3.5. Bioretention

Definition. Practices that capture and store stormwater runoff and pass it through a filter bed of engineered soil media comprised of sand, soil, and organic matter. Filtered runoff may be collected and returned to the conveyance system, or allowed to infiltrate into the soil. Design variants include:

- B-1 Traditional bioretention
- B-2 Streetscape bioretention
- B-3 Engineered tree pits
- B-4 Stormwater planters
- B-5 Residential rain gardens

Bioretention systems are typically not to be designed to provide stormwater detention of larger storms (e.g. 2-yr, 15-yr), but they may be in some circumstances. Bioretention practices shall generally be combined with a separate facility to provide those controls.

There are two different types of bioretention design configurations:

- **Standard Designs.** Practices with a standard underdrain design and less than 24 inches of filter media depth (see Figure 3.5.1).
- **Enhanced Designs.** Practices that can infiltrate the design storm volume in 72 hours (see Figure 3.5.3) or practices with underdrains that contain at least 24 inches of filter media depth and an infiltration sump/storage layer (see Figure 3.5.2).

The particular design configuration to be implemented on a site is typically dependent on specific site conditions and the characteristics of the underlying soils. These criteria are further discussed below.

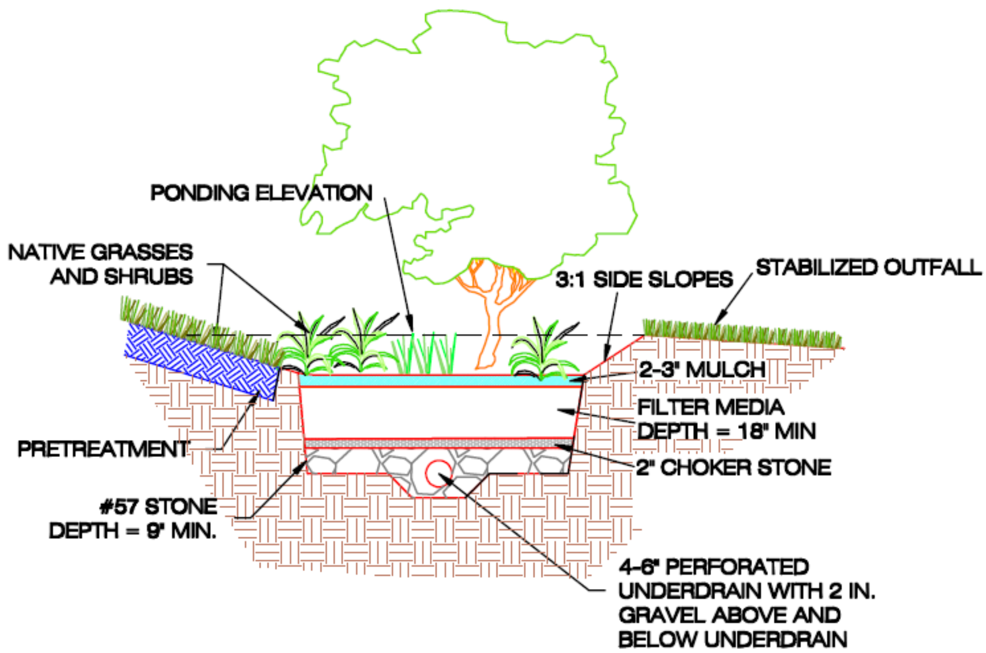

Figure 3.5.1. Bioretention Standard Design.

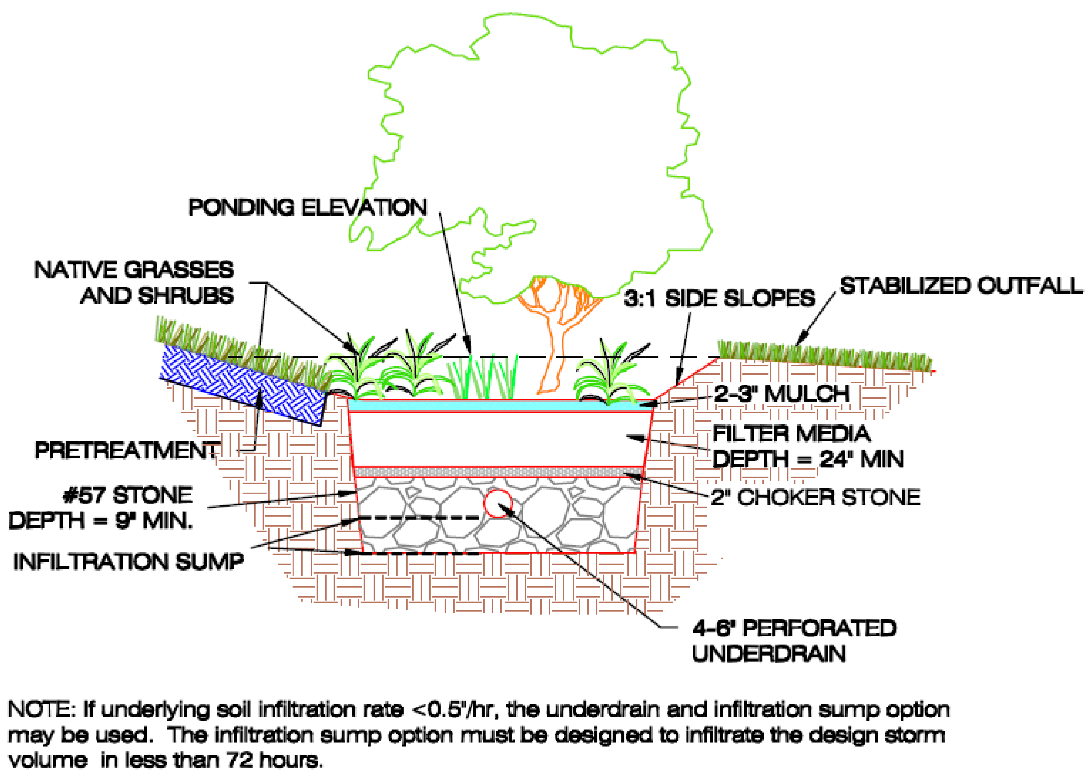

Figure 3.5.2. Bioretention Enhanced Design with Underdrain and Infiltration

Sump/Storage Layer.

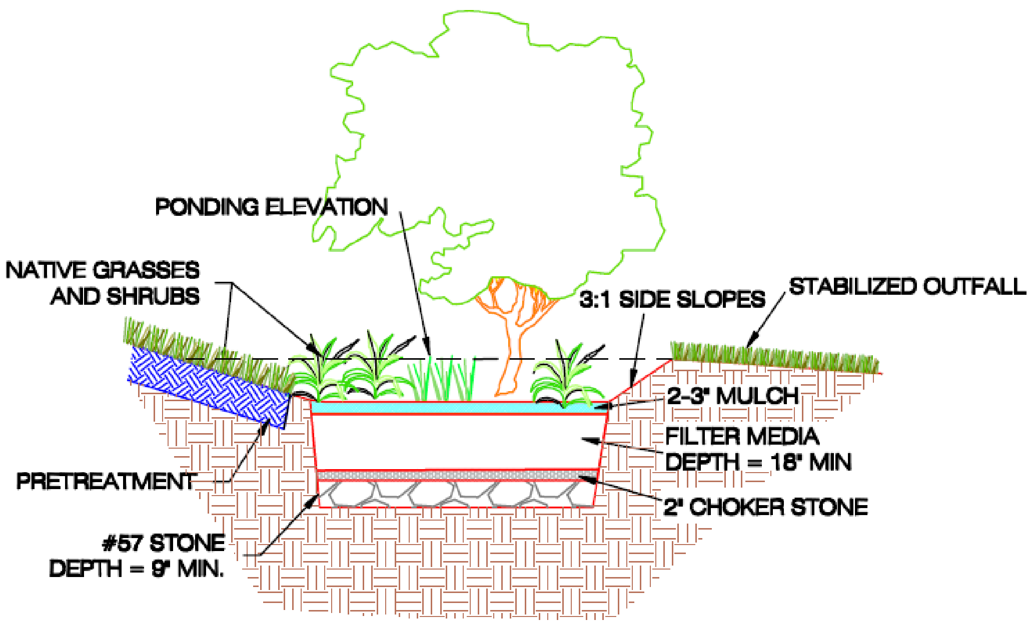

Figure 3.5.3. Bioretention Enhanced Design without Underdrain.

