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Updated Draft Manual of Stormwater Best Management Practices

North Carolina
Department of Environment
and Natural Resources
Division of Water Quality

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3.2 Bioretention

Also Known as Rain Gardens, Biofiltration Devices

Companion BMPs: Grassed Swale; Filter Strip, Buffer
Alternative BMPs: Infiltration Trench; Wet Detention Basin; Stormwater Wetland

3.2.1 Definition

Bioretention is the use of plants and soils for removal of pollutants from stormwater runoff via adsorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition. In addition, bioretention provides landscaping and habitat enhancement benefits.

3.2.2 Description and Purpose

A bioretention facility consists of a depression in the ground filled with a soil media mixture that supports various types of water-tolerant vegetation. The surface of the facility is protected from weeds, mechanical erosion, and desiccation by a layer of mulch. Bioretention is an efficient method for removing a wide variety of pollutants, such as suspended solids and heavy metals. Bioretention areas provide some nutrient uptake in addition to physical filtration. Certain pollutants (many metals) are removed in the mulch layer and the first 30 inches of soil (Prince George's County, 2001). Bioretention can also be effective in reducing peak runoff rates, runoff volumes and recharging groundwater by infiltrating runoff.

Many development projects present a challenge to the designer of conventional stormwater BMPs because of physical site constraints. Bioretention areas are intended to address the spatial constraints that can be found in densely developed urban areas where the drainage areas are highly impervious (see Figure 3.2-1). They can be used on small urban sites that would not normally support the hydrology of a wet detention pond and where the soils would not allow for an infiltration device.

FIGURE 3.2-1
Bioretention in Parking Lot Island

Bioretention facilities are ideally deployed in an offline (having the ability to bypass flow once the inflow begins to exceed the device capacity) configuration to which initial stormwater flows are diverted. An overflow control allows excess flows to bypass the facility. The offline setup can reduce potential erosion that may arise in an inline configuration. Bioretention facilities need an underdrain system when the native soil has a low infiltration rate. The underdrain system connects to another BMP or to the conveyance system. A grassed buffer strip aids in distributing the inflow and pretreats runoff by removing some of the suspended solids which is recommended. Alternatively, a small forebay or a grass swale can serve as pre-treatment.

3.2.3 Advantages

- Efficient removal method for suspended solids, heavy metals, and adsorbed pollutants. Moderate to high removal of phosphorus, provided that the soil medium has low phosphorus content. Certain configurations allow for moderate-high removal of nitrogen.
- Effective means of reducing peak runoff rates for relatively frequent storms, reducing runoff volumes and recharging groundwater by infiltrating runoff.
- Flexible adaptation to urban retrofits.
- Successful use in small areas and, as distributed control measures, in large drainage areas or as part of Low Impact Development.
- Natural integration into landscaping for habitat enhancement.

3.2.4 Disadvantages

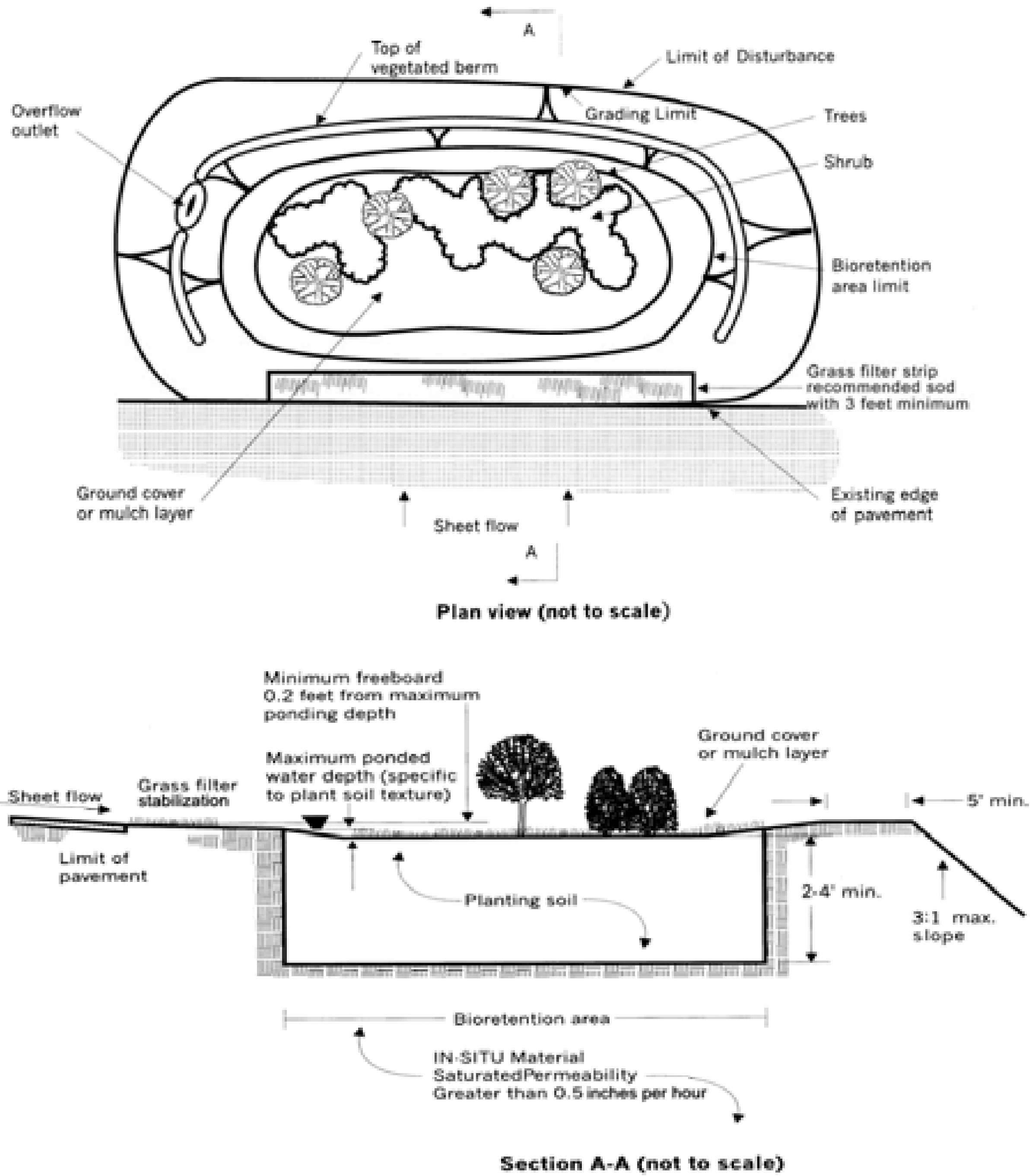
- In residential applications, homeowners need training to maintain the plant material and mulch layer, and provide general cleaning.
- Depending upon design, they may not be effective at removing nitrate.
- Surface soil layer may clog over time (though it can be easily restored).
- Frequent trash removal may be required, especially in high traffic areas.
- Vigilance in protecting the bioretention area during construction is essential.

