3.4 Bioretention Facility

<table>
<thead>
<tr>
<th>Type of BMP</th>
<th>LID – Bioretention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority Level</td>
<td>Priority 1 – Full Retention</td>
</tr>
<tr>
<td>Treatment Mechanisms</td>
<td>Infiltration, Evapotranspiration, Evaporation,</td>
</tr>
<tr>
<td>Infiltration Rate Range</td>
<td>&gt; 0.8 in/hr factored design infiltration rate</td>
</tr>
<tr>
<td>Maximum Drainage Area</td>
<td>This BMP is intended to be integrated into a project’s landscaped area in a distributed manner. Typically, contributing drainage areas to Bioretention Facilities range from less than 1 acre to a maximum of around 5 acres. For facilities treating larger drainage basins, see Fact Sheet 3.7 for additional guidance on design of larger scale facilities.</td>
</tr>
</tbody>
</table>

Description

Bioretention Facilities are shallow, vegetated basins underlain by an engineered soil media designed to retain the design capture volume $V_{BMP}$. Bioretention Facilities function similarly to infiltration basins but have a shallower ponding depth and provide additional treatment through the inclusion of the soil media. Stormwater infiltrates through soil media and the bottom of the basin. Healthy plant and biological activity in the root zone maintain and renew the macro-pore space in the soil media and maximize plant uptake of pollutants and runoff. This helps extend the lifespan before clogging occurs and allows more of the soil column to function as both a sponge (retaining water) and a biofilter. In all cases, the bottom of a Bioretention Facility is unlined as the primary treatment process is infiltration. Flows exceeding $V_{BMP}$ must discharge to a downstream conveyance system. Biofiltration basins can be effective in removing targeted pollutants from stormwater runoff. Low-nutrient soil media (see Fact Sheet 3.8) is necessary to provide treatment and avoid leaching of nutrients.

Siting Considerations

These facilities generally work best when they are designed in a relatively level area. Unlike other BMPs, Bioretention Facilities can be used in smaller landscaped spaces on the site, such as, parking islands, medians, and site entrances. Identification of opportunities for siting bioretention facilities should begin with the initial layout of the site. Landscaped areas on the site (such as may otherwise be required through minimum landscaping ordinances), can often be designed as Bioretention Facilities. This can be accomplished by:

- **Depressing** landscaped areas below adjacent impervious surfaces, rather than elevating those areas
- Grading the site to direct runoff from those impervious surfaces **into** the Bioretention Facility, rather than away from the landscaping
- Sizing and designing the depressed landscaped area as a Bioretention Facility.
For systems treating larger areas also consult Fact Sheet 3.7.

Bioretention Facilities should not be used downstream of areas where large amounts of sediment can clog the system. Placing a Bioretention Facility at the toe of a steep slope should also be avoided due to the potential for clogging the engineered soil media with erosion from the slope, as well as the potential for damaging the vegetation. Inclusion of additional design components such as pretreatment may be included to mitigate clogging potential at the discretion of the local jurisdiction.

The use of bioretention facilities may be restricted by risk of groundwater contamination, low soil permeability, and elevated potential for clogging at the site. Refer to Section 2.3.3 of the SMR WQMP for feasibility considerations for using bioretention BMPs. These BMPs may not be appropriate for the following site conditions:

- Industrial sites or locations where spills of toxic materials may occur, except where spill containment and/or hydrologic isolation is provided to mitigate the risk of groundwater contamination the satisfaction of the local jurisdiction
- Sites with very low soil infiltration rates or rates that cannot be reliably estimated prior to construction (e.g., deeper fills or deeper cuts)
- Sites with high groundwater tables where pollutants can affect groundwater quality
- Sites with unstabilized soil or construction activity upstream
- On steeply sloping terrain

**Setbacks**

Always consult your geotechnical engineer for site specific recommendations regarding setbacks for Bioretention Facilities. Recommended setbacks are needed to protect buildings, existing trees, walls, onsite or nearby wells, streams, and tanks. Setbacks should be considered early in the design process since they can affect where Biofiltration Facilities may be placed and how deep they are allowed to be.