3.5.1. Bioretention Feasibility Criteria

Bioretention can be applied in most soils or topography, since runoff simply percolates through an engineered soil bed and is infiltrated or returned to the stormwater system via an underdrain. Key constraints with bioretention include the following:

Required Space. Planners and designers can assess the feasibility of using bioretention facilities based on a simple relationship between the contributing drainage area and the corresponding required surface area. The bioretention surface area will usually be approximately 3% to 6% of the contributing drainage area (CDA), depending on the imperviousness of the CDA and the desired bioretention ponding depth.

Site Topography. Bioretention is best applied when the grade of contributing slopes is greater than 1% and less than 5%.

Available Hydraulic Head. Bioretention is fundamentally constrained by the invert elevation of the existing conveyance system to which the practice discharges (i.e. the bottom elevation needed to tie the underdrain from the bioretention area into the storm drain system). In general, 4 to 5 feet of elevation above this invert is needed to accommodate the required ponding and filter

media depths. If the practice does not include an underdrain or if an inverted or elevated underdrain design is used, less hydraulic head may be adequate.
Water Table. Bioretention should always be separated from the water table to ensure that groundwater does not intersect the filter bed. Mixing can lead to possible groundwater contamination or failure of the bioretention facility. A separation distance of 2 feet is required between the bottom of the excavated bioretention area and the seasonally high ground water table unless an impermeable liner is utilized.

Soils and Underdrains. Soil conditions do not typically constrain the use of bioretention; although, they do determine whether an underdrain is needed. Underdrains may be required if the measured permeability of the underlying soils is less than 0.5 in./hr. When designing a bioretention practice, designers should verify soil permeability by using the on-site soil investigation methods provided in Appendix P. Impermeable soils will require an underdrain.

In fill soil locations, geotechnical investigations are required to determine if the use of an impermeable liner and underdrain are necessary.

Contributing Drainage Area. Bioretention cells work best with smaller contributing drainage areas, where it is easier to achieve flow distribution over the filter bed. The maximum drainage area to a traditional bioretention area (B-1) is 2.5 acres and can consist of up to 100% impervious cover. The drainage area for smaller bioretention practices (B-2, B-3, B-4, and B-5) is a maximum of 1 acre. However, if hydraulic considerations are adequately addressed to manage the potentially large peak inflow of larger drainage areas, such as off-line or low-flow diversions, or forebays, there may be case-by-case instances where the maximum drainage areas can be adjusted.

Table 3.5.1. Maximum contributing drainage area to bioretention.

	Traditional Bioretention	**Small-scale and Urban Bioretention**
Design Variants	B-1	B-2, B-3, B-4, and B-5
Maximum Contributing Drainage Area	2.5 acres of Impervious Cover	1.0 acres of Impervious Cover

Hotspot Land Uses. An impermeable bottom liner and an underdrain system must be employed when a bioretention area will receive untreated hotspot runoff, and the Enhanced Design configuration cannot be used. However, bioretention can still be used to treat “non-hotspot” parts of the site; for instance, roof runoff can go to bioretention while vehicular maintenance areas would be treated by a more appropriate hotspot practice.

For a list of potential stormwater hotspots, please consult Appendix Q.

On sites with existing contaminated soils, as indicated in Appendix Q, infiltration is not allowed. Bioretention areas must include an impermeable liner, and the Enhanced Design configuration cannot be used.

No Irrigation or Baseflow. The planned bioretention area should not receive baseflow, irrigation water, chlorinated wash-water or other such non-stormwater flows.

Setbacks. To avoid the risk of seepage, do not allow bioretention areas to be hydraulically connected to structure foundations. Setbacks to structures vary based on the size of the bioretention design:

- 0 to 0.5 acre CDA = 10 feet if down-gradient from building; 50 feet if up-gradient.
- 0.5 to 2.5 acre CDA = 25 feet if down-gradient from building; 100 feet if up-gradient.

If an impermeable liner and an underdrain are used, no building setbacks are needed for stormwater planter (B-4) and residential rain garden (B-5) designs.

At a minimum, bioretention basins should be located a horizontal distance of 100 feet from any water supply well and 50 feet if the practice is lined.

Proximity to Utilities. Designers should ensure that future tree canopy growth in the bioretention area will not interfere with existing overhead utility lines. Interference with underground utilities should be avoided, if possible. When large site development is undertaken the expectation of achieving avoidance will be high. Conflicts may be commonplace on smaller sites and in the public right-of-way. Where conflicts cannot be avoided, these guidelines shall be followed:

- Consult with each utility company on recommended offsets that will allow utility maintenance work with minimal disturbance to the stormwater Best Management Practice (BMP).
- Whenever possible, coordinate with utility companies to allow them to replace or relocate their aging infrastructure while BMPs are being implemented.
- BMP and utility conflicts will be a common occurrence in public right-of-way projects. However, the standard solution to utility conflict should be the acceptance of conflict provided sufficient soil coverage over the utility can be assured.
- Additionally, when accepting utility conflict into the BMP design, it is understood that the BMP will be temporarily impacted during utility maintenance but restored to its original condition.

Minimizing External Impacts. Urban bioretention practices may be subject to higher public visibility, greater trash loads, pedestrian traffic, vandalism, and even vehicular loads. Designers should design these practices in ways that prevent, or at least minimize, such impacts. In addition, designers should clearly recognize the need to perform frequent landscaping maintenance to remove trash, check for clogging, and maintain vigorous vegetation. The urban landscape context may feature naturalized landscaping or a more formal design. When urban bioretention is used in sidewalk areas of high foot traffic, designers should not impede pedestrian movement or create a safety hazard. Designers may also install low fences, grates, or other measures to prevent damage from pedestrian short-cutting across the practices.

When bioretention will be included in public rights-of-way or spaces, design manuals and guidance developed by the District Department of Transportation, Office of Planning, National Capital Planning Commission, and other agencies or organizations may also apply (in addition to DDOE).

3.5.2. Bioretention Conveyance Criteria

There are two basic design approaches for conveying runoff into, through, and around bioretention practices:

1. Off-line: Flow is split or diverted so that only the design storm or design flow enters the bioretention area. Larger flows by-pass the bioretention treatment.
2. On-line: All runoff from the drainage area flows into the practice. Flows that exceed the design capacity exit the practice via an overflow structure or weir.

If runoff is delivered by a storm drain pipe or is along the main conveyance system, the bioretention area shall be designed off-line so that flows to do not overwhelm or damage the practice.

Off-line bioretention. Overflows are diverted from entering the bioretention cell. Optional diversion methods include the following:

- Create an alternate flow path at the inflow point into the structure such that when the maximum ponding depth is reached, the incoming flow is diverted past the facility. In this case, the higher flows do not pass over the filter bed and through the facility, and additional flow is able to enter as the ponding water filters through the soil media. With this design configuration, an overflow structure in the bioretention area is not required.
- Utilize a low-flow diversion or flow splitter at the inlet to allow only the design storm volume (i.e. the Stormwater Retention Volume (SWRv)) to enter the facility (Calculations must be made to determine the peak flow from 1.2”, 24-hour storm). This may be achieved with a weir, curb opening, or orifice for the target flow, in combination with a bypass channel or pipe Using a weir or curb opening helps minimize clogging and reduces the maintenance frequency. With this design configuration, an overflow structure in the bioretention area is required (see on-line bioretention below).

On-line bioretention. An overflow structure should always be incorporated into on-line designs to safely convey larger storms through the bioretention area. The following criteria apply to overflow structures:

- An overflow shall be provided within the practice to pass storms greater than the design storm storage to a stabilized water course. A portion of larger events may be managed by the bioretention area so long as the maximum depth of ponding in the bioretention cell does not exceed 18 inches.

