2.10 Bioretention

Description

Bioretention practices are stormwater practices that utilize a soil media, mulch and vegetation to treat runoff and improve water quality for small drainage areas. Bioretention practices can provide effective treatment for many runoff quality problems such as total suspended solids, heavy metals, organic compounds, bacteria and nutrients (phosphorous and nitrogen) by promoting settling, adsorption, microbial breakdown, and nutrient assimilation by plants. Outlet configurations of bioretention practices can be altered in order to encourage exfiltration, enhance nitrogen removal and mitigate discharge temperatures.

A bioretention area consists of a depression that allows shallow ponding of runoff and gradual percolation through a soil media, after which it either exfiltrates through underlying soils or enters the storm sewer system through an underdrain system. Bioretention practices are sized to fully capture and treat common storm events (the water quality volume) whereas runoff volumes from larger events may be designed to bypass these practices.

Condition Where Practice Applies

A bioretention practice is generally applicable for:

- Limited contributing drainage areas, generally less than 2 acres.
- Broad water quality treatment, including temperature, suspended solids, metals and depending upon design characteristics, nutrients. A comparison of practices is provided in Chapter 1.
- Various land uses including highly impervious areas such as roadways, commercial areas, or parking areas, especially in traditionally landscaped areas such as cul-de-sacs or park-

ing lot islands.

- Sites with soils of sufficient hydraulic conductivity or a suitable outlet for an underdrain system to fully drain the practice in a period of 12 to 48 hours.
- Sites with sufficient fall between inflow point and outlet for the underdrain, (generally exceeding 3.5 feet). Shallower facilities are expected to reduce the effectiveness of treatment.

Bioretention practices are not applicable where:

- Continuous groundwater flow will prevent the basin from draining between storm events.
- Groundwater pollution potential is high due to high pollution loads or a high groundwater table.

Planning Considerations

Groundwater Concerns – There is an increased risk of groundwater pollution if there is not adequate separation between bioretention facilities and the groundwater table.

High groundwater may impede the proper functioning of the practice by consuming storage capacity or slowing drainage of the practice. Karst areas, shallow bedrock, a high groundwater or seasonally high groundwater table, or soils that allow surface water to bypass treatment through the soil media all increase the potential for groundwater pollution. A minimum 2ft of separation is recommended and a minimum 1ft of separation is required between the top of the water table and the bottom of the excavated bioretention practice. Separation may also be achieved by using an impermeable liner or a layer of compacted earth. Seasonal high groundwater should also be evaluated so it is sufficiently below (see above) the excavated bottom of the practice or able to be lowered sufficiently with perimeter drains.

Off-line or In-line with Major Flow – Bioretention practices may be designed off-line or in-line with runoff flow. Off-line facilities fill to capacity, and then are bypassed by additional runoff. Off-line design minimizes the potential for eroding mulch or other material from the practice during high flows. Off-line bioretention is typically surrounded by an earth berm to capture the required volume of runoff and utilizes the same opening for flow entering and exiting the practice. Figure 2.10.1 shows an example of such a facility. Numerous installed off-line bioretention facilities have shown how poor design or poor construction may cause the initial treatment volume to bypass inlets to the practice. Therefore careful design must be used to insure that runoff enters and fills the practice before bypassing.

In-line (also called on-line) facilities fill with the required volume of runoff then discharge excess flows through an overflow or outlet structure such as a drop inlet or weir. These facilities must be designed to safely route large storms through the practices without erosion in the facility or at the discharge location.

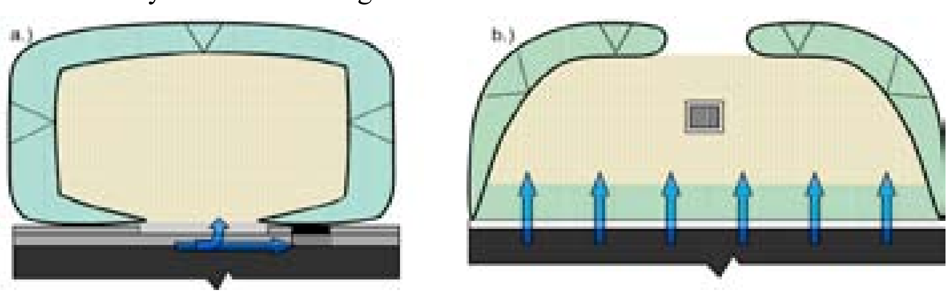

Figure 2.10.1. Flow into a.) offline versus b.) in-line facilities. Offline facilities receive flow then are bypassed by runoff, while in-line facilities receive all contributing runoff.