Bioretention Facilities typically should be set back:

- 10 feet from the historic high groundwater (measured vertically from the bottom of the basin, as shown in Figure 1)
- 5 feet from bedrock or impermeable surface layer (measured vertically from the bottom of the basin, as shown in Figure 1).
- From all existing mature tree drip lines as indicated in Figure 1 (to protect their root structure)
- 100 feet horizontally from wells, tanks or springs

Setbacks to walls and foundations must be included as part of the Geotechnical Report. All other setbacks shall be in accordance with applicable standards of the District’s Basin Guidelines (Appendix C).
**Pretreatment**

Pretreatment should be considered to prevent premature clogging of bioretention BMPs. Pretreatment is strongly encouraged where the BMP will receive runoff from high traffic parking lots or roads, mixed land uses (with some erodible areas), or other land uses likely to generate elevated sediment.

For BMPs receiving overland flow, pretreatment may be provided using forebays with a volume equivalent to at least 10 percent (preferably 20 percent) of $V_{\text{BMP}}$. A forebay is effectively the first cell in the bioretention system, separated from the remaining area by a berm or cross plate. The forebay is designed to maximize sedimentation and will require more frequent, but more spatially-focused maintenance. This portion of the system can be concrete lined to facilitate simpler maintenance.

For BMPs with piped inlets, a forebay or sedimentation manhole may be applicable. In these systems, it is also necessary to consider energy dissipation near the inlet pipe, such as via a gravel/rock pad and berm system or concrete splash block, to avoid erosion of the bioretention media bed.
If the BMP will receive runoff primarily from roofs, low-traffic impervious surface, or similar low sediment generating surfaces, then pre-treatment is not necessary, but energy dissipation should still be considered, particularly if there is a piped inflow such as a downspout.

**Design and Sizing Criteria**
This section summarizes the recommended design parameters for Bioretention Facilities. Use of the recommended parameters will help provide the expected treatment and long term performance of the BMP. Deviations from the recommended parameters may be warranted and approved by the local jurisdiction based on site specific considerations. The recommended cross section for a Bioretention Facility includes:

- Vegetated area
- 6” minimum, 12” maximum, surface ponding, measured from the top of the mulch layer (for designs with deeper depths, consult Fact Sheet 3.7)
- Mulch layer (non-floating organic mulch or rock mulch)
- 24” recommended minimum depth of engineered soil media (36” preferred; 18” allowed in vertically-constrained conditions at the discretion of the local jurisdiction)
- Engineered soil media design filtration rate of 2.5 inches per hour (initial filtration rate should be higher).
- 6” optional filter course layer (required if aggregate storage layer is included)
- Optional gravel storage layer below media
- Optional capped underdrain pipe (see Resilient Design Features section below for specific criteria and conditions related to this option)

![Figure 2: Standard Cross Section for a Bioretention Facility](image)
Pore space in the soil and gravel layer can be credited as storage volume. However, several considerations must be noted:

- Ponding depth above the soil surface (6 to 12 inches) is important to assure that design flows do not bypass the BMP when runoff exceeds the soil infiltration rate.
- In cases where the Bioretention Facility contains engineered soil media deeper than 36 inches, the pore space within the engineered soil media can only be counted to the 36-inch depth.
- A maximum of 30 percent pore space can be used for the soil media whereas a maximum of 40 percent pore space can be used for the gravel and filter course layers.
- Additional depth below the storage layer (via gravel) may be used to increase retention storage, under the following conditions:
  - The total system infiltrates the stored water in less than 72 hours
  - The depth below the media does not exceed the amount of water that can be filtered through the media during a typical DCV storm duration (5 hours, unless otherwise documented).

**Adaptable/Resilient Design Option**

At the discretion of the engineer and with the approval of the local jurisdiction, bioretention BMPs may be designed with a gravel drainage layer and a **capped** underdrain. This is effectively a biofiltration design (Fact Sheet 3.5), but there is no design discharge from the underdrains. The benefit of this configuration is that it allows simpler adaptation to a biofiltration BMP if this is warranted, documented, and approved.

This option **may only** be approved for use under the conditions described in Section 2.3.3.g of the WQMP, including:

1) The BMP must meet applicable infiltration BMP sizing standards without any discharge through the underdrain.

2) The Project-Specific WQMP must also meet all applicable sizing standards (biofiltration sizing, hydromodification, if applicable) standards if the underdrain is uncapped.

3) The underdrain must remain capped. Inspections conducted as part of the O&M Plan must corroborate that the underdrain remains capped.

4) If conditions are identified that require the underdrain to be uncapped to allow the BMP to be enlarged or otherwise modified to remedy the documented unacceptable performance, this must include: (a) documentation of the conditions that prompt and justify the require design revision, (b) revision of the Project-Specific WQMP to reflect the revised configuration, and (c) jurisdictional review, approval, and recordation of the revised Project Specific WQMP with commensurate updates to the O&M Plan.
See Section 5.3.6 for guidance on Project-Specific WQMP updates. Note that this is the same process that would be required to wholly redesign and reconstruct an underperforming BMP. However, if adaptable design features are included, the actual physical change could be limited to uncapping the underdrain.

