4.2 Bioretention Areas

Description: Shallow stormwater basin or landscaped area that utilizes engineered soils or native, well-draining soil and vegetation to capture and treat runoff.

LID/GI Consideration: Low land requirement, adaptable to many situations, and often a small BMP used to treat runoff close to the source.

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Maximum contributing drainage area of 5 acres
- Treatment area consists of ponding area, organic/mulch layer, planting media, and vegetation
- Requires landscaping plan
- Standing water has a maximum drain time of 24 hours
- Pretreatment recommended to prevent clogging of underdrains or native soil
- Ponding depth should be a maximum of 12 inches, 9 inches preferred

ADVANTAGES / BENEFITS:

- Applicable to small drainage areas
- Effective pollutant removals
- Appropriate for small areas with high impervious cover, particularly parking lots
- Natural integration into landscaping for urban landscape enhancement
- Good retrofit capability
- Can be planned as an aesthetic feature and meet local planting requirements

DISADVANTAGES / LIMITATIONS:

- Requires extensive landscaping
- Not recommended for areas with steep slopes
- High capital cost and high maintenance burden
- Soils may clog over time (may require cleaning or replacing)

ROUTINE MAINTENANCE REQUIREMENTS:

- Inspect and repair/replace treatment area components such as mulch, plants, and scour protection, as needed
- Ensure bioretention area is draining properly so it does not become a breeding ground for mosquitos
- Remove trash and debris
- Ensure mulch is 3-4 inches thick in the practice
- Requires plant maintenance plan

STORMWATER MANAGEMENT SUITABILITY

☑ **Runoff Reduction**

☑ **Water Quality**

☐ **Channel Protection**

☐ **Overbank Flood Protection**

☐ **Extreme Flood Protection**

✓ ~~-~~suitable for this practice

~~in certain situations~~may provide partial benefits

IMPLEMENTATION CONSIDERATIONS

L	**Land Requirement**
H	**Capital Cost**
M	**Maintenance Burden**

Residential Subdivision Use: *Yes*

High Density/Ultra-Urban: *Yes*

Roadway Projects: *Yes*

Soils: *Engineered soil media is composed of sand, fines, and organic matter*

Other Considerations: *Use of native plants is recommended*

L=Low **M**=Moderate **H**=High

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POLLUTANT REMOVAL		Runoff Reduction Credit:
85%	**Total Suspended Solids**	• 100% of the runoff reduction volume provided (no underdrain)
80/60%	**Nutrients** - Total Phosphorus / Total Nitrogen removal	• 75% of the runoff reduction volume provided (upturned underdrain system)
95%	**Metals** - Cadmium, Copper, Lead, and Zinc removal	• 50% of the runoff reduction volume provided (underdrain)
90%	**Pathogens** – Fecal Coliform	

4.2.1 General Description

Bioretention areas (also referred to as *rain gardens* on a smaller scale or in residential lots) are structural stormwater controls that capture and infiltrate, or at least temporarily store the water quality volume (WQ_v) using soils and vegetation in shallow basins or landscaped areas.

Bioretention areas are engineered controls in which runoff is conveyed as sheet flow to the "treatment area," which consists of a ponding area, organic or mulch layer, planting soil, and vegetation. An optional sand bed can also be included in the design to provide aeration and drainage of the planting soil. If the native soils are adequate, the captured stormwater runoff will infiltrate into the surrounding soils. If not, the filtered runoff is typically collected and returned to the conveyance system, through an underdrain system. Bioretention areas slightly differ from rain gardens in that they are an engineered structure that ~~can receive~~ has a larger drainage area and may include an underdrain. For additional information of designing a Rain Garden in a residential lot, see the following website: https://www.atlantawatershed.org/greeninfrastructure/atlanta-residential-gi-nov-2012022013/

There are numerous design applications~~, both on-line and off-line,~~ for bioretention areas. These include ~~use on single-family residential lots (*rain gardens*),~~ along highway and roadway drainage swales, within larger landscaped pervious areas, and as landscaped islands in impervious or high-density environments as documented by the sketches in Figure 4.2-1 through Figure 4.2-4.