Suitable Soils for Infiltration and Establishing Need for a Designed Underdrain System – The bioretention practice must be designed so that the treatment volume will be drained between 12 and 48 hours either through infiltration into the soils under the facility, through an underdrain system, or through a combination of in-situ soils and an underdrain system. Facilities designed without an underdrain system shall have a qualified professional certify in-situ soils have the capacity to fully infiltrate the treatment volume within 48 hours. This certification shall include a description of the soil depth and horizons that correspond to the design elevations of the bioretention practice.

Setbacks to Prevent Water Damage - Appropriate setbacks from property lines, wells, septic systems, basements and building foundations shall be maintained to prevent damage to these systems or offsite areas. The following table provides recommended minimum setbacks.

Table 2.10.1 Minimum setbacks from important infrastructure.

	Setback Distance	
Feature protected by setback	Bioretention Utilizing Underdrain System	Bioretention Utilizing Suitable Soils For Infiltration
Property Line	2' (check with local requirements)	
Well	100'	
Septic System (including perimeter drain)	50'	
Building Foundations or Basements	10'	25'
Asphalt (parking, drives or roadways)	2' (check with local requirements)	

Long Term Maintenance and Easements - Since bioretention combines plant materials with the temporary storage and filtering of stormwater, more frequent regular maintenance is required than for other more traditional stormwater facilities. Designs shall include easy access for maintenance as well as an appropriate plan of operations and maintenance that considers the spectrum of activities described later in this standard. A legal and enforceable maintenance agreement shall be in place and executed. Although many bioretention facilities are located on private property and will be privately maintained, the area shall be placed in a drainage easement to permit public access if maintenance should be necessary. For residential developments, additional measures such as educational materials and deed restrictions may be necessary to prevent alterations that would affect the use or diminish the effectiveness of the bioretention practice.

Filter Bed Area - Bioretention facilities may require more area than some other stormwater treatment practices. Generally the surface area of the filter bed will be between five and ten percent of the contributing impervious area.

Slope and Effect of Curbing - Designers must consider the effect of curbing around the bioretention area on the design and construction of side slopes and the filter bed. Curbing may steepen side slopes in some areas and compel contractors to fill areas of the filter bed. Consider wheel stops that allow sheet flow, lower curbing or detailing exact grading on plans to prevent problems.

Construct Bioretention after Site Stabilization - Bioretention facilities shall be constructed after all other areas of the drainage area have been constructed and finally stabilized. That is, sediment-laden runoff from construction shall not be allowed to pass through the practice. Runoff from actively eroding sites will cause the premature failure of bioretention facilities. Avoid using a bioretention facility as a sediment trap or basin. If they must be used to capture construction site sediments, excavation should leave the trap or basin bottom at least 12 inches higher than the planned bioretention bottom elevation. After construction is finalized they may be excavated down to the final elevation after water and sediments have been removed. These measures will help to protect the infiltration capacity of the underlying soils.

Design Criteria

Water Quality Volume - All bioretention practices shall be designed to treat the water quality volume (WQv) by initially ponding that volume and allowing it to infiltrate through soil media within the practice. Bioretention practices have a target drawdown time of 24 hours for the surface ponding area. Drawdown time may be controlled by the soil media (typically), by an orifice on the underdrain or by the the rate of infiltration into in-situ soils under the practice.

Incorporating Additional Objectives - Design of bioretention practices will vary depending on the water quality objectives, the potential for groundwater recharge, and the potential for groundwater pollution. While all bioretention practices provide filtration through the soil media, the following conditions and design variations may enhance or limit the infiltration of water into in-situ soils, or enhance denitrification at the bottom of the practice.

In-situ Soils Suitable for Infiltration – Where in-situ soils can fully infiltrate the water quality volume within 48 hours and where groundwater pollution potential is low, exfiltration may be used as the primary drainage for the bioretention practice. Although this situation may be designed without an underdrain (Figure 2.10.2a), an internal water storage layer provided with a drain near the top serves as a backup to natural exfiltration (Figure 2.10.2b). Systems designed without an underdrain may not be used where extensive ponding of water above the practice will cause damage. Infiltration capacity of the soils shall be tested by a qualified professional.

Limited Infiltration and/or Enhanced Nitrogen Treatment - (Limited infiltration soils = $0.05 \leq Kfs \leq 0.5$ in/hr.) This design provides an internal water storage (IWS) layer below the upturned outlet of the underdrain pipe. This standing water zone (see Figure 2.10.2b and option 1 of 2.10.3) holds water and extends opportunity (both in time and quantity) for exfiltration. This layer also acts as a anoxic zone that encourages denitrification, that is, the conversion of nitrate to nitrogen gas, reduction in nitrogen discharge, and thus is an aid in preventing eutrophication of receiving waters. This design is expected to provide better than 40% and perhaps as high as 80% mass removal of nitrogen from surface runoff.