**Design Adaptations**

Bioretention facilities can be designed to meet both pollutant control and hydromodification control performance standards. Combined facilities typically include increased storage (surface and/or subsurface) and flow control devices (i.e. outlet orifices and/or weirs). Outlets elevations must be set above the $V_{\text{BMP}}$ ponding level and the facilities must satisfy both the pollutant control and hydromodification control performance standards.

For systems exceeding 12 inches ponding depth and/or 5 acres tributary area, see additional design considerations in Fact Sheet 3.7.

Subsurface storage is not required but may be provided in the form of a gravel storage layer. Refer to the Subsurface Storage Requirements section for additional information and criteria.

**Engineered Soil Media and Filter Course Aggregate Requirements**

Refer to Fact Sheet 3.8 for specifications for engineered soil media and aggregate layers serving as filter course and drain rock in bioretention BMPs.

**Subsurface Storage Requirements**

Applicants may choose to provide a portion of the BMP storage volume as subsurface storage in a gravel storage layer. Use of subsurface storage instead of surface storage can be useful when the available surface ponding depth is limited or when a deeper profile is desired to reduce footprint requirements.

The gravel storage layer shall not provide a greater storage volume than can be routed through the soil media during the typical design storm duration (i.e. 2.5 inches/hour x 5 hours = 12 inches effective water depth). Alternatively, a separate routing calculation may be performed by the applicant to demonstrate that the provided volume does not result in surface overflow (bypass of the BMP) before the gravel storage layer is full.

When gravel storage layers are used, the filter course layer should be specifically designed to prevent migration of the engineered soil media into the storage layer. Refer to Fact Sheet 3.8 for filter course requirements. Inclusion of a filter course layer is mandatory unless filter fabric is allowed per manufacturer’s recommendation and is acceptable to the local jurisdiction.

**Vegetation Requirements**

Vegetative cover is important to minimize erosion and ensure that treatment occurs in the Bioretention Facility. The area should be designed for at least 70 percent mature coverage throughout the Bioretention Facility. To prevent the BMP from being used as walkways,
Bioretention Facilities shall be planted with densely planted shrubs and grasses. Grasses shall be compatible with periodic inundation, preferably ones that do not need to be mowed. The application of fertilizers and pesticides should be minimal. To maintain oxygen levels for the vegetation and promote biodegradation, it is important that vegetation not be completely submerged for any extended period of time. Vegetation should be selected to withstand the anticipated drawdown time and ponding depths. Trees should only be used where they can be rooted into underlying native soil.

A 2 to 3-inch layer of standard shredded aged hardwood mulch shall be placed as the top layer inside the Bioretention Facility. Rounded stone mulch may be considered. A sacrificial layer of coarse sand could be considered between the bioretention soil and stone mulch to reduce surface compaction. The ponding depth shown in Figure 2 above shall be measured from the top surface of the 2 to 3-inch mulch layer.

**Curb Cuts and Energy Dissipation**

If the Bioretention Facility is sited to receive runoff from adjacent impervious areas, 1-foot-wide (minimum) curb cuts should be placed approximately every 10 feet around the perimeter of the Bioretention Facility. Figure 3 shows a curb cut in a Bioretention Facility. **Curb cut flow lines must be at or above the V_{BMP} water surface ponding level.** Additionally, vertical curb cuts may be a tripping hazard. Where feasible, curb cuts should be tapered from the bottom to top of curb as shown below. When tapered cuts are used, the minimum bottom cut width remains 1 foot.

![Figure 3: Curb Cut located in a Bioretention Facility](image)

To reduce erosion, a gravel or riprap pad shall be placed at each inlet point to the Bioretention Facility. The pad inside the Bioretention Facility should be flush with the finished surface at the curb cut and extend to the bottom of the slope. The size of gravel or riprap should be selected to withstand the expected peak flows into the basin.
In addition, an apron of stone or concrete, a foot square or larger should be placed inside each inlet to prevent vegetation from growing up and blocking the inlet. See Figure 4.

When runoff is routed to the facility via a pipe, gutter, ditch or other conveyance structure, the conveyance should outlet to the forebay portion of the BMP and include appropriate energy dissipation devices to prevent erosion and scouring of the forebay (i.e. limit outlet velocities to less than 2 feet per second).