Figure 4.2-1 ~~Single-Family Residential "Rain Garden"~~Landscaped Bioretention Area

Figure 4.2-2 Landscaped Island

Figure 4.2-3 Bioretention Area Near Parking Lot

Figure 4.2-4 Bioretention Area After Storm

4.2.2 Stormwater Management Suitability

Bioretention areas can be designed for water quantity and quality, but they are mostly used for water quality, i.e. the removal of stormwater pollutants, depending upon the native soils. Bioretention areas can provide runoff quantity control, particularly for smaller runoff volumes such as the runoff volume generated by the water quality storm event (1.2 inches). These facilities may sometimes be used to partially or completely meet channel protection requirements on smaller sites. However, bioretention areas will typically need to be used in conjunction with another control to provide channel protection, as well as overbank flood protection. Bioretention areas need to be designed and maintained to safely bypass higher flows.

Runoff Reduction

Bioretention areas are one of the most effective low impact development (LID) practices that can be used in Georgia to reduce post-construction stormwater runoff and improve stormwater runoff quality. Like other LID practices, they become even more effective the higher the infiltration rate of the native soils. A bioretention area can be designed to provide 100% of the runoff reduction volume, if properly maintained. In order to provide runoff reduction for a bioretention area that is designed without an underdrain, a soils test or other reliable resource must indicate that the ponding area of the bioretention area will drain within 24 hours and entire bioretention area will drain within 72 hours.

Water Quality

A Bioretention area is an excellent stormwater treatment practice due to the variety of pollutant removal mechanisms. Each of the components of the bioretention area is designed to perform a specific function. The *grass filter strip (or grass channel) pre-treatment component* reduces incoming runoff velocity and filters particulates from the runoff. The *ponding area* provides for temporary storage of stormwater runoff prior to its evaporation, infiltration, or uptake and provides additional settling capacity. The *organic or mulch layer* provides filtration as well as an environment conducive to the growth of microorganisms that degrade hydrocarbons and organic material. The *planting soil* in the bioretention area facility acts as a filtration system, and clay in the soil provides adsorption sites for hydrocarbons, heavy metals, nutrients and other pollutants. Both *woody and herbaceous plants* in the ponding area provide vegetative uptake of runoff and pollutants and also serve to stabilize the surrounding soils.

Channel Protection

For smaller sites, a bioretention area may be designed to capture the entire channel protection volume (Cp_v) ~~in either an off- or on-line configuration~~. Given that a bioretention area facility is typically designed to completely drain over 48-72 hours, the requirement of extended detention of the 1-year, 24-hour storm runoff volume will be met. For larger sites, or where only the WQ_v is diverted to the bioretention area, another control must be used to provide Cp_v extended detention.

Overbank Flood Protection

Another control in conjunction with a bioretention area will likely be required to reduce the post-development peak flow of the 25-year storm (Q_p) to pre-development levels (detention).

Extreme Flood Protection

Bioretention areas must provide flow diversion and/or be designed to safely pass extreme storm flows and protect the ponding area, mulch layer and vegetation.

Credit for the volume of runoff reduced in the bioretention area may be taken in the overbank flood protection and extreme flood protection calculations. If the practice is designed to provide Runoff Reduction for Water Quality compliance, then the practice is given credit for Channel Protection and Flood Control requirements by allowing the designer to compute an Adjusted CN (see section 3.2 for more information).

4.2.3 Pollutant Removal Capabilities

Bioretention areas are presumed to be able to remove 85% of the total suspended solids (TSS) load in typical urban post-development runoff when sized, designed, constructed, and maintained in accordance with the recommended specifications. Other pollutants bioretention areas can remove include Phosphorus, Nitrogen, metals (such as Cadmium, Copper, Lead, and Zinc), and Pathogens (such as Fecal Coliform). An undersized or poorly designed or maintained bioretention area can reduce its pollutant removal performance. The proper design of the bioretention area is critical to ensure that pollutants can be properly removed from stormwater that drains into the ground or storm sewer system. Proper designs improve the quality of our environment. One of the benefits of using an Upturned Underdrain (see figure 4.2-6) is that this particular~~t~~ type of design will increase the removal of nitrogen in the soil.

For additional information and data on pollutant removal capabilities for bioretention areas, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

4.2.4 Application and Site Feasibility Criteria

Bioretention areas are suitable for many types of development, from single-family residential to high-density commercial projects. ~~Rain gardens, a smaller version of bioretention areas, are better suited for small lots.~~ Because of its ability to be incorporated in landscaped areas, the use of bioretention area is extremely flexible whether they are placed along roadways or in areas undergoing development or re-development. Bioretention areas are an ideal stormwater control for use as roadway median strips and parking lot islands and are also good candidates for the treatment of runoff from pervious areas, such as a golf course. Bioretention areas can also be used to retrofit existing development with stormwater quantity and quality treatment capacity. Curbs are not required for this type of practice.

