the sanitary sewer.	❑ Inspect and maintain drains to prevent blockages and overflow.
❑ **D1.** Need for future indoor & structural pest control		❑ Note building design features that discourage entry of pests.	❑ Provide Integrated Pest Management information to owners, lessees, and operators.
❑ **D2.** Landscape/ Outdoor Pesticide Use	❑ Show locations of native trees or areas of shrubs and ground cover to be undisturbed and retained. ❑ Show self-retaining landscape areas, if any. ❑ Show stormwater treatment and hydrograph modification management BMPs. (See instructions in Chapter 3, Step 5 and guidance in Chapter 5.)	State that final landscape plans will accomplish all of the following. ❑ Preserve existing native trees, shrubs, and ground cover to the maximum extent possible. ❑ Design landscaping to minimize irrigation and runoff, to promote surface infiltration where appropriate, and to minimize the use of fertilizers and pesticides that can contribute to stormwater pollution. ❑ Where landscaped areas are used to retain or detain stormwater, specify plants that are tolerant of saturated soil conditions. ❑ Consider using pest-resistant plants, especially adjacent to hardscape. ❑ To insure successful establishment, select plants appropriate to site soils, slopes, climate, sun, wind, rain, land use, air movement, ecological consistency, and plant interactions.	❑ Maintain landscaping using minimum or no pesticides. ❑ See applicable operational BMPs in Fact Sheet SC-41, "Building and Grounds Maintenance," in the CASQA Stormwater Quality Handbooks ❑ Provide IPM information to new owners, lessees and operators.

APPENDIX D—STORMWATER POLLUTANT SOURCES/SOURCE CONTROL CHECKLIST

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❑ **E.** Pools, spas, ponds, decorative fountains, and other water features.	❑ Show location of water feature and a sanitary sewer cleanout in an accessible area within 10 feet. (Exception: Public pools must be plumbed according to County Department of Environmental Health Guidelines.)	If the local municipality requires pools to be plumbed to the sanitary sewer, place a note on the plans and state in the narrative that this connection will be made according to local requirements.	❑ See applicable operational BMPs in Fact Sheet SC-72, "Fountain and Pool Maintenance," in the CASQA Stormwater Quality Handbooks
❑ **F.** Food service	❑ For restaurants, grocery stores, and other food service operations, show location (indoors or in a covered area outdoors) of a floor sink or other area for cleaning floor mats, containers, and equipment. ❑ On the drawing, show a note that this drain will be connected to a grease interceptor before discharging to the sanitary sewer.	❑ Describe the location and features of the designated cleaning area. ❑ Describe the items to be cleaned in this facility and how it has been sized to insure that the largest items can be accommodated.	❑ See the brochure, "Water Pollution Prevention Tips to Protect Water Quality and Keep Your Food Service Facility Clean." Provide this brochure to new site owners, lessees, and operators.

APPENDIX D—STORMWATER POLLUTANT SOURCES/SOURCE CONTROL CHECKLIST

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❑ **G.** Refuse areas	❑ Show where site refuse and recycled materials will be handled and stored for pickup. See local municipal requirements for sizes and other details of refuse areas. ❑ If dumpsters or other receptacles are outdoors, show how the designated area will be covered, graded, and paved to prevent run-on and show locations of berms to prevent runoff from the area. ❑ Any drains from dumpsters, compactors, and tallow bin areas shall be connected to a grease removal device before discharge to sanitary sewer.	❑ State how site refuse will be handled and provide supporting detail to what is shown on plans. ❑ State that signs will be posted on or near dumpsters with the words "Do not dump hazardous materials here" or similar.	❑ State how the following will be implemented: Provide adequate number of receptacles. Inspect receptacles regularly; repair or replace leaky receptacles. Keep receptacles covered. Prohibit/prevent dumping of liquid or hazardous wastes. Post "no hazardous materials" signs. Inspect and pick up litter daily and clean up spills immediately. Keep spill control materials available on-site. See Fact Sheet SC-34, "Waste Handling and Disposal" in the CASQA Stormwater Quality Handbooks
❑ **H.** Industrial processes.	❑ Show process area.	❑ If industrial processes are to be located on site, state: "All process activities to be performed indoors. No processes to drain to exterior or to storm drain system."	❑ See Fact Sheet SC-10, "Non-Stormwater Discharges" in the CASQA Stormwater Quality Handbooks