3.2.5 Location/General Characteristics

A conceptual illustration of a typical bioretention facility is presented in Figure 3.2-2. The bioretention area design provides water storage for infiltration in the soil and uptake by vegetation. Figure 3.2-2 shows the sheet flow runoff from an impervious surface (such as a parking lot) discharging into the bioretention area through a grassed buffer strip.

The surface of the planting soil is depressed to allow for ponding of runoff. The runoff infiltrates through a layer of mulch. Water exits the bioretention area via exfiltration into the surrounding soil, flow out an underdrain, and evapotranspiration. Excess runoff bypasses the facility when the ponded water level in the bioretention area reaches the inlet level.

FIGURE 3.2-2
Bioretention Area Conceptual Layout, from Prince George's County (2000a)



The components of a bioretention facility can be:

- Pretreatment: A grassed buffer, swale or forebay is highly recommended for most applications.
- Flow entrance: Typically sheet flow but could involve curb cuts or other openings with stone reinforcement to minimize erosion.

- Ponding area: Allows for settling of particles and captures first flush.
- Soil media: A mixture that allows for filtration, plant growth, and biological activity.
- Organic layer or mulch: Protects the soil, acts as a filter, and provides an environment for biological activity.
- Plant material: Removes nutrients and pollutants through uptake and promotes filtration and biological degradation.
- Underdrain: Provides proper infiltration rates and drainage to minimize ponding duration and avoid damage to the plants. Required if in-situ soil permeability <2 in/hour.
- Overflow: Allows for a large fraction of excess flows to bypass the facility.

Bioretention can be used successfully in a wide range of applications. The most common applications treat runoff from less than 1 acre. Median strips, ramp loops, traffic circles, and parking lot islands are examples of these areas. Figure 3.2-3 shows a bioretention facility receiving runoff diverted from a storm sewer. Rip rap aprons or other measures can be used to dissipate energy from inflow. Figure 3.2-4 depicts a bioretention terrace that can be used in sloping terrain. Bioretention is not recommended for drainage areas greater than 1 acre. Instead, the facilities should be distributed throughout the site to minimize flow concentration and treat runoff as close as possible to the point where it is generated Preferable locations for this BMP include areas that receive sheet flow from graded terrain, and locations that will be excavated or cut. Bioretention can treat larger areas provided that the facilities are properly designed; for example, higher flow velocities, likely from larger drainage areas, would need to be mitigated.