Because of the many design constraints including limited ponding depths and inlet velocities, bioretention areas generally have a maximum drainage area of 5 acres or less. The size of the bioretention area is generally 3-6% of the contributing drainage area but varies significantly depending on each component of the bioretention area's ability to capture and infiltrate the stormwater runoff and the percent imperviousness of the drainage area.

The following criteria should be evaluated to ensure the suitability of a bioretention area for meeting stormwater management objectives on a site or development.

General Feasibility

- Suitable for Residential Subdivision Usage – YES
- Suitable for High Density/Ultra Urban Areas – YES
- Regional Stormwater Control – NO

Physical Feasibility - Physical Constraints at Project Site

- Drainage Area – 5 acres or less. ~~, although multiple bioretention areas can be used for larger areas~~ If the drainage area is greater than 5 areas, the drainage area can be divided up into multiple areas with each areas having a bioretention area.
- Space Required – Rough rule of thumb of 3-6% of the contributing drainage area
- Site Slope – Slopes should be a maximum of 20%, 5% preferred
- Minimum Depth to Water Table – A separation distance of 2 feet is recommended between the bottom of the bioretention area and the elevation of the seasonally high water table.
- Soils – Native soils if they have at least 0.5 inch/hr infiltration ability. Otherwise engineered media is needed including coarse sand, silt, clay, and other organic matter. The recommended standard media depth is 36 inches, with a minimum depth of 18 inches and a maximum depth of 48 inches. A qualified licensed Professional ~~(Engineer or Geologist)~~ should test the soils to determine the best depth of soil for the practice.

Other Constraints / Considerations

- Hot spots – Do not use for hot spot runoff.
- Damage to existing structures and facilities – Consideration should be given to the impact of water exfiltrating the bioretention areas on nearby road bases.
- Proximity – The following is a list of specific setback requirements for the location of a bioretention area:
  - 10 feet from building foundations
  - 10 feet from property lines
  - 100 feet from private water supply wells
  - 100 feet from open water (measured from edge of water)
  - 200 feet from public water supply reservoirs (measured from edge of water)
  - 1,200 feet from public water supply wells
- Trout Stream – Evaluate for stream warming when an underdrain system is used.

In addition, careful consideration should be given to the potential of perched or raised groundwater levels. Provide adequate distance from building foundations or use impermeable liner on side of excavated area nearest to structure.

Challenges and Potential Solutions

Coastal Areas

- Poorly Drained Soils—This condition minimizes the ability of bioretention areas to reduce stormwater runoff rates and volumes. Possible solutions include an underdrain system. Another possible solution would be to consider small stormwater wetlands or wet swales to intercept and treat stormwater runoff.
- Flat Terrain—May be difficult to provide adequate drainage so multiple smaller bioretention areas may be needed.
- Shallow Water Table—This can prevent the provision of 2 feet of clearance between the bottom of the bioretention area and the top of the water table. This may cause stormwater runoff to pond in the bioretention area. Possible solutions are to minimize the depth of the planting media, or consider using stormwater ponds, wetlands, or wet swales to intercept and treat stormwater runoff.

4.2.5 Planning and Design Criteria

Before designing the bioretention area, the following data is necessary:

- Existing and proposed site, topographic and location maps, and field reviews.
- Impervious and pervious areas. Other means may be used to determine the land use data.
- Roadway and drainage profiles, cross sections, utility plans, and soil report for the site.
- Design data from nearby storm sewer structure.
- Water surface elevation of nearby water systems as well as the depth to seasonally high groundwater.
- Infiltration testing of native soils at proposed elevation of bottom of bioretention area.

*The following criteria are to be considered **minimum** standards for the design of a bioretention area. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.*

4.2.5.1. LOCATION AND LAYOUT

Bioretention areas vary based on site constraints such as proposed and existing infrastructure, soils, existing vegetation, contributing drainage area, and utilities. Bioretention area systems are designed for intermittent flow and must be allowed to drain and reaerate between rainfall events. They should not be used on sites with a continuous flow from groundwater, sump pumps, or other sources. Bioretention area locations should be integrated into the site planning process and aesthetic and maintenance considerations should be taken into account in their siting and design. Elevations must be carefully worked out to ensure that the desired runoff flow enters the facility with no more than the maximum design depth and velocity.