- The overflow device must convey runoff to a storm sewer, stream, or the existing stormwater conveyance infrastructure, such as curb and gutter or an existing channel.
- Common overflow systems within bioretention practices consist of an inlet structure, where the top of the structure is placed at the maximum ponding depth of the bioretention area, which is typically 6 to 18 inches above the surface of the filter bed.
- The overflow device should be scaled to the application – this may be a landscape grate or yard inlet for small practices or a commercial-type structure for larger installations.
- At least 3” – 6” of freeboard must be provided between the top of the overflow device and the top of the bioretention area to ensure that nuisance flooding will not occur.
- The overflow associated with the 2-yr and 15-yr design storms should be controlled so that velocities are non-erosive at the outlet point (i.e. to prevent downstream erosion).

3.5.3. Bioretention Pre-treatment Criteria

Pre-treatment of runoff entering bioretention areas is necessary to trap coarse sediment particles before they reach and prematurely clog the filter bed. Pre-treatment measures must be designed to evenly spread runoff across the entire width of the bioretention area. Several pre-treatment measures are feasible, depending on the type of the bioretention practice and whether it receives sheet flow, shallow concentrated flow, or deeper concentrated flows. The following are appropriate pre-treatment options:

For Small-Scale Bioretention (B-2, B-3, B-4, and B-5)

- **Leaf Screens** as part of the gutter system serve to keep the heavy loading of organic debris from accumulating in the bioretention cell.
- **Grass Filter Strips** (for sheet flow), applied on residential lots, where the lawn area can serve as a grass filter strip adjacent to a rain garden.
- **Stone Diaphragm** (for either sheet flow or concentrated flow); this is a stone diaphragm at the end of a downspout or other concentrated inflow point that should run perpendicular to the flow path to promote settling. Note: stone diaphragms are not recommended for school settings.
- **Trash Racks** (for either sheet flow or concentrated flow) between the pre-treatment cell and the main filter bed or across curb cuts. These will allow trash to collect in specific locations and create easier maintenance.
- **Pre-treatment Cell** (see below) located above ground or covered by a manhole or grate. This type of pretreatment is not recommended for residential rain gardens (B-5).

For Traditional Bioretention

- **Pre-treatment Cells (channel flow).** Similar to a forebay, this cell is located at piped inlets or curb cuts leading to the bioretention area and consists of an energy dissipater sized for the expected rates of discharge. It has a storage volume equivalent to at least 15% of the total storage volume (inclusive) with a recommended 2:1 length-to-width ratio. The cell may be formed by a wooden or stone check dam or an earthen or rock berm. Pre-treatment cells do not need underlying engineered soil media, in contrast to the main bioretention cell.

- **Grass Filter Strips (sheet flow).** Grass filter strips that are perpendicular to incoming sheet flow extend from the edge of pavement (i.e. with a slight drop at the pavement edge) to the bottom of the bioretention basin at a 5:1 slope or flatter. Alternatively, if the bioretention basin has side slopes that are 3:1 or flatter, a 5 foot grass filter strip at a maximum 5% (20:1) slope can be used.
- **Stone Diaphragms (sheet flow).** A stone diaphragm located at the edge of the pavement should be oriented perpendicular to the flow path to pre-treat lateral runoff, with a 2 to 4 inch drop from the pavement edge to the top of the stone. The stone must be sized according to the expected rate of discharge.
- **Gravel or Stone Flow Spreaders (concentrated flow).** The gravel flow spreader is located at curb cuts, downspouts, or other concentrated inflow points, and should have a 2 to 4 inch elevation drop from a hard-edged surface into a gravel or stone diaphragm. The gravel should extend the entire width of the opening and create a level stone weir at the bottom or treatment elevation of the basin.
- **Innovative or Proprietary Structure.** An approved proprietary structure with demonstrated capability of reducing sediment and hydrocarbons may be used to provide pre-treatment. Refer to Section 3.12 for information on approved proprietary structures.

3.5.4. Bioretention Design Criteria

Design Geometry. Bioretention basins must be designed with an internal flow path geometry such that the treatment mechanisms provided by the bioretention are not bypassed or short-circuited. In order for these bioretention areas to have an acceptable internal geometry, the “travel time” from each inlet to the outlet should be maximized by locating the inlets and outlets as far apart as possible. In addition, incoming flow must be distributed as evenly as possible across the entire filter surface area.

Inlets and Energy Dissipation. Where appropriate, the inlet(s) to streetscape bioretention (B-2), engineered tree boxes (B-3), and stormwater planters (B-4) should be stabilized using No. 3 stone, splash block, river stone, or other acceptable energy dissipation measures. The following types of inlets are recommended:

- Downspouts to stone energy dissipaters.
- Sheet flow over a depressed curb with a 3-inch drop.
- Curb cuts allowing runoff into the bioretention area.
- Covered drains that convey flows across sidewalks from the curb or downspouts.
- Grates or trench drains that capture runoff from a sidewalk or plaza area.

Ponding Depth. The recommended surface ponding depth is 6 to 12 inches. Ponding depths can be increased to a maximum of 18”. However, if an 18 inch ponding depth is used, the design must consider carefully issues such as safety, fencing requirements, aesthetics, the viability and survival of plants, and erosion and scour of side slopes. The depth of ponding in the bioretention area should never exceed 18”. Shallower ponding depths (i.e. typically 6 to 12 inches) are recommended for streetscape bioretention (B-2), engineered tree boxes (B-3), and stormwater planters (B-4).

Side Slopes. Traditional bioretention areas (B-1) and residential rain gardens (B-5) should be constructed with side slopes of 3:1 or flatter. In highly urbanized or space constrained areas, a drop curb design or a precast structure can be used to create a stable, vertical side wall. For safety purposes, these drop curb designs should not exceed a vertical drop of more than 12 inches.

Filter Media and Surface Cover. The filter media and surface cover are the two most important elements of a bioretention facility in terms of long-term performance. The following are key factors to consider in determining an acceptable soil media mixture:

- **General Filter Media Composition.** The recommended bioretention soil mixture is generally classified as a loamy sand on the USDA Texture Triangle, with the following composition:

    - 85% to 88% sand
    - 8% to 12% soil fines
    - 1% to 5% organic matter (e.g. aged compost or wood chips)

    It may be advisable to start with an open-graded coarse sand material and proportionately mix in topsoil that will likely contain anywhere from 30% to 50% soil fines (i.e. sandy loam, loamy sand) to achieve the desired ratio of sand and fines. An additional 1% to 5% organic matter can then be added. It is highly recommended that filter media be obtained from a qualified vendor that can verify conformance with the media composition and standards in this specification. Note: The exact composition of organic matter and topsoil material will vary, making particle size distribution and recipe for the total soil media mixture difficult to define in advance of evaluating the available material.

- **P-Index.** The P-index of the soil should be tested to ensure that it is between 10 and 30. The P-Index provides a measure of soil phosphorus content and the risk of that phosphorus moving through the soil media. The risk of phosphorus movement through a soil is influenced by several soil physical properties: texture, structure, total pore space, pore-size, pore distribution, and organic matter. A soil with a lot of fines will hold phosphorus while also limiting the movement of water. A soil that is sandy will have a high permeability, and will therefore be less likely to hold phosphorus within the soil matrix.

    A primary factor in interpreting the desired P-Index of a soil is the bulk density. Saxton et. al. (1986) estimated generalized bulk densities and soil-water characteristics from soil texture.

The expected bulk density of the loamy sand soil composition described above should be in the range of 1.6 to 1.7 g/cu. cm. Therefore, the recommended range for bioretention soil P-index of between 10 and 30 corresponds to a phosphorus content range (mg of P to kg of soil) within the soil media of 7 mg/kg to 23 mg/kg.

- **Cation Exchange Capacity (CEC).** The CEC of a soil refers to the total amount of positively charged elements that a soil can hold; it is expressed in milliequivalents per 100 grams (meq/100g) of soil. For agricultural purposes, these elements are the basic cations of calcium (Ca^{+2}), magnesium (Mg^{+2}), potassium (K^{+1}), and sodium (Na^{+1}) and the acidic cations of hydrogen (H^{+1}) and aluminum (Al^{+3}). The CEC of the soil is determined in part by the amount of clay and/or humus or organic matter present. Soils with CECs exceeding 10 are preferred for pollutant removal. Increasing the organic matter content of any soil will help to increase the CEC.