Low Infiltration In-situ Soils – For sites having in-situ soils with low permeability (clayey subsoils with $Kfs < 0.05$ in/hr), a standard underdrain bedded in a gravel layer provides the primary drainage for the practice (Figure 2.10.2c and Figure 2.10.3c). This configuration may be most appropriate for hydrologic soil group (HSG) D soils.

Impermeable Liner – For areas with a high water table, karst, shallow bedrock or high pollution loads, an impervious liner separates the entire practice from in-situ soils and the water table (Figure 2.10.2c). This design also relies on the underdrain system as the primary drainage. This is appropriate where heavy pollution is expected and/or where groundwater must be protected.

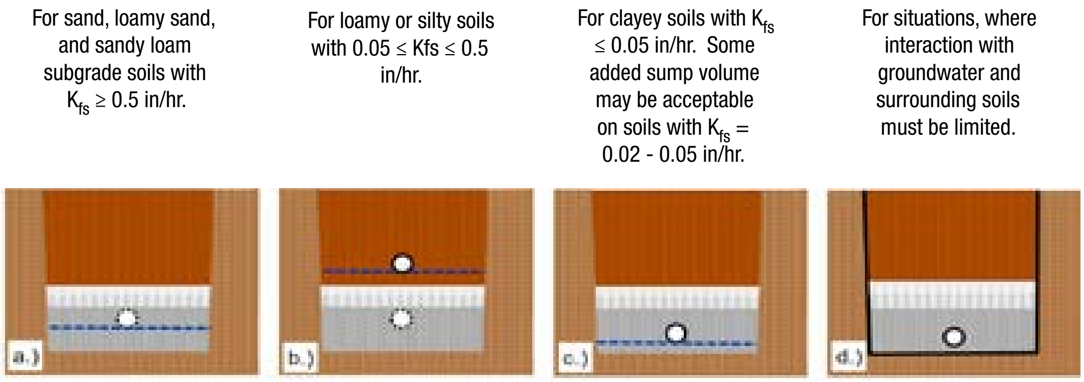

Figure 2.10.2 Underdrain configurations in typical bioretention cross-sections (blue dashed line designates water available for infiltration. From left to right:

a.) Bioretention with soils suitable for infiltration (underdrain optional).

b.) Bioretention with an internal water storage (IWS) layer that has been raised into the soil media for denitrification. An IWS will provide extra storage for infiltration.

c.) Underdrain placed for poorly drained soils.

d.) Lined bioretention cell.

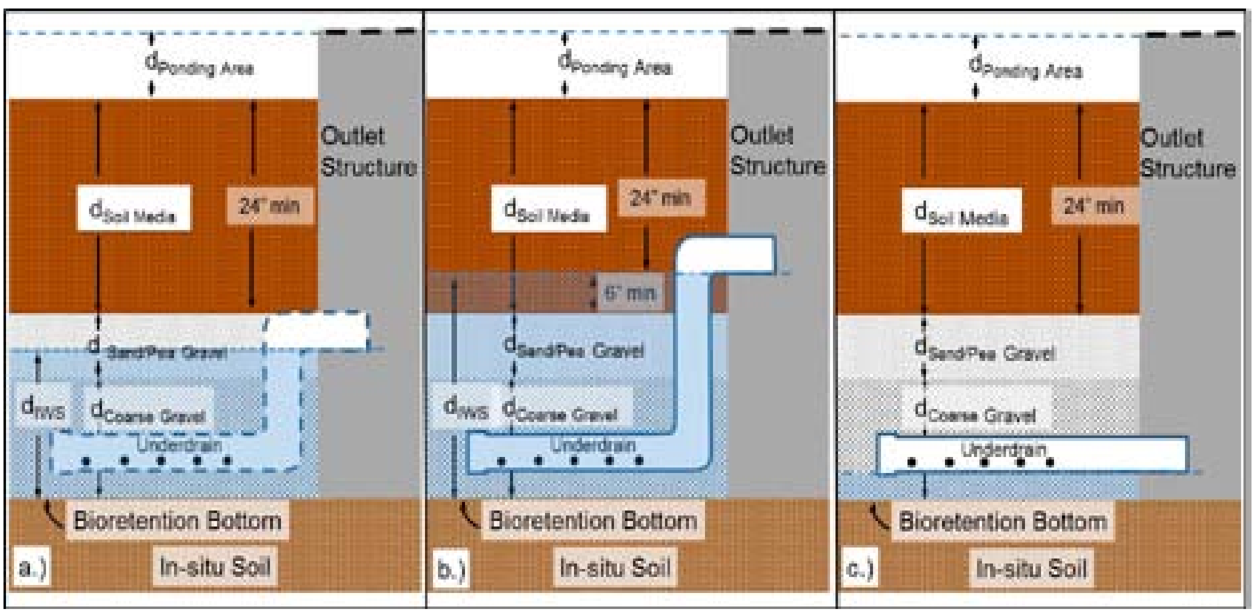

Figure 2.10.3 Comparison of different underdrain and internal water storage configurations. These should be based on the soil properties and the design objectives. The figures labeled a.), b.) and c.) correspond to the same labels in figure 2.10.2.