4.2.5.2. GENERAL DESIGN

- A bioretention area consists of the following:

    (1) A pretreatment area, usually consisting of a grass filter strip between the contributing drainage area and the ponding area or a forebay to ease maintenance of the mulch, sand, or soil layers.
    (2) Ponding area containing vegetation with a planting media.
    (3) Organic/mulch layer to protect planting media.
    (4) Native soils to infiltrate the treated runoff, (see description of infiltration trenches for infiltration criteria).
    (5) Where native soils have low infiltration rates include gravel and perforated pipe underdrain system to collect runoff that has filtered through the soil layers and pipe it to the storm sewer system. An upturned underdrain system can be used, however, the system should be 12-18” below the bottom of the planted area to reduce saturated conditions in root zones.
    (6) Overflow, diversion or bypass structure to safely route larger storms through or around the bioretention area.

- A bioretention area design may include some of the following:

- Optional **sand filter layer** to spread flow, filter runoff, and aid in aeration and drainage of the planting soil.
- For curbed pavements use an inlet deflector to direct flow into the practice.
- A splash/erosion prevention pad at the inlet to the practice.

See Figure 4.2-5 through Figure 4.2-6 for an overview of the various components of a bioretention area.

4.2.5.3. PHYSICAL SPECIFICATIONS / GEOMETRY

- Recommended minimum dimensions of a bioretention area are 3-6% of the total drainage area, though modeling is recommended to accurately size the area.
- The maximum recommended ponding depth of the bioretention areas is 12 inches.
- A grass filter strip or channel can be used for pretreatment. The length of the grass channel or width of the grass filter strip depends on the drainage area, land use, and channel slope. Design guidance on grass channels for pretreatment can be found in subsection 4.9 (*Grass Channel)* and filter strips can be found in subsection 4.29 (*Vegetated Filter Strip*). A pea gravel diaphragm flow spreader can also be used.
- The mulch layer should consist of 3 to 4 inches of triple-shredded hardwood mulch. This provides additional benefits such as removing sediment and metals and retaining soil moisture.
- If the native soils cannot suffice for the planting media used within the bioretention area planting beds, then an engineered soil mix should be provided that meets the following specifications:
    - Texture: Sandy loam or loamy sand.
    - Sand Content: Soils should contain 35%-60% clean, washed sand.
    - Topsoil Content: Soils should contain 20%-30% topsoil.
    - Organic Matter Content: Soils should contain 10%-25% organic matter.
    - Clay: Soils should contain less than 15%.
    - Infiltration Rate: Soils should have an infiltration rate of at least 0.50 inches per hour (in/hr), although an infiltration rate of between 2 and 4 in/hr is preferred.
    - Phosphorus Index (P-Index): Soils should have a P-Index of less than 30.
    - Exchange Capacity (CEC): Soils should have a CEC that exceeds 10 milliequivalents (meq) per 100 grams of dry weight.
    - pH: Soils should have a pH of 6-8.
    - For additional information on the soils for a Bioretention Area, refer to Appendix E

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Figure 4.2.-5 Schematic of Typical Bioretention Area Without an Underdrain

(Source: AECOM 2015)