- **Filter Media Infiltration Rate.** The bioretention soil media should have a minimum infiltration rate of at least 1 inch per hour. Note: a proper soil mix will have an initial infiltration rate that is significantly higher.

- **Filter Media Depth.** The filter media bed depth should be a minimum of 24 inches; although, this can be reduced to 18 inches for small-scale bioretention practices (B-2, B-3, B-4, and B-5). Designers should note that the media depth must be 24 inches or greater to qualify for the enhanced design, unless an infiltration-based design is used. The media depth should not exceed 6 feet. If trees are included in the bioretention planting plan, tree planting holes in the filter bed must be at least 4 feet deep to provide enough soil volume for the root structure of mature trees. Turf, perennials, or shrubs should be used instead of trees to landscape shallower filter beds. See Tables 3.5.2 and 3.5.3 for a list of recommended native plants.

- **Filter Media for Tree Planting Areas.** A more organic filter media is recommended within the planting holes for trees, with a ratio of 50% sand, 30% topsoil, and 20% aged leaf compost.

- **Mulch.** A 2 to 3 inch layer of mulch on the surface of the filter bed enhances plant survival, suppresses weed growth, pre-treats runoff before it reaches the filter media, and keeps from rapid evaporation of rainwater. Shredded hardwood bark mulch, aged for at least 6 months, makes a very good surface cover, as it retains a significant amount of pollutants and typically will not float away.

- **Alternative to Mulch Cover.** In some situations, designers may consider alternative surface covers, such as turf, native groundcover, erosion control matting (e.g. coir or jute matting), river stone, or pea gravel. The decision regarding the type of surface cover to use should be based on function, expected pedestrian traffic, cost, and maintenance. When alternative surface covers are used, methods to discourage pedestrian traffic should be considered.

Stone or gravel are not recommended in parking lot applications, since they increase soil temperature and have low water holding capacity.

- **Media for Turf Cover.** One adaptation suggested for use with turf cover is to design the filter media primarily as a sand filter with organic content only at the top. Leaf compost tilled into the top layers will provide organic content for the vegetative cover. If grass is the only vegetation, the ratio of organic matter in the filter media composition may be reduced.

Choking Layer. A 2 to 4 inch layer of choker stone (e.g. typically ASTM D448 No. 8 or No. 89 washed gravel) should be placed beneath the soil media and over the underdrain stone.

Geotextile. If the available head is limited, or the depth of the practice is a concern, designers have the option of using a woven monofilament polypropylene geotextile fabric in place of the choking layer. Designers should use a woven monofilament polypropylene geotextile with a flow rate greater than 100 gpm/sq. ft. (ASTM D4491).

Underdrains. Many bioretention designs will require an underdrain (see Section 3.5.1). The underdrain should be a 4- or 6-inch perforated schedule 40 PVC pipe, or equivalent corrugated HDPE for small bioretention practices, with 3/8-inch perforations at 6 inches on center. The underdrain should be encased in a layer of clean, washed ASTM D448 No.57 stone. The underdrain should be sized so that the bioretention practice fully drains within 24 hours.

Each underdrain should be located no more than 20 feet from the next pipe.

All traditional bioretention practices should include at least one observation well and/or cleanout pipe (minimum 4” in diameter). The observation wells should be tied into any of the Ts or Ys in the underdrain system and should extend upwards to be flush with the surface with a vented cap.

Underground Storage Layer (optional). For bioretention systems with an underdrain, an underground storage layer consisting of chambers, perforated pipe, stone, or other acceptable material can be incorporated below the filter media layer to increase storage for larger storm events. The depth and volume of the storage layer will depend on the target treatment and storage volumes needed to meet water quality, channel protection, and/or flood protection criteria.

Filter Fabric (optional). Filter fabric shall be applied only to the sides of the practice and along a narrow strip above the underdrain pipes.

Impermeable Liner: This material should be used only for appropriate hotspot designs, small scale practices (B-4) that are located near building foundations, or in appropriate fill applications where deemed necessary by a geotechnical investigation. Designers should use a thirty mil (minimum) PVC Geomembrane liner covered by 8 to 12 oz./sq. yd. non-woven geotextile.

Material Specifications. Recommended material specifications for bioretention areas are shown in Table 3.5.1.

Table 3.5.1. Bioretention material specifications.

Material	Specification	Notes
Filter Media	Filter Media to contain: ▪ 85%-88% sand ▪ 8%-12% soil fines ▪ 1%-5% organic matter in the form of aged compost or wood chips	Minimum depth of 24" (18" for small-scale practices) The volume of filter media used should be based on 110% of the plan volume, to account for settling or compaction.
Filter Media Testing	P-Index range = 10-30, ***OR*** Between 7 and 23 mg/kg of P in the soil media. CECs greater than 10	The media must be procured from approved filter media vendors.
Mulch Layer	Use aged, shredded hardwood bark mulch	Lay a 2 to 3 inch layer on the surface of the filter bed.
Alternative Surface Cover	Use river stone or pea gravel, coir and jute matting, or turf cover.	Lay a 2 to 3 inch layer of to suppress weed growth.
Top Soil For Turf Cover	Loamy sand or sandy loam texture, with less than 5% clay content, pH corrected to between 6 and 7, and an organic matter content of at least 2%.	3 inch tilled into surface layer.
Geotextile or Choking Layer	Use a woven monofilament polypropylene geotextile Flow Rate ≥100 gpm/sq. ft. (ASTM D4491).	Can use in place of the choking layer where the depth of the practice is limited.
	Lay a 2 to 4 inch layer of choker stone (e.g. typically No.8 or No.89 washed gravel) over the underdrain stone.	
Underdrain stone	1-inch diameter stone should be double-washed and clean and free of all fines (e.g. ASTM D448 No. 57 stone).	At least 9 inches deep
Storage Layer (optional)	To increase storage for larger storm events, chambers, perforated pipe, stone, or other acceptable material can be incorporated below the filter media layer	
Filter Fabric (optional)		Apply only to the sides and above the underdrain.
Impermeable Liner (optional)	Use a thirty mil (minimum) PVC Geomembrane liner covered by 8 to 12 oz./sq. yd. non-woven geotextile. Note: This is used only for hotspots and small practices near building foundations, or in fill soils as determined by a geotechnical investigation.	
Underdrains, Cleanouts, and Observation Wells	Use 4- or 6-inch rigid schedule 40 PVC pipe, or equivalent corrugated HDPE for small bioretention practices, with 3/8-inch perforations at 6 inches on center; each underdrain should be located no more than 20 feet from the next pipe.	Lay the perforated pipe under the length of the bioretention cell, and install non-perforated pipe as needed to connect with the storm drain system or to daylight in a stabilized conveyance. Install Ts and Ys as needed, depending on the underdrain configuration. Extend cleanout pipes to the surface with vented caps at the Ts and Ys.
Plant Materials	See Section 3.5.5	Establish plant materials as specified in the landscaping plan and the recommended plant list.

Signage. Bioretention units in highly urbanized areas should be stenciled or otherwise permanently marked to designate it as a stormwater management facility. The stencil or plaque should indicate (1) its water quality purpose, (2) that it may pond briefly after a storm, and (3) that it is not to be disturbed except for required maintenance.

Specific Design Issues for Streetscape Bioretention (B-2). Streetscape bioretention is installed in the road right-of way either in the sidewalk area or in the road itself. In many cases, streetscape bioretention areas can also serve as a traffic calming or street parking control devices. The basic design adaptation is to move the raised concrete curb closer to the street or in the street, and then create inlets or curb cuts that divert street runoff into depressed vegetated areas within the expanded right of way. Roadway stability can be a design issue where streetscape bioretention practices are installed. Designers should consult design standards pertaining to roadway drainage. It may be necessary to provide an impermeable liner on the road side of the bioretention area to keep water from saturating the road's sub-base.

Specific Design Issues for Engineered Tree Boxes (B-3). Engineered tree boxes are installed in the sidewalk zone near the street where urban street trees are normally installed. The soil volume for the tree pit is increased and used to capture and treat stormwater. Treatment is increased by using a series of connected tree planting areas together in a row. The surface of the enlarged planting area may be mulch, grates, permeable pavers, or conventional pavement. The large and shared rooting space and a reliable water supply increase the growth and survival rates in this otherwise harsh planting environment.