APPENDIX D—STORMWATER POLLUTANT SOURCES/SOURCE CONTROL CHECKLIST

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❑ **I.** Outdoor storage of equipment or materials. (See rows J and K for source control measures for vehicle cleaning, repair, and maintenance.)	❑ Show any outdoor storage areas, including how materials will be covered. Show how areas will be graded and bermed to prevent run-on or run-off from area. ❑ Storage of non-hazardous liquids shall be covered by a roof and/or drain to the sanitary sewer system, and be contained by berms, dikes, liners, or vaults. ❑ Storage of hazardous materials and wastes must be in compliance with the local hazardous materials ordinance and a Hazardous Materials Management Plan for the site.	Include a detailed description of materials to be stored, storage areas, and structural features to prevent pollutants from entering storm drains. Where appropriate, reference documentation of compliance with the requirements of Contra Costa Hazardous Materials Programs for: ▪ Hazardous Waste Generation ▪ Hazardous Materials Release Response and Inventory ▪ California Accidental Release (CalARP) ▪ Aboveground Storage Tank ▪ Uniform Fire Code Article 80 Section 103(b) & (c) 1991 ▪ Underground Storage Tank www.cchealth.org/groups/hazmat/	❑ See the Fact Sheets SC-31, "Outdoor Liquid Container Storage" and SC-33, "Outdoor Storage of Raw Materials " in the CASQA Stormwater Quality Handbooks

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❑ **J.** Vehicle and Equipment Cleaning	❑ Show on drawings as appropriate: (1) Commercial/industrial facilities having vehicle/equipment cleaning needs shall either provide a covered, bermed area for washing activities or discourage vehicle/equipment washing by removing hose bibs and installing signs prohibiting such uses. (2) Multi-dwelling complexes shall have a paved, bermed, and covered car wash area (unless car washing is prohibited on-site and hoses are provided with an automatic shut-off to discourage such use). (3) Washing areas for cars, vehicles, and equipment shall be paved, designed to prevent run-on to or runoff from the area, and plumbed to drain to the sanitary sewer. (4) Commercial car wash facilities shall be designed such that no runoff from the facility is discharged to the storm drain system. Wastewater from the facility shall discharge to the sanitary sewer, or a wastewater reclamation system shall be installed.	❑ If a car wash area is not provided, describe measures taken to discourage on-site car washing and explain how these will be enforced.	Describe operational measures to implement the following (if applicable): ❑ Washwater from vehicle and equipment washing operations shall not be discharged to the storm drain system. ❑ Car dealerships and similar may rinse cars with water only. See Fact Sheet SC-21, "Vehicle and Equipment Cleaning," in the CASQA Stormwater Quality Handbooks

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❑ **K.** Vehicle/Equipment Repair and Maintenance	❑ Accommodate all vehicle equipment repair and maintenance indoors. Or designate an outdoor work area and design the area to prevent run-on and runoff of stormwater. ❑ Show secondary containment for exterior work areas where motor oil, brake fluid, gasoline, diesel fuel, radiator fluid, acid-containing batteries or other hazardous materials or hazardous wastes are used or stored. Drains shall not be installed within the secondary containment areas. ❑ Add a note on the plans that states either (1) there are no floor drains, or (2) floor drains are connected to wastewater pretreatment systems prior to discharge to the sanitary sewer and an industrial waste discharge permit will be obtained.	❑ State that no vehicle repair or maintenance will be done outdoors, or else describe the required features of the outdoor work area. ❑ State that there are no floor drains or if there are floor drains, note the agency from which an industrial waste discharge permit will be obtained and that the design meets that agency's requirements. ❑ State that there are no tanks, containers or sinks to be used for parts cleaning or rinsing or, if there are, note the agency from which an industrial waste discharge permit will be obtained and that the design meets that agency's requirements.	In the Stormwater Control Plan, note that all of the following restrictions apply to use the site: ❑ No person shall dispose of, nor permit the disposal, directly or indirectly of vehicle fluids, hazardous materials, or rinsewater from parts cleaning into storm drains. ❑ No vehicle fluid removal shall be performed outside a building, nor on asphalt or ground surfaces, whether inside or outside a building, except in such a manner as to ensure that any spilled fluid will be in an area of secondary containment. Leaking vehicle fluids shall be contained or drained from the vehicle immediately. ❑ No person shall leave unattended drip parts or other open containers containing vehicle fluid, unless such containers are in use or in an area of secondary containment.