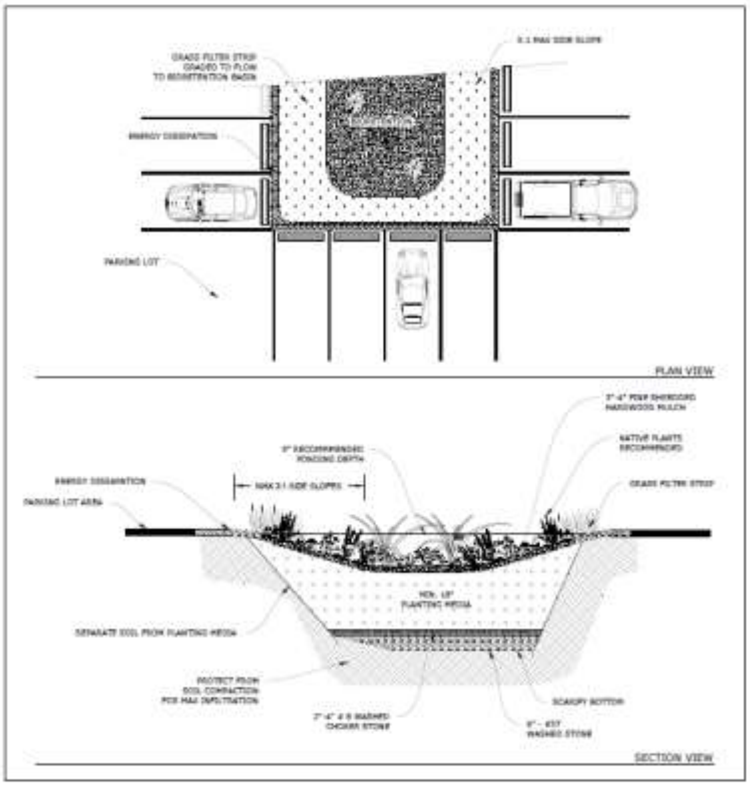

PARKING LOT
PLAN VIEW
SECTION VIEW

Figure 4.2.-6 Schematic of a Typical Bioretention Area with an Upturned Underdrain

(Source: AECOM, 2015)

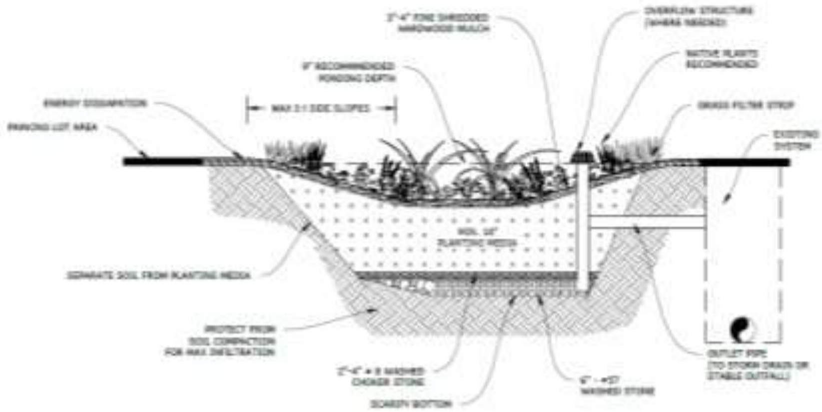
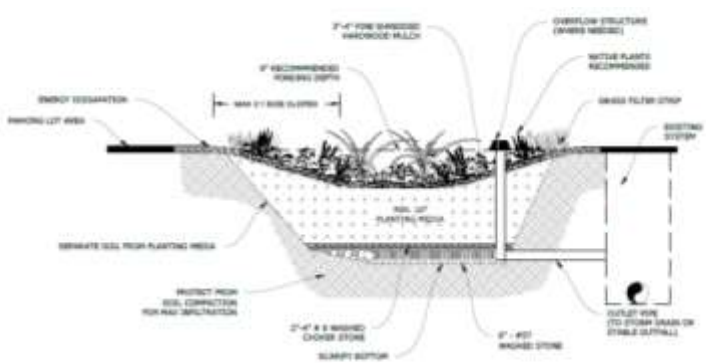


Figure 4.2.-7 Schematic of a Typical Bioretention Area with Underdrain

(Source: AECOM, 2015)



- ~~Where needed,~~ It is recommended that the underdrain collection system should be equipped with a 4-6-inch perforated PVC pipe (AASHTO M 252) in an 8-inch gravel layer. The pipe should have 3/8-inch perforations, spaced at a minimum of 6-inch centers, with a minimum of 4 holes per row. The pipe is spaced at a maximum of 10 feet on center and a minimum grade of 0.5% must be maintained. Should the size of the pipe need to be bigger, a qualified licensed Professional ~~(Engineer or Geologist)~~ should model the area to ensure the size of the pipe is sufficient. It is recommended that there is a separation between the stone and the soil in the practice. This can be done by either placing a permeable geotextile fabric between the gravel layer and the planting media. Or a stone choker layer 2-3 inches deep of #89 stone could be used to separate the practice from the soil. It is recommended that a qualified licensed Professional ~~(Engineer or Geologist)~~ be consulted to determine how this should be done based on the native soils and other physical properties around the practice.

4.2.5.4. PRETREATMENT / INLETS

- Adequate pretreatment is provided when a forebay, grass filter strip, or grass channel is provided.

- Inlet protection needs to be designed to reduce the velocity and energy of the stormwater entering the practice and prevent scour of the mulch and plantings. Inlet protection may include splash blocks, stone diaphragm, level spreader or similar device.