a.) A bioretention area with soils suitable for infiltration may or may not require an underdrain. The internal water storage (IWS) layer should be sized to hold a volume that is equal or greater than the water quality volume.

b.) Bioretention with an internal water storage (IWS) layer for increased infiltration or for treating nitrogen. Raising the upturned elbow so that at least 6 inches of the IWS is in the soil media creates conditions for denitrification.

c.) Underdrain placed with a minimum of three inches of cover and three inches of bedding. This design still allows some minimal water storage for infiltration even on poorly drained soils.

Area Dimensions – The filter bed area typically will have a minimum 10 foot width though there are scenarios, especially in densely urban areas, where narrower bioretention areas make sense in order to take advantage of available space in parking lot islands, curb bump-outs, or landscape planters. Basin sides slopes, and pretreatment and conveyance areas, may increase the overall area dedicated to the practice and may affect slope of the filter area.

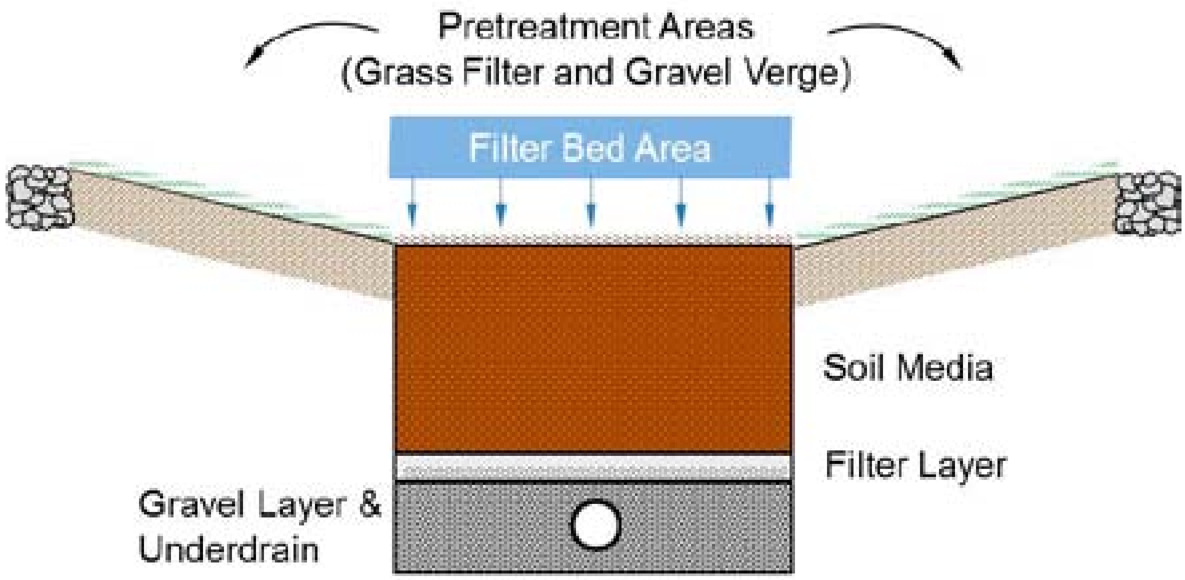

Figure 2.10.4 Components of Bioretention

General Components of Bioretention Practices

1. *Pretreatment Area* – Pretreatment is necessary to ensure long-term function of bioretention practices. High sediment loads cause clogging of the bioretention surface and failure of the practice. Pretreatment is designed to capture excessive sediment before it reaches the filter bed area and to dissipate energy so that flows into the practice don't erode adjacent soils or scour the filter bed. Pretreatment options vary based on whether flow is concentrated or enters the practice as sheet flow. Ideally, paved areas will be directed to the bioretention practice as sheet flow. For many bioretention areas, both types of pretreatment are necessary. The following pretreatment requirements apply:
   a. Sheet flows from paved areas shall use a gravel verge (a shallow stone-filled trench) at the edge of the pavement to dissipate energy and spread flow onto a grassed filter at least 10 feet long with 4:1 or flatter sideslopes (see Figure 2.10.4).
   b. For concentrated flows, the discharge must pass through either a grass swale or a pretreatment forebay. The grass swale must be at least 20 ft in length with a discharge of 1 fps or less for the 1-year 24-hour storm event. The forebay(s) must be sized to capture at least 20% of the WQv. Concentrated flows into the grass swale or forebay shall have an apron stabilized with appropriately sized riprap/stone.