When designing engineered tree boxes, the following criteria should be considered:

- The bottom of the soil layer must be a minimum of 4 inches below the root ball of plants to be installed.
- Engineered tree box designs sometimes cover portions of the filter media with pervious pavers or cantilevered sidewalks. In these situations, it is important that the filter media is connected beneath the surface so that stormwater and tree roots can share this space.
- Installing an engineered tree pit grate over filter bed media is one possible solution to prevent pedestrian traffic and trash accumulation.
- Low, wrought iron fences can help restrict pedestrian traffic across the tree pit bed and serve as a protective barrier if there is a dropoff from the pavement to the micro-bioretention cell.
- A removable grate may be used to allow the tree to grow through it.
- Each tree needs a minimum of 400 cubic feet of root space.

Specific Design Issues for Stormwater Planters (B-4). Stormwater planters are a useful option to disconnect and treat rooftop runoff, particularly in ultra-urban areas. They consist of confined planters that store and/or infiltrate runoff in a soil bed to reduce runoff volumes and pollutant loads. Stormwater planters combine an aesthetic landscaping feature with a functional form of stormwater treatment. Stormwater planters generally receive runoff from adjacent rooftop downspouts and are landscaped with plants that are tolerant to periods of both drought and inundation. The two basic design variations for stormwater planters are the infiltration planter and the filter planter.

An **infiltration planter** filters rooftop runoff through soil in the planter followed by infiltration into soils below the planter. The minimum filter media depth is 18 inches, with the shape and length determined by architectural considerations. Infiltration planters should be placed at least 10 feet away from a building to prevent possible flooding or basement seepage damage.

A **filter planter** does not allow for infiltration and is constructed with a watertight concrete shell or an impermeable liner on the bottom to prevent seepage. Since a filter planter is self-contained and does not infiltrate into the ground, it can be installed right next to a building. The minimum filter media depth is 18 inches, with the shape and length determined by architectural considerations. Runoff is captured and temporarily ponded above the planter bed. Overflow pipes are installed to discharge runoff when maximum ponding depths are exceeded, to avoid water spilling over the side of the planter. In addition, an underdrain is used to carry runoff to the storm sewer system.

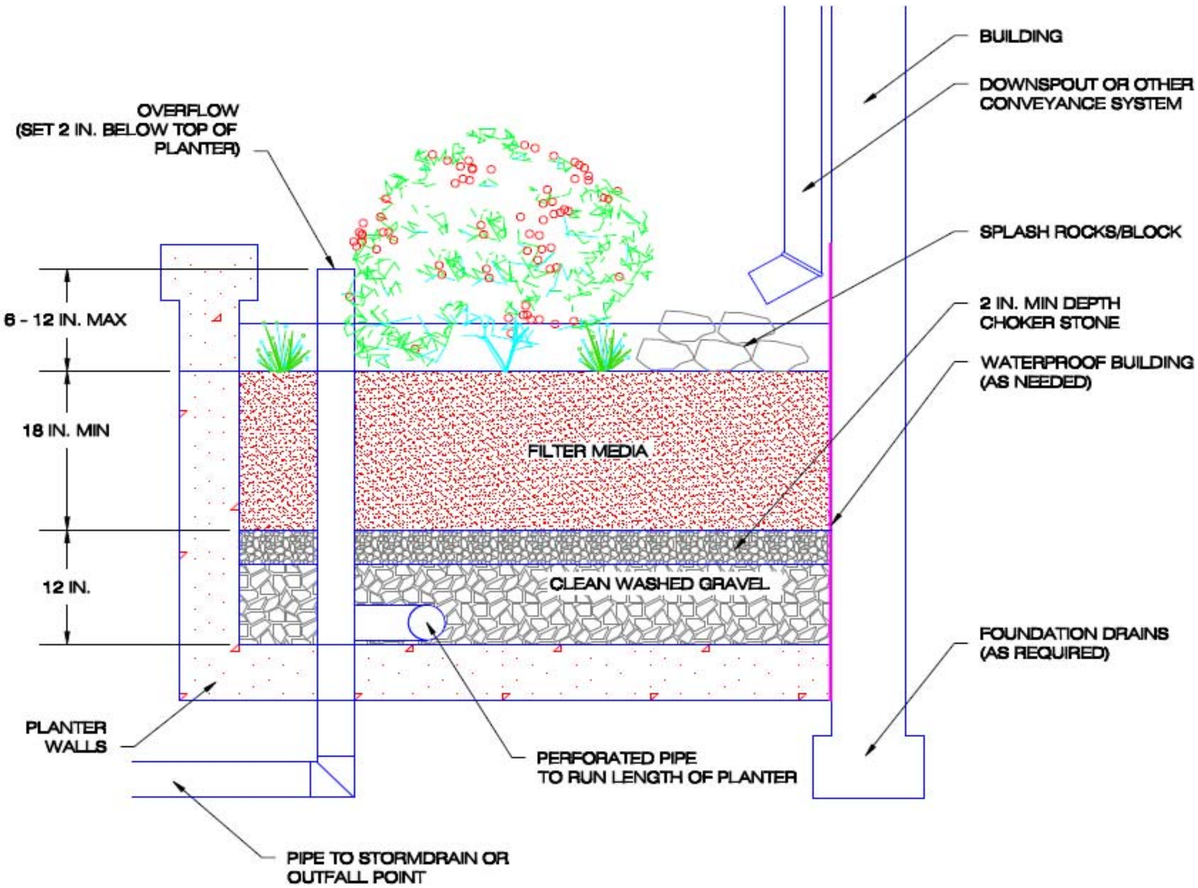

Figure 3.5.4. Stormwater Planter

All planters should be placed at grade level or above ground. They should be sized to allow captured runoff to drain out within four hours after a storm event. Plant materials should be capable of withstanding moist and seasonally dry conditions. Planting media should have an infiltration rate of at least 1 inch per hour. The sand and gravel on the bottom of the planter should have a minimum infiltration rate of 5 inches per hour. The planter can be constructed of stone, concrete, brick, wood, or other durable material. If treated wood is used, care should be taken so that trace metals and creosote do not leach out of the planter.

Specific Design Issues for Residential Rain Gardens (B-5). For some residential applications, front, side, and/or rear yard bioretention may be an attractive option. This form of bioretention captures roof, lawn, and driveway runoff from low- to medium- density residential lots in a depressed area (i.e. 6 to 12 inches) between the home and the primary stormwater conveyance system (i.e. roadside ditch or pipe system). The bioretention area connects to the drainage system with an underdrain.

The bioretention filter media should be at least 18 inches deep. The underdrain is directly connected into the storm drain pipe running underneath the street or in the street right-of-way. A trench needs to be excavated during construction to connect the underdrain to the street storm drain system.

Construction of the remainder of the front yard bioretention system is deferred until after the lot has been stabilized. A front yard design should reduce the risk of homeowner conversion because it allows the owners to choose whether they want turf or landscaping. Front yard bioretention requires regular mowing and/or landscape maintenance to perform effectively. It is recommended that the practice be located in an expanded right-of-way or stormwater easement so that it can be easily accessed by DDOE inspectors or maintenance crew in the event that it fails to drain properly.

Practice Sizing. Bioretention is typically sized to capture the SWRv or larger design storm volumes in the surface ponding area, soil media, and gravel reservoir layers of the practice.

First, designers should calculate the total storage volume of the practice using Equation 3.5.1.

Equation 3.5.1. Bioretention Storage Volume

$$Sv_{practice} = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{gravel} \times \eta_{gravel})] + (SA_{average} \times d_{ponding})$$

Where:

$Sv_{practice}$	=	total storage volume of practice (cu. ft.)
SA_{bottom}	=	bottom surface area of practice (sq. ft.)
d_{media}	=	depth of the filter media (ft)
η_{media}	=	effective porosity of the filter media (typically 0.25)
d_{gravel}	=	depth of the underdrain and underground storage gravel layer (ft)
η_{gravel}	=	effective porosity of the gravel layer (typically 0.4)
$SA_{average}$	=	the average surface area of the practice (sq. ft.) typically = ½ x (top area plus the bottom (SA_{bottom}) area)
$d_{ponding}$	=	the maximum ponding depth of the practice (ft.)

Equation 3.5.1 can be modified if the storage depths of the soil media, gravel layer, or ponded water vary in the actual design or with the addition of any surface or subsurface storage components (e.g. additional area of surface ponding, subsurface storage chambers, etc.). The maximum depth of ponding in the bioretention should not exceed 18 inches. If storage practices will be provided off-line or in series with the bioretention area, the storage practices should be

sized using the guidance in Section 3.11.

During high intensity storm events, the bioretention practice will fill up faster than the collected stormwater is able to filter through the soil media. To ensure that the runoff volume from these storms is filtered, **the surface storage volume of the system (including pretreatment) shall be designed to store at least 75% of the SWRv or alternative design storm prior to filtration.** The surface storage volume ($V_{ponding}$) of the practice, expressed as ($SA_{average}$ x $d_{ponding}$) in Equation 3.5.1, should be sized to ensure that at least 75% of the SWRv or alternative design storm volume is captured. If $V_{ponding}$ is less than 75% of the design storm volume, the total storage volume of the practice credited towards compliance (*Sv*) is reduced to the ponding volume divided by 0.75, as determined using Equation 3.5.2. If $V_{ponding}$ is greater than or equal to 75% of the design storm volume, then the total storage volume of the practice ($Sv_{practice}$) is credited towards compliance such that *Sv* equals $Sv_{practice}$, Equation 3.5.3.

Equation 3.5.2. Bioretention Ponding Volume Check 1

$$\text{If } V_{ponding} < 0.75 \text{ x } Design\ Volume,\ Sv = (V_{ponding}) / 0.75$$

Equation 3.5.3 Bioretention Ponding Volume Check 2

$$\text{If } V_{ponding} \geq 0.75\ Design\ Volume,\ Sv = Sv_{total}$$

Bioretention can be designed to address, in whole or in part, the detention storage needed to comply with channel protection and/or flood control requirements. The Sv can be counted as part of the 2-yr or 15-yr runoff volumes to satisfy stormwater quantity control requirements.

Note: In order to increase the storage volume of a bioretention area, the ponding surface area may be increased beyond the filter media surface area. However*, the top surface are of the practice (i.e. at the top of the ponding elevation)* may not be more than twice the size of surface area of the filter media (SA_{bottom}*)*.

3.5.5. Bioretention Landscaping Criteria

Landscaping is critical to the performance and function of bioretention areas. Therefore, a landscaping plan shall be provided for bioretention areas.

Minimum plan elements should include the proposed bioretention template to be used, delineation of planting areas, the planting plan, including the size, the list of planting stock, sources of plant species, and the planting sequence, including post-nursery care and initial maintenance requirements. It is highly recommended that the planting plan be prepared by a qualified landscape architect or horticulturalist, in order to tailor the planting plan to the site-specific conditions.

Native plant species are preferred over non-native species, but some ornamental species may be used for landscaping effect if they are not aggressive or invasive. Some popular native species that work well in bioretention areas and are commercially available can be found in Tables 3.5.2 and 3.5.3. Internet links to more detailed bioretention plant lists developed in the Chesapeake Bay region are provided below:

- Prince Georges County, MD
  http://www.princegeorgescountymd.gov/Government/AgencyIndex/DER/ESG/Bioretention/pdf/Bioretention%20Manual_2009%20Version.pdf
- Delaware Green Technology Standards and Specifications
  http://www.dnrec.state.de.us/DNREC2000/Divisions/Soil/Stormwater/New/GT_Stds%20&%20Specs_06-05.pdf

The degree of landscape maintenance that can be provided will determine some of the planting choices for urban bioretention areas. Plant selection differs if the area will be frequently mowed, pruned, and weeded, in contrast to a site which will receive minimum annual maintenance. In areas where less maintenance will be provided and where trash accumulation in shrubbery or herbaceous plants is a concern, consider a "turf and trees" landscaping model where the turf is mowed along with other turf areas on the site. Spaces for herbaceous flowering plants can be included.

Table 3.5.2. Herbaceous plants appropriate for bioretention areas in the District.

Plant	Light	Wetland Indicator[1]	Plant Form	Inundation Tolerance	Notes
Aster, New York (*Aster novi-belgii*)	Full Sun-Part Shade	FACW+	Perennial	Yes	Attractive flowers; tolerates poor soils
Aster, New England (*Aster novae-angliae*)	Full Sun-Part Shade	FACW	Perennial	Yes	Attractive flowers
Aster, Perennial Saltmarsh (*Aster tenuifolius*)	Full Sun-Part Shade	OBL	Perennial	Yes	Salt tolerant
Coreopsis, Threadleaf (Coreopsis verticillata)	Full Sun-Part Shade	FAC	Perennial	No	Drought tolerant
Beardtongue (*Penstemon digitalis*)	Full Sun	FAC	Perennial	No	Tolerates poor drainage
Beebalm (Monarda didyma)	Full Sun-Part Shade	FAC+	Perennial	Saturated	Herbal uses; attractive flower
Black-Eyed Susan (Rudbeckia hirta)	Full Sun-Part Shade	FACU	Perennial	No	Common; Maryland state flower
Bluebells, Virginia	Part Shade-	FACW	Perennial	Yes	Attractive flower;

Table 3.5.2. Herbaceous plants appropriate for bioretention areas in the District.

Plant	Light	Wetland Indicator[1]	Plant Form	Inundation Tolerance	Notes
(*Mertensia virginica*)	Full Shade				dormant in summer
Blueflag,Virginia (*Iris virginica*)	Full Sun-Part Shade	OBL	Perennial	Yes	Tolerates standing water
Bluestem, Big (*Andropogon gerardii*)	Full Sun	FAC	Grass	No	Attractive in winter; forms clumps
Bluestem, Little (*Schizachyrium scoparium*)	Full Sun	FACU	Grass	No	tolerates poor soil conditions
Broom-Sedge (Andropogon virginicus)	Full Sun	FACU	Grass	No	Drought tolerant; attractive fall color
Cardinal Flower (Lobelia cardinalis)	Full Sun-Part Shade	FACW+	Perennial	Yes	Long boom time
Fern, New York (Thelypteris noveboracensis)	Part Shade-Full Shade	FAC	Fern	Saturated	Drought tolerant; spreads
Fern, Royal (Osmunda regalis)	Full Sun-Full Shade	OBL	Fern	Saturated	Tolerates short term flooding; drought tolerant
Fescue, Red (Festuca rubra)	Full Sun-Full Shade	FACU	Groundcover	No	Moderate growth; good for erosion control
Iris, Blue Water (Iris versicolor)	Full Sun-Part Shade	OBL	Perennial	0-6"	Spreads
Lobelia, Great Blue (Lobelia siphilitica)	Part Shade-Full Shade	FACW+	Perennial	Yes	Blooms in late summer; bright blue flowers
Phlox, Meadow (Phlox maculata)	Full Sun	FACW	Perennial	Yes	Aromatic; spreads
Sea-Oats (Uniola paniculata)	Full Sun	FACU-	Grass	No	Salt tolerant; attractive seed heads
Swamp Milkweed (Asclepias incarnata)	Full Sun-Part Shade	OBL	Perennial	Saturated	Drought tolerant
Switchgrass (Panicum virgatum)	Full Sun	FAC	Grass	Seasonal	Adaptable; great erosion control
Turtlehead, White (Chelone glabra)	Full Sun-Part Shade	OBL	Perennial	Yes	Excellent growth; herbal uses
Violet, Common Blue (Viola papilionacea)	Full Sun-Full Shade	FAC	Perennial	No	Stemless; spreads
Virginia Wild Rye (Elymus virginicus)	Part Shade-Full Shade	FACW-	Grass	Yes	Adaptable

Table 3.5.2. Herbaceous plants appropriate for bioretention areas in the District.

Plant	Light	Wetland Indicator[1]	Plant Form	Inundation Tolerance	Notes

[1]Notes:
FAC = Facultative, equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
FACU = Facultative Upland, usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).
FACW = FACW Facultative Wetland, usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
OBL = Obligate Wetland, occurs almost always (estimated probability 99%) under natural conditions in wetlands.

Sources: Prince George's County Maryland Bioretention Manual; Virginia DCR Stormwater Design Specification No. 9: Bioretention

Table 3.5.3. Woody plants appropriate for bioretention areas in the District.

Plant	Light	Wetland Indicator [1]	Plant Form	Inundation Tolerance	Notes
Arrow-wood *(Viburnum dentatum)*	Full Sun- Part Shade	FAC	Shrub	Seasonal	Salt tolerant
River Birch *(Betula nigra)*	Full Sun- Part Shade	FACW	Tree	Seasonal	Attractive bark
Bayberry, Northern *(Myrica pennsylvanica)*	Full Sun- Part Shade	FAC	Shrub	Seasonal	Salt tolerant
Black Gum *(Nyssa sylvatica)*	Full Sun- Part Shade	FACW+	Tree	Seasonal	Excellent fall color
Dwarf Azalea *(Rhododendron atlanticum)*	Part Shade	FAC	Shrub	Yes	Long lived
Black-Haw *(Viburnum prunifolium)*	Part Shade- Full Shade	FACU+	Shrub	Yes	Edible Fruit
Choke Cherry *(Prunus virginiana)*	Full Sun	FACU+	Shrub	Yes	Tolerates some salt; can be maintained as hedge
Cedar, Eastern Red *(Juniperus virginiana)*	Full Sun	FACU	Tree	No	Pollution tolerant
Cotton-wood, Eastern *(Populus deltoides)*	Full Sun	FAC	Tree	Seasonal	Pollutant tolerant; salt tolerant
Silky Dogwood *(Cornus amomum)*	Full Sun- Part Shade	FACW	Shrub	Seasonal	High wildlife value
Hackberry, Common *(Celtis occidentalis)*	Full Sun-Full Shade	FACU	Tree	Seasonal	Pollution Tolerant
Hazelnut, American *(Corylus americana)*	Part Shade	FACU	Shrub	No	Forms thickets; edible nut
Holly, Winterberry *(Ilex laevigata)*	Full Sun-Part Shade	OBL	Shrub	Yes	Winter food source for birds

Table 3.5.3. Woody plants appropriate for bioretention areas in the District.

Plant	Light	Wetland Indicator [1]	Plant Form	Inundation Tolerance	Notes
Holly, American *(Ilex opaca)*	Full Sun-Full Shade	FACU	Shrub-Tree	Limited	Pollution Tolerant
Maple, Red *(Acer rubrum)*	Full Sun-Part Shade	FAC	Tree	Seasonal	Very adaptable; early spring flowers
Ninebark, Eastern *(Physocarpus opulifolius)*	Full Sun-Part Shade	FACW-	Shrub	Yes	Drought tolerant; attractive bark
Oak, Pin *(Quercus palustris)*	Full Sun	FACW	Tree	Yes	Pollution Tolerant
Pepperbush, Sweet *(Clethra alnifolia)*	Part Shade- Full Shade	FAC+	Shrub	Seasonal	Salt tolerant
Winterberry, Common *(Ilex verticillata)*	Full Sun-Full Shade	FACW+	Shrub	Seasonal	Winter food source for birds
Witch-Hazel, American *(Hamamelia virginiana)*	Part Shade-Full Shade	FAC-	Shrub	No	Pollution tolerant

[1]Notes:
FAC = Facultative, equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
FACU = Facultative Upland, usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).
FACW = FACW Facultative Wetland, usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
OBL = Obligate Wetland, occurs almost always (estimated probability 99%) under natural conditions in wetlands.

Sources: Prince George's County Maryland Bioretention Manual; Virginia DCR Stormwater Design Specification No. 9: Bioretention

Planting recommendations for bioretention facilities are as follows:

- The primary objective of the planting plan is to cover as much of the surface areas of the filter bed as quickly as possible. Herbaceous or ground cover layers are as or more important than more widely spaced trees and shrubs.
- Native plant species should be specified over non-native species.
- Plants should be selected based on a specified zone of hydric tolerance and must be capable of surviving both wet and dry conditions.
- Woody vegetation should not be located at points of inflow; trees should not be planted directly above underdrains but should be located closer to the perimeter.
- "Wet footed" species should be planted near the center, whereas upland species do better planted near the edge.
- Shrubs and herbaceous vegetation should generally be planted in clusters and at higher densities (i.e. 10 feet on-center and 1 to 1.5 feet on-center, respectively).
- If trees are part of the planting plan, a tree density of approximately one tree per 250 square feet (i.e. 15 feet on-center) is recommended.

- Designers should also remember that planting holes for trees must be at least 4 feet deep to provide enough soil volume for the root structure of mature trees. This applies even if the remaining soil media layer is shallower than 4 feet.
- Tree species should be those that are known to survive well in the compacted soils and the polluted air and water of an urban landscape.
- If trees are used, plant shade-tolerant ground covers within the drip line.
- If the bioretention area is to be used for snow storage or is to accept snowmelt runoff, it should be planted with salt-tolerant, herbaceous perennials.

3.5.6. Bioretention Construction Sequence

Erosion and Sediment Controls. Bioretention areas should be fully protected by silt fence or construction fencing. Ideally, bioretention should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment. Large bioretention applications may be used as small sediment traps or basins during construction. However, these must be accompanied by notes and graphic details on the erosion and sediment control plan specifying that (1) the maximum excavation depth of the trap or basin at the construction stage must be at least 1 foot higher than the post-construction (final) invert (bottom of the facility), and (2) the facility must contain an underdrain. The plan must also show the proper procedures for converting the temporary sediment control practice to a permanent bioretention facility, including dewatering, cleanout, and stabilization.

Bioretention Installation. The following is a typical construction sequence to properly install a bioretention basin. The construction sequence for micro-bioretention is more simplified. These steps may be modified to reflect different bioretention applications or expected site conditions:

Step 1. Construction of the bioretention area may only begin after the entire contributing drainage area has been stabilized with vegetation. It may be necessary to block certain curb or other inlets while the bioretention area is being constructed. The proposed site should be checked for existing utilities prior to any excavation.

Step 2. The designer, the installer, and DDOE inspector must have a preconstruction meeting, checking the boundaries of the contributing drainage area and the actual inlet elevations to ensure they conform to original design. Since other contractors may be responsible for constructing portions of the site, it is quite common to find subtle differences in site grading, drainage and paving elevations that can produce hydraulically important differences for the proposed bioretention area. The designer should clearly communicate, in writing, any project changes determined during the preconstruction meeting to the installer and the inspector. Material certifications for aggregate, soil media, and any geotextiles must be submitted for approval to the inspector at the preconstruction meeting.

Step 3. Temporary erosion and sediment controls (e.g. diversion dikes, reinforced silt fences) are needed during construction of the bioretention area to divert stormwater away from the bioretention area until it is completed. Special protection measures, such as erosion control fabrics, may be needed to protect vulnerable side slopes from erosion during the construction process.

Step 4. Any pre-treatment cells should be excavated first and then sealed to trap sediments.

Step 5. Excavators or backhoes should work from the sides to excavate the bioretention area to its appropriate design depth and dimensions. Excavating equipment should have scoops with adequate reach so they do not have to sit inside the footprint of the bioretention area. Contractors should use a cell construction approach in larger bioretention basins, whereby the basin is split into 500 to 1,000 sq. ft. temporary cells with a 10-15 foot earth bridge in between, so that cells can be excavated from the side.

Step 6. It may be necessary to rip the bottom soils to a depth of 6 to 12 inches to promote greater infiltration.

Step 7. If using a filter fabric, place the fabric on the sides of the bioretention area with a 6-inch overlap on the sides. If a stone storage layer will be used, place the appropriate depth of No. 57 stone on the bottom, install the perforated underdrain pipe, pack No. 57 stone to 3 inches above the underdrain pipe, and add the choking layer or woven monofilament polypropylene geotextile layer as a filter between the underdrain and the soil media layer. If no stone storage layer is used, start with 6 inches of No. 57 stone on the bottom and proceed with the layering as described above.

Step 8. Purchase the soil media from an approved vendor, and store it on an adjacent impervious area or plastic sheeting. Apply the media in 12-inch lifts until the desired top elevation of the bioretention area is achieved. Wait a few days to check for settlement and add additional media, as needed, to achieve the design elevation. Note: A DDOE inspector must receive and approve the batch receipt confirming the source of the soil media prior to installation.

Step 9. Prepare planting holes for any trees and shrubs, install the vegetation, and water accordingly. Install any temporary irrigation.

Step 10. Place the surface cover (i.e. mulch, river stone, or turf) in both cells, depending on the design. If coir or jute matting will be used in lieu of mulch, the matting will need to be installed prior to planting (Step 9), and holes or slits will have to be cut in the matting to install the plants.

Step 11. Install the plant materials as shown in the landscaping plan, and water them during weeks of no rain for the first two months.

Step 12. If curb cuts or inlets are blocked during bioretention installation, unblock these after the drainage area and side slopes have good vegetative cover. It is recommended that unblocking curb cuts and inlets take place after two to three storm events if the drainage area includes newly installed asphalt, since new asphalt tends to produce a lot of fines and grit during the first several storms.

Step 13. Conduct the final construction inspection (see below), providing DDOE with an as-built, then log the GPS coordinates for each bioretention facility, and submit them for entry into the maintenance tracking database.

Construction Inspection. An example construction phase inspection checklist is available in Appendix L.

3.5.7. Bioretention Maintenance Criteria

When small-scale bioretention practices are applied on private residential lots, homeowners will need to (1) be educated about their routine maintenance needs, (2) understand the long-term maintenance plan, and (3) be subject to a maintenance covenant or agreement, as described below.

Maintenance of bioretention areas should be integrated into routine landscape maintenance tasks. If landscaping contractors will be expected to perform maintenance, their contracts should contain specifics on unique bioretention landscaping needs, such as maintaining elevation differences needed for ponding, proper mulching, sediment and trash removal, and limited use of fertilizers and pesticides.

Maintenance tasks and frequency will vary depending on the size and location of the bioretention, the landscaping template chosen, and the type of surface cover in the practice. A generalized summary of common maintenance tasks and their frequency is provided in Table 3.5.4.

Table 3.5.4. Recommended maintenance tasks for bioretention practices.

Maintenance Tasks	Frequency

▪ For the first 6 months following construction, the practice and CDA should be inspected at least twice after storm events that exceed 1/2 inch of rainfall. Conduct any needed repairs or stabilization. ▪ Inspectors should look for bare or eroding areas in the contributing drainage area or around the bioretention area, and make sure they are immediately stabilized with grass cover. ▪ One-time, spot fertilization may be needed for initial plantings. ▪ Watering is needed once a week during the first 2 months, and then as needed during first growing season (April-October), depending on rainfall. ▪ Remove and replace dead plants. Up to 10% of the plant stock may die off in the first year, so construction contracts should include a care and replacement warranty to ensure that vegetation is properly established and survives during the first growing season following construction.	Upon establishment
▪ Mow grass filter strips and bioretention with turf cover ▪ Check curb cuts and inlets for accumulated grit, leaves, and debris that may block inflow	At least 4 times a year
▪ Spot weed, remove trash, and rake the mulch	Twice during growing season
▪ Add reinforcement planting to maintain desired vegetation density ▪ Remove invasive plants using recommended control methods ▪ Remove any dead or diseased plants ▪ Stabilize the contributing drainage area to prevent erosion	As needed
▪ Conduct a maintenance inspection ▪ Supplement mulch in devoid areas to maintain a 3 inch layer ▪ Prune trees and shrubs ▪ Remove sediment in pre-treatment cells and inflow points	Annually
▪ Remove sediment in pre-treatment cells and inflow points ▪ Remove and replace the mulch layer	Once every 2 to 3 years

The most common non-routine maintenance problem involves standing water. If water remains on the surface for more than 72 hours after a storm, adjustments to the grading may be needed or underdrain repairs may be needed. The surface of the filter bed should also be checked for accumulated sediment or a fine crust that builds up after the first several storm events. There are several methods that can be used to rehabilitate the filter. These are listed below, starting with the simplest approach and ranging to more involved procedures (i.e. if the simpler actions do not solve the problem):

- Open the underdrain observation well or cleanout and pour in water to verify that the underdrains are functioning and not clogged or otherwise in need of repair. The purpose of this check is to see if there is standing water all the way down through the soil. If there is standing water on top, but not in the underdrain, then there is a clogged soil layer. If the underdrain and stand pipe indicates standing water, then the underdrain must be clogged and will need to be cleaned out.
- Remove accumulated sediment and till 2 to 3 inches of sand into the upper 6 to 12 inches of soil.

- Install sand wicks from 3 inches below the surface to the underdrain layer. This reduces the average concentration of fines in the media bed and promotes quicker drawdown times. Sand wicks can be installed by excavating or auguring (i.e. using a tree auger or similar tool) down to the top of the underdrain layer to create vertical columns which are then filled with a clean open-graded coarse sand material (e.g. ASTM C-33 concrete sand or similar approved sand mix for bioretention media). A sufficient number of wick drains of sufficient dimension should be installed to meet the design dewatering time for the facility.
- Remove and replace some or all of the soil media.

It is highly recommended that a spring maintenance inspection and cleanup be conducted at each bioretention area. Example maintenance inspection checklists for bioretention areas can be found in Appendix M.

A declaration of covenants that includes all maintenance responsibilities to ensure the continued stormwater performance for the BMP is required. The declaration of covenants specifies the property owner's primary maintenance responsibilities, and authorizes DDOE staff to access the property for inspection or corrective action in the event the proper maintenance is not performed. The declaration of covenants is attached to the deed of the property. An example form is provided at the end of Chapter 5 though variations will exist for scenarios where stormwater crosses property lines. The covenant is between the property and the District Government. It is submitted through the Office of the Attorney General (OAG). All SWMPs have a maintenance agreement stamp that must be signed for a building permit to proceed. A maintenance schedule must appear on the SWMP. Additionally, a maintenance schedule is required in schedule c of the declaration of covenants.

Covenants are not required on government properties, but maintenance responsibilities must be defined through a partnership agreement or a memorandum of understanding.

Waste material from the repair, maintenance, or removal of a BMP or land cover change shall be removed, and the maintenance contractor shall submit a written report to DDOE within forty-eight (48) hours after disposing of the waste material. The report shall include:

(a) The name, address, phone number, and business license number of the contractor transporting the waste materials;
(b) Date of removal;
(c) The address of the BMP;
(d) Type of BMP serviced;
(e) Amount and type of waste material removed;
(f) The name and location of the facility where the waste material was disposed of; and
(g) A sworn statement that disposal was in compliance with applicable federal and District law.

3.5.8. Bioretention Stormwater Compliance Calculations

Bioretention performance varies depending on the design configuration of the system:

Enhanced Designs (Bioretention Applications with no Underdrain or at least 24" of Filter Media and an Infiltration Sump): receive 100% retention value for the amount of storage volume (Sv) provided by the practice (Table 3.5.5). No additional pollutant removal is awarded.

Table 3.5.5. Enhanced bioretention retention value and pollutant removal.

Retention Value	$= Sv$
Additional Pollutant Removal	N/A*

* No additional pollutant removal is awarded since the practice retains 100% of the storage volume

Standard Designs (Bioretention Applications with an Underdrain and less than 24" of Filter Media): receive 60% retention value and 50% TSS EMC reduction for the amount of storage volume (Sv) provided by the practice (Table 3.5.6).

Table 3.5.6. Standard bioretention design retention value and pollutant removal.

Retention Value	$= 0.6 \times Sv$
Additional Pollutant Removal	50% TSS EMC reduction for *Sv* provided

The practice must be sized using the guidance detailed in Section 3.5.4.

Note: Additional retention value can be achieved if trees are utilized as part of a bioretention area. (See Section 3.13).

Bioretention also contributes to peak flow reduction. This contribution can be determined in several ways. One method is to subtract the Sv or Rv from the total runoff volume for the 2-year, 15-year, and 100-year storms. The resulting reduced runoff volumes can then be used to calculate a Reduced Natural Resource Conservation Service (NRCS) Curve Number for the site or drainage area. The Reduced Curve Number can then be used to calculate peak flow rates for the various storm events. Other hydrologic modeling tools that employ different procedures may be used as well.

3.5.9. References

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