4.2.5.5. OUTLET STRUCTURES

- Outlet structures should be included in the design of a bioretention area configuration to ensure that larger storms can be bypassed without damaging the practice. Exceptions include small bioretention areas with flow bypass structures. Outlet configurations can include riser boxes and/or emergency spillway channels.

4.2.5.6. SAFETY FEATURES

- Bioretention areas generally do not require any special safety features, provided side slopes are maintained at 3:1 or flatter. Fencing of bioretention area facilities is not generally desirable.

4.2.5.7. LANDSCAPING

- Landscaping is critical to the performance and function of bioretention areas; the vegetation filters and transpires runoff and the root systems encourage infiltration.
- The vegetation should be selected to match the desired look and maintenance effort desired by the locals and responsible party.
- The bioretention area should be vegetated to resemble a terrestrial forest ecosystem, with a mature tree canopy, subcanopy of understory trees, scrub layer, and herbaceous ground cover. Three species each of trees, shrubs, and grass/herbaceous species should be planted to avoid a monoculture. When determining what trees should be planted in the bioretention area, remember that tree leaves can clog the bioretention area. Consider using trees that only drop their leaves once in the fall.
- The shrub-to-tree ratio should be 2:1 to 3:1. Trees should be spaced based on anticipated full grown tree canopy size (i.e. 25' canopy, 25' spacing'.) and desired aesthetics. Shrubs and grasses should be spaced based on species recommendation for optimal health. Woody vegetation should not be specified at inflow locations.
- Trees and shrubs should be installed prior to mulch.
- Choose plants based on factors such as whether native or not, resistance to drought and inundation, cost, aesthetics, maintenance, etc. Planting recommendations for bioretention area facilities are as follows:
  - Native plant species should be specified over non-native species.
  - Vegetation should be selected based on a specified zone of hydric tolerance.

- A selection of trees with an understory of shrubs and herbaceous materials should be provided.

Additional information and guidance on the appropriate woody and herbaceous species appropriate for bioretention areas in Georgia, and their planting and establishment, can be found in Appendix D, *Planting and Soil Guidance*.

4.2.5.8. Construction Considerations

- Construction equipment should be restricted from the bioretention area to prevent compaction of the native soils.
- A dense and vigorous vegetative cover should be established over the contributing pervious drainage areas before runoff can be accepted into the facility. Otherwise the sediment from the stormwater runoff will clog the pores in the planting media and native soils.

4.2.5.9 Construction and Maintenance Costs

- A budget level construction cost estimate is between $3.00 and $10.00 per square foot.
- A budget level maintenance cost estimate is between $1.50 and $3.50 per square foot annually.

4.2.6 Design Procedures

Step 1. Determine the goals and primary function of the bioretention area

Consider whether the bioretention area is intended to:

- Meet a runoff reduction* target or water quality (treatment) target. ***Note that minimum infiltration rates of the surrounding native soils must be acceptable and suitable when used in runoff reduction applications.**
- Be "oversized" to include partial credit for storage capacity for other stormwater requirements (Channel Protection Volume (Cp_v), Overbank Flood Protection Volume (Q_p), or the Extreme Flood Volume (Q_f))
- Provide a possible solution to a drainage problem
- Enhance landscape and provide aesthetic qualities

Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply. In addition, consider if the bioretention area has any special site-specific design conditions or criteria. List any restrictions or other requirements that may apply or affect the design.

The design of the bioretention area should be centered on the restrictions/requirements, goals, targets, and primary function(s) of a bioretention area. By considering the primary function, as well as, topographic and soil conditions, the design elements of the bioretention area can be determined (i.e. planting media, underdrain, inlet/outlet, overflow, etc.)

Step 2. Determine if the development site and conditions are appropriate for the use of a bioretention area

Consider the application and site feasibility criteria in this chapter. In addition, determine if site conditions are suitable for a bioretention area. Create a rough layout of the bioretention area dimensions taking into consideration existing trees, utility lines, and other obstructions.

Complete Steps 3A & 3B for a runoff reduction approach, or skip 'Step 3' and complete Steps 4A & 4B for a water quality (treatment) approach. Refer to your local community's guidelines for any additional information or specific requirements regarding either

method. In cases where RRv can be partially met, the remaining amount of WQv must be traditionally treated, refer to 'Step 5' for an additional discussion.