2. *Filter Bed and Ponding Area* - The bioretention practice is designed to capture and temporarily store the entire water quality volume (WQv) so that it will infiltrate through the filter media. The ponding depth for the WQv should be less than or equal to 12 inches to ensure the WQv drains in a timely fashion (~24 hr) in preparation for the next runoff event. The depth of ponding is controlled by the height of the overflow structure or the berm containing runoff. [Note: Additional storage can be included above the WQv, with appropriate outlet, to achieve additional volume reduction or to help meet peak discharge requirements - see sections below.]

   Minimum size of the filter bed:

   For situations **where impervious areas exceed 25% of the contributing drainage area**, the filter bed area shall be a minimum of 5% of the contributing impervious area.

   Example -

   Contributing Drainage Area, A_{da} = 1.49 Ac = 65,000 ft^2

   Impervious Area, A_{imp} = 0.57 Ac = 24,800 ft^2

   Impervious Percentage, $I = (A_{imp}/A_{da})*100 = (24{,}800\ ft^2/65{,}000\ ft^2)*100 = 38.2\%$

   Since I = 38.2% is greater than 25%, then

   $A_{filter\ bed} = 0.05*A_{imp} = 0.05*24{,}800\ ft^2 = 1240\ ft^2$ (the minimum filter bed area)

   For situations **where impervious areas are less than 25% of the contributing drainage area,** the filter bed area shall be at least equal to the WQv divided by the one foot maximum ponding depth.

   Example -

   Contributing Drainage Area, A_{da} = 1.49 Ac = 65,000 ft^2

   Impervious Area, A_{imp} = 0.28 Ac = 12,200 ft^2

   Impervious Percentage, $I = (A_{imp}/A_{da})*100 = (12{,}200\ ft^2/65{,}000\ ft^2)*100 = 18.8\%$

   Because I = 18.8% is less than 25%, then $A_{filter\ bed}$ = WQv/1 ft

   $WQv = Rv*P*A = 0.2192*(0.9\ in)*(65{,}000\ ft^2)*(1\ ft/12\ in) = 1068.6\ ft^3$

   $A_{filter\ bed} = WQv/1\ ft = 1068.6\ ft^3/1\ ft = 1068.6\ ft^2$ (the minimum filter bed area)

3. *Mulch* – If the bioretention area is not vegetated with dense turf, a minimum 3 inch layer of coarse shredded hardwood mulch shall be placed around plants and over the planting soil. Besides protecting the filter bed surface from erosion, the mulch creates an organic layer conducive to filtering, capturing and degrading pollutants, and promoting biological growth. Pine mulches and fine or chipped hardwood mulches may not be used since they will float and move, blocking drainage or leaving the area with high flows.

4. *Planting Soil* – The planting soil filters the treatment volume, detains runoff in the available void space and provides a media for plant growth and a biological community. Much of the pollutant removal occurs in this zone due to filtering, microbial activity, ion exchange, adsorption and plant uptake. The planting soil (an engineered soil media) shall be at least two feet deep and up to four feet in depth (settled) depending upon the planned vegetation. Greater depth is necessary to accommodate the root ball of trees planted in bioretention facilities. Soils and soil mixes must be certified by a qualified laboratory (1 test per 100 yd^3 of soil) and have the following attributes:

- Texture class: loamy sand. Having no less than 80% sand and no greater than 10% clay considering only the mineral fraction of the soil.
- pH range: 5.2 - 8.0
- Soluble Salts: 500 ppm maximum.
- Decomposed organic matter: 3-5% by weight [Note: this translates to 8-20% organic matter by volume. See note on "Creating a Suitable Soil Media" below.]
- Phosphorus: phosphorus of the planting media should fall between 15 and 60 mg/kg (ppm) as determined by the Mehlich III test. For sites in watersheds with a phosphorus TMDL or sites with high phosphorus loads, the phosphorus content of the planting media should fall between 10 and 30 mg/kg as determined by the Mehlich III test.
- Sand added shall be clean and meet AASHTO M-6 or ASTM C-33 with a grain size of 0.02-0.04" inches.

Note: Portions of this text regarding creating soil media is being considered for revision. It appears that a sand-soil-compost ratio of 5-1-2 (maybe 5-1-3) may be a better starting point to reach the specified attributes above. Input is welcome.

John Mathews 7-9-14

Creating Suitable Soil Media - To meet the above soil media criteria, the following mix (by volume) is recommended as a starting point:

Sand: 7.5 parts clean sand (i.e., ASTM C-33 or equivalent, < 1% passing No. 200 sieve)

Native Soil: 1.5 part (loam, silt loam or clay loam texture)

Decomposed Organic Matter: 1 part (leaf compost, pine bark fines, mulch fines, etc.)