FIGURE 3.2-3
Bioretention Facility Receiving Runoff from a Storm Sewer

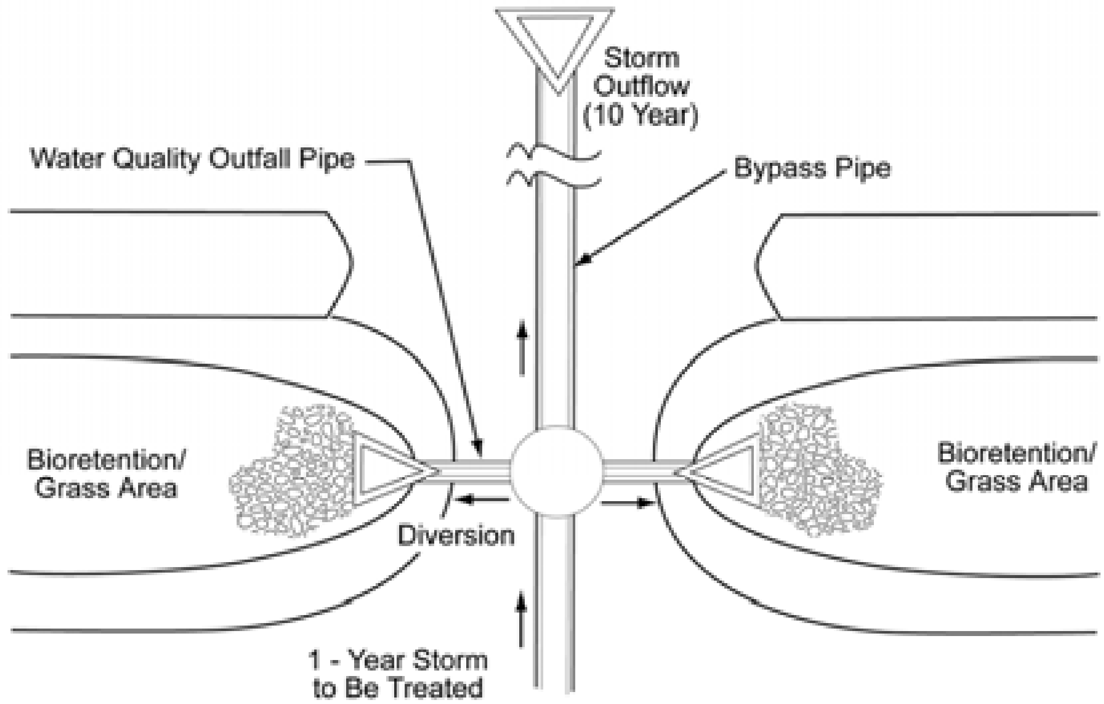
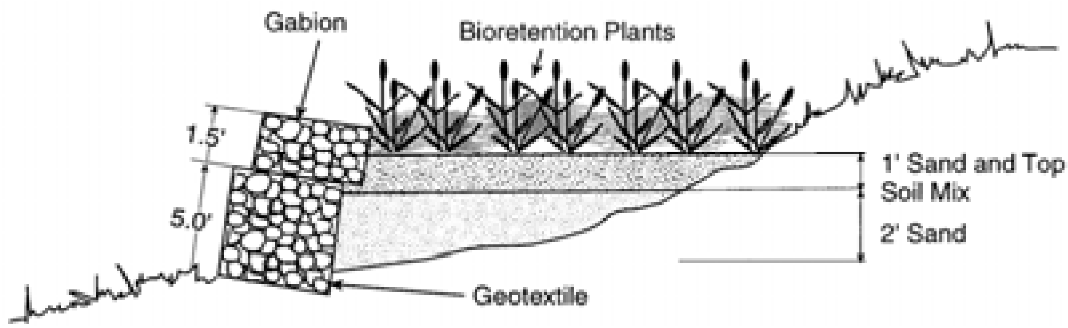


FIGURE 3.2-4
Bioretention Terrace Suitable for Deployment in Mild Slopes



Bioretention facilities can be incorporated in an overall site plan for capturing runoff and recharging groundwater. Bioretention facilities are generally most effective if they receive runoff as close as possible to the source for many reasons, including minimizing the concentration of flow to reduce entry velocity, allowing for blending of facilities with the site (e.g., parking median basins), avoiding excessive groundwater mounding, and having redundant treatment. Site designers need to look for opportunities to incorporate bioretention facilities throughout the site in order to reduce the use of inlets, pipes, and downstream controls.

Developments that incorporate selective grading and clearing with distributed stormwater management practices (e.g., bioretention) can achieve savings by eliminating stormwater management ponds; reducing pipes, inlet structures, curbs and gutters; and having less grading and clearing. Depending on the type of development and site constraints, the costs for using stormwater and site development bioretention methods can be reduced by 10 to 25 percent compared to stormwater and site development using other BMPs (Coffman et al., 1998).

Bioretention should not be used in areas with the following characteristics:

- The seasonal high water table is less than 2 feet below the proposed bottom of the facility.
- The maximum possible depth for the facility is less than 1.5 feet.
- Mature trees would have to be removed solely to construct the bioretention area.
- Slopes are 20 percent or greater, unless bioretention terraces are planned.

3.2.6 Design

Requirements for Regulatory Compliance

According to recent research conducted at North Carolina State University, bioretention can remove up to 40 percent of total nitrogen. Further nitrogen removal can be achieved if bioretention is combined with grass swales, filter strips, etc. In addition, nitrogen reduction by denitrification can be attained by incorporating an anaerobic region at the bottom of the facility. This region is created by raising or putting an elbow in the underdrain pipes. Bioretention must also be designed to achieve reduction of the 1-year, 24-hour storm flow to predevelopment conditions in the Neuse River Basin. Bioretention alone may not be able to meet this condition.

For purposes of satisfying the requirements of 15A NCAC 2H .1000, properly designed and constructed bioretention is assumed to have a TSS removal efficiency of 85 percent.

For purposes of satisfying the nutrient control requirements found in several Environmental Management Commission rules, properly designed and constructed bioretention are assumed to have a nitrogen removal efficiency of 35 percent and phosphorus removal efficiency of 45 percent.

Bioretention may be sized as part of a BMP system to control and treat the applicable runoff volume requirements from the stormwater rules including 15A NCAC 2H .1008 [runoff from the first one-inch of rainfall] or 15 A NCAC 2H .0126 (e) [the difference in the runoff volume between pre and post-development conditions generated by the 1-year, 24-hour storm]. The size of the system must take into account the runoff at the potential ultimate built-out from all surfaces draining to the system including any off-site drainage.

The design guidelines in Section 3.2.6.2 should be followed to achieve these TSS and N removal efficiencies; however, alternative designs, materials, and methodologies will be considered on a case-by-case basis.

Design Guidelines

Introduction

Conceptual illustrations of various types of bioretention areas are presented below. The layout of bioretention areas varies according to individual sites and to specific site constraints such as underlying soils, existing vegetation, drainage, location of utilities, sight distances for traffic, and aesthetics.

Figure 3.2-1 illustrates a concept for a bioretention traffic island.