**Terracing the Facility**

It is recommended that Bioretention Facilities be level. In the event the facility site slopes and lacks proper design, water would fill the lowest point of the BMP and then discharge from the basin without being treated. To ensure that the water will be held within the Bioretention Facility on sloped sites, the BMP must be terraced with nonporous check dams to provide the required storage and treatment capacity.

The terraced version of this BMP shall be used on non-flat sites with no more than a 3 percent slope. The surcharge depth cannot exceed 0.5 feet, and side slopes shall not exceed 4:1. Table 1 below shows the spacing of the check dams, and slopes shall be rounded up (i.e., 2.5 percent slope shall use 10' spacing for check dams).

**Table 1: Check Dam Spacing**

<table>
<thead>
<tr>
<th>Slope</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>25'</td>
</tr>
<tr>
<td>2%</td>
<td>15'</td>
</tr>
<tr>
<td>3%</td>
<td>10'</td>
</tr>
</tbody>
</table>

**Roof Runoff**

Roof downspouts may be directed towards Bioretention Facilities. However, the downspouts must discharge onto a concrete splash block or other appropriate energy dissipation device to protect the Bioretention Facility from erosion.

**Retaining Walls**

When Bioretention facilities are located adjacent to structures, walkways, roadways, parking lots, etc., it is recommended that Retaining Wall Type 1A, per Caltrans Standard B3-3 or equivalent, be constructed around the entire perimeter of the Bioretention Facility. This practice will protect the sides of the Bioretention Facility from collapsing during construction and maintenance or...
from high service loads adjacent to the BMP. Where such service loads would not exist adjacent to the BMP, an engineered alternative may be used if signed by a licensed civil engineer.

**Side Slope Requirements**

*Bioretention Facilities Requiring Side Slopes*

The design should assure that the Bioretention Facility does not present a tripping hazard. Bioretention Facilities proposed near pedestrian areas, such as areas parallel to parking spaces or along a walkway, should have a gentle slope to the bottom of the facility. Side slopes inside of a Bioretention Facility should generally be 4:1 unless steeper is approved by the local jurisdiction. A typical cross section for the Bioretention Facility is shown in Figure 2.

*Bioretention Facilities Not Requiring Side Slopes*

Where cars park perpendicular to the Bioretention Facility, side slopes are not required. A 12-inch maximum drop may be used for vertical walls, and the Bioretention Facility should be planted with shrubs to prevent pedestrian access. In this case, a curb is not placed around the Bioretention Facility, but wheel stops shall be used to prevent vehicles from entering the Bioretention Facility, as shown in Figure 5: Bioretention Facility Layout without Side Slopes.

![Figure 5: Bioretention Facility Layout without Side Slopes](image)

**Overflow**

An overflow route is needed in the Bioretention Facility design to bypass stored runoff from storm events larger than $V_{BMP}$ or in the event of facility clogging. Overflow systems must connect to an acceptable discharge point, such as a downstream conveyance system as shown in Figure 2 and Figure 6. The inlet to the overflow structure shall be elevated inside the Bioretention Facility to be flush with the ponding surface for the design capture volume ($V_{BMP}$) as shown in Figure 6. This will allow the design capture volume to be fully infiltrated by the Bioretention Facility, and for larger events to safely be conveyed to downstream systems. The overflow inlet shall **not** be located in the entrance of a Bioretention Facility, as shown in Figure 6.
Underdrain Gravel and Pipes
An underdrain gravel layer and capped perforated pipes may be provided in accordance with Appendix B – Underdrains. This is an optional configuration that is recommended when the design infiltration rate is between 0.8 and 2 inches per hour. When the BMP is installed, the underdrain must be capped, such that no water is discharged. The underdrain serves only as a backup plan, which allows the facility to be converted to a biofiltration with partial infiltration facility if the post-construction infiltration rate is significantly less than measured during planning and design. Removal of the underdrain cap and conversion of the bioretention facility to a biofiltration with partial infiltration facility must be approved by the local jurisdiction with appropriate modifications to the Project-Specific WQMP and O&M Plan, as applicable.