Based on testing, experience and native soil characteristics the sand, soil or organic matter content can be adjusted to achieve the desired mix. The soil mix supplier should pre-test the sand, native soil and organic matter to evaluate their phosphorus content. The soil mix supplier must present a soil test showing the planting media meets the criteria above.

5. *Filter Layer* - The filter layer is composed of a layer of sand over a layer of pea gravel and is required to prevent fines from the planting soil migrating down through to the underdrain or to the subsoil below the practice.

   - Three inches of clean medium concrete sand (ASTM c-33) over three inches of #8 or #78 stone (pea gravel).

6. *Gravel Layer and Underdrain System* - A gravel bed consisting of # 57 washed stone (excluding recycled concrete) shall be provided as drainage media and bedding material for underdrain pipes and as the water storage reservoir in whole or as a part (with 6 inches of soil media) for the purpose of denitrification. The gravel layer shall generally be 10-12" thick with a minimum of 3-in. of gravel provided above and below underdrain pipes. The thickness of the gravel layer (or sump) below the drain may be increased to promote infiltration into the underlying soil.

Underdrains shall be a perforated pipe capable of withstanding the expected load above and exceeding the drainage capacity of the planting soil layer. The following requirements apply to underdrains:

- The underdrain system shall be placed level or on a positive slope.
- Underdrain pipes shall be a minimum 4-in. diameter perforated PVC pipe with the holes oriented downward.
- Underdrains are placed within a layer of # 57 washed gravel, having a minimum of 3-in. of gravel above and 3-in. below the pipe.
- Underdrains shall be placed depending upon the purpose of the reservoir created:
    - o For promoting infiltration into appropriate in-situ soils, underdrains are outletted at a higher elevation from the gravel layer either by raising the underdrained or utilizing an upturned elbow. Provide suitable gravel thickness to create an internal water storage (IWS) layer (temporary storage sump) capable of storing the entire water quality volume. See the figure below.
    - o For treating nitrogen, an upturned elbow is also used to raise the outlet of the underdrain and thus create an anoxic zone for denitrification. Ponding water into the bottom six inches of soil media is necessary for this to occur and will increase nitrogen removal by the practice. Gravel depth is determined by the volume of water targeted for anaerobic treatment. See the figure below.
- Underdrain pipes shall end with an elbow or a capped tee with a vertical pipe providing observation and/or cleanout at the elevated end of the pipe. Observation/cleanout pipes shall consist of a minimum 4 inch diameter vertical non-perforated PVC pipe extending to the surface of the practice and sealed with a removable watertight cap.
- Underdrains shall drain to an existing drainage system or other suitable stable outlet having positive drainage.

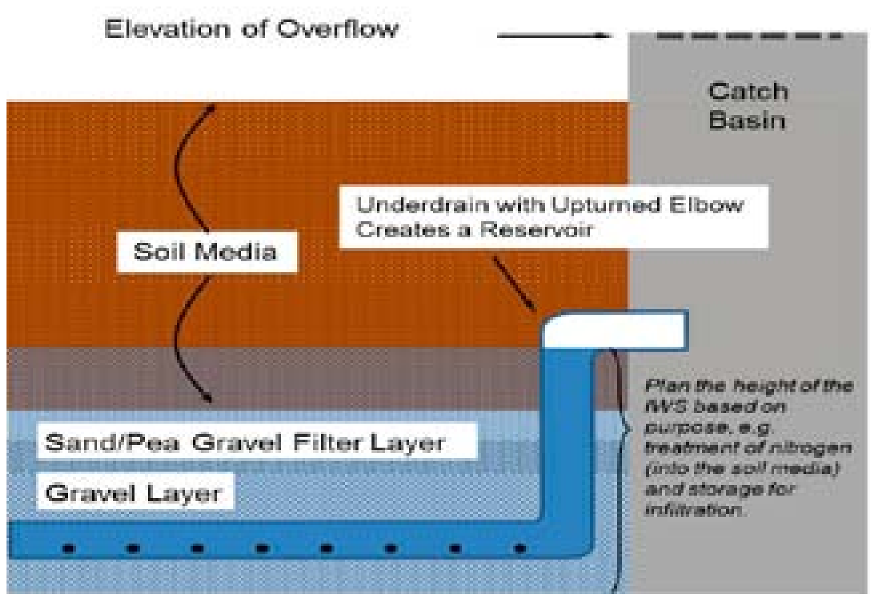

Figure 2.10.5 Bioretention with an underdrain and reservoir for increased infiltration. The reservoir or internal water storage (IWS) is created by using an upturned elbow. An orifice can also be added to modify the drain time through the filter media.