The bioretention area featured in Figure 3.2-2 represents the simplest configuration in which runoff flows naturally into the facility as sheet flow. This configuration is suitable for residential lots and commercial applications, to be located adjacent to a parking area with a curb. With no curb, pre-cast car stops can be installed along the pavement perimeter to protect the bioretention area.

A bioretention area that can be installed along the perimeter of a parking lot is shown in Figure 3.2-5. The water is diverted to the bioretention area through the use of inlet deflector blocks, which have ridges to help channel the runoff into the bioretention area. The gutter and diversion block should meet the guidelines set forth by the relevant local permitting authority. A 2-foot buffer between the curb and the bioretention area serves as pretreatment and reduces the possibility of drainage seeping under the pavement section and creating "frost heave" during winter months.

A bioretention area suitable for installation along a swale is shown in Figure 3.2-6. A berm one foot in height separates the swale from the bioretention area. To maintain an off-line system, the bioretention area should be graded such that the overflow from the bioretention area discharges into the swale. The bioretention area invert should be a maximum of 6 inches below the swale invert to provide for the appropriate depth of ponded water.

FIGURE 3.2-5
Parking Edge and Perimeter with Curb, from Prince George's County (2000a)

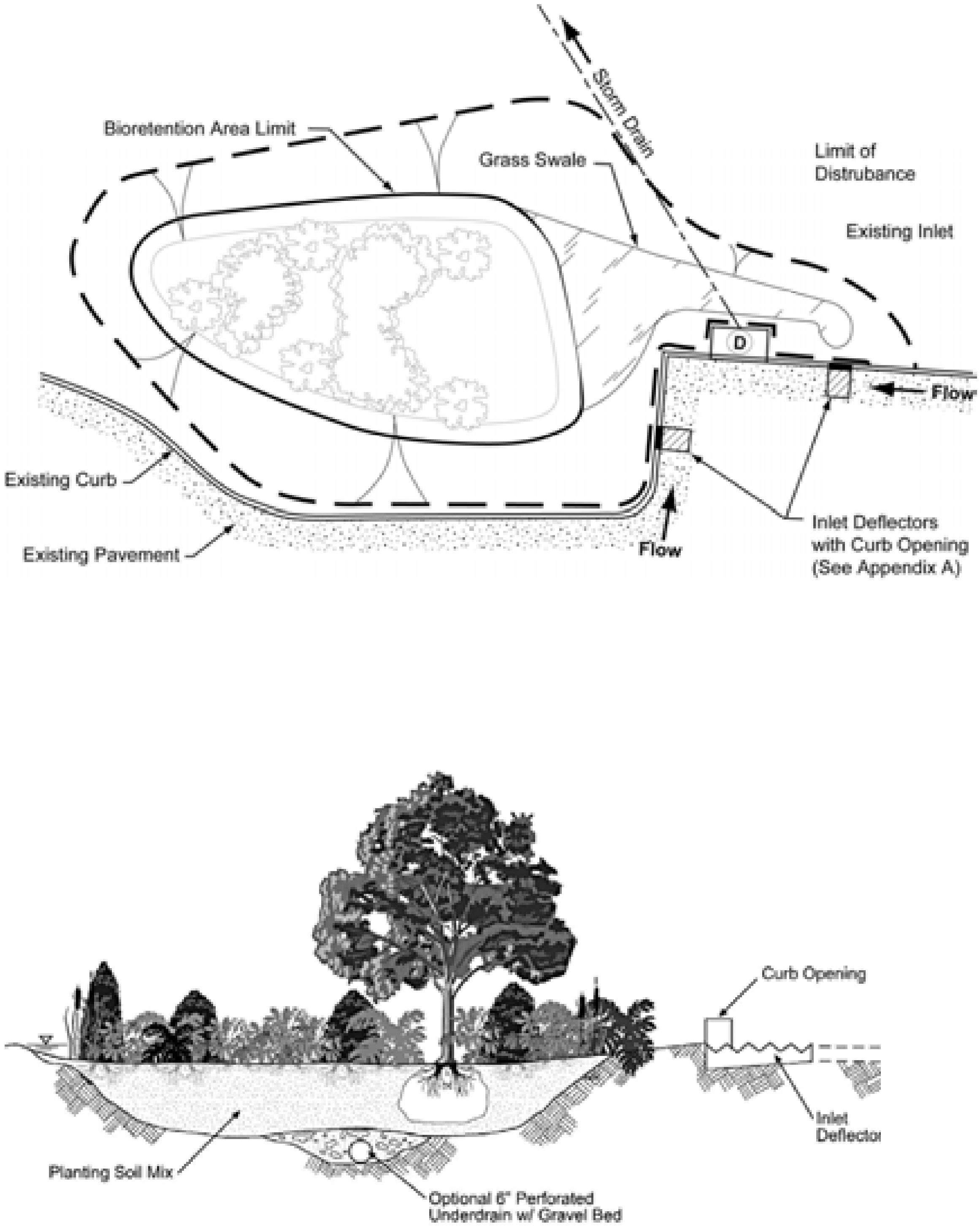
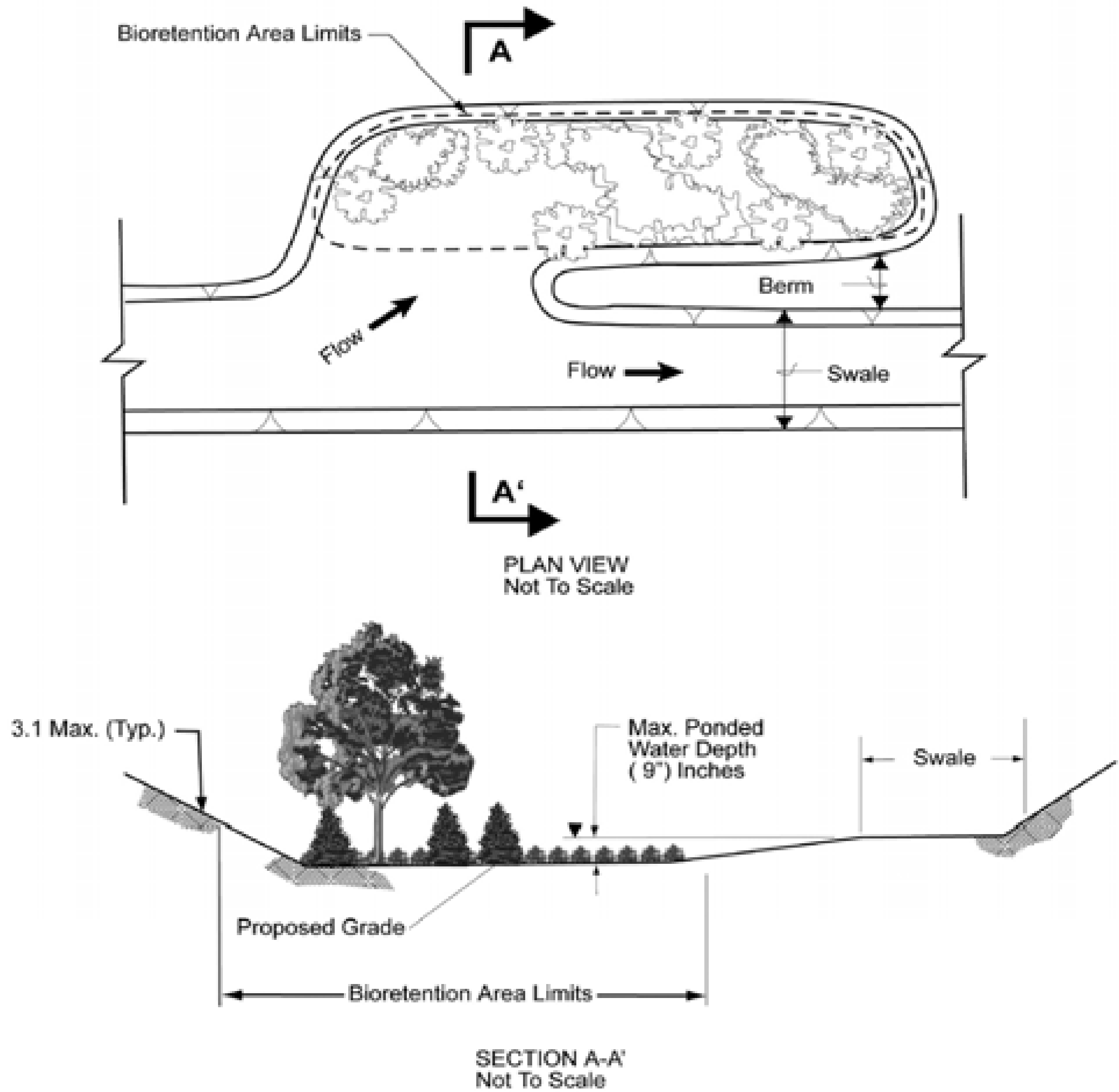