APPENDIX D—STORMWATER POLLUTANT SOURCES/SOURCE CONTROL CHECKLIST

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❑ **L.** Fuel Dispensing Areas	❑ Fueling areas[1] shall have impermeable floors (i.e., portland cement concrete or equivalent smooth impervious surface) that are: a) graded at the minimum slope necessary to prevent ponding; and b) separated from the rest of the site by a grade break that prevents run-on of stormwater to the maximum extent practicable. ❑ Fueling areas shall be covered by a canopy that extends a minimum of ten feet in each direction from each pump. [Alternative: The fueling area must be covered and the cover's minimum dimensions must be equal to or greater than the area within the grade break or fuel dispensing area[1].] The canopy [or cover] shall not drain onto the fueling area.		❑ The property owner shall dry sweep the fueling area routinely.

[1] The fueling area shall be defined as the area extending a minimum of 6.5 feet from the corner of each fuel dispenser or the length at which the hose and nozzle assembly may be operated plus a minimum of one foot, whichever is greater.

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❑ **M.** Loading Docks	❑ Show a preliminary design for the loading dock area, including roofing and drainage. Loading docks shall be covered and/or graded to minimize run-on to and runoff from the loading area. Roof downspouts shall be positioned to direct stormwater away from the loading area. Water from loading dock areas shall be drained to the sanitary sewer, or diverted and collected for ultimate discharge to the sanitary sewer. ❑ Loading dock areas draining directly to the sanitary sewer shall be equipped with a spill control valve or equivalent device, which shall be kept closed during periods of operation. ❑ Provide a roof overhang over the loading area or install door skirts (cowling) at each bay that enclose the end of the trailer.		❑ Move loaded and unloaded items indoors as soon as possible. ❑ See Fact Sheet SC-30, "Outdoor Loading and Unloading," in the CASQA Stormwater Quality Handbooks
❑ **N.** Fire Sprinkler Test Water		❑ Provide a means to drain fire sprinkler test water to the sanitary sewer.	❑ See the note in Fact Sheet SC-41, "Building and Grounds Maintenance," in the CASQA Stormwater Quality Handbooks

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O. Miscellaneous Drain or Wash Water or Other Sources ❑ Boiler drain lines ❑ Condensate drain lines ❑ Rooftop equipment ❑ Drainage sumps ❑ Roofing, gutters, and trim. ❑ Other sources		❑ Boiler drain lines shall be directly or indirectly connected to the sanitary sewer system and may not discharge to the storm drain system. ❑ Condensate drain lines may discharge to landscaped areas if the flow is small enough that runoff will not occur. Condensate drain lines may not discharge to the storm drain system. ❑ Rooftop equipment with potential to produce pollutants shall be roofed and/or have secondary containment. ❑ Any drainage sumps on-site shall feature a sediment sump to reduce the quantity of sediment in pumped water. ❑ Avoid roofing, gutters, and trim made of copper or other unprotected metals that may leach into runoff. ❑ Include controls for other sources as specified by local reviewer.	
❑ **P.** Plazas, sidewalks, and parking lots.			❑ Sweep plazas, sidewalks, and parking lots regularly to prevent accumulation of litter and debris. Collect debris from pressure washing to prevent entry into the storm drain system. Collect washwater containing any cleaning agent or degreaser and discharge to the sanitary sewer not to a storm drain.

Appendix

E

Regulatory and Technical Background

Some background, including updates, on selected policies and criteria in the Guidebook 7th Edition

LAND development is a complex undertaking, and no two projects are the same. Municipal staff can and should exercise latitude and discretion, within the boundaries of permit compliance, when interpreting the C.3 requirements as they apply to a specific project. This appendix provides information and explanations of technical and regulatory issues which may help with decision-making.

Stormwater NPDES Permit History

In 1993, the Regional Water Board first issued a municipal stormwater NPDES permit to Contra Costa County, the 19 cities and towns within the County, and the Contra Costa Flood Control and Water Conservation District. The permit mandated a comprehensive program to prevent stormwater pollution. The comprehensive program includes measures to prevent pollution from municipal facilities and operations, identification and elimination of illicit discharges to storm drains, business inspections, public outreach, construction site inspections, monitoring and studies of stream health, and control of runoff pollutants from new developments and redevelopments.