7. *Overflow, Tailwater and Routing -* Bioretention facilities shall have a means of discharging runoff that exceeds the capacity of the practice (in a non-erosive manner). This will be a drop inlet or weir set at the maximum ponding elevation of the treatment volume (WQv). In contrast, off-line facilities collect runoff until the ponding area fills, then are bypassed by additional storm flows. As with all stormwater practices, the designer must evaluate and account for potential tailwater conditions in the storm sewer or receiving stream.

   The bioretention practice is going to perform as intended, and most predictably, when the underdrain outlet is free draining (i.e., not subject to tailwater conditions where the underdrain outlet would be fully or partially submerged). However, bioretention practices are part of the larger stormwater management or drainage network of the development site. Having the outflow rate of the bioretention practice reduced due to increased head at the outlet is likely to have minimal negative impacts. However, any scenario in which water from the larger drainage network (such as a detention basin, a receiving stream or lake, or a storm sewer) is backed into the bioretention cell by having a higher head at the outlet than is present in the bioretention practice should be avoided. From a practical standpoint, the engineer might use the following rules of thumb when checking for back flow into the bioretention practice from tailwater/surcharge in the drainage network:

   - the bioretention practice should be designed such that the tailwater elevation does not exceed the elevation of the internal water storage zone for the 1-year, 24-hour event;
   - the bioretention practice should be designed such that the tailwater elevation does not enter the top 12 inches of planting media for the 10-year, 24-hour event.

8. *Planting Materials –* Species planted in bioretention practices should be adapted to the region, pollution tolerant, and able to survive the variable moisture conditions. Most plants should be facultative (found equally in wetland or upland conditions) though some species found in either environment may be acceptable. Native and non-invasive plants shall be used. Turf is an option if it can withstand the duration of ponding.

   Select plants that in a mature condition will be appropriate to the depth of soil and the underdrain system. For examples, trees may be selected if the planting soil will be at least 4 inches deeper than the root ball of the selected trees. Trees and large shrubs will require staking to prevent being dislodged by wind. It is recommended that a qualified landscape architect, horticulturalist, or native plant dealer be consulted during the design of the planting plan.

Design Checklist

1. Compute water quality volume (WQv). _____

WQv = Rv * P * A / 12, where:

WQv = water quality volume in acre-feet

Rv = volumetric runoff coefficient

Planned Site Imperviousness (i) _____ (e.g. for 80% imperviousness use 0.8)

Rv = 0.05 + 0.9 (i)

Rv = _____

P = 0.9 inch precipitation depth

A = area draining into the BMP in acres _____

2. Compute critical storm detention requirements. Substitute local requirements if they differ from the critical storm method.

Design Storm	Peak Discharge Rate (cfs)	24-hour Runoff Volume (show units)		Percent Increase	Design Discharge (cfs)
		Pre-Development	Post- Development		
1-year					
2-year					
5-year					
10-year					
25-year					
50-year					
100-year					

Critical Storm _______ Design Discharge ________

3. Determine whether bioretention is an appropriate stormwater practice for the area.

- Limited drainage area (generally <2 acres)
- Outlet for an underdrain and or soils of sufficient hydraulic conductivity to fully drain the practice in a period of 12 to 48 hours.
- Sites with sufficient fall between inflow elevation to outfall (generally exceeding 3.5 feet). Shallower facilities are expected to reduce the effectiveness of treatment.
- Consider whether peak discharge requirements will be managed at the bioretention practice and whether these stormwater detention needs make bioretention infeasible.
- No continuous groundwater flow or seasonal high groundwater table above the practice bottom, or perimeter drains are sufficient to lower seasonal high groundwater table.
- Low potential for groundwater pollution (high pollution loads or high groundwater table). A liner may be used in areas with high pollutant loads or high groundwater table.
- Can meet setback requirements found in Table 2.10.1

4. Additional local conditions or criteria affecting design:

5. Determine the size of the bioretention filter bed area. The surface area of the filter bed is determined based upon site imperviousness and the ponded area needed to capture the water quality volume (WQv). For sites where impervious areas are greater or equal to 25% of the total drainage area, then the minimum filter bed area is equal to 5% of the contributing impervious area. For sites where impervious areas are less than 25%, then the filter bed area shall be at least equal to the WQv divided by the maximum ponding depth (≤ one foot). The WQv divided by the design depth provides the minimum surface area of the filter bed. Actual ponding of the WQv will be shallower as side slopes allow ponding over a larger bowl volume.

Where the drainage area is ≥ 25% impervious area, the filter bed area shall be at least 5% of the contributing impervious area.

Where $A_{da} \geq$ 25% impervious, then $A_{filter\ bed} = 0.05 * A_{imp}$

Where the drainage area is < 25% impervious area, the filter bed area shall be the WQv divided by the maximum ponding depth (1 foot).