FIGURE 3.2-6
Bioretention Swale, from Prince George's County, 2001



Design Specifications and Methodology

Size

There are no size limitations for bioretention facilities. Small depressions containing a single tree can function effectively and contribute to runoff control. A set of minimum dimensions may be prescribed to meet landscaping and aesthetic criteria. Size is a function of the amount of impervious surfaces drainage in the contributing drainage area but a good rule of thumb is 3 to 8 percent of the contributing area.

The depth of the facility should be between 2 and 4 feet but no less than 1.5 feet. This range reflects the fact that most of the pollutant removal occurs within the first 1.5 feet of soil and that excavations deeper than 4 feet become more expensive. The depth should accommodate the expected size of the trees' root balls. If only shallow-rooted plants (grass)will be used, the depth can be reduced to 1.5 feet.

The ponding depth can be up to 12 inches. The duration of ponding should be kept to less than 12 hours, with sandy soils often the infiltration rate can be 1 inch per hour. The ponding depth may be increased in cases where a soil investigation shows that the infiltration rate is sufficient to draw down the water in the specified maximum time.

Drainage Considerations

There are two major drainage considerations in the design of bioretention areas:

- The diversion of runoff into the bioretention area.
- The potential erosion of the surface of the bioretention area by the inflow.

Runoff can enter the bioretention area directly as sheet flow through curb openings, or by small drainage pipe. The curb openings and diversion structures should be sized to allow the maximum ponding depth and bypass excess flows. Multiple curb openings may need to be considered in the presence of slopes and depending on the directions from which runoff reaches the facility. Figure 3.2-7 shows details of a typical diversion structure.

Although reduced by the off-line configuration, the potential erosion created by the inflow is a concern in the design of the bioretention areas. Stone may need to be placed to protect the soil and mulch below curb inlets. A small forebay can be constructed or grassed buffer strips can be deployed to avoid concentrated flows. The buffer strip also acts as pretreatment.

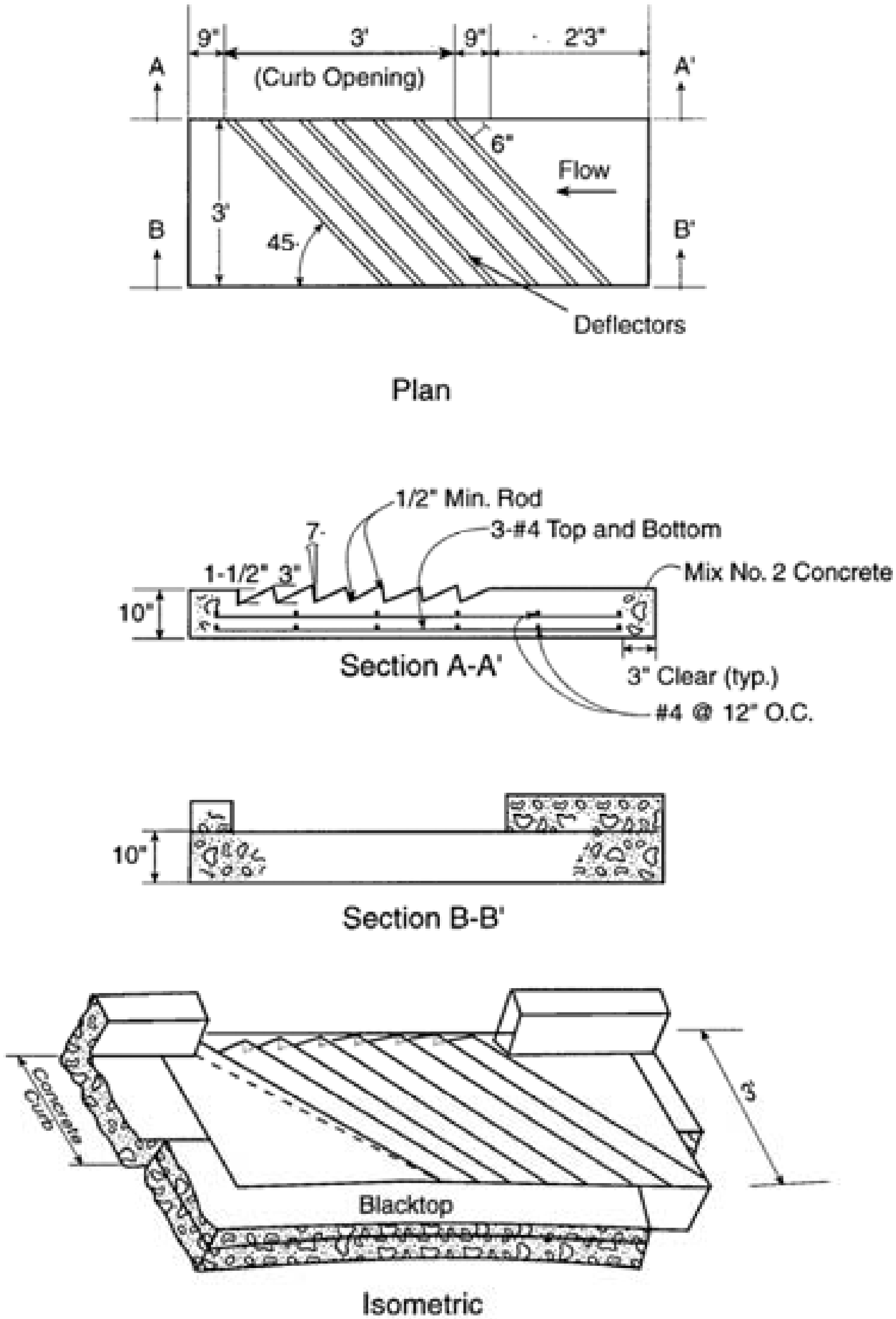
Underdrain

The underdrain system can have many different configurations and typically includes a gravel layer surrounding a horizontal, perforated discharge pipe, 4 to 6 inches in diameter. Filter fabric is often used to protect the underdrain from blockage.

Planting Medium

A homogenous soil mix of 85-88 percent construction sand; 8 to 12 percent fines (silt and clay) and 3 to 5 percent organic matter should be used. Higher (12 percent) fines content should be reserved for areas with required TN removal. Soil amendments can be added according to the plant species selected. For phosphorus removal, the phosphorus content of the soil mix should be low. Soil media should be sent to NCDA labs to be analyzed. P-Index for these soil media should range between 15 and 40.

FIGURE 3.2-7
Plan and Section Views of Curb Diversion Structure (Prince George's County, 1993)



Plant Material

The use of plants in bioretention areas is intended to replicate a variety of native terrestrial ecosystems including forests, ornamental gardens, meadows, hedgerows, and wetlands, as well as wildlife habitats. A diverse plant community is preferred to avoid susceptibility to insects and disease. Variety also creates a microclimate that lessens urban environmental stresses, including heat and drying winds. The plants selected should be able to tolerate typical stormwater pollutant loads, variable often very dry soil moisture, and extended wet conditions. Plants suitable for North Carolina BMP sites are discussed in Section 2.9, **Vegetation for BMPs**.

Planting recommendations for bioretention facilities are as follows:

- Native plant species should be specified over non-native, invasive, or exotic species that require excessive care.
- Vegetation should be selected based on a specified zone of hydric tolerance.
- A selection of trees with an understory of shrubs and herbaceous materials can be provided. If a grass/sod bioretention area is desired, trees are not needed.
- The minimum diameter for trees to be planted is 1 inch.
- Woody vegetation should not be planted at inflow locations.
- Aesthetics and visual characteristics for all seasons should be a prime consideration, including a selection of evergreens to provide winter color.
- Species layout should generally be random and natural.
- Traffic and safety issues must be considered, so often dense plantings are not recommended.
- Existing and proposed utilities must be identified and considered.

Mulch Layer

The mulch layer plays an important role in the performance of the bioretention system by maintaining soil moisture, preventing surface sealing (which reduces permeability), preventing erosion, and providing a microenvironment suitable for soil biota (important for filtering nutrients and other pollutants) at the mulch/soil interface. It also serves as a pretreatment layer by trapping the finer sediments that remain suspended after the primary pretreatment.

Mulch should be:

- Standard landscaping coarse shredded hardwood mulch or chips (commercially available). Grass clippings, pine bark and pine straw are unsuitable for mulch.
- At least 6 months old (12 months is ideal).
- Uniformly placed about 3 inches deep
- Added 1-2 times per year and completely removed/replaced once every two years.

Water Quality Treatment

Bioretention facilities treat the site's "runoff from one inch of rainfall." Allowing for a ponding depth between 6 and 12 inches and using highly permeable planting soils, an underdrain creates a high-rate biofilter that can treat 80 to 90 percent of the total annual volume of runoff. The storage in the ponded depth should be compared to the first-flush volume to verify that the facility can hold that volume. If not, the area of the facility must be increased accordingly. This area can be reduced by no more than 10 percent to account for infiltration in the soil and evapotranspiration.

Runoff Volume Control

The runoff capture volume is the minimum volume of rainfall that must be retained and completely infiltrated onsite during every storm. Prince George's County (2000b) provides a methodology to estimate the area of a site that must be allocated to bioretention so as to retain this volume. The methodology is based on NCRS TR-55 procedures (SCS, 1986). The design storm is taken as the maximum between the 1-year, 24-hour storm and the minimum rainfall depth that produces any runoff in the site under predevelopment conditions, multiplied by a safety factor. This minimum rainfall depth is computed as

$$P_{\min} = 1.5 \times 0.2 \times \left(\frac{1000}{CN_{pre}} - 10 \right)$$

The safety factor of 1.5 accounts for the slower release under natural conditions.

The runoff volume that must be controlled is equal to the difference between the pre- and post-development runoff volumes. Prince George's County (2000b) presents charts to perform this computation. An implicit assumption is that the designer must lay out the site to maintain the same time of concentration for pre- and post-development conditions. The resulting volume is compared with the water quality requirement and the larger of the two is used for the facility.

Runoff Peak Attenuation

Bioretention can reduce the magnitude of post-development peaks provided that facilities are distributed throughout the site so that most of the impervious area drainage is intercepted. For peak attenuation from 1 to 2-yr, 24 hr storms, bioretention areas can be placed in series or used in conjunction with other BMPs. A single bioretention area can rarely be sized to mitigate peak flows to desired levels. Peak attenuation is also effectively achieved in combination with other integrated management practices such as rainwater capture, impervious area minimization, and resource conservation. Prince George's County (2000b) describes the methodology to determine the area of a site to be allocated to bioretention so that adequate peak attenuation can occur. The techniques are also based on the NCRS TR-55 methodology (SCS, 1986), specifically, a relationship between the ratio of facility volume to runoff volume and the ratio of pre-and post- development peaks. As with volume control, Prince George's County (2000b) has charts to perform this computation.

The facility volume is set as the larger between the peak attenuation volume and that required for runoff volume and water quality control. The volume thus computed must allow use of the facility. The size and location of the facility must not interfere with the functions intended for the site. When this is not the case, Prince George's County (2000b) presents a hybrid approach based on both retention and detention.

It should be noted that bioretention alone may not be able to attenuate runoff peak flows to meet state regulations.

3.2.7 Cost

Bioretention facilities in residential areas cost about $3 to $4 per square foot. Costs for non residential applications range between $8 and $40 per square foot. The additional cost is due to additional control structures, curbing, and storm drains. Where bioretention takes the place of required green space, the landscaping expenses that would be required in the absence of bioretention should be subtracted when determining the actual cost (Low Impact Development Center, 2003). Bioretention facilities may also address landscaping / green space requirements of some local governments (Wossink and Hunt, 2003).

3.2.8 Performance Enhancers

- Ensure that the appropriate planting soil (sand and topsoil mixture) is used during construction. The phosphorus content of the soil mixture should be low to promote phosphorus removal. (P-Index 20 to 40 optimal in P-sensitive waters)
- Spread inflow runoff to avoid erosion.
- Use native plants.
- Inspect the facility during the first 6 months of operation, especially during and after storm events. Continue visual inspections every 6 to 12 months to detect any performance decline.
- Perform routine trash removal and landscaping maintenance; for example, remove diseased and dead plants and periodically replace mulch layer once or twice per year.
- Make sure outlet is free of debris, particular after storms that occur soon after mulch application.

3.2.9 Construction Guidelines

General

A dense and vigorous vegetative cover must be established over the contributing drainage area before runoff can be accepted into the facility. The heavy sediment load from a bare earth construction site could render a bioretention BMP ineffective. Direct maintenance access must be provided. Constructing a gravel verge immediately upslope of a sodded perimeter around the bioretention area is recommended.

Material Specifications

Materials recommended for use in bioretention areas are detailed in Table 3.2-1.

