Bioretention Areas

Description

Bioretention areas are designed to mimic natural forest ecosystems with a combination of soil filtration and plant uptake by utilizing a planting soil layer, mulch, plantings, and an underdrain system. Bioretention areas appear as landscaped or natural areas giving this BMP an appealing image. Storm water runoff enters the Bioretention area and is temporarily stored in a shallow pond on top of the mulch layer. The ponded water then slowly filters down through the planting soil mix and is absorbed by the plantings. As the excess water filters through the system it is temporarily stored and collected by an underdrain system that eventually discharges to a designed storm conveyance system.

When and Where to Use It

Bioretention areas are applicable for small sites where storm water runoff rates are low and typically are received into the Bioretention area as sheet flow. Bioretention drainage areas range from 1-2 acres and are well stabilized to prevent excessive debris and sediment from collecting in the Bioretention area. Because Bioretention areas are sensitive to fine sediments, they are not be placed on sites where the contributing area is not completely stabilized or is periodically being disturbed. Applicable sites include:

- Parking lots,
- Individual residential home sites, and
- Small commercial facilities.

Design Criteria

Bioretention areas work best when constructed off-line, capturing only the water quality volume. Divert excess runoff away from Bioretention areas or collect it with an overflow catch basin. Design Bioretention areas to fit around natural topography and complement the surrounding landscape. Design Bioretention areas with any reasonable shape that fits around sensitive areas, natural vegetation, roads, driveways, and parking lots. The minimum width of Bioretention areas is 10 feet in order to establish a strong healthy stand of vegetation.

Surface Area

The Bioretention surface area may be calculated by the following equation from research by the North Carolina Extension Service, 1999:

$$\mathrm{BSA} = \frac{(\mathrm{DA})(Rv)}{D_{avg}}$$

Where:

BSA	=	Bioretention surface area (feet^2)
DA	=	Contributing drainage area of Bioretention area (feet^2)
R_v	=	Runoff volume (feet)
		0.083-feet (1-inch) for SCDHEC
D_{avg}	=	Average ponding water depth above ground (feet)

The Bioretention surface area may also be calculated by the following equation from research by Prince George's County, MD:

$$\text{BSA} = 0.1(Rv)(DA)$$

Where:

BSA	=	Bioretention surface area (feet^2)
0.1	=	Empirical conversion factor
R_v	=	Runoff volume (inches) 1-inch for SCDHEC
DA	=	Contributing drainage area of Bioretention area (feet^2)

Pre-treatment

Pre-treatment of storm water runoff is required to reduce the incoming velocities, evenly spread the flow over the entire Bioretention area, and provide for removal of coarse sediments. The pre-treatment may consist of the following:

- Gravel, landscape stone, or geotextile level spreader located along the upstream edge of the Bioretention area.
- Gently sloping vegetated filter areas along the upstream edge of the Bioretention area.
- Vegetated swale along the upstream edge of the Bioretention area.

The level spreader option is the most desirable because level spreaders successfully reduce incoming energy from the runoff and convert concentrated flow to sheet flow that is evenly distributed across the entire Bioretention area.

Planting Mix

Install the planting mix of the Bioretention area at level grade (0%) to allow uniform ponding over the entire area. The maximum ponding depth should be set at 6-inches to 12-inches to allow the cell to drain within a reasonable time and to prevent long periods of submerging the plantings. The planting mix provides a medium for physical filtration for the storm water runoff plus a source of water and nutrients for plant life. Select a soil mixture with a minimum hydraulic conductivity or permeability of 0.5 in/hour. The planting mix has a significant amount of organic content to support plant life. The average porosity of the planting mix is 0.45.

The planting mix is approximately 60-75 percent sand, 25 percent silt or topsoil, and 10 percent organic or leaf compost. The maximum clay content is less than 5 percent. The minimum depth of the planting mix is based on the following:

- 1.5-foot Bioretention areas utilizing grass as the only vegetative media,
- 3.0-feet for Bioretention areas that utilize shrubs, and
- 4.0-feet for Bioretention areas that utilize trees.

Mulch Layer

The mulch layer provides an environment for plant growth by reducing erosion of the filter bed, maintaining soil moisture, trapping fine sediments, and promoting the decomposition of organic matter. The mulch layer plays an important role in pollutant removal. Liberally apply shredded hardwood mulch 2- to 3-inches deep. Shredded hardwood mulch is the mulch of choice because it resists floatation better than other landscape covers. Pine needles are also applicable for certain situations. Avoid pine bark mulch due to its ability to float.