Where A_{da} = < 25% impervious then $A_{filter\ bed}$ = WQv/1 ft max. depth or other desired depth

6. Check to see that drain time is within the required parameters (12-48 hours):

7. Determine practice dimensions and design depths/elevations. The landscaped ponded area shall be a minimum of 10 feet wide with the length generally exceeding 2:1 (length:width).

- Width _____ • Length _____ • Ponding depth ______
- Overflow catch basin or weir
- Mulch depth 3”
- Soil media depth (generally 2 – 4 feet deep)
- Sand layer _______ • Pea gravel _______
- Gravel layer _____ • Cover over underdrain _____ • Diameter of underdrain ____
  - Underdrain invert elevation (at catch basin) ______
  - Depth of gravel layer beneath underdrain ______
- Liner (only for potential groundwater pollution)

8. Design stable conveyances into the practice. Off-line practices will need to have flow diverted.

- Flow diversion structure.
- Curb cuts or openings, rock channel protection.
- Slotted curb diversion in which flows exceeding WQv bypass the bioretention practice and are routed to other required stormwater detention practices.
- Overflow catch basin inlet.
- Other.

9. Pretreatment. Depending upon whether flow is concentrated or sheet flow, specify the devices used to dissipate runoff energy and to capture excessive sediment or other pollutants/trash before water is ponded. The plan and cross-section should show these devices and their dimensions.

- Stone trench/gravel verge.
- Grass filter strip.
- Grass channel.
- Forebay.
- Other.

10. Gravel layer and underdrain system

- No underdrain. On-site soils are suitable for infiltration. Tested rate of infiltration or hydraulic conductivity at the excavated depth ____.
- Upturned elbow or underdrain above gravel for internal water storage volume.

  Available water storage volume = volume of gravel x porosity (assumed 0.35 for #57 gravel)
- Standard gravel layer and underdrain system. Minimum 3" of gravel above and below the underdrain.

11. Emergency overflow. Conveys larger flows by or safely through the practice without erosion.

12. Landscaping plan. Show locations of plantings on a plan view and the associated quantities of suitable native plants.

Construction Issues

1. **Timing of Construction -** Construction of bioretention practices shall take place after land grading is complete and the contributing drainage area has been stabilized. Construction may take place if the entire contributing area can be effectively diverted until construction is complete and fully-vegetated cover protects all soil areas. Construction shall not occur during periods of precipitation since clogging of soils, bedding, filter or planting media may occur.
2. **Excavation, Soils and Liners -** Excavate the trench to plan dimensions being careful to protect in-situ soils by avoiding compaction of the trench with equipment or foot traffic. An initial 2-3" layer of uniform construction sand will help to avoid this impact. Some smearing of soils at the final grade will occur if a bucket without teeth is used. If this smearing occurs, it shall be remediated by fracturing a few inches deep with an appropriate tool. Bioretention lined with plastic shall use a minimum 30-mil liner and take measures to avoid puncture of the liner.
3. **Planting Soils -** Soils must be tested by a certified laboratory to insure they meet required specifications. Documentation of certification/testing shall be available onsite to site inspectors. The planting soil shall be placed in 12 inch lifts and lightly settled by gentle soaking with water (to promote settling). Planting soil should be placed to a depth approximately 5% higher than finish grade to allow for settling.
4. **Mulch -** Place mulch once sufficient settling of the planting soil has occurred in order to avoid excess compaction. Bioretention vegetated with turf shall be sodded or planted and provided with straw mulch cover as soon as final grade is reached.
5. **Vegetation -** Grassed filter strips should be sodded rather than seeded. Trees and tall shrubs subject to being thrown by wind must be staked to remain upright.

Maintenance

Proper functioning of a bioretention practice is dependent on the planting soil continuing to drain and plant survival. Most maintenance activities influence these goals. Maintaining the pretreatment area and minimizing erosion will extend the function of the planting soil. Bioretention areas are a landscaped feature of a site and regular attention to the plants is necessary. Take measures to insure winter snow plowing does not pile snow on trees or shrubs in the landscaped ponding area.

Over time (3-10 years); fine sediments may accumulate in the top few inches of planting soil. This is expected and can be corrected by replacing a portion of the planting soil or replacing all the planting soil and the filter layer until better permeability is achieved.

Activity	Schedule
Water Plants	As necessary during first growing season
Prune and weed plants for appearance	As needed
Inspect & replace poorly suited or diseased plants	As needed
Check for erosion or deposition in pretreatment and bioretention areas; Clean out and repair damaged areas	Semi-annually
Inspect facility for salt damages	Monthly
Remove litter and debris	Monthly
Add and/or replace mulch	Annually
Test soil and adjust as necessary to maintain in 5.2- 8.0 pH range	Biannually
Check planting soil and filter layer for clogging, replacing nec. portions	2 –10 years/ As needed

Table 2.0.2 These maintenance activities are suggested as a minimum.

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Specifications
for

Bioretention Areas