In 2003, the Regional Water Board added Provision C.3, tightening requirements for new developments and redevelopments. The permittees began implementing the provision in 2005. The Regional

Appendix E Contents

Water Board added hydrograph modification management (flow control) requirements in 2006.

In October 2009, the Regional Water Board included Contra Costa municipalities in its first Municipal Regional Permit (MRP). The MRP applies to 77 municipal Bay Area permittees and supersedes the countywide stormwater NPDES permits. The MRP mandates a Low Impact Development (LID) approach similar to that developed by the CCCWP from 2003 through 2009. The Regional Water Board amended the MRP on November 28, 2011, detailing some exceptions for when LID treatment is required. The LID requirements went into effect December 1, 2011.

The MRP was reissued on November 19, 2015 (MRP 2.0) and is in effect for 5 years beginning January 1, 2016. MRP 2.0 included few new requirements; the minor changes have been incorporated in this 7th Edition of the *Guidebook*.

Regulatory Context and Roles

MRP Provision C.3 requires municipalities to condition development approvals with incorporation of specified stormwater controls. The municipalities' annual report to the Regional Water Board includes a list of development projects approved during the year and the specific stormwater controls that were required for each project. In the annual report, the municipalities also document their program to verify stormwater treatment and flow-control facilities are being adequately maintained. **The municipalities—not the Regional Board or its staff—are charged with ensuring development projects comply with the C.3 requirements.** (Regional Water Board staff sometimes reviews stormwater controls in connection with applications for Clean Water Act Section 401 water-quality certification, which is required for projects that involve work in streams, including dredging and filling.)

Municipal staff review the project proponent's Stormwater Control Plan for compliance with the requirements of Provision C.3. At the same time, they consider how the design of LID features and facilities integrates with the site design, landscape design, and building architecture to support municipal objectives such as design quality, consistency with neighborhood character and values, and contribution to natural qualities achievable within the urban context.

As discussed in Chapter 5, municipalities are responsible for inspecting and verifying the proper operation and maintenance of stormwater treatment facilities, and some pervious pavement installations, in perpetuity. Project proponents and municipalities share the aim of designing and building facilities that are low-maintenance and long-lasting.

Municipal reviewers have latitude and discretion to reject proposed C.3 compliance designs that, while meeting the specific requirements and numeric criteria in this *Guidebook* and the NPDES permit, don't reflect best practices or local values for urban design and architectural design, or are not sustainable.

Imperviousness

Schueler (1995) proposed **imperviousness** as a "unifying theme" for the efforts of planners, engineers, landscape architects, scientists, and local officials concerned with urban watershed protection. Schueler argued (1) that imperviousness is a useful indicator linking urban land development to the degradation of aquatic ecosystems, and (2) imperviousness can be quantified, managed, and controlled during land development.

Imperviousness has long been understood as the key variable in urban hydrology. Peak runoff flow and total runoff volume from small urban catchments is usually calculated as a function of the ratio of impervious area to total area **(rational method)**. The ratio correlates to the composite runoff factor, usually designated "C". Increased flows resulting from urban development tend to increase the frequency of small-scale flooding downstream.

Imperviousness links urban land development to degradation of aquatic ecosystems in two ways.

First, the combination of paved surfaces and piped runoff efficiently collects urban pollutants and transports them, in suspended or dissolved form, to surface waters. These pollutants may originate as airborne dust, be washed from the atmosphere during rains, or may be generated by automobiles and outdoor work activities.

Second, increased peak flows and runoff durations can cause erosion of stream banks and beds, transport of fine sediments, and disruption of aquatic habitat. Measures taken to control stream erosion, such as hardening banks with riprap or concrete, may permanently eliminate habitat. By reducing infiltration to groundwater, imperviousness may also reduce dry-weather stream flows.

Imperviousness has two major components: rooftops and transportation (including streets, highways, and parking areas). The transportation component is usually larger and is more likely to be **directly connected** to the storm drain system.

The effects of imperviousness can be mitigated by disconnecting impervious areas from the drainage system and by making drainage less efficient—that is, by encouraging detention and retention of runoff near the point where it is generated. Detention and retention reduce peak flows and volumes and allow pollutants to settle out or adhere to soils before they can be transported downstream.

Low Impact Development (LID)

MRP Provision C.3.c mandates the use of LID for stormwater treatment, with narrow exceptions. Techniques for implementing LID are detailed in Chapter 3 of this *Guidebook*.

LID aims to mimic a site's pre-development hydrology by minimizing imperviousness and then by detaining, infiltrating, and filtering runoff in landscape-based features—principally bioretention facilities.

► **DISTRIBUTE FACILITIES THROUGHOUT THE SITE.**

In subdivisions and other developments larger than one-half acre, LID should be implemented by distributing runoff to multiple facilities within a site rather than one facility serving the whole site. This practice helps mimic pre-development hydrology within the site and promotes integration of the facilities with the site landscape design. It also helps keep drainage runs short and promotes the use of surface drainage rather than underground pipes. Right-sized bioretention facilities, located in high-visibility, well-trafficked areas, are easy to inspect and more likely to be optimally maintained.

► **MAXIMIZE INFILTRATION**

Setting the underdrain discharge elevation at the top of a bioretention facility's gravel layer maximizes the amount of runoff that is captured and made to infiltrate into native soils rather than being discharged through the underdrain. This, in turn, minimizes the amount of pollutants discharged from the facility, particularly for soluble pollutants.

Where bioretention facilities are to be built close to foundations or pavement, or on steep slopes, the design of curbs, walls, footings, and other elements may need to incorporate consideration of additional soil moisture introduced by the facilities. In many cases, an impermeable cutoff wall is constructed between the bioretention facility and an adjacent foundation or pavement section, as recommended by the project geotechnical engineer.

Flow-through planters may be used as an alternative to bioretention only on upper-story plazas, where infiltration could cause mobilization of pollutants in soil or groundwater, and other situations where infiltration is a concern, such as locations with potential geotechnical hazards that cannot be mitigated except by preventing infiltration.

Limits on the Use of Infiltration Devices

MRP Provision C.3.d.iv. restricts the design and location of "infiltration devices" that, as designed, may bypass filtration through surface soils before reaching groundwater.

Infiltration devices include:

- Dry wells
- Infiltration basins
- Infiltration trenches

Infiltration devices do not include:

- Bioretention facilities
- Self-retaining or self-treating areas
- Pervious pavements

Infiltration devices may not be used in areas of industrial or light industrial activity; areas subject to high vehicular traffic (25,000 or greater average daily traffic on main roadway or 15,000 or more average daily traffic on any intersecting roadway); automotive repair shops; car washes; fleet storage areas (bus, truck, etc.); nurseries, or other areas with pollutant sources that could pose a high threat to water quality, as determined by municipal staff.

The vertical distance from the base of any infiltration device to the seasonal high groundwater mark shall be at least 10 feet. Infiltration devices shall be located a minimum of 100 feet horizontally from any known water supply wells.

In addition, infiltration devices are not recommended where:

- The infiltration device would receive drainage from areas where chemicals are used or stored, where vehicles or equipment are washed, or where refuse or wastes are handled.
- Surface soils or groundwater are polluted.
- The facility could receive sediment-laden runoff from disturbed areas or unstable slopes.
- Increased soil moisture could affect the stability of slopes of foundations.
- Soils are insufficiently permeable to allow the device to drain within 72 hours.

Stormwater Treatment Facility Sizing Criteria

Criteria for sizing stormwater treatment facilities are in MRP Provision C.3.d. All criteria are based on continuous simulation of runoff from a long-term (30-year or more) rainfall record. This is different from the "event-based" or "design storm" hydrology typically used to size drainage and flood-control facilities.

For **flow-based** facilities, the NPDES permit specifies the rational method be used to determine flow. The rational method uses the equation

$Q = CiA$, where

Q = flow

C = weighted runoff factor between 0 and 1

i = rainfall intensity

A = area

The permit identifies three alternatives for calculating rainfall intensity:

1. the intensity-duration-frequency method, with a hydrograph corresponding to a 50-year storm,
2. the 85th percentile rainfall intensity times two, and
3. 0.2 inches per hour.

An analysis conducted for the CCCWP determined all three methods yielded similar results.

The CCCWP used the 0.2 inches per hour criterion to develop a consistent countywide sizing factor for bioretention facilities when used for stormwater treatment only (i.e., not for flow control). The factor is based on a design maximum surface loading rate of 5 inches per hour (now mandated by MRP Provision C.3.c.i.(2)(b)(iv)). The sizing factor is the ratio of the design intensity of rainfall on tributary impervious surfaces (0.2 inches/hour) to the design percolation rate in the facility (5 inches/hour), or **0.04** (dimensionless).

For **volume-based** treatment facilities, MRP Provision C.3.d. references two methods, the **WEF method** and the **California BMP method.** Both the WEF and California BMP methods are based on continuous simulation of runoff from a hypothetical one-acre area entering a basin designed to draw down in 48 hours. Local rainfall data and the California BMP method were formerly used for sizing detention basins in Contra Costa County. The simulation was iterated to find the unit basin size that detains about 80% of the total runoff during the simulation period. The unit basin storage size is expressed as a depth which varies from about 0.45" to 0.85" in Contra Costa County. The results of the method are presented in a nomograph. The technical background is available in a 2005 technical memo.

Since the MRP 2011 amendments took effect, **detention basins may not be used to meet stormwater treatment requirements for Regulated Projects.** The WEF method and California BMP method were included in the 2011 amendments and in the subsequent MRP 2.0, but are **obsolete**.

In the 2009 MRP, a third option for sizing stormwater treatment facilities was added to Provision C.3.d. This option states that "treatment systems that use a combination of flow and volume capacity shall be sized to treat at least 80 percent of the total runoff over the life of the project, using local rainfall data."

Like the other options, this third option is best analyzed by using continuous simulation of runoff, based on a local long-term hourly rainfall record. Applied to a bioretention facility with standard cross-section dimensions (p. 67) this method could be used to track inflows, storage, and outflows for each time-step during the simulation. Results might demonstrate that sizing factors smaller than 0.04 could be used to calculate the minimum footprint, depending on bioretention facility's location. BASMAA intends to conduct such a study in 2017.

Technical Criteria for Non-LID Treatment Facilities

Non-LID Treatment Facilities may be either tree-box-type high-flowrate biofilters or vault-based high-flowrate media filters.

► GENERAL

- Inflow rate is that generated by a continuous rainfall intensity of 0.2 inches per hour.
- Landscape and non-impervious surfaces should be made self-treating or self-retaining and not drain to treatment facilities, if feasible.
- Use the runoff factors in Table 3-2.
- The applicant's Stormwater Control Plan (Plan) must include as an attachment a letter from the manufacturer stating the manufacturer has reviewed the Plan, the proposed device meets these technical criteria, and the manufacturer will provide a warranty for two years following activation of the facility.

► HIGH-FLOWRATE TREE-BOX-TYPE BIOFILTERS

- Maximum design surface loading rate of 50 inches per hour.
- Precast concrete construction.
- Inlet design to capture flows at least up to the maximum design surface loading rate and to bypass high flows.
- Minimum media depth of 1.8 feet (may be reduced, but maintaining the same media volume, if required because of inadequate head to discharge point).
- Media and facility configuration supports a healthy tree or other vegetation.

► VAULT-BASED HIGH-FLOWRATE MEDIA FILTERS

- Replaceable cartridge filters.
- Maximum design filter surface loading rate of 1 gpm/ft2

- Storage volume detains runoff and allows settling of coarse solids prior to filtration.

- Flow through the cartridge filters is controlled by an orifice or other device so that the design surface loading rate is not exceeded.

► **EXAMPLE CALCULATIONS:**

Given a project with the following Drainage Management Areas draining to a non-LID facility:

DMA 1: 2050 SF Roof, runoff factor 1.0
DMA 2: 3035 SF Asphalt, runoff factor 1.0
DMA 3: 250 SF Solid Unit Pavers Set in Sand, runoff factor 0.5

High-Flowrate Tree-Box-Type Biofilter

Equivalent Impervious Area = (2050 + 3035) × 1.0 + (250 × 0.5) = 5,210 SF
Sizing factor = 0.2"/hr ÷ 50"/hr = 0.004
Minimum biofilter surface area = 0.004 × 5,210 SF = 20.84 SF

Vault-Based High-Flowrate Media Filter

Design flowrate = ((3035 + 2050) ft2 × 1.0 + (250 ft2 × 0.5)) × 0.2"/hr × 1 ft/12" × 1 hr./60 min. × 7.48 gal/ft3 = 54 gpm

Cartridge surface area = 10.7 SF/cartridge (obtain from manufacturer and verify)

No. of cartridges required = 54 gpm/1 gpm/ft2 ÷ 10.7 ft2/cartridge = 5.04 cartridges (round to 5)

Flow-Control (Hydromodification Management)

MRP Provision C.3.g. specifies:

> Stormwater discharges from HM projects shall not cause an increase in the erosion potential of the receiving stream over the pre-project (existing) condition. Increases in runoff flow and volume shall be managed so that post-project runoff shall not exceed pre-project rates and durations, where such increased flow and/or volume is likely to cause increased potential for erosion of creek beds and banks, silt pollutant generation, or other adverse impacts on beneficial uses due to increased erosive force.

Comparison of post-project to pre-project flows is based on continuous simulation of runoff over a period of 30 years or more, using local hourly rainfall data, and statistical analysis of the cumulative duration of flows.

As required by a 2003 amendment to the previous NPDES permit, the CCCWP submitted a **Hydrograph Modification Management Plan (HMP)** in July 2005. CCCWP's HMP included design criteria for Low Impact Development **Integrated Management Practices** (IMPs). Applicants for development approvals can comply with both treatment and HM requirements by incorporating IMPs into the project drainage design. The IMPs and IMP design criteria were updated in early 2009.

The flow-control standard was retained in the MRP issued in October 2009. MRP 2.0, issued in November 2015, requires the CCCWP municipalities to update their designs. Current criteria may be applied for projects that receive final planning entitlements on or before 3 January 2018.

Applicability and Exemptions. The flow-control standard applies to projects which create or replace one acre or more of impervious area and for which applications for development approvals were deemed complete after 14 October 2006. See Chapter 1, including Table 1-1.

Projects may be exempted from HM requirements if any of the following apply:

- The post-project impervious area is less than, or the same as, the pre-project impervious area.
- The project is located in a catchment that drains to pipes or hardened channels, or tidally influenced channels that extend continuously to the Bay, Delta, or a flow-controlled reservoir.
- The project is located in a catchment or subwatershed that is highly developed (that is, 70% or more impervious).

The CCCWP is developing maps of exempt catchments. While these maps are being developed, applicants should consult with municipal staff regarding potential exemptions. As general guidance, and as will be reflected in the maps, "hardened" channels are channels where the channel design and materials have been engineered and constructed, typically with concrete. This does not include engineered earthen channels, nor does it include natural channels where riprap, grade control structures, or bank stabilization structures have been added to control erosion.

Sites that Are Already Partially Developed. At the discretion of municipal staff, on HM projects applicants may provide treatment-only controls for an impervious square footage that is less than or equal to the pre-project impervious square footage. Treatment + HM controls must be provided for the remaining impervious square footage.

The rationale for this guidance is that the combination of treatment-only and treatment + HM controls will meet the Permit requirement that runoff flow and volume be managed so that post-project runoff doesn't exceed estimated pre-project rates and durations. The rationale is detailed in a 10 March 2009 memo, "Guidance on Flow Control for Development Projects on Sites that are Already Partially Developed," available on the CCCWP website.

Selection and Design of HM Controls. The LID design procedure and criteria in Chapter 3 have been developed and refined, progressively for over a decade, to meet the needs of Contra Costa development projects. In addition to meeting the HM standard, projects designed using Chapter 3 will also meet the LID goals and principles in MRP Provision C.3.c.

Most projects use a combination of site design measures (self-treating and self-retaining areas) and bioretention facilities to meet runoff treatment and flow-control requirements. Design guidance and criteria for more complex options with smaller surface footprints—"cistern + bioretention" and "bioretention + vault"—are in Chapter 3 and may be used if space on the site is constrained.

Previous editions of the *Stormwater C.3 Guidebook* provided guidance on using site-specific hydrologic modeling as an alternative method to demonstrate compliance with HM requirements. An update to this guidance is pending. In the interim, proposals to use this method will be considered case-by-case.