Inspection and Maintenance Schedule
Inspection and maintenance of Bioretention Facilities is required to provide long term performance of these systems. Table 2 below provides a summary of the typical maintenance activities that may be applicable. Project specific activities and schedules may vary and are required to be included as part of the applicant’s O&M Plan. At a minimum, the Bioretention Facility area shall be inspected for erosion, dead vegetation, soggy soils, or standing water. The use of fertilizers and pesticides on the plants inside the Bioretention Facility should be minimized.
### Table 2: Maintenance Summary

<table>
<thead>
<tr>
<th>Activity</th>
<th>Details</th>
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</table>
| Maintain vegetation as needed. Use of fertilizers, pesticides and herbicides should be avoided as much as possible to ensure they do not contribute to water pollution. If appropriate native plant selections and other IPM methods are used, such products should not be needed. If such projects are used, | - Products should be applied in accordance with their labeling, especially in relation to application to water, and in areas subjected to flooding.  
- Fertilizers should not be applied within 15 days before, after, or during the rainy season. |
| Remove debris and litter from the entire basin to minimize clogging and improve aesthetics. |  |
| Check for obvious problems and repair as needed. Address odor, insects, and overgrowth issues associated with stagnant or standing water in the basin bottom. |  |
| Check for erosion and sediment laden areas in the basin. Repair as needed. Clean forebay if needed. |  |
| Revegetate side slopes where needed. |  |
| Inspect areas for ponding |  |
| Inspect for erosion and clogging, repair as needed. |  |
| Inspect of hydraulic and structural facilities: examine the inlet for blockage, the embankment and spillway for integrity, and damage to any structural element. |  |
| Check for erosion, slumping and overgrowth. Repair as needed. |  |
| Check basin depth for sediment build up and reduced total capacity. Scrape bottom as needed and remove sediment. Restore to original cross-section and infiltration rate. Replant basin vegetation. |  |
| Verify the basin bottom is allowing acceptable infiltration. Scarify the surface using a rake, etc., to restore infiltration, working to avoid damage to plants if possible. |  |
| No water should be present 72 hours after an event. No long term standing water should be present at all. No algae formation should be visible. Correct problem as needed. |  |
Bioretention Facility Sizing and Design Procedure

1) Enter the area tributary, $A_T$, to the Bioretention Facility.

2) Enter the Design Capture Volume, $V_{BMP}$, determined from Section 2.1 of this Handbook.

3) Select the type of design used. There are two types of Bioretention Facility designs: the standard design used for most project sites that include side slopes, and the modified design used when the BMP does not use side slopes.

4) Enter the depth of the engineered soil media, $d_S$. The recommended minimum depth is 24” but a depth of 36” is preferred to provide an enhanced root zone. Engineered soil media deeper than 36” will only get credit for the pore space in the first 36”.

5) Enter the depth of the gravel storage layer, $d_g$ (if included). This dimension includes the associated 6-inch filter course layer (do not double count this dimension).

6) Calculate the total effective depth, $d_E$, within the Bioretention Facility. The maximum allowable pore space of the soil media is 30% while the maximum allowable pore space for the gravel layer is 40%.

This is calculated as:

$$d_E(\text{ft}) = d_p(\text{ft}) + [(0.3) \times d_S(\text{ft}) + (0.4) \times d_g(\text{ft})]$$

Where:

- $d_p =$ ponding depth
- $d_s =$ soil depth
- $d_g =$ gravel depth

7) Check that drawdown time is acceptable (72 hours, or shorter if needed to support selected vegetation):
   a. Drawdown Time = $d_E / K_{design}$

Where:

- $K_{design} =$ design infiltration rate (factored) determined per Section 2.3 of the WQMP and Appendix A of this LID-BMP Manual.

8) Check that storage in gravel does not exceed the amount that can enter these systems during a typical storm event. The depth of effective stored water should be less than 12 inches unless higher permeability media is used to allow faster filling of this layer.

9) Calculate the required effective footprint area, this shall be measured at the mid-ponding depth of the BMP. For systems with side slopes, this should be the contour that is midway between the floor of the basin and the overflow elevation of the basin. The footprint of
the underlying gravel storage should extend to this contour. For systems with vertical walls, the effective footprint area is the full footprint.

This is calculated as:

\[ A_{\text{BMP}} (\text{sq ft}) = \frac{V_{\text{BMP}} (\text{cu ft})}{d_E (ft)} \]

10) Enter the proposed effective surface area. This area shall not be less than the minimum required effective surface area.

11) Verify that side slopes are no steeper than 4:1 in the standard design, and are not required in the modified design.

12) Provide the slope of the site around the Bioretention Facility, if used. The maximum slope is 3 percent for a standard design.

13) Provide the check dam spacing, if the site around the Bioretention Facility is sloped.

14) Describe the vegetation used within the Bioretention Facility.
References Used to Develop this Fact Sheet