Step 3A. Calculate the Stormwater Runoff Reduction Target Volume

Calculate the Runoff Reduction Volume using the following formula:

$RR_V = (P)\ (R_V)\ (A) / 12$

Where:

RR_V = Runoff Reduction Target Volume (acre-feet)

P = Target runoff reduction rainfall (inches)

R_V = Volumetric runoff coefficient which can be found by:

$R_V = 0.05+0.009(I)$

Where:

I = new impervious area of the contributing drainage area (%)

A = Site area (acres)

12 = Unit conversion factor (in/ft)

Using Table 4.1.3-2 - *BMP Runoff Reduction Credits*, lookup the appropriate runoff reduction percentage (or credit) provided by the practice:

Calculate the Runoff Reduction Volume provided by the selected practice

RRv (provided) = (RR%) (RRv)

Where:

RRv (provided) = Runoff Reduction Volume provided (acre-feet) by a specific BMP

RR% = Runoff Reduction percentage, or credit, assigned to the specific practice

RRv = Runoff Reduction Target Volume (acre-feet), as calculated at the beginning of Step 3A

When RRv(provided) = Target RRv, Water Quality requirements are met. If RRv (provided) is less than the Target RRv, then continue to Step 5.

To size the BMP based on RRv(provided), proceed to step 3B to calculate VP.

Step 3B. If using the practice for Runoff Reduction, determine the storage volume of the practice and the Pretreatment Volume

To determine the actual volume provided in the bioretention area, use the following equation:

VP = (PV + VES (N))

Where:

VP = Volume provided (temporary storage)

PV = Ponding Volume

VES = Volume of Engineered Soils

N = Porosity

To determine the porosity, a qualified licensed Professional ~~(Engineer or Geologist)~~ should be consulted to determine the proper porosity based on the engineered soils used. Most soil media has a porosity of 0.25 and gravel a value of 0.40.

Provide pretreatment by using a grass filter strip or pea gravel diaphragm, as needed, (on-line configuration), or a grass channel or forebay (off-line configuration). Where filter strips are used, 100% of the runoff should flow across the filter strip~~., where a forebay is not used~~. Pretreatment may also be desired to reduce flow velocities or assist in sediment removal and maintenance. Pretreatment can include a forebay, weir, or check dam. Splash blocks or level spreaders should be considered to dissipate concentrated stormwater runoff at the inlet and prevent scour. Forebays should be sized to hold 10% of the WQ_v (or RRv). Refer to subsection 4.9 for design criteria for a grass channel and subsection 4.29 for vegetated

Commented [RN2]: Note that this on-line and off-line application is different from the BMP being near or away from the road. This has to do with stormwater flowing straight to the BMP (on-line application) or going to the BMP through a diversion structure (off-line application). This is further explained in a previous sections.

filter strips.

Step 4A. Calculate the Target Water Quality Volume

Calculate the Water Quality Volume using the following formula:
$WQ_V = (1.2)\ (R_V)\ (A) / 12$
Where:
WQ_V = Water Quality Volume (acre-feet)
1.2 = Target rainfall amount to be treated (inches)
R_V = Volumetric runoff coefficient which can be found by:
$R_V = 0.05+0.009(I)$
Where:
I = new impervious area of the contributing drainage area (%)
A = Site area (acres)
12 = Unit conversion factor (in/ft)

Step 4B If using the practice for Water Quality treatment, determine the footprint of the bioretention area practice and the Pretreatment Volume required

The peak rate of discharge for the water quality design storm is needed for sizing of off-line diversion structures (see subsection 2.1.7). If designing off-line, follow steps (a) through (d) below:
.
(a) Using WQ_v, compute CN
(b) Compute time of concentration using TR-55 method
(c) Determine appropriate unit peak discharge from time of concentration
(d) Compute Q_{wq} from unit peak discharge, drainage area, and WQ_v.

To determine the minimum surface area of the bioretention area, use the following formula

$$A_f = (WQv)\ (d_f) / [\ (k)\ (h_f + d_f)\ (t_f)]$$

where:

A_f	=	surface area of ponding area (ft^2)
WQ_v	=	water quality volume (ft^3)
d_f	=	media depth (ft)
k	=	coefficient of permeability of planting media (ft/day) (use 1 ft/day for silt-loam if engineered soils is being used)
h_f	=	average height of water above bioretention area bed (ft)
t_f	=	design planting media drain time (days) (1 day is recommended maximum)

Step 5. For a hybrid approach that would provide partial runoff reduction and the remaining amount of volume through traditional water quality treatment, calculate the following parameters:

Calculate Target RRv (refer to step 3A)

Calculate % Achieved Ratio (% of Overall Reduction provided by RRv):
[RRv (provided by practice) / Target RRv] (100) = RR % Achieved

Where:
RRv provided = Volume of Runoff Reduction that the practice actually provides
Target RRv = Volume of Runoff Reduction that is required per local requirements
RR % Achieved = The portion of overall water quality requirement volume provided by RRv

Calculate WQv (refer to step 4A)

Calculate % Remaining to treat for WQ (% of Overall Treatment provided by WQv):
100 - (RR % Achieved) = Remaining WQ to treat, as a percentage

Where:
WQ % Remaining = The remaining portion of volume that must be treated to reach the overall water quality goal.