Water Draw Down Time

The under drain system is designed using the draw down time. The general equation used to determine draw down time is Darcy's Equation:

$$Q = 2.3e^{-5}\ K\ A\,\frac{\Delta H}{\Delta L}$$

Where:

Q	=	Flow rate through Bioretention (cfs)
K	=	Hydraulic conductivity of the planting mix (in/hr) This value will vary based on the actual planting mix used
A	=	Surface area of Bioretention ($feet^2$)
ΔH	=	Maximum ponding depth above bottom of soil mix (feet)
ΔL	=	Depth of soil mix (feet)

General Hydraulic Conductivity of Soils

Determining the total draw down time is a three-step process.

1. Determine the time it takes to drain the ponded water.
- Utilize Darcy's Equation to calculate the flow rate (cfs).
- Calculate the total ponded water volume ($feet^3$) by multiplying the Bioretention area ($feet^2$) by the ponded water depth (feet).
- Divide the total ponded water volume ($feet^3$) by the flow rate (cfs) to calculate the time to drain the ponded water (seconds)

2. Determine the time it takes to drain the saturated planting mix.
- Calculate the total volume of water contained in the planting mix ($feet^3$) by multiplying the Bioretention area ($feet^2$) by the planting mix depth (feet) by the porosity (dimensionless) of the planting mix.
- Divide the planting mix water volume ($feet^3$) by the flow rate from Darcy's Equation (cfs) to calculate the time to drain the ponded water (seconds).

3. Add up the time to drain the ponded water with the time that it takes to drain the planting mix to calculate the total Bioretention area draw down time.

Under Drain System

Many of the native soils found in South Carolina do not allow for adequate infiltration. Therefore, all Bioretention cells require an under drain system placed beneath the planting mix.

The under drain system consists of a minimum 4-inch diameter perforated PVC pipe (AASHTO M 252), an 8-inch minimum gravel jacket filter layer, and non-woven geotextiles to separate the piping from the native soils and the gravel from the planting mixture. Design the under drain system to safely pass the peak draw down rate calculated.

Select perforated, continuous closed-joint conduits of corrugated plastic pipe, placed on top of an underlying geotextile fabric. The longitudinal slope of the drain pipe is a minimum of 0.5 percent. The

Select perforated, continuous closed-joint conduits of corrugated plastic pipe, placed on top of an underlying geotextile fabric. The longitudinal slope of the drain pipe is a minimum of 0.5 percent. The perforated drain pipe may be connected to a structural storm water conveyance system or receiving natural water system.

Place filter gravel around the drainage pipe at a minimum depth of 8-inches. Place a geotextile between the boundary of the gravel and the planting mix to prohibit the planting mix from filtering down to the perforated drain pipe.

Several non-perforated PVC pipes should vertically connect to the under drain pipe and extend to the surface of the planting mix to provide access to clean out the perforated drainage pipe.

Overflow System

Design an overflow system to pass runoff volumes greater than the water quality volume away from the Bioretention area. If the Bioretention area collects sheet flow from a parking area, design a catch basin at the elevation of the maximum 6-inch to 12-inch ponding depth of the Bioretention area to carry the excess runoff from the Bioretention area to the storm sewer system or receiving natural water system.

Planting Plan

A Bioretention landscape plan includes all vegetation types, total number of each species, and the location of each species. A description of the contractor's responsibilities including a planting schedule, installation specifications, initial maintenance, a warranty period, and expectations of plant survival. Include long-term inspection and maintenance guidelines in the planting plan. Have a qualified landscape architect, botanist or qualified extension agent prepare the planting plan.

Inspection and Maintenance

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

The surface of the ponding area may become clogged with fine sediments over time. Core aeration or cultivating unvegetated areas may be required to ensure adequate filtration. Other required maintenance includes but is not limited to:

- Conduct pruning and weeding to maintain appearance as needed.
- Replace or replenish mulch as needed.
- Remove trash and debris as needed.

Average Pollutant Removal Capability

Total Suspended Solids:	50%-85%	Metals	NA
Total Phosphorus:	55%-70%	Lead:	50%-90%
Pathogens/Bacteria:	10%-60%	Copper:	35%-70%
Total Nitrogen:	35%-55%	Zinc:	35%-90%

Summary of Maintenance Requirements

Required Maintenance	Frequency
Pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Semi-annual (every 6-months)
Repair eroded areas. Re-seed or sod as necessary.	Semi-annual (every 6-months)
Mulch void areas.	Semi-annual (every 6-months)
Inspect trees and shrubs to evaluate their health.	Semi-annual (every 6-months)
Remove and replace dead or severely diseased vegetation.	Semi-annual (every 6-months)
Removal of evasive vegetation.	Semi-annual (every 6-months)
Nutrient and pesticide management.	Annual, or as needed
Water vegetation, shrubs, and trees.	Semi-annual (every 6-months)
Remove mulch, reapply new layer.	Annual
Test planting mix for pH.	Annual
Apply lime if pH < 5.2.	As needed
Add iron sulfate + sulfur if pH > 8.0.	As needed
Place fresh mulch over entire area.	As needed
Replace pea gravel diaphragm.	Every 2 to 3 years if needed