TABLE 3.2-1
Material Specifications

Material	Specification	Size	Notes
Plantings	Native vegetation	1” minimum tree diameter	Plantings are site-specific
Planting soil (2’ to 4’ deep, 1.5’ minimum)	sand – 85-88 percent clay – less than 5 percent compost – 3-5%	n/a	Low P-Index Soils (20 to 40 optimal) needed in phosphorus sensitive woodsheds Organic Matter recommended
Mulch	Coarse shredded hardwood		Aged 6 months, minimum replaced 1-2 fines annually
Geotextile	Class “C” – apparent opening size (ASTM-D-4751), grab tensile strength (ASTM-D-4632), puncture resistance (ASTM-D-4833)	n/a	For use as necessary beneath underdrains only
Underdrain gravel	Washed 57. A 2” layer of stone such as #8, 57, 78 or 89 is recommended.	0.25” to 0.75”	
Underdrain piping	F 758, Type PS 28 or AASHTO M-278	Should convey 10 times maximum flow from soil medium. Minimum of 4” to 6” rigid schedule 40 PVC or SDR35 or smooth wall corrugated plastic pipe. Minimum of two pipes for redundancy.	3/8” perf. @ 6” on center, 4 holes per row; minimum of 3” of gravel over pipes; not necessary underneath pipes

Adapted from 2000 Maryland Stormwater Design Manual

Compaction

It is very important to minimize compaction of both the base of the bioretention area and the required backfill. When possible, use excavation hoes to remove original soil. If bioretention areas are excavated using a loader, the contractor should use wide-track or marsh-track equipment, or light equipment with turf-type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires causes excessive compaction resulting in unacceptably reduced infiltration rates. Compaction significantly contributes to design failure. This is particularly important if no underdrain is installed.

Compaction can be alleviated at the base of the bioretention facility by using a primary tilling operation, such as a chisel plow, ripper, or subsoiler. These tilling operations are used to refracture the soil profile through the 12-inch compaction zone. Substitute methods must be approved by the engineer. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment. This is particularly important if no underdrain is installed.

Two to three inches of sand should be rototilled into the base of the bioretention facility before backfilling. Any ponded water should be pumped before rototilling the base.

When backfilling the bioretention facility, soil should be placed in lifts 12 to 18 inches deep. Heavy equipment should not be placed within the bioretention basin. Heavy equipment can be used around the perimeter of the basin to supply soils and sand. Without some compaction, differential settling may occur. Bioretention materials should be graded with light equipment such as a compact loader or a dozer/loader with marsh tracks. In addition, presoaking of the facility should be used to help settle the material.

Plant Installation

Root stock of the plant material must be kept moist during transport and onsite storage. The plant root ball should be planted so that one-fourth of the ball is above final grade. The diameter of the planting pit must be at least 6 inches larger than the diameter of the planting ball. The plant should be set and kept straight during the entire planting process. The ground bed cover should be thoroughly watered after installation.

Trees must be braced using 2-by 2 -inch stakes only as necessary and for the first growing season only. Stakes must be equally spaced on the outside of the root ball.

Grasses and legume seed should be drilled into the soil to a depth of at least 1-inch. Grass and legume plugs must be planted following the non-grass ground cover planting specifications.

Underdrains

Underdrains must be placed on a 3-foot-wide section of filter cloth, followed by the gravel bedding. The ends of underdrain pipes that do not terminate in an observation well must be capped. The observation well should be capped, too.-

The main collector pipe for underdrain systems must be constructed at a minimum slope of 0.5 percent. Observation wells and/or clean-out pipes must be provided (one minimum per every 1,000 square feet of surface area). The underdrain pipes should be designed to carry 10 times the maximum flow exfiltrating from the bioretention medium. This maximum flow is computed from Darcy's law and assuming maximum ponding and complete saturation along the depth of the medium. Manning's formula is then used to size the pipe. At least two pipes should be installed to allow for redundancy (Hunt and White, 2001).

3.2.10 Monitoring

Monthly inspections are recommended until the plants are established. Annual or semiannual inspections should then be adequate, and can be a part of routine monthly maintenance, such as trash removal.

3.2.11 Maintenance

An example maintenance schedule is presented in Table 3.2-2. Bioretention areas may be considered relatively maintenance-intensive but when incorporated into a site design, are generally no more maintenance-intensive than the landscape areas they replace.

TABLE 3.2-2
Example Maintenance Schedule for Bioretention Areas

Description	Method	Frequency	Time of Year
		Soil	
Inspect and repair erosion; clean up trash; flush underdrain pipes	Visual	Monthly	Monthly
		Organic Layer	
Remulch any void areas	By hand	Whenever needed	Whenever needed
Remove previous mulch layer before applying new layer (optional)	By hand	Once every 2 times mulch is added	Spring
Add any additional mulch if necessary	By hand	Twice a year	Spring/Fall
		Plants	
Remove and replace all dead and diseased vegetation considered beyond treatment	Mechanical or by hand	Twice a year	March /15 to April 30 and October 1 to November 30
Treat all diseased trees and shrubs	Mechanical or by hand	N/A	Varies, but will depend on insect or disease infestation
Water plant material at the end of each day for 14 consecutive days and after planting has been completed	By hand	Once a year	Remove stakes only in the spring
Replace support stakes	By hand	Once a year	Whenever needed
Replace any deficient stakes or wires	By hand	Whenever needed	Whenever needed
Remove mulch from outlets and cleanouts	By hand	Monthly or as needed	Monthly

Underdrains

Collector pipe systems can become clogged. Therefore, pipe cleanouts are recommended to facilitate unclogging of the pipes without disturbing the bioretention areas.

Soil Media

When the filtering capacity diminishes substantially (e.g., when water ponds on the surface for more than 24 hours), the top few inches of material must be removed and replaced with fresh material. The removed sediments should be disposed of in an acceptable manner (e.g., landfill).

Plants

Dead or diseased plant material must be replaced. Areas devoid of mulch should be re-mulched on an annual basis.

3.2.12 References and Additional Resources

3.2.13 References

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