Calculate the remaining volume to be traditionally treated by WQv
(WQv) [(WQ % Remaining) / 100] = WQv remaining

Step 6. Size flow diversion structure, if needed

A flow regulator (or flow splitter diversion structure) should be supplied to divert the WQ_v (or RRv) to the bioretention area.

Size low flow orifice, weir, or other device to pass Q_{wq}.

Step 7. Size underdrain system

See subsection 4.2.5 (Physical Specifications/Geometry)

Step 8. Design emergency overflow

An overflow must be provided to bypass and/or convey larger flows to the downstream drainage system or stabilized watercourse. Non-erosive velocities need to be ensured at the outlet point. The overflow should be sized to safely pass the peak flows anticipated to reach the practice, up to a 100-year storm event.

Step 9. Prepare Vegetation and Landscaping Plan

A landscaping plan for the bioretention area should be prepared to indicate how it will be established with vegetation.

See section 4.2.5.7 (Landscaping) and Appendix D for more details.

4.2.7 Inspection and Maintenance Requirements

Maintenance of the bioretention area will primarily consist of inspections of the drainage surface to remove debris, invasive species, obstructions, or sediment buildup and to perform seasonal pruning and occasional plant replacement.

Inspections of the practice should be done before the first rain event in the spring and also during and after each major rain event to ensure that the water completely drains from the practice within 24 hours of a storm event.

The bioretention area should be checked every 1 to 2 years for the growth of unwanted woody species. Excessive mowing or cutting the vegetation can reduce evapotranspiration and can consequently reduce the amount of pollutant uptake. Fertilizers and pesticides should not be used to maintain the plants in the bioretention area. Proper plant selection should eliminate the use of fertilizers and pesticides.

If the bioretention area is not draining properly, repairs to any underdrain as well as inflow and outflow structures may be needed to prevent the practice from becoming a breeding place for mosquitos. Any geotextile fabric may need to be evaluated for blinding. Soil media may need to be replaced if the soil becomes clogged and the practice does not drain well.

Table 4.2-1 Typical Maintenance Activities for Bioretention Areas
(Source: EPA, 1999)

Activity	Schedule

Table 4.2-1 Typical Maintenance Activities for Bioretention Areas
(Source: EPA, 1999)

Activity	Schedule
• Pruning and weeding to maintain appearance. • Mulch replacement when erosion is evident. • Remove trash and debris. • Remove and replace dead or damaged plants. • Mow around the bioretention area as necessary, ensuring grass clippings are not placed into the practice.	As needed or 4 times during growing season
• Inspect inflow points for clogging. Remove any sediment. • Inspect for erosion, rills, or gullies and repair. • Inspect filter strip/grass channel for erosion or gullying. Re-seed or sod as necessary. • Trees and shrubs should be inspected to evaluate their health and remove and replace any dead or severely diseased vegetation. • Mulching depth of at least 3 to 4 inches should be inspected and obtained. Additional mulch should be added as necessary. • Observe infiltration rates after rain events. Bioretention areas should have no standing water within 24 hours of a storm event.	Semi-annually in spring and fall
• The planting soils should be tested for pH. Consult with a qualified licensed ~~p~~Professional ~~(horticulturalist or a landscape architect)~~ to determine and maintain the proper pH levels.	Annually
• Replace/repair inlets, outlets, scour protection or other structures as needed. • Implement plant maintenance plan to trim and divide perennials to prevent overcrowding and stress. • Check soil infiltration rates to ensure the bioretention area soil is draining the water at a proper rate. • Re-aerate or replace soil and mulch layers as needed to achieve infiltration rate of at least 0.5 inches per hour.	2 to 3 years

Regular inspection and maintenance is critical to the effective operation of bioretention areas as designed. Maintenance responsibility for a bioretention area should be vested with a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval.