

APPENDIX K

Anderson County Standard Specifications and Details

Erosion and Sediment Control (ES) BMPs

and

Post-Construction Water Quality (WQ) BMPs

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ES-01: Surface Outlet and Baffle Sediment Basin

1.0 Surface Outlet and Baffle Sediment Basin

This Specification contains requirements for the design and construction for Temporary *Surface Outlet and Baffle Sediment Basins* and permanent Multipurpose *Surface Outlet and Baffle Sediment Basins*.

1.1 Description

Provide a Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* to remove sediment from construction site runoff at locations shown on the Plans. A Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* is a Basin where sediment-laden runoff is temporarily detained, allowing sediment to settle out before the runoff is discharged. The purpose of a Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* is to collect and store sediment from disturbed areas cleared or graded during construction. To maximize effectiveness, locate Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* at the lowest points or near the edge of a watershed catchment.

A Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* includes Baffles across the width of the Basin to spread flow across the entire width of the Basin reducing the potential for turbid flow and short circuiting. These Baffles may consist of Porous Baffle materials or Class A or B riprap.

Traditional temporary Sediment Basin designs typically used a perforated riser or staged riser with a low flow orifice for dewatering. This Specification utilizes dewatering from the water surface where the density of total suspended solids is at a minimum in the water column. A **Temporary Surface Outlet and Baffle Sediment Basin** implements three spillway devices:

1. A Primary Riser Spillway consisting of a solid circular concrete monolithic base or extended base riser with no staged discharges or low flow orifices connected to an Outflow Barrel. Stormwater enters the Primary Riser spillway by overtopping the structure and through a Floating Skimmer.
2. A Floating Skimmer attached to the bottom of the Primary Riser dewatering the runoff volume below the top elevation of the Primary Riser. The Floating Skimmer dewateres the volume below the Primary Riser in a time period ranging between 24 to 72 hours.
3. A stabilized Emergency Spillway that safely passes the 100-year 24-hr storm event with a minimum 0.5-foot of freeboard from the 100-year 24-hour water surface elevation to the top of the dam.

1.2 Site Assessment

Select Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* locations during a site evaluation, or by reviewing a detailed topographic map. Note natural watershed catchments and select Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* locations so runoff from land disturbing activities can easily be diverted into the *Surface Outlet and Baffle Sediment Basin*. Install Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* before land disturbance activities begin.

Consider construction phasing when selecting locations for Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin*. Select a location that allows the Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* to remain in service as long as possible before final stabilization is achieved. Select locations that are accessible for periodic sediment removal and other necessary maintenance. Identify locations for sediment disposal as part of the Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basin* site selection. Identify sediment disposal locations on the Plans or as directed by the Engineer.

1.3 Design Requirements

Design **Temporary** *Surface Outlet and Baffle Sediment Basins* that do **not** require peak flow reduction to pre-development conditions with **no** perforations in the Primary Riser structure.

Design permanent **Multipurpose** *Surface Outlet and Baffle Sediment Basins* utilizing peak flow reduction to keep the 2-year and 10-year 24-hour storm during and post construction peak flow rates from the Basin less than or equal to the pre-disturbance peak flow rates with orifices and weirs incorporated into the Primary Riser structure. Design **Multipurpose** *Surface Outlet and Baffle Sediment Basins* with a Forebay. Ensure that all **Multipurpose** *Surface Outlet and Baffle Sediment Basins* are designed in accordance with the WQ-01 Dry Detention Specification and WQ-02Wet Detention Specification where applicable.

1.3.1 General Design Requirements

Use Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basins* on sites where 10 or more acres are disturbed and drain to a single point. Do not install Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basins* in Waters of State designated by a solid or dashed blue line on USGS 7.5 minute quadrangle maps). Utilize Temporary *Surface Outlet and Baffle Sediment Basins* until the contributing flow areas to the basin have undergone final stabilization.

The design requirements outlined in this Specification must ensure a minimum of 80% trapping efficiency of total suspended solids (TSS).

Ensure Temporary or Multipurpose *Surface Outlet and Baffle Sediment Basins* adhere to the following requirements:

- Drainage Area: 150 acre maximum.
- Drainage Area: 10 acres or more draining to one location **requires** a Surface Outlet and Baffle Sediment Basin.
- Minimum 80 percent design removal efficiency for TSS.
- Sediment storage volume accounted for in the overall design volume of the sediment basin.
- Do not incorporate side slopes steeper than 3H:1V where applicable.
- Optimum Basin length to width ratio is 2L:1W.
- The Temporary Basin bottom slope is 0.5%.
- The final Basin bottom slope for permanent Multipurpose Basins is 2%.
- Floating Skimmer with minimum dewatering time of 24 hours and maximum dewatering time of 72 hours.
- Anti-vortex device / trash rack required for Primary Riser.
- Minimum of 3 Baffles installed in the Basin.
- At least one row of Baffles placed between the Primary Riser structure and all pipes or channels discharging to the Basin.
- Minimum embankment width at the top of the dam is 8 feet.
- Antiseep collars required on all penetrations through the dam.
- Perform temporary stabilization by seeding and install Temporary Erosion Control Blankets on exposed basin side slopes.

1.3.2 Safety

Follow the safety design criteria such as those outlined by the USDA Soil Conservation Service (previously the Natural Resources Conservation Service), U.S. Army Corps of Engineers, and the Dam Safety.

Incorporate all possible safety precautions such as signs and fencing for permanent Multipurpose Basins that are readily accessible to populated areas. Ensure the inside pond slopes are no steeper than 3H:1V where applicable.

1.3.3 Anderson County **Temporary** Surface Outlet and Baffle Sediment Basin Design

Design **Temporary Surface Outlet and Baffle Sediment Basin** using one of two strategies.

1. Use the Design Aids of this Specification for drainage areas ranging from 5 acres to 25 acres.
2. In accordance to the requirements in standards for Stormwater Management and Sediment Reduction Act 72-300 using South Carolina Design Aids, Sedimot, SEDCAD4, Pond Pack, SEDPRO and other computer models that utilize eroded particle size distributions and calculates a corresponding 80% trapping efficiency for TSS.

For true **Temporary Surface Outlet and Baffle Sediment Basins**:

1. Utilize a temporary sediment basin riser configuration.
2. Design a Primary Riser consisting of a solid circular concrete monolithic base or extended base riser with no staged discharges or low flow orifices.
3. Design the basin so stormwater runoff enters the Primary Riser by overtopping the riser structure and through a Floating Skimmer.
4. Design the riser to have a Floating Skimmer attached to the bottom of the riser dewatering the runoff volume below the top elevation of the riser in a time period ranging between 24 to 72 hours.
5. Provide calculations or Design Aids showing that this basin will meet a minimum 80% TSS trapping efficiency.
6. Provide a minimum of 3 rows of Baffles in the basin. Place a minimum of one row of Baffles between the riser structure and all pipes or channels discharging to the Basin. Designers may use 0% dead space when using Baffles.
7. Design a stabilized Emergency Spillway that safely passes the 100-year 24-hr storm event with a minimum 0.5-foot freeboard from the 100-year 24-hour water surface elevation to the top of the dam.

1.3.3.1 **Temporary** Sediment Basin Design Aid Instructions

Use the Anderson County Design Aids (Chart 1 and Graph 1) for **Temporary Surface Outlet and Baffle Sediment Basin** to determine the basin size, runoff storage volume, sediment storage volume, Primary Riser spillway and Outlet Barrel configuration.

1. Determine the required Basin volume by using one of 3 strategies:
 - a. Use Chart 1 to determine the Basin bottom Length and Width based on the Basin drainage area classification (5, 10, 15, 20, and 25 acres). Area classifications shown in Chart 1 used to select the basin bottom Length and Width must be greater than the actual construction site Basin drainage area.
 - b. Use Graph 1 to determine the total required Basin Volume below the top elevation of the Primary Riser.
 - c. Calculate the total Basin volume at the top elevation of the Primary Riser by:
 - i. 2,400 cubic feet per disturbed acre of runoff volume and 415 cubic feet per disturbed acre sediment storage.
2. The Basin volumes calculated using Method 1.b, or 1.c represent the Basin volume between the Basin bottom and the Primary Riser top elevation. Basin stage area calculations must be calculated when using Method 1.b, or 1.c.

3. Use Chart 1 to select Basin requirements (Primary Riser Diameter, Outlet Barrel Diameter, Emergency Spillway Bottom Width and Riser Concrete Foundation) corresponding to one of the 4 drainage area classifications (5, 10, 15, 20, and 25 acres). Area classifications shown in Chart 1 used to select the Basin requirements must be greater than the actual construction site Basin drainage area.
4. Freeboard as shown in Chart 1 is the Vertical distance between the top elevation of the Primary Riser and the top elevation of the Basin Dam.
5. The following **Temporary Surface Outlet and Baffle Sediment Basin** design features are constant for all drainage area classifications less than or equal to 25-acres when using the Design Aids:
 - a. Total Basin Depth: seven (7) feet
 - b. Primary Riser Top Elevation: four (4) feet above the Basin bottom
 - c. Freeboard Height: three (3) feet
 - d. Emergency Spillway Depth: 1.5 feet
 - e. Pipe Barrel Slope: 1.5% when feasible.
 - f. A Recessed Riser configuration is required for 60-inch and 72-inch Riser diameters. The riser bottom and outlet barrel pipe invert elevation is located below the basin bottom elevation.

1.3.3.2 Temporary Riser and Spillway Design

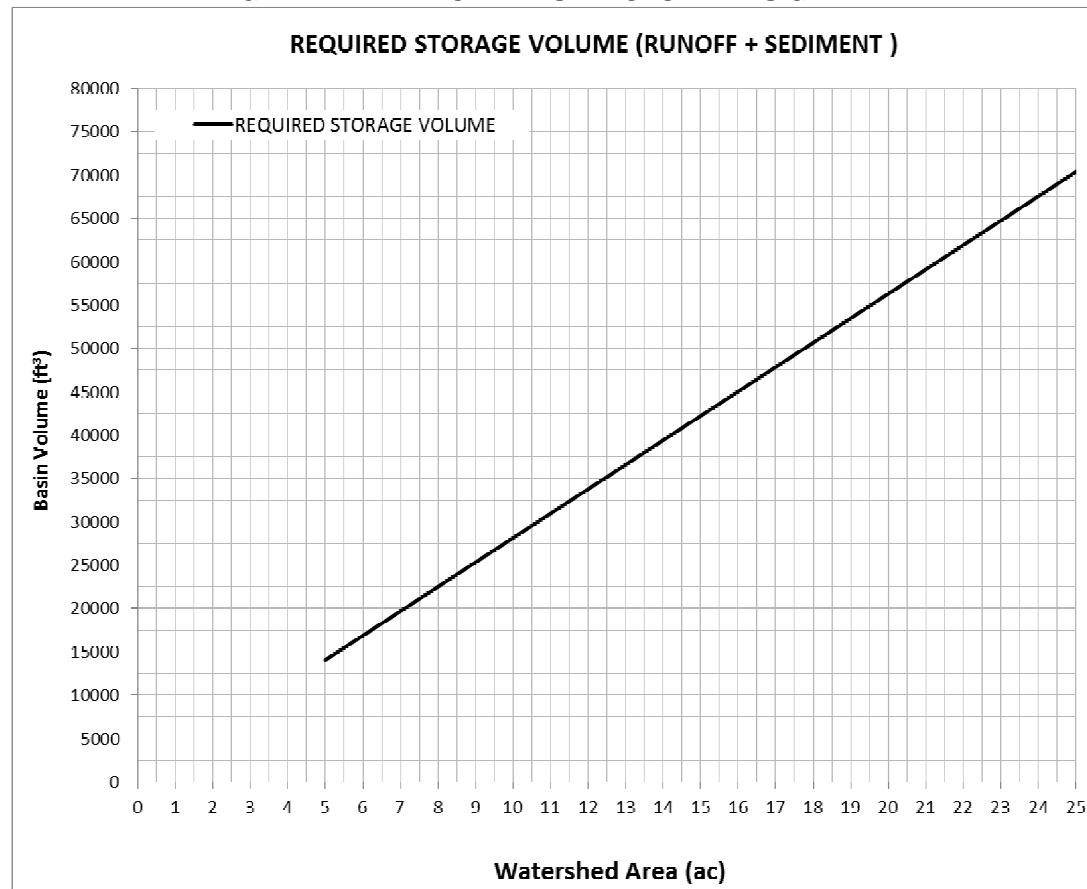
1. The Primary Riser consists of a solid circular concrete monolithic base or extended base riser with no low flow orifice or staged orifice/weir discharges. Runoff only enters the Primary Riser structure by overtopping and through the Floating Skimmer.
2. Design the 10-year 24-hour storm event peak stage in the Basin at an elevation of approximately 6 inches above the top elevation of the Primary Riser.
3. Design the Primary Riser and Outlet Barrel to operate in weir flow control and transition to pipe/barrel flow control. Orifice flow of the Primary Riser structure is not allowed for the 10-year 24-hour storm event.
4. Minimum 1.5-foot elevation difference from the top of riser to the crest of the emergency spillway.
5. Design the Emergency Spillway to safely pass the peak runoff from the 100-year 24-hour storm event storm with a minimum 0.5-foot of freeboard between the 100-year peak water surface elevation and the top of the Emergency Spillway. Design the Emergency Spillway as a run-around conveyance that is constructed on existing ground and not over the Basin Dam/Embankment when practicable.
6. Show all Basin dimensions and slopes on the Plans.

CHART 1: TEMPORARY SURFACE OUTLET AND BAFFLE SEDIMENT BASIN DESIGN AID

MAX AREA DRAINING TO BASIN	RUNOFF STORAGE VOLUME	SEDIMENT STORAGE VOLUME	SEDIMENT BASIN TOP OF DAM (LENGTH X WIDTH)		SEDIMENT CONTROL STRUCTURE SIZE (RISER DIA)	BARREL DIAMETER	RECESSED RISER	TOP OF RISER TO BASIN BOTTOM HEIGHT	FREEBOARD HEIGHT	EMERGENCY SPILLWAY DEPTH	EMERGENCY SPILLWAY BOTTOM WIDTH	48-HR SKIMMER DEWATERING RATES
5	2400FT ³ /AC	415FT ³ /AC	130' x 65'	88' x 23'	48"	24"	NO	4' - 0"	3' - 0"	1' - 6"	10'	35 GPM
10			164' x 82'	122' x 40'	48"	30"	NO				18'	75 GPM
15			192' x 96'	150' x 54'	60"	36"	YES				22'	110 GPM
20			214' x 107'	172' x 65'	72"	42"	YES				22'	145 GPM
25			234' x 117'	192' x 75'	72"	42"	YES				28'	183 GPM

*Basin Side Slopes are 3H:1V

GRAPH 1: TEMPORARY BASIN VOLUME DESIGN AID



1.3.5 **Permanent Multipurpose** Surface Outlet and Baffle Sediment Basin Design

The Primary Riser spillway configuration for permanent Multipurpose Basins used for both during construction sediment control and post construction water quality and quantity control for peak flow rate reduction contains orifices/weirs in the Primary Riser Structure.

1. Design and utilize one Permanent Riser and outlet barrel configuration for both phases of the project that is based on post-construction water quality and quantity control.
 - a. This ensures that there is no damage or introduction of a point of structural weakness to the primary riser, outflow barrel and permanent dam structure as a result of installing a temporary riser, removing it, and then installing a permanent riser. Maintaining the structural integrity of the outflow barrel and permanent dam structure is of the highest importance.
 - b. This ensures that a small temporary riser is not installed to maintain peak flow rates by forcing a large head on top of the riser that could jeopardize the stability of the riser, barrel, and permanent dam.
2. Design the Primary Riser to have a Floating Skimmer attached to the bottom of the riser (typically the post construction water quality low flow orifice) during the construction phase of the project to dewater in a time period ranging between 24 to 72 hours.
 - a. The Floating Skimmer provides withdrawal from the water surface for the majority of storm events during the construction phase of the project.
3. Design the Primary Riser with orifices/weirs to provide peak flow rate control.
4. Design the Primary Riser to have a trash rack and anti-vortex device.
5. Provide a minimum of 3 rows of Baffles during construction. Install at least one row of Baffles between the riser structure and all pipes or channels discharging to the Basin. Designers may use 0% dead space when using Baffles.
6. Provide calculations or design aids showing that the basin will meet a minimum 80% trapping efficiency.
7. Provide calculations showing that the basin is designed to meet pre-construction peak flow rates for the 2-year and 10-year 24-hour storm events.
8. Design a stabilized Emergency Spillway that safely passes the 100-year 24-hr storm event with a minimum freeboard of 0.5 feet between the 100-year 24-hour water surface elevations to the top of the dam.
9. Post construction staged orifices, low flow orifices, or staged weirs are installed in the Primary Riser structure prior to the construction phase.
10. Provide a Forebay for all inlets to the Multipurpose Basins and place Forebays upstream of the main basin area. A Forebay is not required for an outlet that contributes less than 10% of the total drainage area to the basin.

The Forebay is separated from the larger basin area by berms, barriers, or baffles that may be constructed of earth, stones, riprap, gabions, or geotextiles. The berm, barrier, or baffles act as a trap for coarse sediments and minimize their movement into the main basin.

Design the Forebay in a manner that it is accessible for easy cleanout because it will eventually fill in with coarse particles. Design the access to the Forebay with a maximum slope of 15-20 percent extending from the top of the embankment to the toe.

1.4 Construction

Construct the *Surface Outlet and Baffle Sediment Basin* in accordance with these Specifications, Standard Drawings, as indicated on the Plans, or as directed by the Engineer.

1.4.1 Equipment

Ensure that the equipment necessary for the proper installation of the *Surface Outlet and Baffle Sediment Basin* is on site, in acceptable working condition, and approved by the Engineer regarding both type and condition before the start of work under this section. Provide sufficient equipment to execute the work in accordance with the project schedule.

1.4.2 Installation Requirements

Installation includes constructing the sediment basin, installing the Primary Riser Structure, installing the Riser Outlet Barrel, installing Baffles, furnishing, installation and cleanout of Floating Skimmers, providing and placing Riprap pad on bottom of Basin underneath the Floating Skimmer, providing and placing an Emergency Spillway and liner, disposing of excess materials, removing Baffles, Emergency Spillway liner and Floating Skimmer, backfilling basin area with suitable material and providing proper drainage when basin area is abandoned

1.4.3 Site Work

Locate and construct the *Surface Outlet and Baffle Sediment Basin* before performing other earthwork on-site. Clear and grub the entire area of the Basin and Emergency Spillway in accordance with the Plans. Turn the entire area to a depth of 6 inches with a disk harrow and compact it to 95.0% compaction. Fill all holes in the foundation area of the dam with suitable material and compact to 95.0% compaction.

1.4.4 Temporary and Permanent Sediment Control Basins

Locate and construct the *Surface Outlet and Baffle Sediment Basin* as shown in the Plans. Construct the bottom of the Basin on a 0.5% slope. If the inflow into the Basin is from a pipe or from a ditch with a flow line higher than the bottom of the basin, place Riprap at the end of the pipe or ditch down to the bottom elevation of the Basin to prevent erosion.

Perform Temporary Stabilization by seeding and protect the temporary seeded area with a Temporary ECB on all areas of the Basin, except for the bottom of the Basin. .

When grading operations are complete and the permanent grassing or stabilization is in place, restore the area occupied by the temporary *Surface Outlet and Baffle Sediment Basin* as nearly as practicable to the original ground line and seed the area.

1.4.5 Earth Dam

Construct the earth dam to the dimensions shown on the Plans. The maximum Basin inside slopes is 2H:1V., and the maximum Basin outside slopes is 3H:1V Typical dam height to top width dimensions are provided in the following table.

Dam Height (Ft)	Minimum Top Width (Ft)
<10	8
11-14	9
15-19	10

For permanent Multipurpose Basins construct a key and core on all embankment areas. Construct the key and core with clay or other impervious materials. Construct the dam core to the dimensions shown on the Plans and to an elevation level with the flowline of the Emergency Spillway. Construct the core with a top

width of 8 feet and 1:1 side slopes. Place fill adjacent to pipes or other structures in 4-inch layers and compact by hand or by manually directed tampers or plate vibrators. Place the fill over pipes to a minimum of 2 feet before using heavy equipment. Do not place fill around concrete structures until the concrete has cured sufficiently to support the load. As soon as final grades are reached, seed all areas.

1.4.6 Aggregate Diaphragm or Anti Seep Collars

Construct an aggregate diaphragm or anti seep collars parallel to the dam, around the outlet pipe immediately at the outlet side of the cutoff trench. Construct the aggregate diaphragm to a depth of 2 feet extending three times the pipe diameter vertically and horizontally, and a minimum of 18 inches beneath the pipe. Use FA-10 fine aggregate. Place a minimum of 2 feet of fill material over the diaphragm.

1.4.7 Aggregate Drain

Construct an aggregate drain for the diaphragm, 1.5 times the diameter of the pipe or a minimum of 1 foot around the pipe, to the down stream edge of the dam. Use FA-10 fine aggregate for the aggregate drain. Install a Riprap pad over a fabric filter where the drain and the outlet pipe exit the fill. Extend the Riprap pad at least 2 feet outside the aggregate drain in all directions.

1.4.8 Emergency Spillway

Construct an Emergency Spillway on original ground at the grades and locations shown on the Plans. Construct a spillway outfall channel to the main outfall channel as shown on the Plans. Protect the Spillway by:

1. Seeding the sides and bottom of the Emergency Spillway and spillway outfall channel and protecting the Spillway with an appropriate TRM as directed by the Engineer unless otherwise specified on the Plans.
2. Lining the sides and bottom of the Emergency Spillway and spillway outfall channel with a non-woven geotextile fabric and protecting the Spillway with Class B Riprap, as directed by the Engineer, or as shown on the Plans.

1.4.9 Primary Riser Spillway and Outlet Barrel

Temporary *Surface Outlet and Baffle Sediment Basin* Primary Riser Spillways consists of a solid circular concrete monolithic base or extended base riser with no staged orifices.

Multipurpose *Surface Outlet and Baffle Sediment Basin* Primary Riser Spillways consist of a riser with staged orifices/weirs.

For **Temporary** *Surface Outlet and Baffle Sediment Basin*, install the top of the Primary Riser at a minimum elevation 4.0 feet above the Basin bottom.

Install the Primary Riser Spillway after final grading and excavating the Basin footprint is complete. Use the following instructions when installing the Primary Riser Spillway:

1. Remove all loose soil and debris in the area where the riser is installed.
2. Excavate, prepare, and compact the location of the riser with dimensions two (2) feet greater than the riser bottom diameter.
3. Place the concrete Primary Riser and level the structure with the appropriate equipment.
4. Join all Outlet Barrel Pipe sections to the Riser so that the connections are water tight.
5. Fill the riser bottom to the flow line of the Outlet Barrel Pipe as required.
6. Join all Outlet Barrel Pipe so that the connections are water tight.

For **Temporary Surface Outlet and Baffle Sediment Basin**, use either polyethylene Type C or corrugated steel pipe or reinforced concrete pipe for the Outlet Barrel, and use reinforced concrete pipe or corrugated metal pipe for the Primary Riser. Use the pipe sizes shown on the Plans.

For **Multipurpose** Basins, construct a Primary Riser consisting of reinforced concrete pipe. Install a trash rack and antivortex device. Place a stub out de-watering orifice at the same flow line as the Outlet Barrel as shown on the Plans. Use either reinforced concrete or aluminum alloy pipe for the Outlet Barrel. Join all pipe sections so that the connections are watertight.

Place a trash rack and anti-vortex device over the top of the Primary Riser as shown on the Plans. Use the diameter indicated on the Plans for the Primary Riser and the Outlet Barrel.

Place the Outlet Barrel on a 0.5% slope.

Provide outlet protection to prevent erosion and scouring using Riprap, TRM, or similar erosion prevention at the barrel outlet of the Basin. Ensure outlet velocities do not exceed the capability of the BMP selected.

Line the outflow channel with Class B Riprap or install a stilling basin as indicated on the Plans. Use a non-woven geotextile under the Riprap.

1.4.10 Floating Skimmer

Install an appropriate Floating Skimmer attached to the bottom of the Primary Riser structure.

Excavate a shallow pit under the Floating Skimmer to account for sediment that accumulates on the Basin bottom around the Floating Skimmer. The pit allows the Floating Skimmer to completely drain the basin. At a minimum, the pit has dimensions of 4feet x 4feet with a minimum depth of 2 feet. Fill the Skimmer Pit with Class A or Class B Riprap to the top elevation of the Skimmer Pit. Ensure the top elevation of the Skimmer Pit is lower than the invert of the outlet barrel from the riser.

1.4.11 Baffles

Install 3 rows of Baffles a minimum of 4-feet in height with a spacing of $\frac{1}{4}$ the basin length for Basins greater than 25 feet in length. Install 2 rows of Baffles with a spacing of $\frac{1}{3}$ the basin length for Basins less than 25 feet in length.

Ensure that at least one row of Baffles is placed between the Primary Riser structure and all pipes or channels discharging to the Basin.

Baffles may consist of Porous Baffles, or Riprap Baffles.

Install Riprap Baffles a minimum of 4-feet in height consisting of Class A or B Riprap. Do not place washed stone on the face of the Riprap Baffles.

1.4.12 Sediment Cleanout Stake

Install a metal sediment clean out stake that is 4-feet above the Basin bottom in the first Baffle cell upstream of the first Baffle. Cleanout the *Surface Outlet and Baffle Sediment Basin* when the sediment level reaches the 2-foot mark on the sediment cleanout stake (50% of the sediment storage volume).

1.5 Inspection and Maintenance

The key to a functional *Surface Outlet and Baffle Sediment Basin* is continual monitoring, regular maintenance and regular sediment removal. Attention to sediment accumulations within the Basin is extremely important. Continually monitor sediment deposition in the Basin.

Inspect *Surface Outlet and Baffle Sediment Basin* a minimum of once per week and make necessary repairs immediately. Inspect all *Surface Outlet and Baffle Sediment Basin* components including but not limited to:

- Inlet/outlet pipes – Inspect pipes for sediment and debris blockage, maintenance is required when the pipe is 1/3 blocked or damaged to a point to restrict flow.
- Inlet/outlet protection – Inspect inlet/outlet protection and repair or replace when protection is damaged, Riprap is displaced, or covered by sediment.
- Floating Skimmer - Inspect the Floating Skimmer after each rain event to ensure that it is not clogged with sediment. Remove sediment that accumulates on the Riprap pad underneath the Floating Skimmer.
- Inspect *Surface Outlet and Baffle Sediment Basin* after each significant rainfall.
- Inspect the Emergency Spillway for erosion and damage.
- Clean trapped sediment from *Surface Outlet and Baffle Sediment Basin* when sediment accumulations reach the 2-foot mark on the sediment clean out stake.
- Remove trapped sediment from the site, or stabilized on site.
- Repair, seed, and replace ECBs on Basin side slope areas that have eroded or have become damaged by equipment from silt cleanout.
- Inspect Baffles after each rain event for erosion damage.

1.6 Removal

Remove **Temporary** *Surface Outlet and Baffle Sediment Basin* when the watershed is completely stabilized. Remove temporary *Surface Outlet and Baffle Sediment Basin* within 30 days after final site stabilization is achieved or after it is no longer needed.

Immediately stabilize areas disturbed as a result of Temporary *Surface Outlet and Baffle Sediment Basin* removal.

1.7 Acceptance

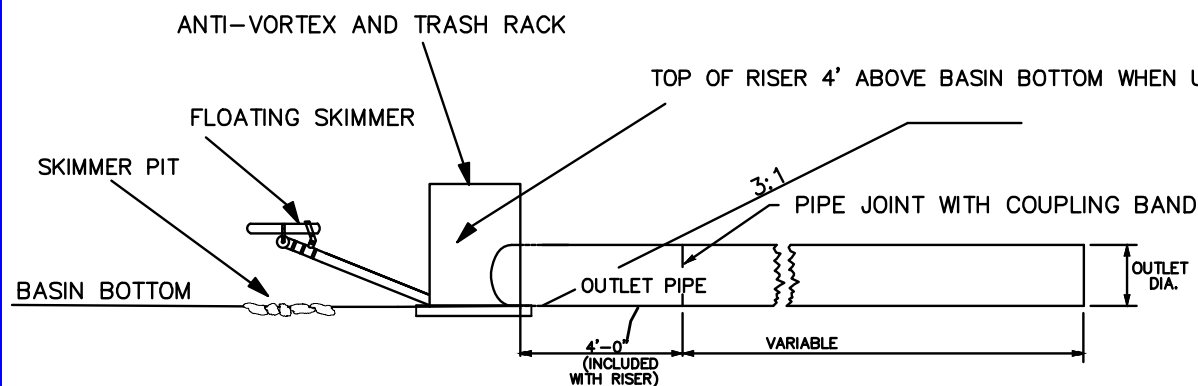
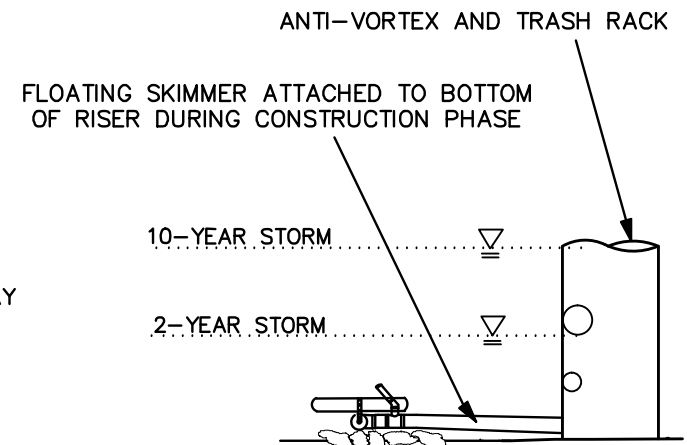
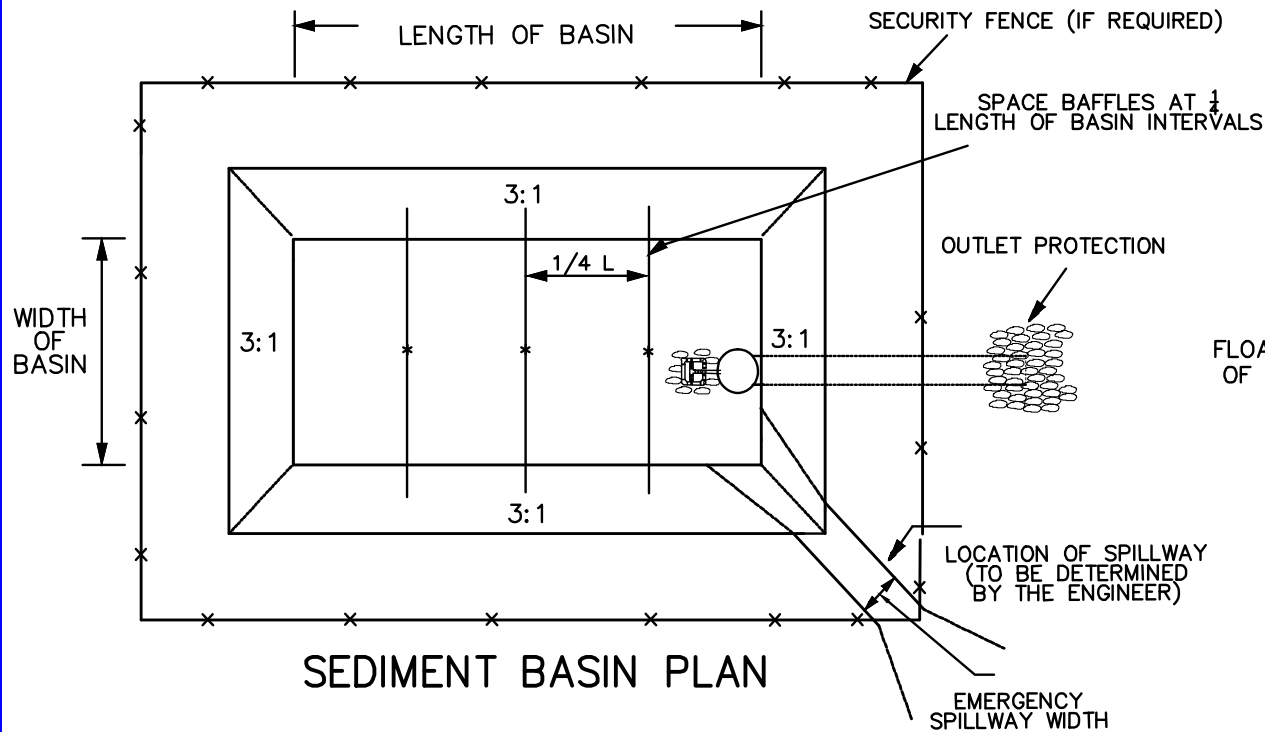
Remove Floating Skimmers and Baffles from Multipurpose *Surface Outlet and Baffle Sediment Basins* when the construction phase of the project ends when the Basin is converted to the permanent Multipurpose Basin for permanent water quality and quantity control. Remove deposited sediment, re-grade the Basin contours as needed, and make any necessary modifications to the Emergency Spillway to meet the Permanent Basin requirements when the Basin is converted to the permanent Multipurpose Basin.

Temporary *Surface Outlet and Baffle Sediment Basins* converted to Permanent Multipurpose Basins will be retained and maintained after completion of the project by the owner of the site.

Obtain Engineer acceptance and approval of all *Surface Outlet and Baffle Sediment Basin* installations.

Provide an As-Built plan to Anderson County certified by a registered professional upon the completion of the construction of the Permanent Multipurpose Basins. The registered professional certification ensures that Permanent Multipurpose Basins are constructed as shown on the As-Built plans and that Permanent Multipurpose Basins meet the approved site plan and specifications or achieve the function they were designed to perform.

Provide home owners association documents to Anderson County defining the responsible party for maintaining Permanent Multipurpose Basins installed in the subdivision.

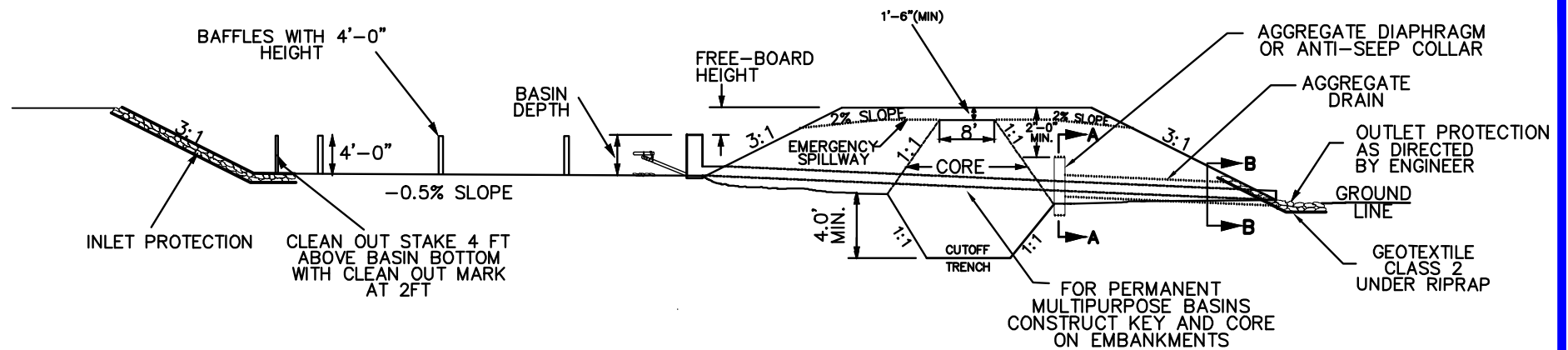


Anderson County, SC

SURFACE OUTLET AND BAFFLE
SEDIMENT BASIN

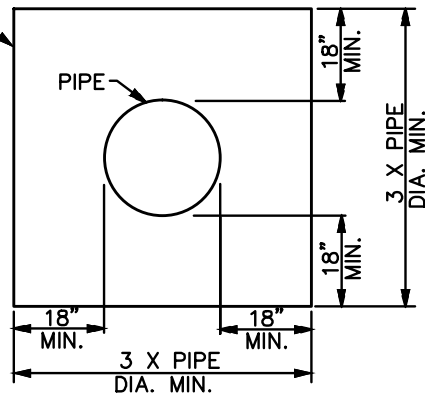
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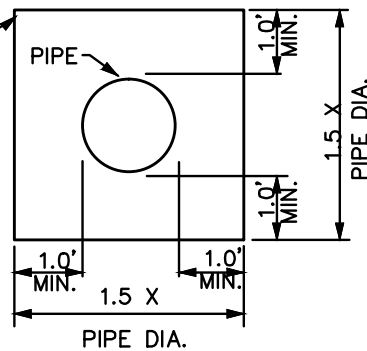
SEDIMENT BASIN PROFILE

FA 10 FINE AGGREGATE



SECTION A-A THRU AGGREGATE DIAPHRAGM OR ANTI-SEEP COLLAR

FA 10 FINE AGGREGATE



SECTION B-B THRU AGGREGATE DRAIN

Anderson County, SC

SURFACE OUTLET AND BAFFLE
SEDIMENT BASIN

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PRECAST CONCRETE RISER WITH BASE

ENSURE ALL RISER (MANHOLE) MATERIALS, MANUFACTURING, TESTING AND PRODUCT PERFORMANCE FOR PRECAST CONCRETE COMPONENTS AND ACCESSORIES ARE IN ACCORDANCE WITH AASHTO M199 AND SECTION 719 OF THE SCDOT STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION, 2007 EDITION, OR LATEST REVISION.

USER PRECAST CONCRETE COMPONENTS DESIGNED IN ACCORDANCE WITH THE REQUIREMENTS OF THE LATEST AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS.

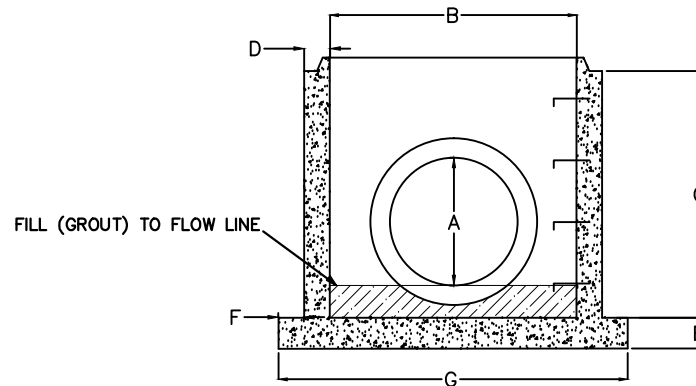
USE PRECAST CONCRETE MANHOLES WITH A HL-93 DESIGN LIVE LOADING.

USE CLASS 4000 CONCRETE (MINIMUM) FOR ALL PRECAST CONCRETE ELEMENTS.

USE REINFORCING BARS CONFORMING TO THE REQUIREMENTS OF ASTM A706, GRADE 60.

USE WELDED WIRE FABRIC MEETING THE REQUIREMENTS OF AASHTO M55 AND AASHTO M221, ASTM A185, or ASTM A497.

USE WATER TIGHT BARREL TO RISER CONNECTORS



THIS DRAWING IS NOT TO SCALE

PIPE DIAMETER (A) inches	RISER DIAMETER (B) inches	RISER HEIGHT (C) inches	WALL THICKNESS (D) inches MIN	BASE THICKNESS (E) inches MIN	BASE EXTENTION (F) inches MIN	BASE DIAMETER (G) inches MIN
24 and 30	48	48	5	6	6	70
36	60	60	5	6	8	86
42	72	72	6	8	8	110

Anderson County, SC

SURFACE OUTLET AND BAFFLE
SEDIMENT BASIN

STANDARD DRAWING NO. ES-01 PG 3 OF 3

APPROVED BY: _____ JANUARY 2013

ES-02: FLOATING SKIMMER

1.0 Floating Skimmer

This Specification is for Floating Skimmers used as surface dewatering devices for sediment basins.

1.1 Description

Use Floating Skimmers as a surface dewatering device that floats at the water surface of a sediment basin. Use Floating Skimmers that dewater from the water surface where sediment concentrations are at a minimum in the water column. Floating Skimmers release a low rate of flow draining the basin slowly at a constant rate. The inlet of the skimmer device is sized according to the basin volume and designed to drain the basin in a fixed amount of time.

1.2 Materials

Use Floating Skimmers from a manufacturer listed on *SCDOT Qualified Product List 81*. Materials and sizes of Floating Skimmers will vary depending on device type and design. Regardless of device type or design, all PVC materials used are Schedule 40 or greater.

1.2.1 Quality Assurance

Provide Floating Skimmers listed on the most recent edition of *SCDOT Qualified Product List 81*.

At the time of delivery, provide the Engineer with the Floating Skimmer packing list containing complete identification, including but not limited to the following:

- Manufacturer's name and location.
- Manufacturer's telephone number and fax number.
- Manufacturer's e-mail address and web address.
- Floating Skimmer name, model, and/or serial number.
- Floating Skimmer dimensions.
- Certification that the Floating Skimmer meets the physical and performance criteria of this specification.

1.3 Design & Construction Requirements

1.3.1 Dewatering Rates

Skimmers are designed to completely dewater sediment basins from the top of riser elevation in 24 to 72 hours. Submit flow rates for the Floating Skimmer prepared by a qualified individual in accordance with standard practices for construction projects. Provide Floating Skimmer dewatering flow rate tables signed and sealed by a qualified individual who is licensed as follows:

1. South Carolina registered professional engineer as described in *Title 40, Chapter 22*;
2. South Carolina registered landscape architect as described in *Title 40, Chapter 28, Section 10, item (b)*;
3. South Carolina registered Tier B land surveyor as described in *Title 40, Chapter 22*; or

1.3.2 Floatation Requirements

Floating Skimmers which sink or completely suspend under the water surface will not be accepted. A

portion of the Floating Skimmer must be visible above the water surface at all times. Vent holes are required on all Floating Skimmers to ensure the device drains by gravity flow. Inlets or orifices to the skimmer may be submerged no greater than 6 inches below the water surface.

1.3.3 Trash Guard & Maintenance Rope

All Floating Skimmer designs include a trash guard and maintenance rope in order to prevent and remove blockage from floating debris. Trash guards prevent larger debris from entering the skimmer which may cause internal blockage. The maintenance rope is used to remove trash and debris which accumulates on the outside of the trash guard. Ensure the maintenance rope is floatable.

1.3.4 Skimmer Pit

Excavate a shallow pit filled with riprap under the Floating Skimmer to account for sediment that accumulates on the sediment basin bottom around the Floating Skimmer. The pit allows the Floating Skimmer to completely drain the basin. At a minimum, the pit has dimensions of 4ft x 4ft with a minimum depth of 2 ft. Ensure the bottom of the pit is lower than the invert of the outlet barrel from the riser.

Floating Skimmers that have a footed design which prevents the device from lodging in accumulated sediment do not require a skimmer pit.

1.3.5 Installation

Assembly of the Floating Skimmer components varies by device type and design. Install manufactured Floating Skimmers in accordance with the manufacturer's written installation instructions. Position the Floating Skimmer over the excavated skimmer pit (when applicable). Ensure the Floating Skimmer is assembled level over the skimmer pit in order to prevent debris from floating under the skimmer which can create a blockage of flow and damage the device. Install a flexible joint with a section of Schedule 40 flexible PVC pipe at the connection with the riser. The flexible joint and flexible PVC pipe allows the Floating Skimmer to be retrieved from the bank using the maintenance rope.

A stable, water tight connection between the skimmer barrel and basin riser is extremely vital to ensure sustained functioning. To ensure a proper connection, use a manufactured bracket, construct an extended PVC connection apparatus to the basin riser, or grout the open space between the skimmer barrel and riser.

Tie one end of the maintenance rope around a secure portion of the Floating Skimmer. Tie the other end of the maintenance rope to a metal stake driven into the basin embankment near the riser. Ensure the rope attachment to the metal stake is higher than the design water surface level. Ensure a good knot is established that will not become loose. Put tension on the rope but ensure there is enough slack in the rope to allow the Floating Skimmer to float up and down through its full range of motion so the Floating Skimmer settles into the skimmer pit after the basin drains.

Remove Floating Skimmers at the end of the construction phase of the project. If the Basin is to be converted to a permanent water quantity or quality basin, ensure the orifice where the Floating Skimmer was attached to the Basin riser is covered, adjusted, or modified according to the Project Plans and Specifications.

1.3.6 Inspection and Maintenance

Inspect Floating Skimmers together with the Sediment Basin inspections. Inspect the Floating Skimmer for any structural damage, clogging, or excessive sediment accumulation.

While draining the basin, the trash guard of the Floating Skimmer may clog with debris. Typically, a few jerks on the maintenance rope will clear the Floating Skimmer of debris and restore flow. If jerking the maintenance rope does not work, pull the Floating Skimmer to the embankment with the maintenance rope

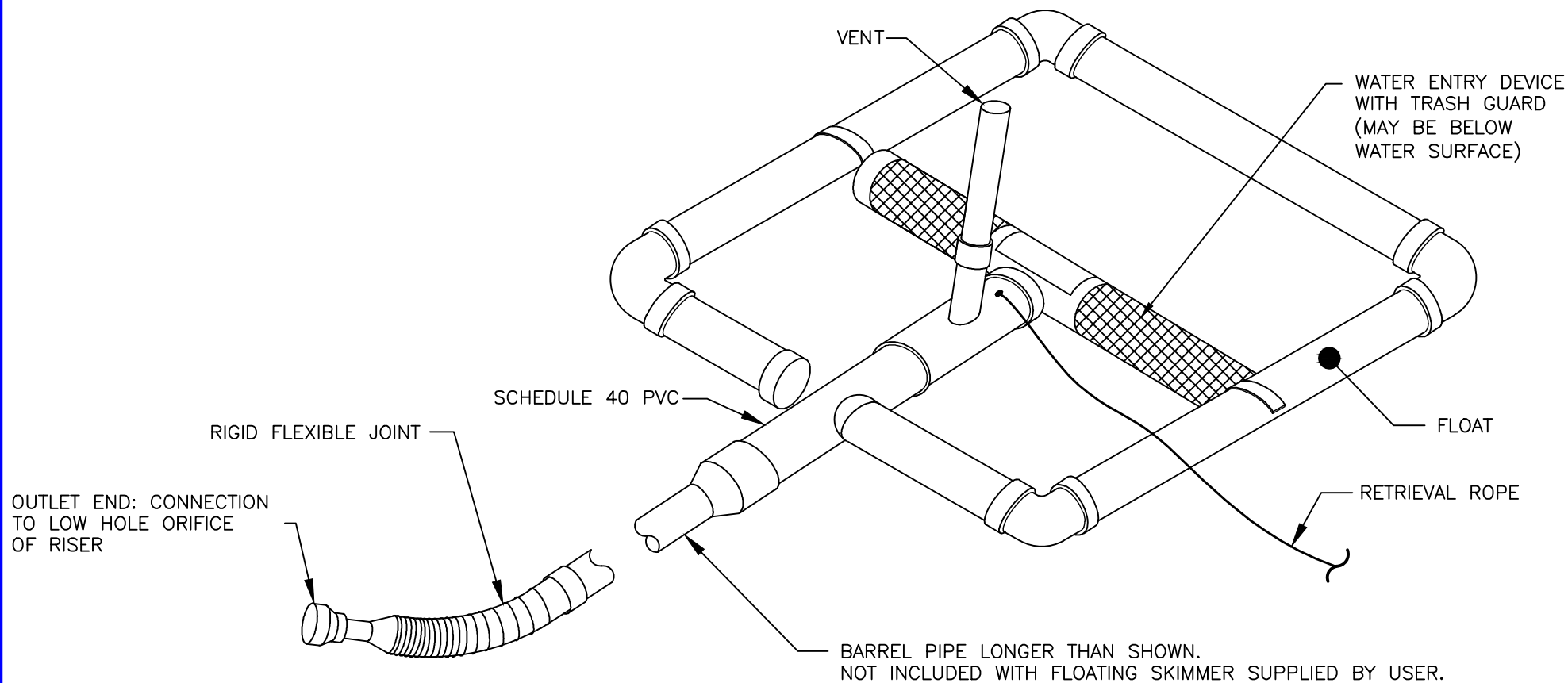
and manually remove all debris from the trash guard. An internal clog or blockage may require the device to be disassembled and repaired.

If the skimmer becomes stuck in the mud at the bottom of the basin it must be freed to allow for normal operation. This can typically be done by use of the maintenance rope.

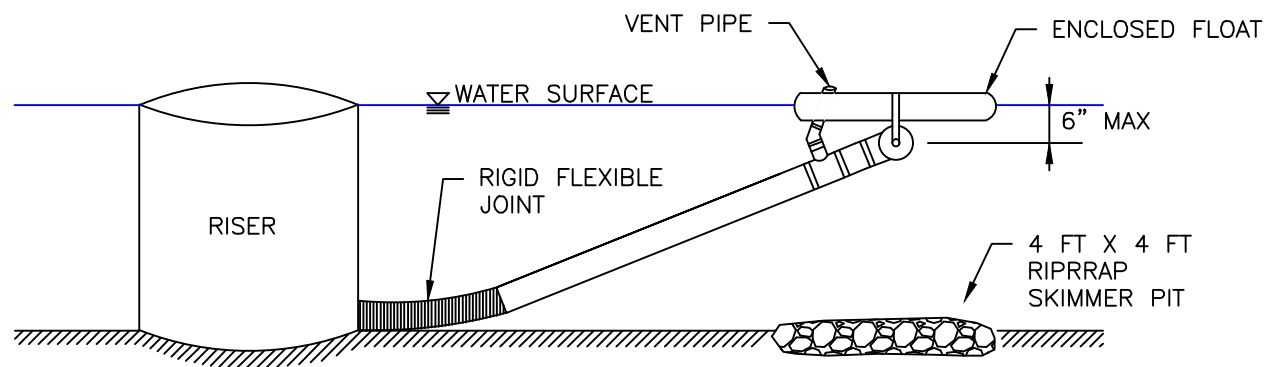
Remove sediment deposits when the Floating Skimmer cannot settle low enough to completely drain the entire basin. Remove or pull the skimmer to a side embankment using the maintenance rope and remove sediment from the skimmer pit.

1.4 Acceptance

Obtain Engineer acceptance and approval of Floating Skimmer installations. When requested by Anderson County, ensure that a manufacturer's representative is on-site to oversee and approve the initial installation of Floating Skimmer operations. Obtain a letter from the manufacturer approving the installation when requested by the Engineer.



FLOATING SKIMMER DETAIL (NTS)



FLOATING SKIMMER/RISER PROFILE VIEW

SCALE: NONE

Anderson County, SC

FLOATING SKIMMER

STANDARD DRAWING NO. ES-02

APPROVED BY: _____ JANUARY 2013
DATE

ES-03: Porous Baffles

1.0 Porous Baffle Systems

1.1 Description

Porous baffle systems are used inside temporary sediment detainment structures such as sediment dams and sediment basins to reduce the velocity and turbulence of water flowing through the structure by spreading the flow across the entire width of the basin. The reduction of turbulent flow facilitates the settling of sediment and improves sediment retention efficiency for sediment detainment structures.

1.2 Materials

Provide porous baffle system material consisting of either turf reinforcement matting (TRM), or coconut erosion control blanket, or excelsior erosion control blanket meeting the requirements of this Specification. **Do not use** Silt Fence material for porous baffle systems under this specification.

1.2.1.2 Porous Baffle TRM Material

Provide turf reinforcement matting (TRM) composed of non-degradable synthetic fibers, filaments, nets, processed into a permanent, three-dimensional matrix. The non-degradable three-dimensional matrix may be infilled with coconut or excelsior materials. Do not use TRMs infilled with straw materials.

Provide TRMs with properties derived from quality control testing listed in the American Association of State Highway and Transportation Officials (AASHTO) National Transportation Product Evaluation Program (NTPEP) for Erosion Control Products (ECP) and conforming to the performance and physical requirements shown in Table 1.

Table 1: Minimum TRM Porous Baffle Material Performance Requirements

Physical Property ¹	Test Method	Required Value
Light Penetration (% openings)	ASTM D 6567 or Equivalent	10% Min 35% Max
Tensile Strength ²	ASTM D 6818	145 X 110 lb/ft min.
Ultraviolet Stability (retained strength after 1000 hrs of exposure)	ASTM D 4355	80%

¹ Unless otherwise indicated, numerical values represent the MARV

² Minimum tensile strength in both machine and cross machine directions, under dry or saturated conditions using ASTM D6818.

1.2.1.2 Porous Baffle Coconut / Excelsior Blanket Material

Provide Coconut / Excelsior erosion control blankets composed of un-dyed and unbleached 100% natural fibers that are totally biodegradable. Do not use erosion control blankets composed of straw.

Provide Coconut / Excelsior erosion control blankets with properties derived from quality control testing listed in the American Association of State Highway and Transportation Officials (AASHTO) National Transportation Product Evaluation Program (NTPEP) for Erosion Control Products (ECP) and conforming to the performance and physical requirements shown in Table 2.

**Table 2: Minimum Coconut / Excelsior Blanket
Porous Baffle Material Performance Requirements**

Physical Property	Test Method	Required Value
Light Penetration (% openings)	ASTM D 6567 or Equivalent	10% Min 35% Max
Tensile Strength ¹ (machine direction)	ASTM D 6818 ASTM D 4595	145 lb/ft Min

¹ Minimum tensile strength in the machine direction under wet conditions.

1.2.1.3 Steel Posts

Provide steel posts or approved equivalent for Porous Baffle systems. **Do not** use wood posts.

Furnish steel posts meeting the following minimum physical requirements:

- Minimum length of five (5) feet.
- Composed of high strength steel with minimum yield strength of 50,000 psi.
- Standard “T” section with a nominal face width of 1.38 inches and nominal “T” length of 1.48 inches.
- Weighs 1.25 pounds per foot ($\pm 8\%$).
- Painted with a water based baked enamel paint.
- Has a soil stabilization plate made of 15-gauge steel with a minimum cross section area of 17 square inches.

Use steel posts with the addition of a metal soil stabilization plate welded near the bottom. When the post is driven to the proper depth, the plate will be below the ground level for added stability. Attach soil stabilization plates to the steel posts according to Table 3.

Table 3: Soil Stabilization Plate Requirements

Post Length (feet)	Top of Soil Stabilization Plate Relative to Bottom of Steel Post (inches)
5.0 and 5.5	13.0
6.0, 6.5, and 7.0	15.25

1.2.2 Quality Assurance

Provide porous baffle material listed on the most recent edition of *SCDOT Qualified Product List 82* in the appropriate category, or Equivalent. Porous baffle material acceptance is granted based on the manufacturers’ certification and testing with the American Association of State Highway and Transportation Officials (AASHTO) National Transportation Product Evaluation Program (NTPEP) for Erosion Control Products (ECP).

At the time of delivery, provide the Engineer with the porous baffle material packing list containing complete identification, including but not limited to the following:

- Manufacturer name and location,
- Manufacturer telephone number and fax number,
- Manufacturer’s e-mail address and web address, and
- Porous baffle material name, model and/or serial number.
- Certification that the specific porous baffle material meets the physical and performance criteria of this specification.

1.3 Construction Requirements

Install the porous baffle systems in sediment detention structures perpendicular to the flow of water to ensure porous baffles achieve coalescent flows through the sediment detention structure. Extend porous baffle systems up the side slopes of the detention structure a minimum of 1 foot above the 10-year 24-hour storm event design flow depth to prevent flow around the porous baffle system.

Ensure the inlet zone is accessible for frequent maintenance as the majority of sediment is trapped in the inlet zone. Secure the porous baffle system to the basin bottom and sides using 12-inch anchors (stakes, pins, or staples). Install a support wire across the top of the porous baffle system to prevent sagging. The expected design life of porous baffle systems is 6-12 months, but may require replacement more frequently if blocked or damaged.

1.3.1 Installation

Construct the porous baffle system inside sediment traps and sediment basins with appropriately sized zones to ensure flow is coalesced to the maximum extent. Ensure porous baffles are installed perpendicular to flow within the sediment control structure. Install porous baffle systems across the entire width of the sediment basin/trap.

For sediment traps or basins greater than 25 feet in length, install three rows of porous baffle systems, dividing the sediment dam or basin chamber into four equally sized separate chambers. Install porous baffles with spacing to create appropriately sized zones as listed in Table 4.

Table 4: Three Row Porous Baffle Locations

Porous Baffle Row	Installation Location
1	$\frac{1}{4}$ Length of Basin
2	$\frac{1}{2}$ Length of Basin
3	$\frac{3}{4}$ Length of Basin

For sediment traps or basins less than or equal to 25 feet in length, install two rows of porous baffle systems, dividing the sediment dam or basin chamber into three equally sized separate chambers. Install porous baffles with spacing to create appropriately sized zones as listed in Table 5.

Table 5: Two Row Porous Baffle Location

Porous Baffle Row	Installation Location
1	$\frac{1}{3}$ Length of Basin
2	$\frac{2}{3}$ Length of Basin

Do not install porous baffle systems until the sediment trap or sediment basin bottom is excavated and graded with a smooth bottom surface.

Install steel posts and porous baffle system material according to Table 6:

Table 6: Porous Baffle Installation Requirements

Min. Porous Baffle Material Height Above Bottom (ft)	Steel Post Length (ft)
3*	5
4*	6
5*	7

*As directed by the Engineer, the height may be greater based on the 10-yr 24-hour design water surface elevation of the basin. In no case will the porous baffle material height be higher than the primary spillway elevation of the sediment basin or sediment trap.

Install steel posts on 4 foot centers across the structure bottom and up the embankments. Drive steel post to a minimum depth of 2 feet or to the maximum extent practicable.

Attach porous baffle system material to the upstream side of the steel posts using heavy-duty plastic ties, or wire ties that are evenly spaced and placed in a manner to prevent sagging or tearing of the fabric. In all cases, affix ties spaced at maximum 6 inch intervals.

Use 12-inch anchors (stakes, pins, or staples) spaced on 1 foot intervals to secure the porous baffle system material to the bottom and up the sediment basin/trap embankments.

In cases where the porous baffle material sags between support posts, weave a 9 gauge steel wire or rope support across the top of the porous baffle system to prevent sagging. Drive a steel post on each side of the sediment trapping structure and attach one side of the support wire to the post. Pull the support wire tight and attach the support wire to each porous baffle system steel post and the opposing steel wire support post.

Purchase porous baffle material in continuous rolls and cut to the specific length of the baffle to avoid joints. When joints are necessary, wrap the materials together at a support steel post with both ends fastened to the post, with a twelve (12) inch minimum overlap.

1.3.2 Inspection and Maintenance

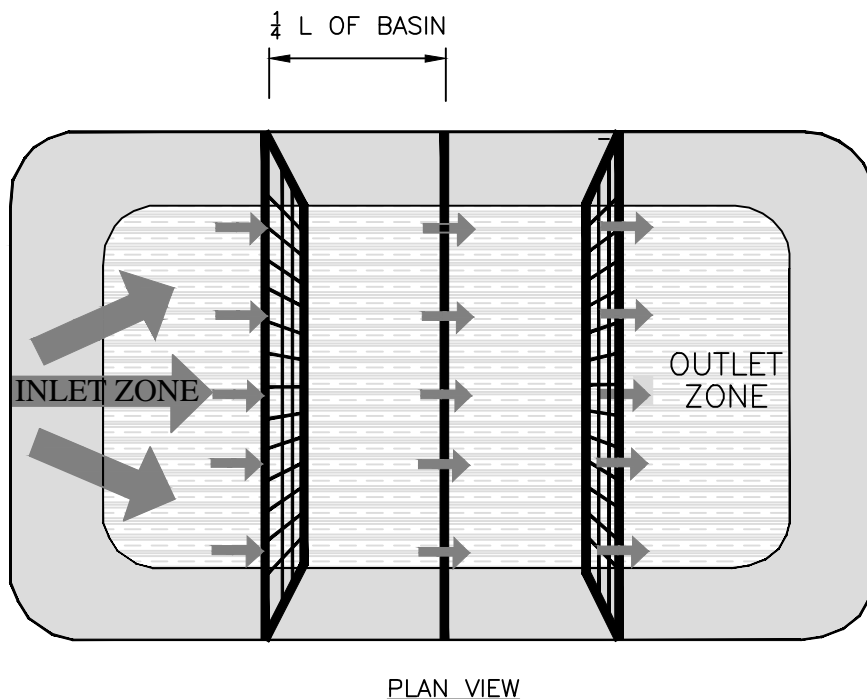
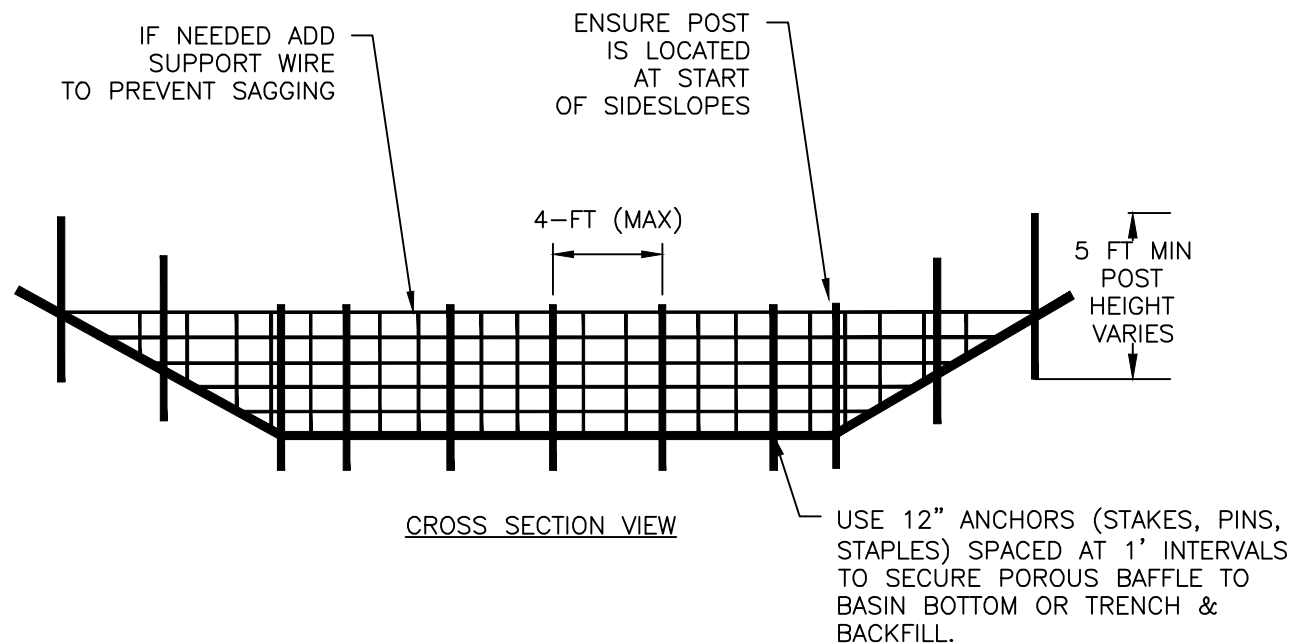
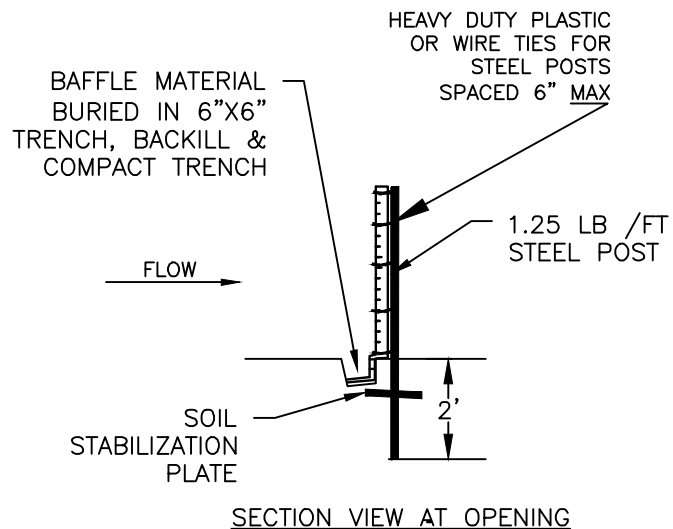
Inspect porous baffle system every seven (7) days. Immediately correct any deficiencies. Check for sediment buildup and structure integrity. Remove sediment when it reaches 50% of the height of the first baffle row. Remove sediment deposits with care to avoid damage during cleanout.

Check where runoff has eroded a channel beneath the baffle, or where the baffle has sagged or collapsed. Ensure that baffle material stays securely installed along the basin sides and in the bottom. Ensure the baffle system does not sag across the top of the baffle system. Replace baffle material if torn or if evidence of deterioration is noted.

Remove porous baffles and replace whenever it has deteriorated to the extent that it reduces the effectiveness of the porous baffle system. Maintain access to the porous baffles and replace promptly if the baffle collapses tears, decomposes or becomes ineffective. Install additional porous systems as directed by the Engineer where deficiencies exist.

1.3.3 Acceptance

Obtain Engineer acceptance and approval for all porous baffle system installations.



NOTES:

- SECURE BAFFLE MATERIAL AT THE BOTTOM AND SIDES USING STAPLES OR BY TRENCHING.
- MOST SEDIMENT ACCUMULATES IN THE 1ST BAY, AND SHOULD BE READILY ACCESSIBLE FOR MAINTENANCE.
- PROVIDE 3 ROWS OF BAFFLES EVENLY SPACED AT $\frac{1}{4}$ BASIN LENGTH (2 ROWS IF BASIN IS LESS THAN 25 FEET IN LENGTH).
- WOOD POSTS ARE NOT ALLOWED.
- ATTACH POROUS MATERIAL ON UPSTREAM SIDE OF STEEL POST WITH HEAVY DUTY PLASTIC OR WIRE TIES EVENLY SPACED TO PREVENT SAGGING OR TEARING OF BAFFLE MATERIAL.
- SPACE TIES AT 6" MAX. INTERVALS

Anderson County, SC

POROUS BAFFLES

STANDARD DRAWING NO. ES-03

APPROVED BY: _____

JANUARY 2013
DATE

WQ-01: DRY DETENTION BASIN

1.0 Dry Detention Basin

1.1 Description

A dry detention basin does not maintain a permanent pool and is intended to manage both the quantity and quality of stormwater runoff before discharging off-site. Stormwater runoff enters a dry detention basin through one or more inlets that discharge into a Forebay that is designed to settle out larger sediment. The runoff then passes over a forebay berm and into the main dry detention basin. From the main basin, runoff exits the basin through the principal spillway. In the case of extreme rainfall events, an emergency spillway is included in the design in order to safely pass high flow rates.

1.2 Design

The temporary water quality pool volume of a dry detention basin is designed to treat the water quality volume which is **1-inch of runoff from the drainage area**. Each dry detention basin must be able to hold the water quality volume and release this volume over a 24-hour period. This is achieved through an outlet orifice or other low flow control device.

In addition to the design requirements of this Specification, follow all design requirements in Section 3 of the Anderson County Stormwater Management Design Manual.

1.2.1 Converting Sediment Basins to Dry Detention Basins (Multipurpose Basins)

Sediment basins that are used during construction can be converted into dry detention basins after the construction is completed. If used during construction as a sediment basin, completely clean out the basin, re-grade, and vegetate with permanent vegetation within 14 days of completion of construction.

1.2.2 Site Selection

Ensure the seasonally high groundwater table is at least 2 feet below the bottom of the basin. Less separation distance makes the dry extended detention basin vulnerable to developing ephemeral pools of standing water during wet-weather periods. If the 2-foot minimum separation distance cannot be met, consider the design of a stormwater wetland or wet detention basin.

1.2.3 Safety

Follow the safety design criteria such as those outlined by the USDA Soil Conservation Service (previously the Natural Resources Conservation Service), U.S. Army Corps of Engineers, and the Safe Dams Act. A dam is defined as being an artificial barrier that impounds water to a depth of 15- feet or greater and has a maximum storage volume of 10-acre-feet or greater; therefore, impoundment depths greater than 15-feet are subject to the requirements of the Safe Dams Act unless the facility is excavated. Several exemptions are allowed from the Safe Dams Act and any questions concerning specific design application should be addressed by SCDHEC.

Incorporate all possible safety precautions such as signs and fencing for permanent dry basins that are readily accessible to populated areas. Ensure the inside pond slopes are no steeper than 3H:1V where applicable.

1.2.4 Basin Geometry

The volume of a dry detention basin is driven exclusively by the volume of stormwater that is required to be captured. Once that volume is calculated, the dimensional aspect of the basin is mostly site driven. Utilize the following dimensional and layout requirements:

- The maximum depth is 10 feet without requiring a Geotechnical slope stability analysis.
- The Dry Basin bottom has an optimal slope of 2% .
- Ensure there are no depressions in a dry detention facility where water might pocket after the water level has receded.
- Dry detention systems and swales are designed to drain within three (3) days.
- A minimum of 0.5 feet of freeboard is provided between the design flow pool elevation and the emergency spillway overflow invert.
- The minimum flow length to width ratio is 2:1, but 3:1 is recommended. The basin width preferably expands as it approaches the outlet.
- Side slopes of the basin are no steeper than 3H:1V if stabilized by vegetation.
- Direct the discharge from the basin to a stable channel or outlet.

In addition to detention volume, the design must provide for sediment storage equal to 25 percent of detention volume. Provide additional sediment storage if the upstream drainage basin will contribute high sediment loads over several years.

Minimize flow short-circuiting as it causes turbulence and eddies in the flow, and can interfere with the function of the basin outlet system. The most direct way of minimizing short-circuiting is to maximize the distance between the riser and the inlet(s). Provide larger length to width ratios if sedimentation of particulates during low flows is desirable. Irregularly shaped basins appear more natural. If a relatively long, narrow facility is not suitable at a given site, baffles constructed from gabions or other materials can be placed in the basin to lengthen the flow length.

1.2.5 Flow Length

For maximum dry detention basin water quality benefits, the optimal ratio of flow length to flow width is 3L:1W. Due to site constraints, the minimum allowable design ratio of flow length to flow width is 1.5L:1W. To increase the basin flow length to flow width ratio, the basin may be design with baffles.

Optimizing the dry basin flow shape and flow distance through the basin promotes better water quality treatment. Settling is the primary pollutant removal mechanism sought when addressing flow length as a water quality design feature. Dry detention basins designed with optimum flow lengths avoid the problem of dead storage or incoming runoff short circuiting through the basin. Optimum flow lengths decrease the turbulence within the basin and minimize the re-suspension of deposited sediments.

Design dry detention basins with a wedge-shape (when practicable), with the widest cross sections occurring at the downstream end of the basin.

1.2.6 Dry Basin Bottom Requirements

Grade the dry detention basin bottom towards the outlet structure to prevent standing water conditions and stabilize to prevent scour. A minimum 2 percent bottom slope is recommended for both cross slope and longitudinal slope. If the 2% grade cannot be obtained an acceptable alternative is to install an under drain. Install the under drain in the following manner:

- The under drain is one of the last items installed to eliminate any sediment build-up causing the under drain to not function properly.
- Install a non-woven geotextile fabric in the excavated trench first.
- Install a perforated drain pipe covered with washed stone.
- Wrap both the stone and perforated drain pipe with the non-woven geotextile and backfill with sandy porous material.

1.2.7 Low Flow Channel

Low flow channels may be used for dry basins in areas with low permeable soils. Install a low flow channel to prevent standing water conditions when the pond bottom may be subject to non-storm flow from groundwater, footing drainage, storm sewer acting as under drain and sump discharge. Stabilize the low flow channel using Class B riprap with an underlying filter fabric, a TRM, or concrete. The upstream side of the low flow channel starts downstream of the forebay and extends to the outlet structure. Low flow channels are not recommended for basins with highly permeable soils.

Use a low flow orifice or dewatering device to slowly release the water quality volume over a period of 24-hours or longer depending upon the design criteria for the water quality structure. Dry basins with slow release rates for water quality control require a small orifice at the bottom of the outlet control structure with a minimum size of 2-inches. These structures are prone to becoming clogged. Ensure the low flow orifice is protected from clogging by designing appropriate trash guards. Acceptable low flow or dewatering methods include orifices with trash boxes made of sturdy wire mesh or Floating Skimmers.

1.2.8 Low Flow Orifice for Basin Dewatering

Use a low flow orifice or dewatering device to slowly release the water quality volume over a period of 24-hours or longer depending upon the design criteria for the water quality structure. Dry basins with slow release rates for water quality control require a small orifice at the bottom of the outlet control structure with a minimum size of 2-inches. These structures are prone to becoming clogged. Ensure the low flow orifice is protected from clogging by designing appropriate trash guards. Acceptable low flow or dewatering methods include orifices with trash boxes made of sturdy wire mesh or Floating Skimmers.

1.2.9 Forebay

The function of the Forebay is to trap the majority of the coarse fractions of the suspended solids in the runoff before it enters the main dry detention area.

Design the Forebay volume (or combined volume of Forebays) equal to a minimum of 10% of the overall water quality treatment volume. Each Forebay is sized according to the outlets contribution to the basin. Provide a Forebay for all inlets to a dry detention basin and place Forebays upstream of the main dry detention area. A Forebay is not required for an outlet that contributes less than 10% of the total drainage area to the basin.

Design Forebay side slopes to be 2H:1V or flatter.

The Forebay is separated from the larger dry detention basin area by berms, barriers, or baffles that may be constructed of earth, stones, riprap, gabions, or geotextiles. The berm, barrier, or baffles act as a trap for coarse sediments and minimize their movement into the main detention basin.

Design the Forebay so approximately 75 percent of the required sediment storage volume is allocated to the Forebay.

Design the Forebay in a manner that it is accessible for easy cleanout because it will eventually fill in with coarse particles. Design the access to the Forebay with a maximum slope of 15-20 percent extending from the top of the embankment to the toe.

1.2.10 Principal Spillway

Design the principal spillway to safely pass, at a minimum, the 10-year 24-hour storm event. Design the principal spillway with a trash rack to control clogging by debris and to provide safety to the public. Ensure the riser is installed with anti-floatation measures to prevent the riser floating.

1.2.11 Emergency Spillway

Design a stabilized emergency spillway to safely pass the post development 100-year, 24-hour storm event without overtopping any dam structures. Design the 100-year water surface elevation a minimum of 0.5 feet below the top of the dam embankment.

1.3 Installation

Perform the following for dry detention basin installation requirements:

1. Route all channels and pipes conveying flow to the basin away from the basin area until the basin is complete and stabilized.
2. Clear, grub, and strip the area under the embankment of all vegetation and root mat. Remove all surface soil containing high amounts of organic matter, and stockpile or dispose of it properly. Remove all unused fill material to the designated disposal area.
3. Ensure that fill material for the embankment is free of roots, woody vegetation, organic matter, and other objectionable material. Place the fill in lifts not to exceed 9 inches, and machine compact it. Over fill the embankment 6 inches to allow for settlement.
4. Install inlet and outlet control structures. Ensure principal spillway and emergency spillway installed to proper elevations as specified in the engineering drawings.
5. Grade the basin with a slope towards the outlet structure to ensure basin dewatering.
6. Install forebay and erosion control at basin inlets/outlets.
7. Stabilize all berms and embankments in accordance with the Seeding specification.
8. Route flow from contributing watershed to the dry detention basin as shown in the engineering drawings.
9. Follow required maintenance guidelines.

1.4 Maintenance

Proper maintenance ensures the continued functionality of the dry detention basin. Tables 1, 2 and 3 outline the various maintenance requirements after the installation of a dry detention basin.

Table 1: Summary of Maintenance Requirements

Required Maintenance	Frequency
Clean and remove debris from inlet and outlet structures.	After large storm events
Mow side slopes	As needed
Removal of invasive vegetation	Semi-annual
Inspect for damage to outlet control structure	Annual
Inspect for sediment accumulation in the basin and forebay	Annual
Inspect for operational inlet and outlet structures	Annual
Repair embankment, side slopes, undercut or eroded areas	Annual, or as needed
Pesticide/ Nutrient management	Annual, or as Needed
Remove sediment from the forebay	Per design cycle (typical 5-10 year maintenance), after 50% of total forebay capacity is filled
Remove sediment accumulations from the main permanent pool	Per design cycle, (typical 5-10 year maintenance) after 25% of permanent pool volume is filled

Table 2: Summary of Maintenance Requirements

BMP Component	Maintenance	Frequency
Basin banks	Pruning and weeding.	As required
	Remove trash and debris.	As required
	Repair eroded areas, replant grass. If recurring problem, consider sodding.	Semi-Annual (every 6 months)
	Inspect trees and shrubs to evaluate their health.	Annually
Outlet structure	Clean out outlet of all debris	Semi-Annually (every 6 months)
	Check if bank needs stabilization downstream of outlet.	Semi-Annually (every 6 months)
Forebay	Remove sediment when accumulated sediment reaches 25-50% volume	As required

Table 3: Summary of Trouble Shooting Activities

BMP Component	Problem	Solution
Entire detention basin	Trash/debris is present.	Remove the trash/debris.
Perimeter	Areas of bare soil and/or erosion	Re-grade the area as necessary, plant vegetation, and water until established.
Inlet device: pipe or swale	Pipe is clogged.	Unclog the pipe. Dispose of sediment properly.
	Pipe is cracked or damaged.	Replace the pipe.
	Erosion is occurring	Re-grade as necessary to smooth and provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Forebay	Sediment has accumulated and reduced the depth to 50% of the original design depth.	Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a proper location.
	Erosion has occurred or riprap is displaced.	Provide additional erosion protection such as turf reinforcement matting or riprap if needed to prevent future erosion problems.
	Weeds are present.	Remove the weeds, preferably by hand. If pesticides are used, wipe them on the plants rather than spraying.
Main treatment area	Sediment has accumulated to a depth greater than the original design sediment storage depth.	Search for source of sediment and remedy the problem if possible. Remove sediment and dispose of properly. Re-vegetate disturbed areas immediately with sod (preferred) or seed protected with erosion blankets.
	Pruning is needed to maintain optimal plant health.	Prune according to best professional practices

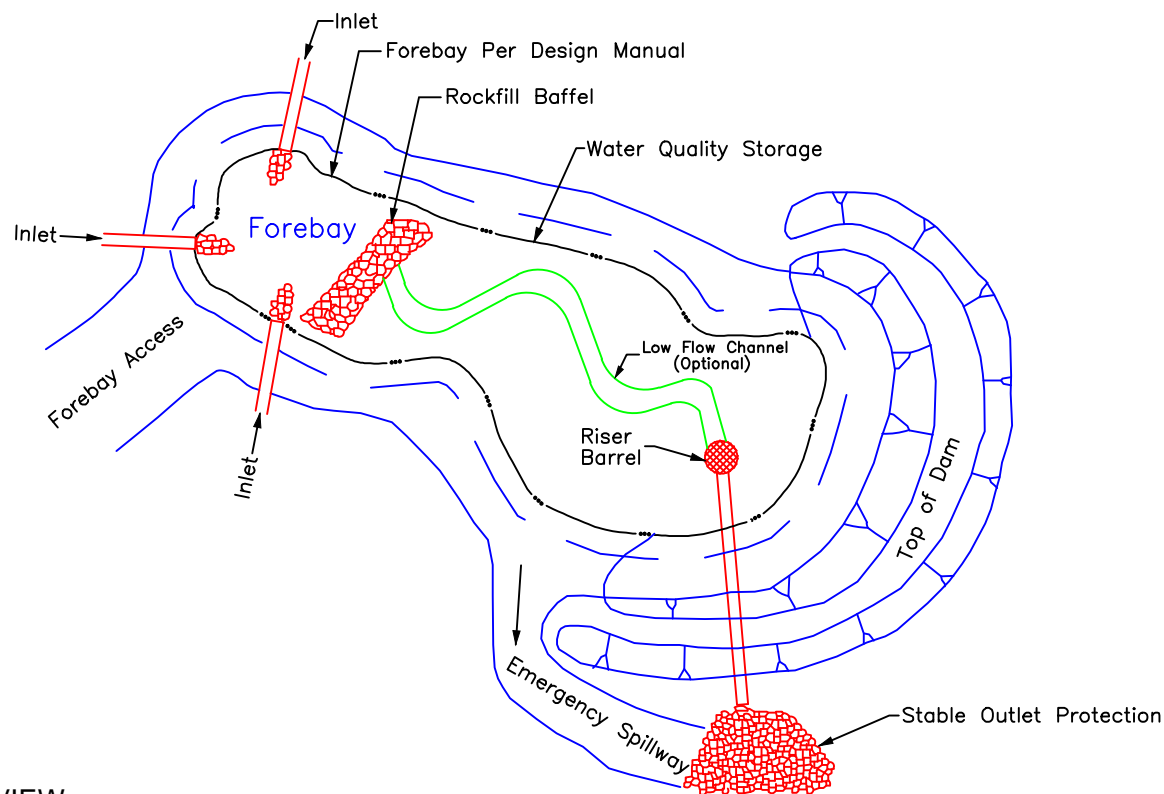
Main treatment area	Plants are dead, diseased or dying.	Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a one-time fertilizer application to establish the ground cover if a soil test indicates it is necessary.
	Weeds and noxious plants are growing in the main treatment area.	Remove the plants by hand or by wiping them with pesticide (do not spray).
Embankment	Shrubs or trees have started to grow on the embankment.	Remove shrubs or trees immediately.
	Grass cover is unhealthy or eroding.	Restore the health of the grass cover – consult a professional if necessary.
	Signs of seepage on the downstream face.	Consult a professional.
	Evidence of muskrat or beaver activity is present.	Use traps to remove muskrats and consult a professional to remove beavers.
	An annual inspection shows that the embankment needs repair.	Make all needed repairs.
Outlet structure	Clogging has occurred.	Clean out the outlet device. Dispose of the sediment off-site.
	The outlet device is damaged	Repair or replace the outlet device.

1.5 References

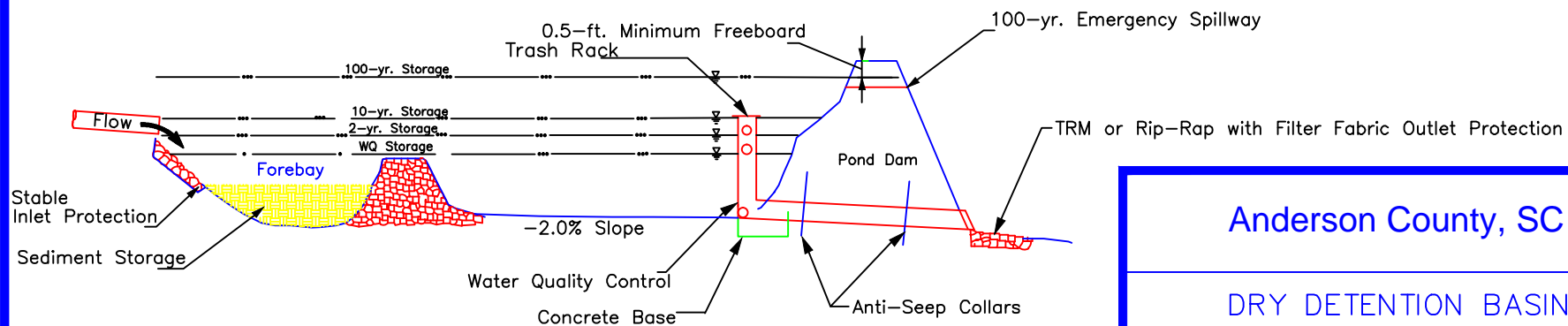
Knox County Tennessee Stormwater Management Manual. 4.3.3 Dry Extended Detention Ponds, Chapter 4 Vol. 2.

NCDENR Stormwater BMP Manual, Chapter 10 Wet Detention Basin, Chapter Revised 06-16-09

Virginia Department of Conservation and Recreation. Extended – Detention Basin & Enhanced Extended Detention, Basin Chapter 3



PLAN VIEW



Note: Elevation & Sizes of all Culverts & Orifices

PROFILE

Anderson County, SC

DRY DETENTION BASIN

STANDARD DRAWING NO. WQ-01

APPROVED BY: _____ JANUARY 2013
DATE

DRY DETENTION BASIN MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Dry Detention Basins. Document Dry Detention Basin deficiencies during **annual** inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as a Dry Detention Basin.

The dry detention basin system is defined as the dry detention basin, outlet structure, and pretreatment if provided.

Important maintenance procedures:

- Manage the contributing drainage area to reduce the sediment load.
- Immediately after installing the dry detention basin, water the vegetation twice weekly as needed until the plants become established (typically six weeks).
- Only fertilize the dry detention basin according the results of a soil analysis after the initial fertilization required to establish vegetation.

After the dry detention basin is established, perform inspections once a quarter and after every storm event greater than 1.0 inch for the first year, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Ensure the measuring device used to determine the deposited sediment elevation/depth gives an accurate depth reading and does not penetrate into accumulated sediments.

When the depth reads _____ feet in the main pond, remove the deposited sediment.

When the depth reads _____ feet in the forebay, remove the deposited sediment.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Clean and remove debris from inlet and outlet structures.	After large storm events
Mow side slopes	As needed
Removal of invasive vegetation	Semi-annual
Inspect for damage to outlet control structure	Annual
Inspect for sediment accumulation in the basin and forebay	Annual
Inspect for operational inlet and outlet structures	Annual
Repair embankment, side slopes, undercut or eroded areas	Annual, or as needed
Pesticide/ Nutrient management	Annual, or as Needed
Remove sediment from the forebay	Per design cycle (typical 5-10 year maintenance), after 50% of total forebay capacity is filled
Remove sediment accumulations the main permanent pool	Per design cycle, (typical 5-10 year maintenance) after 25% of permanent pool volume is filled

Perform trouble shooting activities as follows:

BMP element:	Potential problem:	How to remediate the problem:
Entire dry detention basin	Trash/debris is present.	Remove the trash/debris.
Perimeter of dry detention basin	Areas of bare soil and/or erosion	Re-grade the area as necessary, plant vegetation, and water until established.
Inlet device: pipe or swale	Pipe is clogged.	Unclog the pipe. Dispose of sediment off-site.
	Pipe is cracked or damaged.	Replace the pipe.
	Erosion is occurring	Re-grade as necessary to smooth and provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Forebay	Sediment has accumulated and reduced the depth to 50% of the original design depth.	Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a location where it will not cause impacts to streams or the BMP.
	Erosion has occurred or riprap is displaced.	Provide additional erosion protection such as reinforced turf matting or riprap if needed to prevent future erosion problems.
	Weeds are present.	Remove the weeds, preferably by hand. If pesticides are used, wipe them on the plants rather than spraying.
Main treatment area	Sediment has accumulated to a depth greater than the original design sediment storage depth.	Search for source of sediment and remedy the problem if possible. Remove sediment and dispose of properly. Re-vegetate disturbed areas immediately with sod (preferred) or seed protected with erosion blankets.
	Water is standing more than 5 days after a storm event.	Check outlet structure for clogging. If it is a design issue, consult an appropriate professional.
	Weeds and noxious plants are growing in the main treatment area.	Remove the plants by hand or by wiping them with pesticide (do not spray).
Embankment	Shrubs or trees have started to grow on the embankment.	Remove shrubs or trees immediately.
	Grass cover is unhealthy or eroding.	Restore the health of the grass cover – consult a professional if necessary.
	Signs of seepage on the downstream face.	Consult a professional.
	Evidence of muskrat or beaver activity is present.	Use traps to remove muskrats and consult a professional to remove beavers.
	An annual inspection shows that the embankment needs repair.	Make all needed repairs.
Outlet structure	Clogging has occurred.	Clean out the outlet device. Dispose of the sediment off-site.
	The outlet device is damaged	Repair or replace the outlet device.

WQ-2: WET DETENTION BASINS

1.0 Wet Detention Basins

1.1 Description

A wet detention basin is intended to manage both the quantity and quality of stormwater runoff before discharging off-site. The minimum drainage area for wet detention ponds ranges from 10-25 acres, depending on the specific wet detention application.

Stormwater runoff enters a wet detention basin through one or more inlets that discharge into a Forebay that is designed to settle out larger sediment. The runoff then passes over a forebay berm and into the main wet detention basin, becoming part of a combined temporary and permanent storage. The temporary water quality storage volume drains from the wet detention basin over a period of 24-hours. Permanent storage remains in the wet detention basin, where natural processes facilitate both settling and nutrient reduction of the water contained within the wet detention basin.

Wet detention basins are applicable where larger developments in a watershed substantially modify the hydrology and pollutant loading of a watershed. Because wet detention basins are area-intensive, their use in drainage areas smaller than 10 acres is not recommended. Applicable sites include:

- Large single family developments,
- Industrial facilities, and
- Large commercial facilities.

Wet detention basins are capable of removing metals, suspended solids, nitrogen and phosphorous, and other nutrients. Wet detention basins may also be used for water quantity control. The tendency of wet detention basins to attract waterfowl has the potential for higher fecal coliform counts and may not be applicable in watersheds with fecal impairments. Wet detention basins also have the potential to raise the temperature of a receiving stream, and may not be applicable in watersheds with biota susceptible to thermal pollution.

Wet detention basins are classified as being one of the following:

Wet Detention Basin. Wet detention basins have a permanent (dead storage) pool of water. The water quality volume is stored above the permanent pool and released over 24-hours. *The optimum drainage area for a wet detention basin is 25 acres or more.*

Wet Extended Basin. A wet extended basin is a wet basin with an Aquatic Bench where the water quality volume is split evenly between the permanent pool and extended detention storage provided above the permanent pool. The water quality volume is stored above the permanent pool and released over 24-hours. This basin has the potential to have greater pollutant removal efficiencies for Nitrogen and Phosphorus and may be required for nutrient impaired water bodies. *The optimum drainage area for a wet extended basin is 25 acres or more.*

Micropool Extended Basin. The micropool extended basin is a variation of the wet extended detention basin where only a “micropool” is maintained at the outlet to the pond. The outlet structure is designed to detain the water quality volume as extended detention for 24-hours. The micropool prevents re-suspension of previously settled sediments and prevents clogging of the low flow orifice. *The minimum drainage area for a micropool pond is 10 acres and the maximum drainage area is 25 acres.*

1.2 Design

The design of a wet detention basin can be divided into three components of volume: forebay volume, permanent pool volume, and temporary water quality pool volume. Refer to Figures 1 and 2 are schematic and plan views of a properly oriented wet detention pond.

Figure 1: Schematic of a Wet Detention Basin

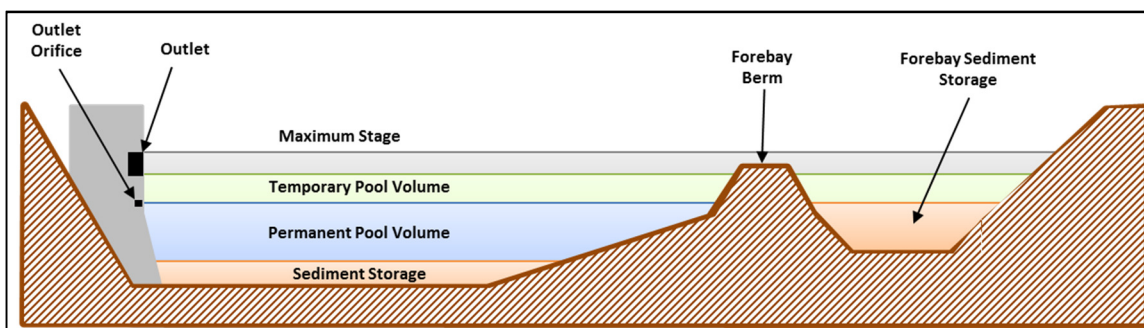
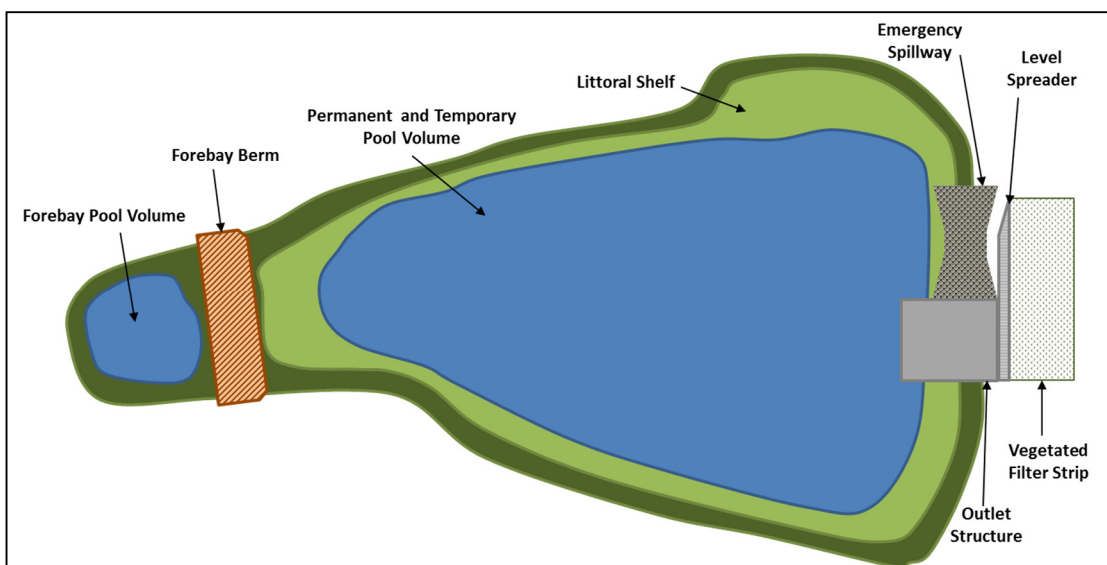


Figure 2: Plan View of a Wet Detention Basin



1.2.1 Flow Length

For maximum wet detention basin water quality benefits, the optimal ratio of flow length to flow width is **3L:1W**. Due to site constraints, the minimum allowable design ratio of flow length to flow width is **1.5L:1W**. To increase the pond's flow length to flow width ratio, the basin may be design with baffles.

Optimizing the wet basin flow shape and flow distance through the pond promotes better water quality treatment. Settling is the primary pollutant removal mechanism sought when addressing flow length as a water quality design feature. Wet detention basins designed with optimum flow lengths will avoid the problem of dead storage or incoming runoff short circuiting through the pond. Optimum flow lengths will also decrease the turbulence within the basin and minimize the re-suspension of deposited sediments.

Design wet detention basins with a wedge-shaped (when practicable), with the widest cross sections occurring at the downstream end of the basin. Design the deepest pools at the downstream end of the basins to help facilitate cooler effluent water temperatures.

1.2.2 Permanent Pool Volume

A wet detention basin is designed to meet an 80% target TSS removal efficiency. This is accomplished by providing the following minimum Permanent Pool Volumes:

Wet Detention Basins, design the minimum permanent pool volume equal to **1-inch of runoff** from the drainage area.

Wet Extended Basins with Aquatic Bench, design the minimum permanent pool volume equal to **½-inch of runoff** from the drainage area.

Micropool Extended Basins, design the minimum permanent pool volume equal to **0.1-inch of runoff** from the drainage area.

Design the permanent pool with an optimal depth between **4 and 6 feet**, with a minimum depth of 4 feet and a maximum depth of 12 feet. Ensure the bottom of the basin is located at least 2 feet from the seasonally high water table.

1.2.3 Temporary Water Quality Pool Volume

The temporary water quality volume is **½-inch of runoff from the drainage area**. Each wet detention basin must be able to hold the water quality volume above the permanent pool and release this volume over a 24-hour period. This is achieved through an outlet orifice or other flow control device.

1.2.4 Low Flow Orifice

Use a low flow orifice to slowly release the water quality volume over a period of 24-hours or longer depending upon the design criteria for the water quality structure. Wet ponds with slow release rates for water quality control require small outlet control structures. These structures are prone to becoming clogged. Ensure the low flow orifice is protected from clogging by designing appropriate trash guards.

Acceptable trash guards include:

- Trash boxes made of sturdy wire mesh that cover the low flow orifice.
- Floating Skimmers
- Hoods that extend at least **6-inches** below the permanent pool water surface elevation.
- Reverse flow pipes where the outlet structure inlet is located below the permanent pool water surface elevation.
- **Hoods or Reverse flow pipes are required for wet extended basins and micropool extended basins.**

1.2.5 Aquatic Vegetation

Aquatic vegetation plays an important role in pollutant removal in a wet extended basins and micropool extended basins. Vegetation enhances the appearance of wet extended basins and micropool extended basins and stabilizes side slopes.

1.2.5.1 Wet Extended Basin Aquatic Bench

To facilitate nutrient removal by emergent wetland vegetation, design a planted littoral shelf **5-15** feet wide around the permanent pool where **6 to 18 inches** of the permanent pool is maintained over the littoral shelf to promote the growth of emergent wetland vegetation. Plant a minimum of **3 types** of indigenous emergent wetland species at a minimum density of **50 plants per 200 square feet**. The selection of the proper plant

species and planting locations is an integral part in designing a successful aquatic bench in the wet extended basin. Prepare a planting plan by a qualified landscape architect or wetland ecologist for the aquatic bench.

Do not plant woody vegetation on the embankment or within **100 feet** of the toe of the embankment or **25 feet** from the principal spillway structure.

Ensure a maintenance plan is established for maintaining the aquatic vegetation.

1.2.5.2 Micropool Extended Basin Aquatic Vegetation

To facilitate nutrient removal by emergent wetland vegetation, design a planted littoral shelf **5-10 feet** wide around the permanent pool where **6 to 18 inches** of the permanent pool is maintained over the littoral shelf to promote the growth of emergent wetland vegetation. Plant a minimum of **3 types** of indigenous emergent wetland species at a minimum density of **50 plants per 200 square feet**.

Plant the main extended detention area of micropool basins with plant species that are tolerant to wide fluctuations in soil moisture content. Use plantings capable of tolerating saturated soil conditions for the length of time anticipated for the water quality volume, as well as anticipated runoff constituents.

The selection of the proper plant species and planting locations is an integral part in designing a successful micropool extended basin. Prepare a planting plan by a qualified landscape architect or wetland ecologist for the aquatic vegetation.

Do not plant woody vegetation on the embankment or within **100 feet** of the toe of the embankment or **25 feet** from the principal spillway structure.

Ensure a maintenance plan is established for maintaining the aquatic vegetation.

1.2.6 Forebay

The function of the Forebay is to trap the majority of the coarse fractions of the suspended solids in the runoff before it enters the main wet detention area, therefore allowing the main pond to maintain its original design volume

Design the Forebay volume (or combined volume of Forebays) equal to a minimum of **10%** of the overall water quality treatment volume. Each Forebay is sized according to the corresponding outlet's contribution to the basin. Provide a Forebay for all inlets to a wet detention basin and place Forebays upstream of the main wet detention area. A Forebay is not required for an outlet that contributes less than **10%** of the total drainage area or to the basin.

Design Forebay side slopes to be **2H:1V** or flatter.

The Forebay is separated from the larger wet detention basin area by berms, barriers, or baffles that may be constructed of earth, stones, riprap, gabions, or geotextiles. The berm, barrier, or baffles act as a trap for coarse sediments and minimize their movement into the main detention basin. The Forebay berm may incorporate drain pipe or be constructed of riprap to facilitate equalization of the pond over time.

Design the top of the Forebay barrier a maximum of **1-foot** below the permanent pool elevation, and it may extend above the elevation of the permanent pool.

Design the Forebay depth, as measured from the maximum water quality event surface level, between **4 and 6 feet**. To minimize the re-suspension of settled particles, design the minimum permanent pool depth of water in the forebay **3-feet** above the design sediment storage elevation.

Design the Forebay so approximately **75%** of the required permanent sediment storage volume (per maintenance design cycle with a typical 5-10 year maintenance), is allocated to the Forebay.

Design the Forebay in a manner that it is accessible for easy cleanout because it will eventually fill in with coarse particles. Design the access to the Forebay with a maximum slope of **15% - 20%** extending from the top of the embankment to the toe

1.2.7 Principal Spillway

Design the principal spillway to safely pass, at a minimum, the 10-year, 24-hour storm event. Design the principal spillway with a trash rack.

1.2.8 Emergency Spillway

Design emergency spillways to safely pass the post development 100-year, 24-hour storm event without overtopping any dam structures. Design the 100-year water surface elevation a minimum of 1 foot below the top of the dam embankment

1.3 Other Design Requirements

If the underlying soil is Hydrologic Soil Group A, B, or C, perform an infiltration test on the wet detention basin bottom must. If the infiltration rate exceeds **0.01in/hour**, a liner or clay pack is required.

A level spreader may be installed at the wet detention basin outlet structure to prevent destabilization of the receiving water body. The installation of a **30 foot** wide filter strip beyond the level spreader is recommended.

1.4 Installation

Perform the follow for all Wet Detention Basin installations:

1. Route all channels and pipes conveying flow to the basin away from the basin area until the basin is complete and stabilized.
2. Clear, grub, and strip the area under the embankment of all vegetation and root mat. Remove all surface soil containing high amounts of organic matter, and stockpile or dispose of it properly. Remove all unused fill material to the designated disposal area.
3. Ensure that fill material for the embankment is free of roots, woody vegetation, organic matter, and other objectionable material. Place the fill in lifts not to exceed 9 inches, and machine compact it. Over fill the embankment 6 inches to allow for settlement.
4. Install inlet and outlet control structures. Ensure principal spillway and emergency spillway installed to proper elevations as specified in the engineering drawings.
5. Grade the basin so that the bottom is level front to back and side to side and prepare subsoil.
6. Apply and grade planting soil for wet extended aquatic bench.
7. Install forebay and erosion control at pond inlets/outlets
8. Seed, plant and mulch the embankments and the wet extended aquatic bench
9. Route flow from contributing watershed to the basin as shown in the engineering drawings.
10. Follow required maintenance guidelines.

1.5 Maintenance

1.5.1 Aquatic Vegetation Maintenance

Maintain a minimum cover of **85%** cover of the emergent vegetation. Perform annual vegetation harvesting to increase the nutrient removal efficiencies. Perform harvesting in the summer so that there is adequate

regrowth before winter. Ensure minimal pond disturbance, especially to bottom sediments, during harvesting.

Aquatic shelves can become overgrown with invasive plants. The most common invasive plant is the Cattail (*Typha* species). Cattails crowd out other, more desirable plants. Other unwanted plant species include common reed (*Phragmites* species), various noxious floating aquatics (such as parrot feather, *Myriophyllum aquaticum*, and giant salvinia, *Salvinia* spp.), and Asiatic dayflower (*Murdannia keisak*).. Noxious floating aquatics may require careful chemical or physical removal. If these exotic invasive species are present, contact the County Extension agent. The frequency of required invasive plant removal varies based on several factors including:

- the density at which the wetland is planted with desirable species,
- the time of year the wetland is planted, and
- the maturity of the wetland.

During the first year or two after establishment, remove invasives twice a year. As the desirable species begin to dominate, reduce the maintenance frequency to once a year.

1.5.2 General Maintenance

Proper maintenance ensures the continued functionality of the wet detention basin. Tables 1, 2 and 3 outline the various maintenance requirements after the installation of a wet detention basin.

Table 1: Summary of Maintenance Requirements

Required Maintenance	Frequency
Clean and remove debris from inlet and outlet structures.	After large storm events
Mow side slopes	As needed
Removal of invasive vegetation	Semi-annual
Inspect for damage to outlet control structure	Annual
Inspect for sediment accumulation in the basin and forebay	Annual
Inspect for operational inlet and outlet structures	Annual
Repair embankment, side slopes, undercut or eroded areas	Annual, or as needed
Perform wetland plant management and harvesting	Annual
Pesticide/ Nutrient management	Annual, or as Needed
Remove sediment from the forebay	Per design cycle (typical 5-10 year maintenance), after 50% of total forebay capacity is filled
Remove sediment accumulations from the main permanent pool	Per design cycle, (typical 5-10 year maintenance) after 25% of permanent pool volume is filled

Table 2: Summary of Maintenance Requirements

Component	Maintenance	Frequency
Basin banks	Pruning and weeding.	As required
	Remove trash and debris.	As required
	Repair eroded areas, replant grass. If recurring problem, consider sodding.	Semi-Annual (every 6 months)
	Inspect trees and shrubs to evaluate their health.	Annually
Littoral Shelf	Survey the plant species, if monoculture developing, take appropriate action.	Annually
	Remove and replace dead or severely diseased vegetation.	Annually
	Removal of evasive vegetation.	Semi-Annual (every 6 months)
Permanent pool	Remove sediment when accumulated sediment reaches 20-25% volume or every 5-15 years.	As required
	Apply algacide	When algal growth > 50% pond surface.
Forebay	Remove sediment when accumulated sediment reaches 25-50% volume	As required
Outlet structure	Clean out outlet of all debris	Semi-Annually (every 6 months)
	Check if bank needs stabilization downstream of outlet.	Semi-Annually (every 6 months)

Table 3: Summary of Trouble Shooting Activities

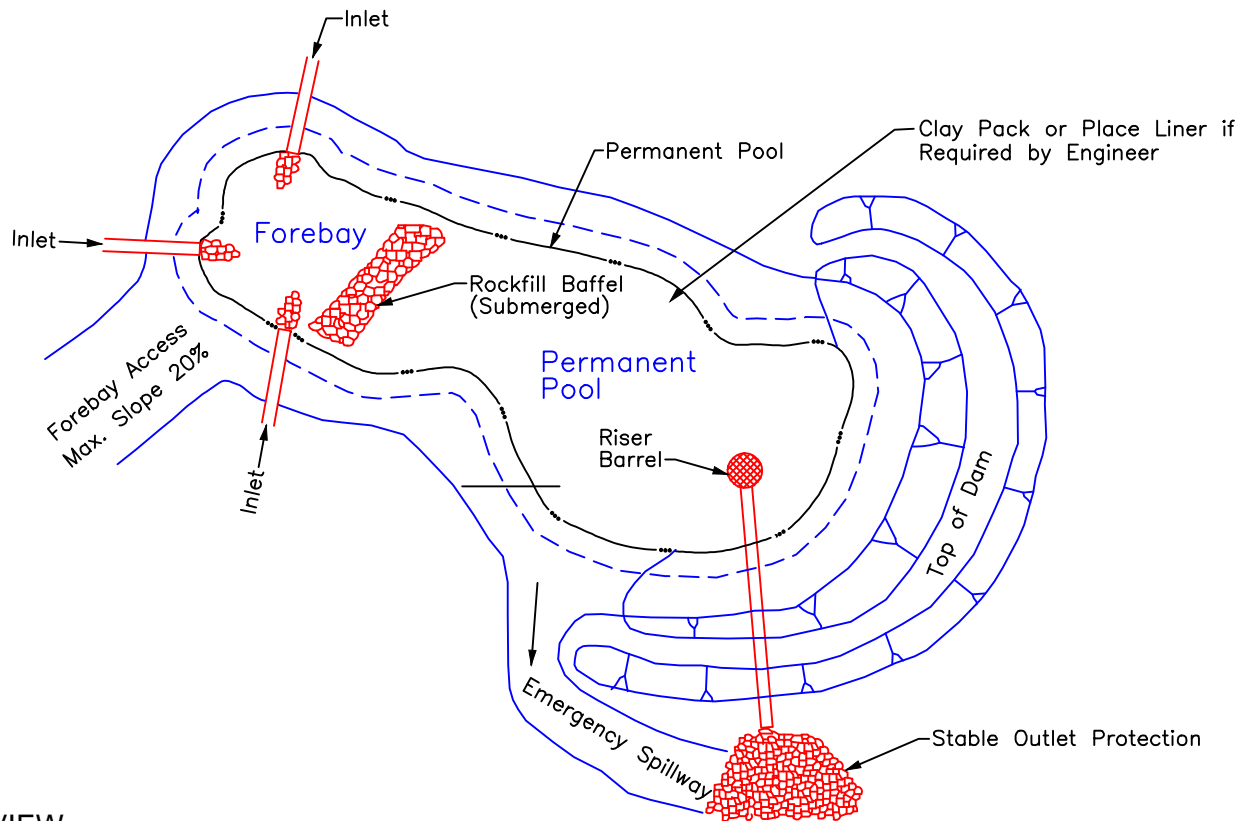
Component	Problem	Solution
Entire wet detention basin	Trash/debris is present.	Remove the trash/debris.
Perimeter	Areas of bare soil and/or erosion	Re-grade the area as necessary, plant vegetation, and water until established.
Inlet device: pipe or swale	Pipe is clogged.	Unclog the pipe. Dispose of sediment properly.
	Pipe is cracked or damaged.	Replace the pipe.
	Erosion is occurring	Re-grade as necessary to smooth and provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Forebay	Sediment has accumulated and reduced the depth to 50% of the original design depth.	Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a proper location.
	Erosion has occurred or riprap is displaced.	Provide additional erosion protection such as turf reinforcement matting or riprap if needed to prevent future erosion problems.
	Weeds are present.	Remove the weeds, preferably by hand. If pesticides are used, wipe them on the plants rather than spraying.
Main treatment area	Sediment has accumulated to a depth greater than the original design sediment storage depth.	Search for source of sediment and remedy the problem if possible. Remove sediment and dispose of properly. Re-vegetate disturbed areas immediately with sod (preferred) or seed protected with erosion blankets.
	Pruning is needed to maintain optimal plant health.	Prune according to best professional practices
	Plants are dead, diseased or dying.	Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a one-time fertilizer application to establish the ground cover if a soil test indicates it is necessary.
	Weeds and noxious plants are growing in the main treatment area.	Remove the plants by hand or by wiping them with pesticide (do not spray).

Embankment	Shrubs or trees have started to grow on the embankment.	Remove shrubs or trees immediately.
	Grass cover is unhealthy or eroding.	Restore the health of the grass cover – consult a professional if necessary.
	Signs of seepage on the downstream face.	Consult a professional.
	Evidence of muskrat or beaver activity is present.	Use traps to remove muskrats and consult a professional to remove beavers.
	An annual inspection shows that the embankment needs repair.	Make all needed repairs.
Outlet structure	Clogging has occurred.	Clean out the outlet device. Dispose of the sediment off-site.
	The outlet device is damaged	Repair or replace the outlet device.

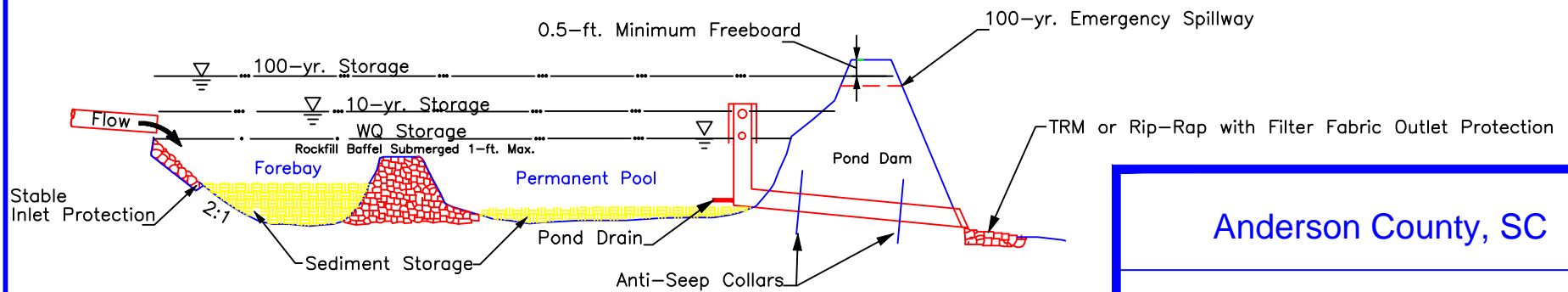
1.6 References

2010 Greenville County Storm Water Management Design Manual.

NCDENR Stormwater BMP Manual, Chapter 10 Wet Detention Basin, Chapter Revised 06-16-09



PLAN VIEW



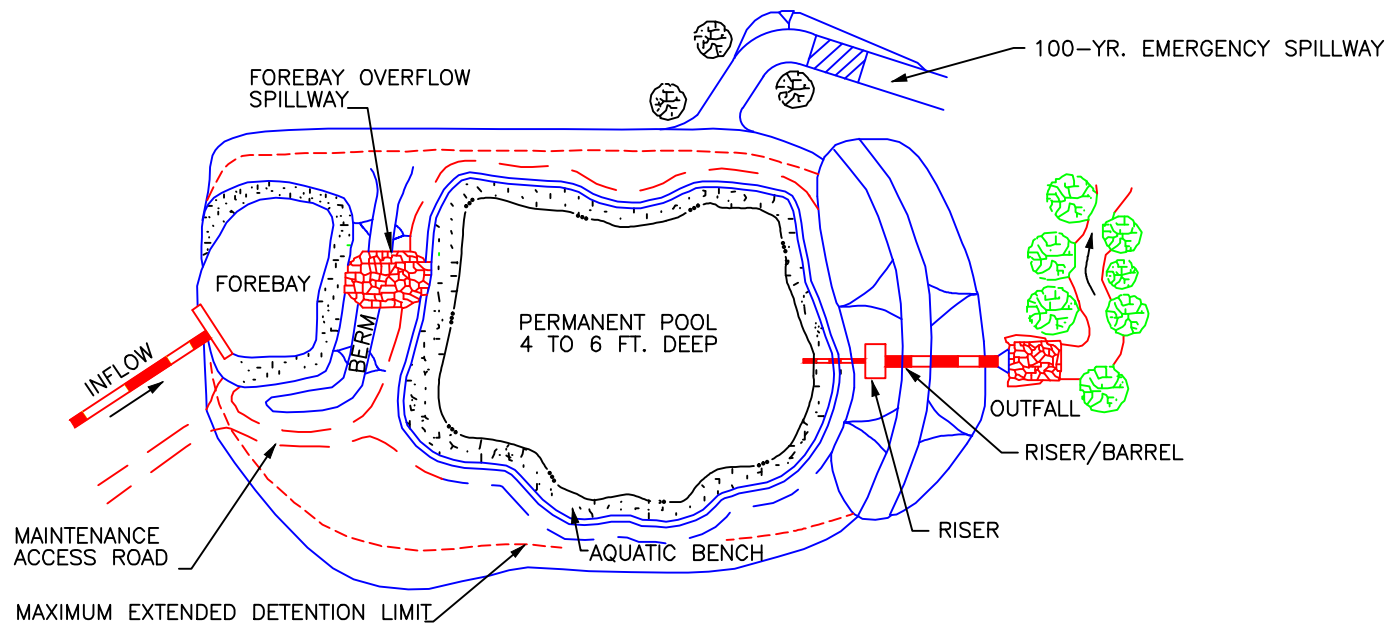
PROFILE

Anderson County, SC

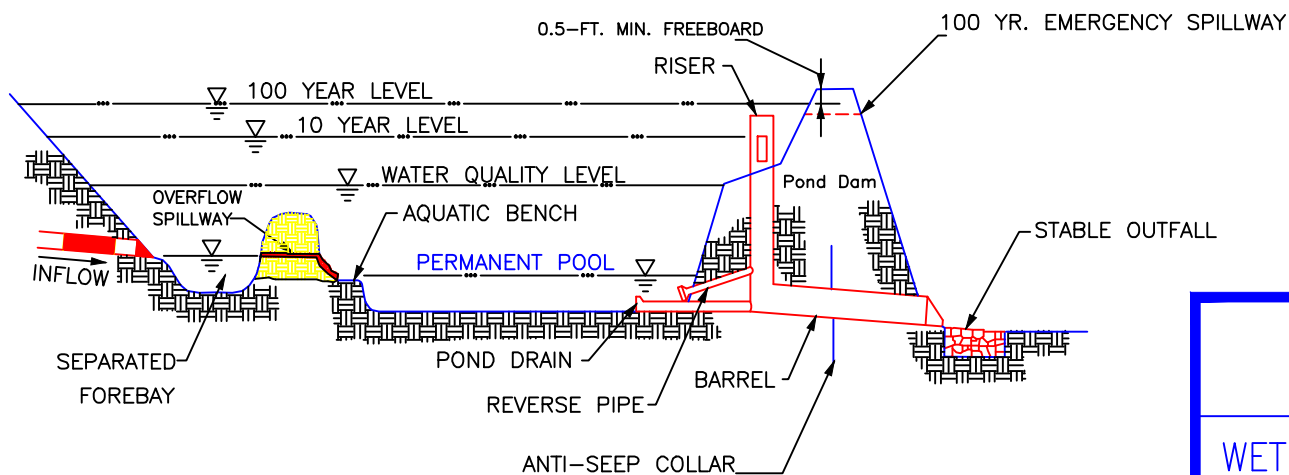
WET DETENTION POND

STANDARD DRAWING NO. WQ-1A

APPROVED BY: _____ JANUARY, 2013
DATE



PLAN VIEW



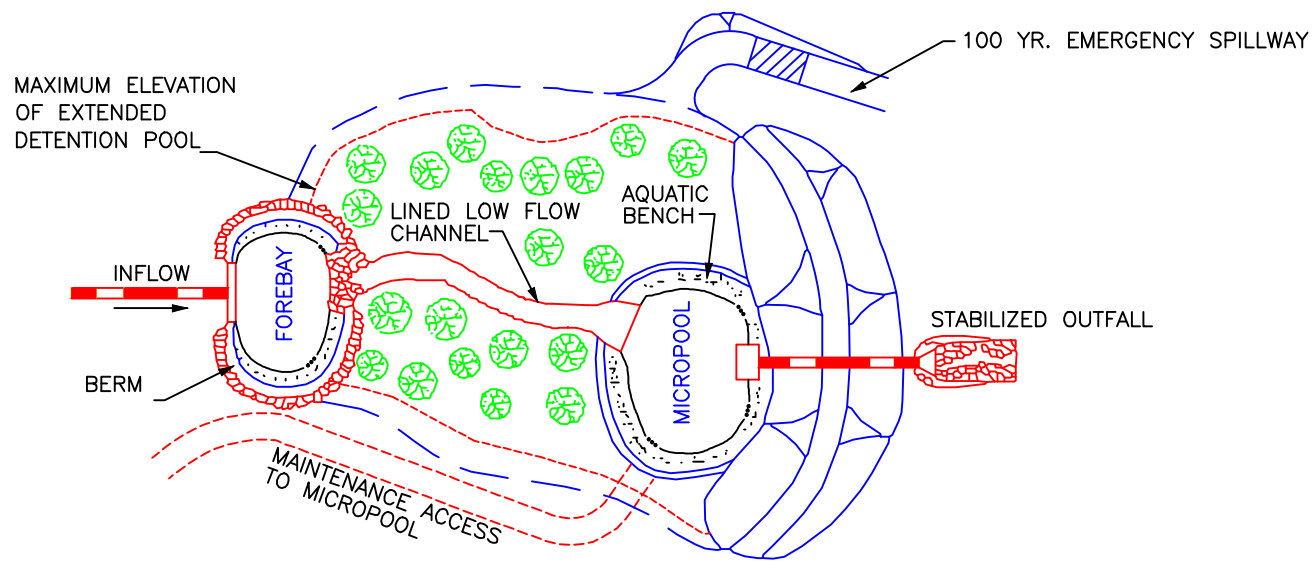
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Anderson County, SC

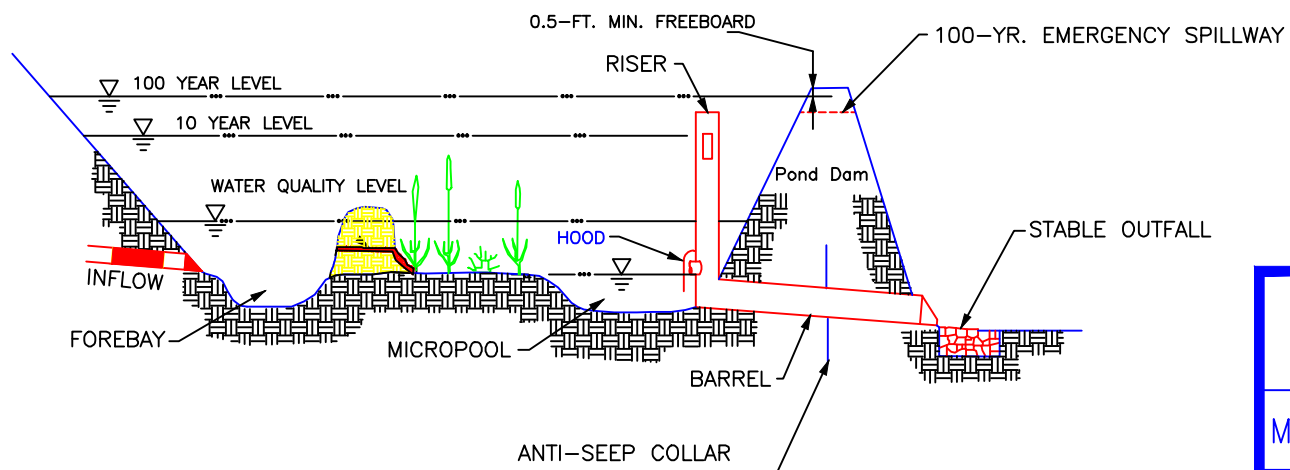
WET EXTENDED DETENTION POND

STANDARD DRAWING NO. WQ-01B

APPROVED BY: _____ JANUARY, 2013
DATE



PLAN VIEW



PROFILE

Anderson County, SC

MICROPOOL EXTENDED DETENTION POND

STANDARD DRAWING NO. WQ-1C

APPROVED BY: GREENVILLE COUNTY STORM WATER MANAGEMENT

JANUARY, 2013
DATE

WET DETENTION BASIN MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Wet Detention Basins. Document Wet Detention Basin deficiencies during annual inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as a Wet Detention Basin.

The wet detention basin system is defined as the dry detention basin, outlet structure, and pretreatment if provided.

Important maintenance procedures:

- Immediately after the wet detention basin is established, water the plants on the vegetated shelf and perimeter of the basin twice weekly if needed, until the plants become established (typically six weeks).
- Only fertilize the wet detention pond according the results of a soil analysis after the initial fertilization required to establish vegetation.
- Ensure a stable groundcover is maintained in the drainage area to reduce the sediment load.
- Minimize the flushing of sediment through the emergency drain to the maximum extent practical when draining the wet detention basin for maintenance or emergency activities.

After the wet detention basin is established, perform inspections once a quarter and after every storm event greater than 1.0 inch for the first year, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Ensure the measuring device used to determine the deposited sediment elevation/depth gives an accurate depth reading and does not penetrate into accumulated sediments.

When the depth reads _____ feet in the main pond, remove the deposited sediment.

When the depth reads _____ feet in the forebay, remove the deposited sediment.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Clean and remove debris from inlet and outlet structures.	After large storm events
Mow side slopes	As needed
Removal of invasive vegetation	Semi-annual
Inspect for damage to outlet control structure	Annual
Inspect for sediment accumulation in the basin and forebay	Annual
Inspect for operational inlet and outlet structures	Annual
Repair embankment, side slopes, undercut or eroded areas	Annual, or as needed
Perform wetland plant management and harvesting	Annual
Pesticide/ Nutrient management	Annual, or as Needed
Remove sediment from the forebay	Per design cycle (typical 5-10 year maintenance), after 50% of total forebay capacity is filled
Remove sediment accumulations the main permanent pool	Per design cycle, (typical 5-10 year maintenance) after 25% of permanent pool volume is filled

Perform trouble shooting activities as follows:

BMP Component	Problem	Solution
Entire wet detention basin	Trash/debris is present.	Remove the trash/debris.
Perimeter	Areas of bare soil and/or erosion	Re-grade the area as necessary, plant vegetation, and water until established.
Inlet device: pipe or swale	Pipe is clogged.	Unclog the pipe. Dispose of sediment properly.
	Pipe is cracked or damaged.	Replace the pipe.
	Erosion is occurring	Re-grade as necessary to smooth and provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Forebay	Sediment has accumulated and reduced the depth to 50% of the original design depth.	Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a proper location.
	Erosion has occurred or riprap is displaced.	Provide additional erosion protection such as turf reinforcement matting or riprap if needed to prevent future erosion problems.
	Weeds are present.	Remove the weeds, preferably by hand. If pesticides are used, wipe them on the plants rather than spraying.
Main treatment area	Sediment has accumulated to a depth greater than the original design sediment storage depth.	Search for source of sediment and remedy the problem if possible. Remove sediment and dispose of properly. Re-vegetate disturbed areas immediately with sod (preferred) or seed protected with erosion blankets.
	Pruning is needed to maintain optimal plant health.	Prune according to best professional practices
	Plants are dead, diseased or dying.	Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a one-time fertilizer application to establish the ground cover if a soil test indicates it is necessary.
	Weeds and noxious plants are growing in the main treatment area.	Remove the plants by hand or by wiping them with pesticide (do not spray).
Embankment	Shrubs or trees have started to grow on the embankment.	Remove shrubs or trees immediately.
	Grass cover is unhealthy or eroding.	Restore the health of the grass cover – consult a professional if necessary.
	Signs of seepage on the downstream face.	Consult a professional.
	Evidence of muskrat or beaver activity is present.	Use traps to remove muskrats and consult a professional to remove beavers.
	An annual inspection shows that the embankment needs repair.	Make all needed repairs.
Outlet structure	Clogging has occurred.	Clean out the outlet device. Dispose of the sediment off-site.
	The outlet device is damaged	Repair or replace the outlet device.

WQ-03: BIORETENTION

1.0 Bioretention

1.1 Description

Bioretention areas are stormwater basins intended to provide water quality management by filtering stormwater runoff before release into a stormwater conveyance system or stabilized outfall. Use individual Bioretention areas for drainage areas up to two (2) acres in size.

Stormwater runoff enters Bioretention areas and is temporarily stored in a shallow pond on top of a filter media layer. The ponded water then slowly filters down through the filter media 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.

Bioretention is applicable for small sites where stormwater runoff rates are low and can be received into the Bioretention area as sheet flow. Because Bioretention areas are sensitive to fine sediments, do not install them on sites where the contributing area is not completely stabilized or is periodically being disturbed. Applicable sites include:

- Parking lot islands,
- Cul-de-sacs,
- Common areas,
- Individual residential home sites, and
- Small commercial facilities.

Bioretention areas are capable of removing metals, suspended solids, and oil and grease, and phosphorus but may perform poorly in the removal of nitrogen. In areas where nitrogen is a pollutant of concern, the Bioretention area underdrain system can be adapted to provide some denitrification.

1.2 Design

1.2.1 General Design Criteria

Design Bioretention areas to treat the water quality volume of runoff from the entire drainage basin. Bioretention areas work best when constructed off-line, capturing only the water quality volume. Divert excess runoff away from the Bioretention area or collect it with an overflow catch basin.

Design Bioretention areas to fit around natural topography and complement the surrounding landscape. Bioretention areas can be of any reasonable shape and can be fit around sensitive areas, natural vegetation, roads, driveways, and parking lots.

Typical Bioretention areas have a minimum width of ten (10) feet and a minimum flow length of forty (40) feet to establish a strong healthy stand of vegetation.

Where nitrogen or phosphorus is a concern, create a 90 degree elbow in the underdrain system from the bottom of the Bioretention area to create an Internal Water Storage Zone to encourage the denitrification process.

A summary of the design characteristics for Bioretention areas is shown in Table 1.

Table 1. General Design Characteristics for Bioretention Areas

Infiltration Rate	Between 1- and 6-inches per hour for Filter Media.
Maximum Water Depth	Range from 6- to 12-inches, with a 9-inch standard.
Surface Area	Varies, but typically 3 to 8% of the contributing watershed, depending on the amount of impervious area.
Water Table	Vertical distance of 3 feet between bottom of Bioretention area and seasonally high ground water table (typically 4- to 6-feet below ground surface of the Bioretention).
Places to Avoid	Areas that regularly flood (at least once a year) and areas adjacent to building foundations.
Mulch	A minimum of 2-inches is required while 3- to 4-inches is preferable. Use hardwood, not pine bark nuggets (float). Double-shredded hardwood works well.
Stone for Gravel Layer	Washed stone is preferred. Separate the gravel from the Filter Media with a permeable geotextile.

Source: Urban Waterways / Urban Storm Water Structural Best management Practices (BMPs), North Carolina Extension Service, June, 1999.

1.2.2 Surface Area

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

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

Where:

- BSA = Bioretention surface area (feet²)
- DA = Contributing drainage area of Bioretention area (feet²)
- Rv = Runoff volume (feet) 0.083-feet (1-inch) for Anderson County
- Davg = 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:

$$BSA = 0.1(Rv)(DA)$$

Where:

- BSA = Bioretention surface area (feet²)
- 0.1 = Empirical conversion factor
- Rv = Runoff volume (inches) 1-inch for Anderson County
- DA = Contributing drainage area of Bioretention area (feet²)

1.2.3 Water Draw Down Time

Design Bioretention areas to fully de-water within a 24- to 72-hour period depending on the dimensions, filter media, and underdrain system. In order to allow for proper pollutant removal, design for the ponded runoff above the Bioretention area surface to drain in a maximum of 12 hours. Design for runoff within the filter media to drain to a depth of 2-feet below the Bioretention area surface within 48 hours.

Design the underdrain system to safely pass the peak draw down flow rate of the filter media. 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 filter media (in/hr) (Value varies based on actual filter media used)
A = Surface area of bioretention (feet²)
 ΔH = Maximum ponding depth above bottom of soil mix (feet)
 ΔL = Depth of soil mix (feet)

Typical hydraulic conductivity values are given in Table 2.

Table 2. General Hydraulic Conductivity of Soils

Soil Classification	Hydraulic Conductivity (inches/hour)
Sand	6.0
Loamy Sand	2.0
Sandy Loam	0.5-1.0

Source: Urban Waterways / Urban Storm Water Structural Best Management Practices (BMPs), North Carolina Extension Service, June, 1999.

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 (feet³) by multiplying the Bioretention area (feet²) by the ponded water depth (feet).
 - Divide the total ponded water volume (feet³) 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 filter media.
 - Calculate the total volume of water contained in the filter media (feet³) by multiplying the Bioretention area (feet²) by the filter media depth (feet) by the porosity (dimensionless) of the filter media.
 - Divide the filter media water volume (feet³) 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 filter media to calculate the total Bioretention area draw down time.

1.3 Materials

Bioretention areas consist of an underdrain system, an internal water storage zone/ denitrification zone (if required) a filter media, an overflow system, plantings, a mulch layer and a pre-treatment system.

1.3.1 Underdrain System

Place an underdrain system beneath the filter media for all Bioretention areas as many of the native soils found in Anderson County do not allow for adequate infiltration.

Provide an underdrain system that consists of continuous closed joint perforated plastic pipe underdrains with a minimum 4-inch diameter, an 8-inch minimum gravel filter layer, a nonwoven geotextile filter fabric to separate the gravel from the native soils and the gravel from the filter media, and minimum 4-inch diameter non-perforated PVC clean out wells.

The maximum spacing of pipe underdrains is 10 feet.

Design the under drain system to safely pass the peak draw down rate calculated in Section 1.2.3.

Table 3: Underdrain Material Specifications

Material	Specification
No. 57 Aggregate	Use course aggregate No. 57 consisting of crushed slag or gravel.
Pipe Underdrains	Use PVC perforated pipe (AASHTO M 252) underdrains with a minimum diameter of 4-inches.
Clean Out and Outlet Pipe	Use non-perforated pipe underdrains with a minimum diameter of 4-inches.
Nonwoven Geotextile Fabric	Use Class 2 Type C non-woven geotextile fabric.

1.3.2 Internal Water Storage Zone (Denitrification Zone)

If required for enhanced nitrogen and phosphorus removal, provide an Internal Water Storage Zone sized to hold the water quality volume below the outlet of the underdrain system. A nonwoven geotextile fabric is not required between this zone and the underdrain system. Provide a nonwoven geotextile fabric between the Internal Water Storage Zone and the underlying native soil. The Internal Water Storage Zone consists of the Filter Media and the stone used in the underdrain system. Adding a suitable carbon source like wood chips to the gravel in the Internal Water Storage Zone provides a nutrition source for anaerobic microbes and can enhance the denitrification process.

Design the Internal Water Storage Zone to treat the water quality volume of runoff from the entire drainage basin. Calculate the surface area of the Internal Water Storage Zone area by dividing the water quality volume by the ponding depth (min 12 inches).

Provide a minimum of 12 inches of Filter Media above the max ponding height of the Internal Water Storage Zone.

Install a valve as specified in Section 1.4.2.3 for dewatering the Internal Water Storage Zone if prolonged standing water occurs.

1.3.2 Filter Media

The filter media provides a medium for physical filtration for the stormwater runoff with enough organic matter content to support provide water and nutrients for plant life.

Ensure the filter media of the Bioretention area is level to allow uniform ponding over the entire area. The maximum ponding depth above the filter media is 9-inches to 12-inches to allow the Bioretention area to drain within a reasonable time and to prevent long periods of plant submergence. Provide a filter media with a minimum infiltration rate of 1.0 in/hour and a maximum rate of 6.0 in/hr. The average porosity of the filter media is approximately 0.45.

The USDA textural classification of the filter media is Loamy Sand or Sandy Loam. The filter media is furnished, and on-site soils are not acceptable. Test the filter media to meet the following criteria:

Table 4: Filter Media Material Specifications

Item	Percent of Total Filter Media by Weight	ASTM Sieve Size	Percent Passing by Weight
Sand* Clean, Washed, Well Graded, No Organic Material <i>Aggregate No. FA-10</i> <i>ASTM C-33 Concrete Sand</i> <i>AASHTO M-6</i> <i>AASHTO M-43, No. 9 or No. 10</i>	80% Max	3/8 in.	100
		No. 4	95-100
		No. 8	80-100
		No. 16	50-85
		No. 30	25-60
		No. 50	10-30
		No. 100	2-10
		No. 200	0-3
Screened Topsoil <i>Loamy Sand or Sandy Loam</i> <i>ASTM D5268</i> <i>(imported or manufactured topsoil)</i> <i>Max 5% clay content</i>	15% Max.	2 in.	100
		1 in.	95- 100
		No. 4	75-100
		No. 10	60-100
		No. 200	10-50
		0.002 mm	0-5
Organic Matter in the form of Compost, Leaf Compost, Peat Moss or Pinebark Nursery Mix**	5% Min	3/8 in.	85-100
		No. 8	50-80
		No. 30	0-40

***Do not use lime stone screenings.**

**** Potting grade pine bark with no particles larger than 1/2 inches.**

Submit the source of the filter media and test results to the ENGINEER prior to the start of construction of Bioretention areas. Do not add material to a stockpile of filter media once a stockpile has been sampled. Allow sufficient time for testing. Utilize a filter media from a certified source or laboratory to reduce mobilization time and construction delays.

Use a filter media that is uniform, free of stones, stumps, roots or other similar objects larger than two inches excluding mulch. Do not mix or dump materials or substances within the Bioretention area that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations.

Test the filter media to meet the criteria shown in Table 5:

Table 5: Filter Media Chemical Analysis

Item	Criteria	Test Method
Corrected pH	6.0 – 7.5	ASTM D4972
Magnesium	Minimum 32 ppm	*
P-Index	0-30	USDA Soil Test
Phosphorus (Phosphate - P ₂ O ₅)	Not to exceed 69 ppm	*
Potassium (K ₂ O)	Minimum 78 ppm	*
Soluble Salts	Not to exceed 500 ppm	*

* Use authorized soil test procedures.

Should the filter media pH fall outside of the acceptable range, modify with lime (to raise pH) or iron sulfate plus sulfur (to lower pH). Uniformly mix lime or iron sulfate into the filter media prior to use in Bioretention areas.

Modify the filter media with magnesium sulfate if the filter media does not meet the minimum requirement for magnesium. Modify the filter media with potash if the filter media does not meet the minimum requirement for potassium. Uniformly mix magnesium sulfate and potash into the filter media prior to use in Bioretention areas.

A filter media that fails to meet the minimum requirements must be replaced.

The recommended depth of the filter media is shown in Table 6.

Table 6: Filter Media Depth

Vegetation	Filter Media Depth (ft)
Turf Grass Only	2.0
Native Grasses or Shrubs	3.0
Small Trees	4.0

1.3.3 Overflow System

Design an overflow system to pass runoff volumes greater than the water quality volume away from the Bioretention area. Place an outflow structure at the elevation of the maximum 9-inch to 12-inch ponding depth above the Bioretention area surface to carry excess runoff to a stormwater conveyance system or stabilized outlet.

1.3.4 Plantings

Use plantings that conform to the standards of the current edition of *American Standard for Nursery Stock* as approved by the American Standards Institute, Inc.

For Bioretention applications near roadways, consider site distances and other safety concerns when selecting plant heights. Consider human activities which may damage the plantings, cause soil compaction or otherwise damage the function of the Bioretention area when selecting plant species.

Use plant materials that have normal, well developed stems or branches and a vigorous root system. Only use plantings that are healthy, free from physical defects, plant diseases, and insect pests. Symmetrically balance shade and flowering trees. Ensure major branches do not have V shaped crotches capable of causing structural weakness. Ensure trunks are free of unhealed branch removal wounds greater than a 1 in. diameter.

Use plant species that are tolerant to wide fluctuations in soil moisture content. Use plantings capable of tolerating saturated soil conditions for the length of time anticipated for the water quality volume, as well as anticipated runoff constituents.

Acceptable Bioretention area plantings include:

- Turf Grass only,
- Native Grasses and Perennials,
- Shrubs, and
- Trees.

1.3.4.1 Turf Grass Only

Use turfgrass species with a thick dense cover, slow growing, applicable to the expected moisture conditions (dry or wet), do not require frequent mowing, and have low nutrient requirements. The preferred method of establishing turf grass is sodding. Use temporary erosion control blankets to provide temporary cover when establishing turf grass by seeding.

1.3.4.2 Native Grasses and Perennials

Create a low maintenance native grass or wildflower meadow with native grasses and native perennial species. Temporary erosion control blankets may be used in lieu of a hardwood mulch layer. Plant native grasses and perennials of the same species in clusters 1.0 to 1.5 feet on-center.

1.3.4.3 Shrubs

Provide shrubs a minimum of 2-feet in height. Do not plant shrubs near the inflow and outflow points of the Bioretention area. Plant shrubs of the same species in clusters 10 feet on-center.

1.3.4.4 Trees

Provide trees with a minimum 1-inch caliper. Plant trees near the perimeter of the Bioretention area. Do not plant trees near the inflow and outflow points of the Bioretention area. Do not plant trees directly above Underdrains. Plant trees at a density of one tree per 250 square feet.

1.3.4.5 Planting Plan

A Bioretention area landscape plan includes all planting types, total number of each species, and the location of each species used. The plan includes a description of the contractor's responsibilities including a planting schedule, installation specifications, initial maintenance, a warranty period, and expectations of plant survival. A planting plan includes long-term inspection and maintenance guidelines. Use planting plans prepared by a qualified landscape architect, botanist or qualified extension agent. Use native plant species over non-native species. Ornamental species may be used for landscaping effect if they are not aggressive or invasive. Typical plantings are shown in Table 7.

Table 7: Native Plant Species for Bioretention Areas

Perennials/Grasses	Shrubs	Trees
Eastern Bluestar (<i>Amsonia tabernaemontana</i>)	Beautyberry (<i>Callicarpa americanas</i>)	Red Buckeye (<i>Aesulus pavia</i>)
Swamp Milkweed (<i>Asclepias incarnata</i>)	Button Bush (<i>Cephalanthus occidentalis</i>)	Serviceberry (<i>Amelanchier canadensis</i>)
Butterfly Milkweed (<i>Asclepias tuberosa</i>)	Sweet Pepperbush (<i>Clethra ainifolia</i>)	Ironwood - American Hornbeam (<i>Carpinus caroliniana</i>)
White Turtlehead (<i>Chelone glabra</i>)	Common Winterberry (<i>Ilex verticillata</i>)	Eastern Redbud (<i>Cercis candensis</i>)
Joe Pye Weed (<i>Eupatorium purpureum</i>)	Virginia Sweetspire (<i>Itea virginica</i>)	Fringe Tree (<i>Chionanthus virginicus</i>)
Swamp Sunflower (<i>Helianthus angustifolius</i>)	Spicebush (<i>Lindera benzoin</i>)	Silky Dogwood (<i>Cornus amomum</i>)
Rose / Swamp Mallow (<i>Hibiscus moscheutos</i>)	Possumhaw (<i>Viburnum nudum</i>)	Mayhaw, May Hawthorn (<i>Crataegus aestivalis</i>)
Cardinal Flower (<i>Lobelia cardinalis</i>)		Hawthorn (<i>Crataegus marshallii</i>)
Black-eyed Susan (<i>Rudbeckia fulgida</i>)	Evergreens	
Goldenrod (<i>Solidago rugosa</i>)	Inkberry Holly (<i>Ilex glabra</i>)	Evergreens
Ironweed (<i>Vernonia noveboracensis</i>)	Dwarf Yaupan / Yaupan Holly (<i>Ilex vomitoria</i>)	American Holly (<i>Ilex Opaca</i>)
Grasses	Wax Myrtle (<i>Myrica cerifera</i>)	Sweetbay Magnolia (<i>Magnolia virginiana</i>)
Big Bluestem (<i>Andropogon gerardii</i>)		
River Oats (<i>Chasmanthium latifolium</i>)	Ferns	
Virginia Wild Rye (<i>Elymus virginicus</i>)	Cinnamon Fern (<i>Onoclea cinnamomea</i>)	
Muhly Grass (<i>Muhlenbergia capillaries</i>)	Royal Fern (<i>Osmunda regalis</i>)	
Switch Grass (<i>Panicum virgatum</i>)		
Little Bluestem (<i>Schiachyrium scoparium</i>)		
Indian Grass (<i>Sorghastrum nutans</i>)		
Note: Prior to selection, review detailed Bioretention plant lists for more detailed information regarding inundation, drought and salt tolerance for each species.		

Botanical Name	Common Name	Height	Zone ¹	Light	Description
Small Trees Under 30-feet Tall					
<i>Aesculus pavia</i>	Red Buckeye	10-15 ft.	2	Sun /shade	Spring flowers, prefers part shade, may defoliate early in season.
<i>Amelanchier canadensis</i>	Serviceberry	12-20 ft.	2	Sun/ part shade	Salt resistant; moist to average soils; Tolerates part shade; Multi-stem grey bark, early spring white flowers, early purple berries, red in fall; high wildlife value, fruits for birds.
<i>Carpinus caroliniana</i>	Ironwood/ American Hornbeam	30 ft.	1,3	Sun /shade	Shade tolerant, handles inundation of water, unique silver fluted trunk.
<i>Cercis canadensis</i>	Eastern Redbud	20-35 ft.	1,2	Part shade/ shade	Shade tolerant. Moist soils but not too wet; Drought tolerant; many good cultivars.
<i>Chionanthus virginicus</i>	Fringe Tree	20 ft.	2	Sun /shade	Moist soils; excellent small urban tree; Can be shrubby; fragrant pendulous white spring flowers and gold fall color.
<i>Cornus amomum</i>	Silky Dogwood	6-12 ft.	3	Sun	Flood tolerant; intermediate drought & heat resistant; fruit for birds
<i>Crataegus aestivalis</i>	Mayhaw, May Hawthorn	20 ft.	3	Sun	Thorn attractive to nesting birds, red fruit, purple to scarlet in fall.
<i>Crataegus marshallii</i>	Hawthorn	25 ft.	3	Sun /shade	Slender, thorny, or sometimes thorn less, branches. White blossoms followed by bright-red, persistent fruits. Leaves become colorful in fall. Seasonally poor drainage is okay.
<i>Ilex opaca</i> (evergreen)	American Holly	15-30 ft.	1,2	Sun/ shade	Medium drought tolerance; Bioretention soil must be sandy loam - intolerant to coarse soils (loamy sand); Sun to shade evergreen, slow growing, white flowers, red berries.
<i>Magnolia virginiana</i> (evergreen)	Sweetbay Magnolia	15-30 ft.	3	Sun/ part shade	Sun to shade semi-evergreen, fragrant flowers, bright red berries, often multi-stem.
Shrubs					
<i>Callicarpa americana</i>	Beautyberry	6 ft.	2	Sun/ shade	Average to droughty soils ; no anaerobic tolerance; Striking purple berries on new growth, yellow fall color, sun to part shade; well-suited for mountains.
<i>Cephalanthus occidentalis</i>	Button Bush	8 ft.	3	Part shade/ shade	Tolerates flooding, white button flowers persist, attracts hummingbirds; salt-tolerant
<i>Clethra alnifolia</i>	Sweet Pepperbush	8 ft.	2	Sun/ shade	Extremely fragrant white or pink flowers in summer, yellow in fall; Excellent for coastal gardens due to salt-tolerance.
<i>Ilex verticillata</i>	Common Winterberry	6-10 ft.	3	Sun/ part shade	Very flood tolerant intermediate drought resistance; Bioretention soil must be sandy loam - intolerant to coarse soils (loamy sand). White flowers with red berries retained in winter; sun to part shade; well-suited for mountains.
<i>Itea virginica</i>	Virginia Sweetspire	3-6 ft.	3	Sun/ shade	Medium shrub. Fragrant white tassel flowers, deep red or purple fall foliage. Well suited for Piedmont. Prefers moist soils.
<i>Lindera benzoin</i>	Spicebush	8 ft.	3	Part shade/ shade	Very early chartreuse flowers, fragrant leaves, pale yellow fall color. Suitable for Coast.
<i>Viburnum nudum</i>	Possumhaw Viburnum	6-12 ft.	3	Sun/ part shade	Very flood tolerant & drought tolerant; salt resistant; spring flowers, fruit for birds, fall color, tolerates part shade.
<i>Ilex glabra</i> (evergreen)	Inkberry Holly	6-8 ft.	3	Sun/ shade	Very flood tolerant. Salt resistant; Hi anaerobic tolerance. White flowers with black berries.
<i>Ilex vomitoria</i> (evergreen)	Yaupon Holly	8-15 ft.	1,2	Sun/ part shade	High drought tolerance, No anaerobic tolerance. Red fruit in fall & winter. Long lasting translucent berries.
<i>Myrica cerifera</i> (evergreen)	Wax Myrtle	15-20 ft.	1,2	Sun/ part shade	Very flood tolerant; excellent salt & resistance; medium drought resistance; medium anaerobic tolerance; medium N fixing. Fragrant leaves, berries for candles, can prune as a hedge.

Botanical Name	Common Name	Height	Zone ¹	Light	Description
Perennials					
<i>Amsonia tabernaemontana</i>	Eastern Bluestar	1-3 ft.	3	Sun/ part shade	Wetland plant that is Drought resistant; pale blue tubular flowers.
<i>Asclepias incarnata</i>	Swamp Milkweed	2-4 ft.	3	Sun	Pink rose-purple blooms in mid-summer, attracts butterflies. Thrives in mucky clay soils
<i>Asclepias tuberosa</i>	Butterfly Milkweed	2-3 ft.	1	Sun/ part shade	Prefers well-drained sandy soils. Tolerates drought. Striking and rugged plant with orange flowers that attract butterflies. Slow to establish and easy to grow from seed.
<i>Chelone glabra</i>	White Turtlehead	1-4 ft.	3	Sun	Snapdragon type white flowers, often lavender tinged. Attracts butterflies and hummingbirds. Suitable for Piedmont.
<i>Eupatorium dubium</i>	Joe Pye Weed	3-6 ft.	3	Sun	Rapid grower with large pink to purple flowers that attract butterflies. Has no salt tolerance.
<i>Helianthus angustifolius</i>	Swamp Sunflower	4-7 ft.	3	Sun/ part shade	Tall yellow daisy flowers with maroon center. Good seed source for birds. Salt-tolerant.
<i>Hibiscus moscheutos</i>	Rose or Swamp Mallow	3-8 ft.	3	Sun/ part shade	Huge white to pink flowers that attract hummingbirds. Salt-tolerant.
<i>Lobelia cardinalis</i>	Cardinal Flower	1-6 ft.	3	Sun/ shade	Drought resistant; Bioretention soil must be sandy loam - intolerant to coarse soils (loamy sand). Brilliant red flower spikes that attract butterflies and hummingbirds.
<i>Rudbeckia fulgida</i>	Black-eyed susan	1-3 ft.	2	Sun	Moist to dry soils; showy flowers; other species & cultivars. Self-sows and produces abundant offsets.
<i>Solidago rugosa</i>	Goldenrod	1-4 ft.	3	Sun	Thin sprays of arching flowering stems occur at the top of sturdy stems.; Other species & cultivars
<i>Vernonia noveboracensis</i>	Ironweed	5-8 ft.	3	Sun	Tall red-purple flower clusters late summer & early fall that attract butterflies. Tolerates inundation.
Grasses					
<i>Andropogon gerardii</i>	Big Bluestem	6-8 ft.	1,2	Sun/ part shade	Bunch grass with a blue-green color turning maroon-tan color in fall. Deep roots and drought resistant. Moderately tolerant of acidity and salinity
<i>Chasmanthium latifolium</i>	River Oats	2-4 ft.	1,3	Part shade/ shade	Clump forming. Dangling oats are ornamental and copper in fall. Medium drought and anaerobic tolerance; showy seed clusters, spreads by seed.
<i>Elymus virginicus</i>	Virginia Wild Rye	2-4 ft.	1,3	Sun/ part shade	Lush green, upright growing grass.
<i>Muhlenbergia capillaris</i>	Muhly Grass	1-3 ft.	1,3	Sun	In the fall, creates a stunning pink to lavender floral display. Functions well in meadow gardens.
<i>Panicum virgatum</i>	Panic Grass / Switch grass	3-6 ft.	1,3	Sun/ part shade	Clump forming grass very tolerant of flooding and tolerates dry soils and is drought resistant; some salt-tolerance; fuzzy flower heads.
<i>Schizachyrium scoparium</i>	Little Bluestem	2-3 ft.	1,2	Sun/ part shade	Clump grass that attracts birds and mammals. Blue-green stems that turn mahogany-red with white seed tufts in the fall. Readily reseeds. Suitable for the Coast.
<i>Sorghastrum nutans</i>	Indiangrass	3-6 ft.	1,2	Sun/ shade	Tall, bunching sod-former, with broad blue-green blades and a large, plume-like, soft, golden-brown seed head. Fall color is deep orange to purple. Drought tolerant
Ferns					
<i>Osmunda cinnamomea</i>	Cinnamon Fern	3-4 ft.	3	Part shade/ shade	Ideal for moist areas of Bioretention area. Non-flowering plant that reproduces by spores.
<i>Osmunda regalis</i>	Royal Fern	2-3 ft.	3	Part shade/ shade	Tolerates year-round shallow water.
Wetness Zone²	1 Plants that, once established, withstand drought (3-4 weeks without rainfall); Establishment is 1-2 yrs for trees & shrubs, 1 yr for perennials & grasses 2 Plants that grow best in moist to average soils and only tolerate short periods (1-2 days) of flooding. 3 Plants that tolerate longer periods of flooding (3-5 days), but also grow in moist to average soils.				

1.3.5 Mulch Layer

Provide a uniform 3 inch layer of mulch on the surface of the Bioretention area that provides an environment to enhance plant growth, enhance plant survival, suppresses weed growth, reduce erosion of the filter media, maintain soil moisture, trap fine sediments, promote the decomposition of organic matter, and pre-treat runoff before it reaches the filter media.

Provide shredded hardwood bark that consists of bark from hardwood trees milled and screened to a maximum 4 inch particle size, uniform in texture, free from sawdust and foreign materials, and free from any artificially introduced chemical compounds detrimental to plant life. Provide mulch that is well aged a minimum of 6-months.

Do not use pine needle, or pine bark mulch due to the ability of floatation.

Use alternative surface covers such as native groundcover, erosion control blankets, river rock, or pea gravel as directed by the ENGINEER. Use alternative surface covers based on function, cost and maintenance.

Do not provide a mulch layer for Bioretention areas that utilize turf grass as the vegetation material.

1.3.6 Pre-treatment System

Provide a pre-treatment system to reduce incoming velocities, evenly spread the flow over the entire Bioretention area, and to trap coarse sediment particles before they reach the filter media. Several pre-treatment systems are applicable, depending on whether the Bioretention area receives sheet flow, shallow concentrated flow or deeper concentrated flows. The following are appropriate pretreatment options:

- **Forebay** (for channel flow): Located at pipe inlets or curb cuts leading to the Bioretention area consisting of energy dissipation and flow dispersion sized for the expected peak discharge rate. The Forebay may be formed by a wooden or stone check dam or an earthen or rock berm. Ensure the Forebay is protected with the proper erosion prevention measures. The Forebay does not require an underlying filter media.
- **Grass Filter Strips** (for sheet flow): Extend a minimum of 10 feet from edge of pavement to the upstream edge of the Bioretention area with a maximum slope of 5%.
- **Gravel or Stone Diaphragms** (for sheet or concentrated flow): Located at the edge of pavement or other inflow point, running perpendicular to the flow path to promote settling. Size the stone according to the expected peak discharge rate.
- **Level Spreaders** (for sheet flow): Gravel, landscape stone, or concrete level spreader located along the upstream edge of the Bioretention area. 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.
- This requires a 2 to 4 inch elevation drop from a hard-edged surface into the Bioretention area.
- **Manufactured Stormwater Devices (MTDs)**: An approved MTD may be used to provide pre-treatment.

1.4 Construction Requirements

Do not construct Bioretention areas until all contributing drainage areas are stabilized as directed by the ENGINEER. Do not use Bioretention areas as sediment control facilities for during construction sediment control. Do not operate heavy equipment within the perimeter of Bioretention areas during excavation, underdrain placement, backfilling, planting, or mulching.

Separate Bioretention areas from the water table to ensure groundwater does not enter the facility leading to groundwater contamination or Bioretention failure. Ensure a vertical distance of 4 feet between the bottom of the Bioretention area and the seasonally high ground water table.

1.4.1 Site Preparation

Pre-treat stormwater runoff to reduce the incoming velocities, evenly spread the flow over the entire Bioretention area, and provides removal of coarse sediments. Because Bioretention areas are sensitive to fine sediments, do not install them on sites where the contributing area is not completely stabilized or is periodically being disturbed.

1.4.2 Installation

Bioretention areas work best when constructed off-line, capturing only the water quality volume. Divert excess runoff away from the Bioretention area or collect excess runoff with an overflow system. Install Bioretention areas around the natural topography to complement the surrounding landscape by fitting around sensitive areas, natural vegetation, roads, driveways, and parking lots. Bioretention areas have a minimum width of ten (10) feet and a minimum flow length of forty (40) feet to establish a strong healthy stand of vegetation.

1.4.2.1 Excavation

Excavate the Bioretention area to the dimensions, side slopes, and elevations shown on the Plans. Excavate Bioretention areas to the required depth based on the plantings utilized.

Ensure excavation minimizes the compaction of the bottom of the Bioretention area. Operate excavators and backhoes on the ground adjacent to the Bioretention area or use low ground-contact pressure equipment. Do not operate heavy equipment on the bottom of the Bioretention area.

Remove excavated materials from the Bioretention area and dispose of them properly.

1.4.2.2 Underdrain System

Prior to placing the underdrain system, alleviated compaction on the bottom of the Bioretention area by using a primary tilling operation such as a chisel plow, ripper, or subsoiler to a depth of 12 inches. Substitute methods must be approved by the ENGINEER. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment.

Remove any ponded water from the bottom of the excavated area. Line the excavated area with a Class 2, Type C nonwoven geotextile fabric.

Place a layer of No. 57 Aggregate 3-foot wide, and minimum of 3-inches deep on top of the nonwoven filter fabric. Place the pipe underdrains on top of the underlying aggregate layer. Lay the underdrain pipe at a minimum 0.5 percent longitudinal slope. The perforated underdrain drain pipe may be connected to a stormwater conveyance system or stabilized outlet. Cap the ends of underdrain pipes not terminating in an observation well.

Install observation wells/cleanouts of non-perforated vertically in the Bioretention area. Install observation wells and/or clean-out pipes at the ratio of one minimum per every 1000 square feet of surface area as shown on the Plans. Connect the wells/cleanouts to the perforated underdrain with the appropriate manufactured connections as shown on the Plans. Extend the wells/cleanouts 6 inches above the top elevation of the Bioretention area mulch layer, and cap with a screw cap.

Place No. 57 Aggregate around the pipe underdrain system to a minimum depth of 8-inches. Place a Class 2, Type C nonwoven geotextile fabric between the boundary of the gravel and the filter media to prohibit the filter media from filtering down to the perforated pipe underdrain.

Place an outflow structure at the elevation of the maximum 9-inch to 12-inch ponding depth of the Bioretention area to carry excess runoff from the Bioretention area to a stormwater conveyance system, or stabilized outlet.

1.4.2.3 Internal Water Storage Zone (Denitrification Zone)

Create the Internal Water Storage Zone by adding a 90 degree angle (elbow) to the outlet of the underdrain system that is perpendicular (vertical) to the horizontal underdrain. The 90 degree elbow extends to a minimum height of 12 inches above the invert of the underdrain system. The pipe from the elbow will reconnect with the underdrain pipe upstream of the overflow spillway. Install a valve at the 90 degree elbow, to allow drainage of the Internal Water Storage Zone. Install the 90 degree elbow and valve in the primary outlet structure or in an access well for a means of opening/closing the valve.

1.4.2.4 Filter Media

Install a permeable non-woven geotextile filter fabric between the filter media and the on-site soils. Place and grade the filter media using low ground-contact pressure equipment or excavators and/or backhoes operating on the ground adjacent to the Bioretention area. Do not use heavy equipment within the perimeter of the Bioretention area before, during, or after the placement of the filter media. Place the filter media in vertical layers with a thickness of 12 to 18 inches. Compact the filter media by saturating the entire Bioretention area after each lift of filter media is placed until water flows from the underdrain system. Apply water for saturation by spraying or sprinkling. Perform saturation of each lift in the presence of the ENGINEER. Do not use equipment to compact the filter media. Use an appropriate sediment control BMP to treat any sediment-laden water discharged from the underdrain during the settling process.

Test the installed filter media to determine the actual infiltration rate after placement. Ensure the infiltration rate is within the range of 1 to 6 inches per hour.

1.4.2.5 Plantings

Plant all Bioretention areas grasses, native grasses, perennials, shrubs, trees, and other plant materials specified to applicable landscaping standards.

Ensure all plant materials are kept moist during transport and on-site storage. Plant the root ball so 1/8th of the ball is above final filter media surface. Ensure the diameter of the planting pit/hole is at least six inches larger than the diameter of the planting ball. Set and maintain the plant straight during the entire planting process. Thoroughly water all plantings after installation.

Brace trees using 2-inch by 2-inch stakes only as necessary. Ensure stakes are equally spaced on the outside of the tree ball.

1.4.2.6 Mulch

Immediately mulch the entire Bioretention area to a uniform thickness of 3 inches after all planting are in place. Do not use mulch for Bioretention areas that utilize turf grass as the only vegetation material.

1.5 Inspection and Maintenance of Bioretention

Regular inspection and maintenance is critical to the effective operation of Bioretention areas. Maintenance responsibility of the Bioretention area is 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. Perform light core aeration or cultivate unvegetated areas as required to ensure adequate filtration. Other required maintenance includes but is not limited to:

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

Table 8: Summary of Maintenance Requirements

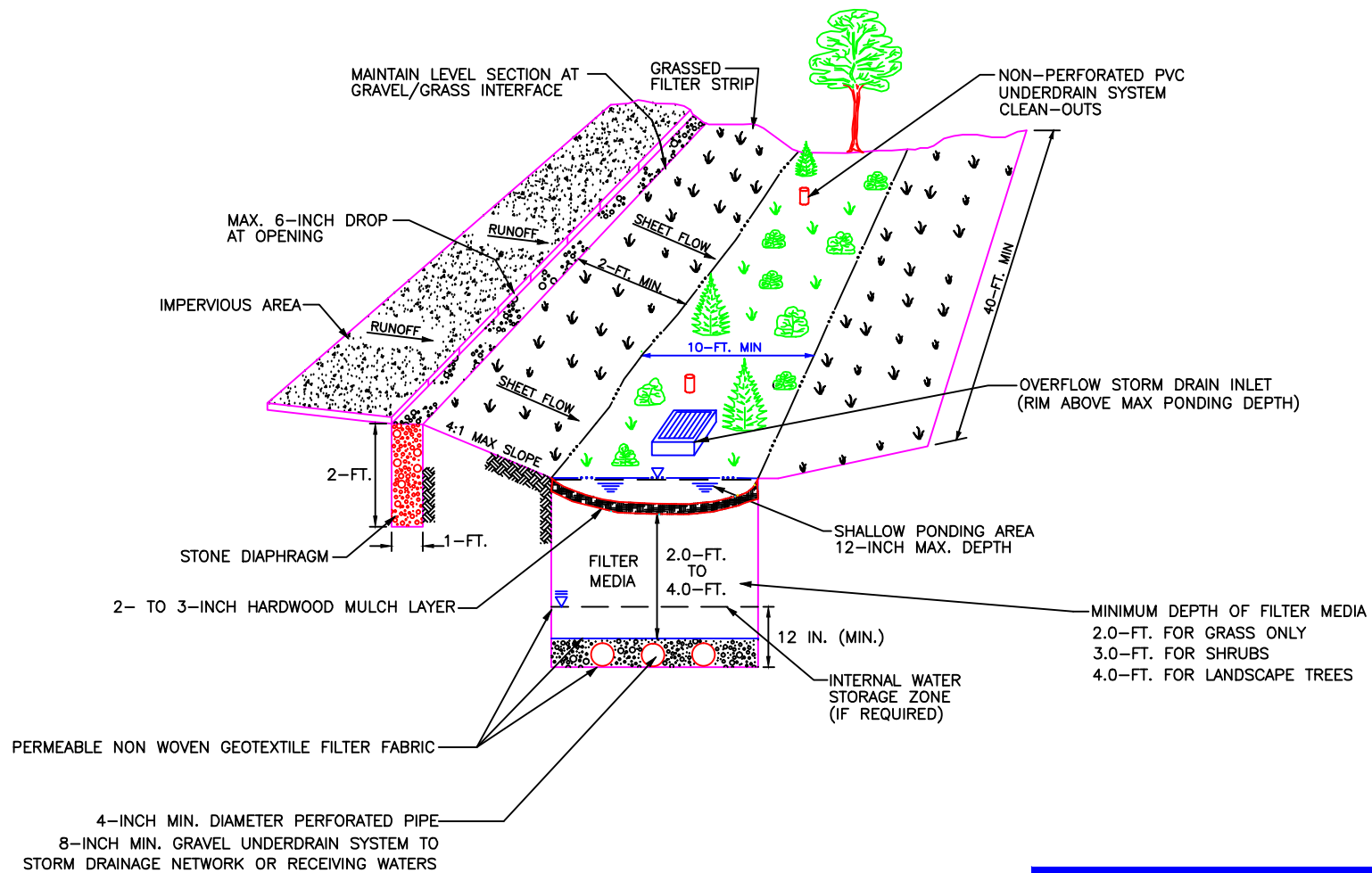
Required Maintenance	Frequency
Pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment	Semi-annual (every 6 months)
Repair eroded areas. Stabilize as necessary.	Semi-annual (every 6 months)
Mulch void areas.	Semi-annual (every 6 months)
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 filter media for pH.	Annual
Apply lime if pH < 5.2.	Annual, or 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

1.6 References

Clemson University Public Service Activities Carolina Clear, Rain Gardens, A Rain Garden Manual for South Carolina.

NCDENR Stormwater BMP Manual, Chapter 12 Bioretention, Chapter Revised 07-24-09

Prince George's County, Maryland, Bioretention Design Specifications and Criteria, Section 2.0 - Siting and Design Criteria



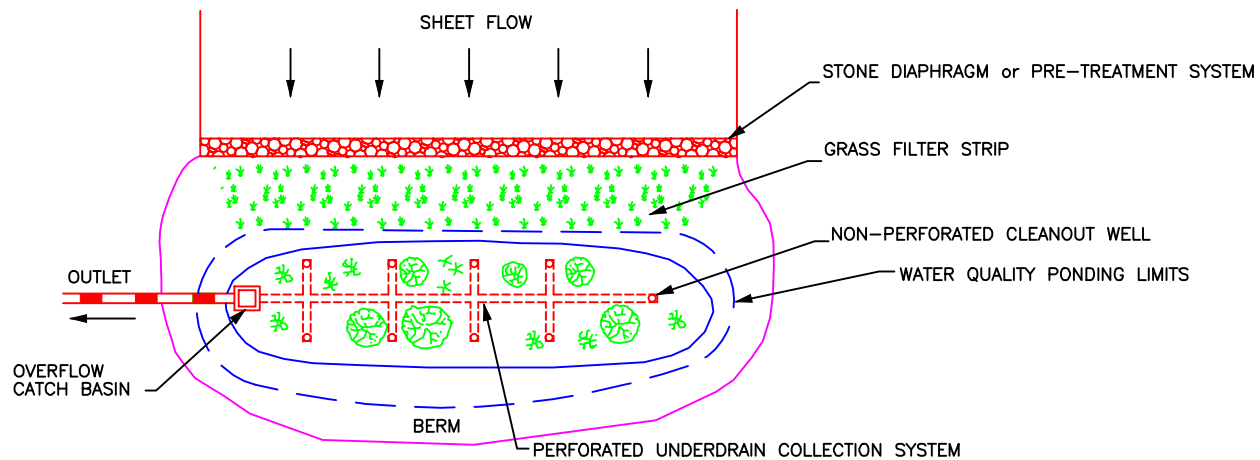
SOURCE: ADAPTED FROM PRINCE GEORGE'S COUNTY DESIGN MANUAL FOR THE USE OF BIORETENTION IN STORMWATER MANAGEMENT, 1993

Anderson County, SC

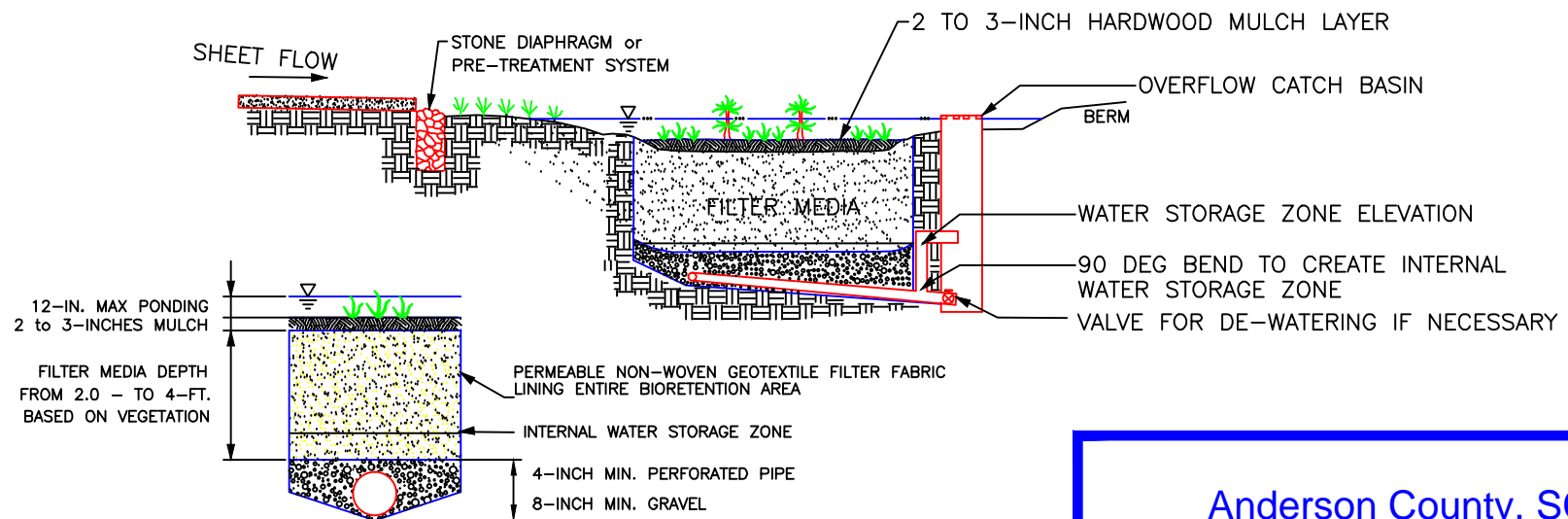
BIORETENTION

STANDARD DRAWING NO. WQ-03 Page 1 of 2

APPROVED BY: _____ JANUARY 2013
DATE



PLAN VIEW



Anderson County, SC

BIORETENTION

STANDARD DRAWING NO. WQ-03 Page 2 of 2

APPROVED BY: _____ JANUARY 2013
DATE

BIORETENTION AREA MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Bioretention Areas. Document Bioretention Area deficiencies during **annual** inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as a Bioretention Area.

Important maintenance procedures:

- Immediately after installing Bioretention Areas, water plants twice weekly as needed until the plants become established (typically six weeks).
- Do not place mulch or any other material on the surface of the Bioretention Area.
- Do not drive heavy equipment over the Bioretention Area.
- Prevent sediment from discharging to the Bioretention Area.
- Conduct a soil sample of the filter media once per year.

After the Bioretention Area is established, perform inspections once a quarter and after every storm event greater than **1.0 inch** for the first year, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

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

Perform trouble shooting activities as follows:

Field Conditions	Common Solutions
Trash/debris is present.	Remove the trash/debris.
Areas of bare soil and/or erosive gullies have formed.	Re-grade the soil if necessary to remove the gully, and then plant a ground cover and water until it is established.
Outlet pipe is clogged.	Unclog the pipe. Dispose of the sediment off-site.
Outlet Pipe is cracked or damaged.	Replace the pipe.
Erosion is occurring at entrance.	Re-grade as necessary to smooth and provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Stone entrance is clogged or covered in sediment.	Remove sediment and clogged stone and replace with clean stone.
Flow is bypassing pretreatment area and/or gullies have formed.	Re-grade if necessary to route all flow to the pretreatment area. Re-stabilize the area after grading.
Sediment has accumulated to a depth greater than three inches.	Search for the source of the sediment and remedy the problem if possible. Remove the sediment and re-stabilize.
Erosion has occurred.	Provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Weeds are present.	Remove the weeds, preferably by hand.
Pruning is needed to maintain optimal plant health.	Prune according to best professional practices.
Plants are dead, diseased or dying.	Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a fertilizer application to establish the ground cover if a soil test indicates it is necessary.
Tree stakes/wires are present six months after planting.	Remove tree stake/wires (which can kill the tree if not removed).
Mulch is breaking down or has floated away.	Spot mulch if there are only random void areas. Replace whole mulch layer if necessary. Remove the remaining much and replace with triple shredded hard wood mulch at a maximum depth of three inches.
Soils and/or mulch are clogged with sediment.	Determine the extent of the clogging - remove and replace either just the top layers or the entire media as needed. Dispose of the spoil in an appropriate off-site location. Use triple shredded hard wood mulch at a maximum depth of three inches. Search for the source of the sediment and remedy the problem if possible.
An annual soil test shows that pH has dropped or heavy metals have accumulated in the soil media.	Apply lime as recommended per the soil test and toxic soils shall be removed, disposed of properly and replaced with new filter mix.
Clogging has occurred	Wash out the underdrain system. Clean out the drop inlet. Dispose of the sediment off-site.
Clogging has occurred	Aerate filter mix surface
The outlet structure is damaged	Repair or replace the outlet structure.

WQ-04: INFILTRATION TRENCHES

1.0 Infiltration Trenches

1.1 Description

Infiltration Trenches are excavations filled with stone to create an underground reservoir to manage stormwater runoff. Use individual Infiltration Trenches for drainage areas up to two (2) acres in size.

The stormwater runoff volume enters the Infiltration Trench, is temporarily stored, and gradually exfiltrates through the bottom and sides of the trench into the subsoil. Infiltration Trenches fully de-water within a 24- to 72-hour period depending on trench dimensions, soil type, and underdrain system.

By diverting storm water runoff into the soil, the Infiltration Trench not only treats the water quality volume, but it also preserves the natural water balance. Using natural filtering properties, Infiltration Trenches can remove a wide variety of pollutants from the runoff through adsorption, precipitation, filtering, and bacterial and chemical degradation.

Use Infiltration Trenches to capture sheet flow from a drainage area or function as an off-line device. Due to the relatively narrow shape, Infiltration Trenches can be adapted to many different types of sites and can be utilized in retrofit situations. Because Infiltration Trenches are sensitive to fine sediments, do not install them on sites where the contributing area is not completely stabilized or is periodically being disturbed.

Infiltration Trenches are limited to areas with highly porous soils where the water table and or bedrock are located well below the trench bottom. Infiltration Trenches:

- Are only applicable for Hydrologic Soil Group A soils, or soils that have a minimum infiltration rate of 0.5-inches per hour determined from site specific soil boring samples.
- Are located to avoid ground water contamination.
- Are not intended to trap sediment during construction activities.
- Have a sediment forebay or other pre-treatment measure to prevent clogging in the gravel.
- Have an overflow system to provide non-erosive flow velocity along the length and at the outfall.
- Are applicable for impervious areas where there are low levels of fine particulates in the runoff and the site is completely stabilized and the potential for possible sediment loads are very low.

1.2 Design

Calculate the Infiltration Trench area using the following equation:

$$A = \frac{V}{\left(nd + \frac{kT}{12} \right)}$$

Where:

A = Surface area of Infiltration Trench (feet²)

V = Water Quality volume (1-inch)

n = Porosity of stone in infiltration trench (0.3 to 0.5 depending on stone)
Use conservative porosity value (n) of 0.32 in unless an aggregate specific value is known.

d = Depth of trench (ft)

k = Percolation rate of soil (in/hour)

T = Fill time(hours). A fill time of 2 hours is recommended for most design calculations.

1.3 Materials

1.3.1 Stone Fill

The stone fill media consists of 1.0- to 2.5-inch D_{50} crushed stone with 6-inches of pea gravel located on top separated by a permeable nonwoven geotextile filter fabric.

1.3.2 Permeable Nonwoven Geotextile Fabric

Place a permeable nonwoven geotextile filter fabric between the pea gravel and stone fill and the stone fill and adjacent soil. The filter fabric prevents sediment from passing into the stone media, and is easily separated from the nonwoven geotextile fabric that protects the sides of the excavated trench.

1.2.3 Sand Filter

Place a 6-inch sand filter or permeable nonwoven filter fabric on the bottom of the trench.

1.3.3 Observation Well

Install observation wells spaced a maximum of 100-feet in every infiltration trench. The well is made of 4- to 6-inch PVC pipe. Extend the observation well to the bottom of the trench. The observation well shows the rate of de-watering after a storm event, and predicts when maintenance is required for the Infiltration Trench. Install the observation well along the centerline of the trench, flush with the ground elevation of the trench. Cap the top of the well to discourage vandalism and tampering.

Table 1: Material Specifications

Material	Specification
No. 57 Aggregate	Use course aggregate No. 57 consisting of crushed slag or gravel
1.0- to 2.5-inch D_{50} Crushed Stone	Coarse Aggregate Size No.: 2, 24 or 3
Pea Gravel	ASTM D 448; Stone Size No. 6 or 1/8" to 3/8"
Sand Filter Material	AASHTO Std. M-43, Size No. 9 or No. 10) (SCDOT FA-10 Size No. 8)
Pipe Underdrains	Use perforated pipe underdrains with a minimum diameter of 4-inches
Observation Well and Outlet Pipe	Use non-perforated pipe underdrains with a minimum diameter of 4-inches
Type C Permeable Non- Woven Geotextile Fabric	Use Type C non-woven geotextile fabric

1.4 Construction Requirements

Ensure stormwater runoff from areas draining to Infiltration Trenches passes through stabilized vegetated filter at least 20-feet in length, a sediment forebay or other pre-treatment measure before discharging to the Infiltration Trench. Do not install Infiltration Trenches in fill material because piping along the fill and natural ground interface may cause slope failure.

1.4.1 Site Preparation

Ensure a vertical distance of 4 feet between the Infiltration Trench bottom and the elevation of the seasonally high water table, whether perched or regional. The water table is determined by direct piezometer measurements and on-site soil borings.

Locate Infiltration Trenches greater than 3-feet deep a minimum of 10 feet from basement walls.

Locate Infiltration Trenches a minimum of 150-feet from any public or private water supply well.

Construct Infiltration Trenches with a maximum width of 25-feet.

1.4.2 Installation

Construct an excavated trench with a minimum depth of 3-feet, and a maximum depth of 8-feet. The maximum slope bottom of the infiltration practice is 5 percent.

Do not install Infiltration Trenches in fill material as piping along the fill/natural ground interface may cause slope failure.

Do not install an Infiltration Trench on or atop a slope whose natural angle of incline exceeds 20 percent.

Line the excavated trench with a permeable nonwoven geotextile filter fabric.

Place a 6-inch sand filter on the bottom of the trench and place a permeable geotextile filter fabric over the sand filter.

Install observation wells spaced a maximum of 100-feet. Extend the well to the bottom of the trench.

Install the observation well along the centerline of the trench, and flush with the ground elevation of the trench. Cap the top of the well to discourage vandalism and tampering.

Place the crushed stone fill media to a depth of 6-inches below the top ground surface and place a permeable geotextile filter fabric over the crushed stone. Install this permeable filter fabric so it is easily separated from the geotextile filter fabric that protects the sides of the excavated trench.

Place 6-inches of pea gravel on top of the crushed stone.

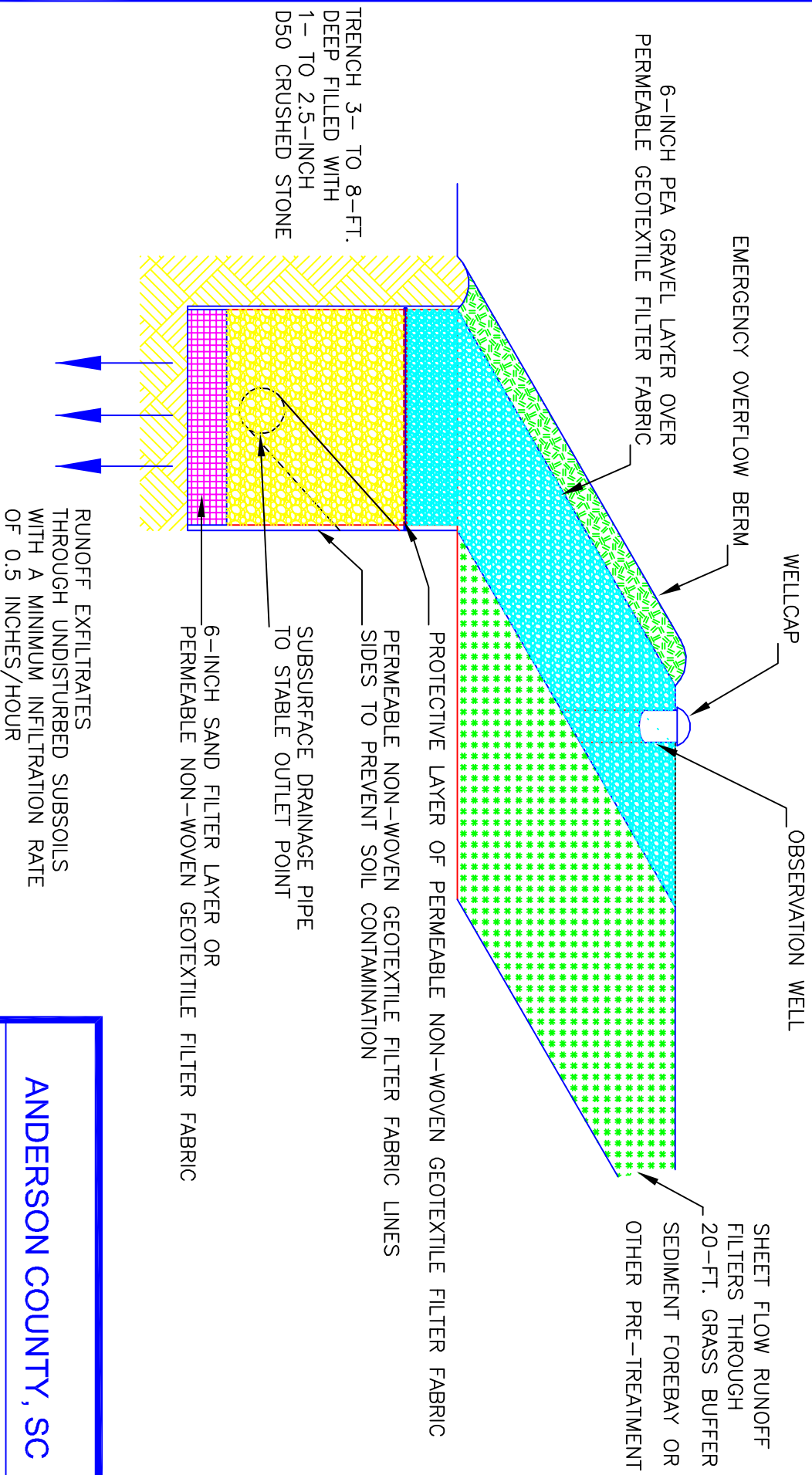
1.5 Inspection and Maintenance of Infiltration Trenches

Regular inspection and maintenance is critical to the effective operation of Infiltration Trenches. Maintenance responsibility for the Infiltration Trench is vested with a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval. Typical maintenance responsibilities include:

- Keeping a record of the average de-watering time of the Infiltration Trench to determine if maintenance is required.
- Replacing the top 6 inch layer of pea gravel and the permeable nonwoven geotextile filter fabric separating the pea gravel from the stone media when they become full of sediment.
- Clearing debris and trash from all inlet and outlet structures monthly.
- Checking the observation wells after three consecutive days of dry weather after a rainfall event. If complete de-watering is not observed within this period, there may be clogging within the trench and proper maintenance is required.
- Removing trees, shrubs, or invasive vegetation semi-annually.
- If complete failure is observed, performing total rehabilitation of the trench by excavating the trench walls to expose clean soil, and replacing the gravel, geotextile filter fabric, and topsoil.

Table 2: Summary of Maintenance Requirements

Required Maintenance	Frequency
Ensure that the contributing area is stabilized with no active erosion	Monthly
Mow grass filter strips and remove grass clippings.	Monthly
Check observation wells after 72 hours of rainfall. Ensure Wells are empty after this time period. If wells have standing water, the underdrain system or outlet may be clogged.	Semi-annual (every 6 months)
Remove evasive vegetation.	Semi-annual (every 6 months)
Inspect pretreatment structures for deposited sediment.	Semi-annual (every 6 months)
Replace pea gravel, topsoil and top surface geotextile filter fabric.	When clogging or surface standing water is observed
Perform total rehabilitation of infiltration trench.	Upon observed failure



SCHEMATIC OF AN INFILTRATION TRENCHES

ANDERSON COUNTY, SC

TYPICAL INFILTRATION TRENCH

STANDARD DRAWING NO.

APPROVED BY: _____ JAN. 2012
DATE

INFILTRATION TRENCH MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Infiltration Trenches. Document Infiltration Trench deficiencies during annual inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as an Infiltration Trench.

Important maintenance procedures:

- Ensure the drainage area is stabilized to reduce sediment discharge.
- Replace the top 6-inch layer of pea gravel and geotextile separating the pea gravel from the stone media when full of sediment.
- Record the water level in the monitoring wells after every storm event greater than **1.0 inches**.
- Check the observation well after three consecutive days of dry weather after a rainfall event greater than **1.0 inches**. If complete de-watering is not observed, there may be clogging within the trench requiring maintenance.
- Keep a record of the average de-watering time to determine when maintenance is required.
- If complete failure is observed, perform total rehabilitation by excavating the trench walls to expose clean soil, and replacing gravel, geotextiles and topsoil.

After the Infiltration Trench is established, perform inspections once a quarter and after every storm event greater than **1.0 inch** for the first year, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Clear trash and debris from all inlet and outlet structures	Monthly
Remove trees, shrubs or evasive vegetation	Every 6-months
Ensure that the contributing area is stabilized with no active erosion.	Monthly
Mow grass filter strips and remove grass clippings.	Monthly, or as needed
Check observation wells after 72 hours of rainfall. Ensure Wells are empty after this time period. If wells have standing water, the underdrain system or outlet may be clogged.	Every 6-months
Inspect pretreatment structures for deposited sediment.	Every 6-months
Replace pea gravel, topsoil, and top surface filter fabric.	When clogging or surface standing water is observed
Perform total rehabilitation of infiltration trench.	Upon observed failure

Perform trouble shooting activities as follows:

BMP Component	Problem	Solution
Entire Infiltration Trench	Trash/debris is present.	Remove the trash/debris.
Pretreatment area	Areas of bare soil and/or erosive gullies have formed.	Re-grade the area as necessary, plant vegetation, and water until established.
	Sediment has accumulated and reduced the depth to 50% of the original design depth.	Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of in a proper location.
Flow diversion structure	The structure is clogged	Unclog the conveyance and dispose of any sediment off-site.
	The structure is damaged.	Make any necessary repairs or replace if damage is too large for repair.
Trench	Water is ponding on the surface for more than 24 hours after a storm.	Check observation wells and outlets to ensure system is not clogged or blocked.
	The depth in the trench is reduced to 75% of the original design depth.	Remove accumulated sediment from the infiltration system and dispose in a proper location.
	Grass, weeds or other plants are growing on the surface of the trench.	Remove the plants, preferably by hand. If pesticide is used, wipe it on the plants rather than spraying.
Observation well(s)	The water table is within one foot of the bottom of the system for a period of three consecutive months.	The infiltration trench may be deemed non-functional and additional BMPs may be required.
	The outflow pipe is clogged.	Clean repair or replace the outflow pipe.
	The outflow pipe is damaged.	Repair or replace the pipe.
Emergency overflow	Erosion or other signs of damage have occurred at the outlet.	Repair or replace as needed.

WQ-05: GRASS CHANNELS

1.0 Grass Channels

1.1 Description

Grass channels can be designed and installed as an alternate to curb and gutter and hard piping stormwater conveyance systems. Grass channels improve water quality by providing partial pollutant removal as runoff is filtered by the vegetation and by the opportunity to infiltrate into the underlying soil layer. Grass channels also reduce flow velocities in comparison to hard piping systems.

Grass channels are similar to traditional drainage ditches, but are designed to generate a relatively slow flow velocity to facilitate water quality treatment of small but frequent storm events.

1.2 When and Where to Use

Grass channels are commonly installed along roadway and sidewalk corridors, and within residential developments. Grass channels require continual permanent vegetative cover in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant turf grasses.

Grass channels are susceptible to erosion and channelization if a thick stand of permanent vegetation is not sustained. A thick permanent vegetative cover is essential for proper functioning and to prevent damage from erosion.

1.3 Application and Limitations

The suitability of grass channels at a site depends on land use, size of the drainage area, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the channel system. Grass channels are not designed to treat drainage areas greater than 5 acres. Large drainage areas may be divided into sub-watersheds and treated using multiple grass channels.

1.4 Design Requirements

Perform the design of grass channels for the following two design conditions:

- Stability/Permissible Velocity: This design process involves evaluating how the channel will respond under low vegetation retardance conditions. This condition is defined when vegetation is cut low or lies down, producing a lower Manning's n value, lower flow depths, and higher flow velocities. The limiting factor for stability design is the permissible velocity of the flow in the vegetated channel.
- Capacity: This design process involves evaluating how the channel will respond under high vegetation retardance conditions. This condition is defined when vegetation is not maintained or is very long and rigid, producing a higher Manning's n value, higher flow depths, lower flow velocities, and higher shear stresses. The limiting factor for capacity design is the cross sectional area of the vegetated channel and the design shear stress.

Table 1: Permissible Velocities

Permanent Cover	Permissible Velocity (ft./sec.) Without TRMS*					
	Erosion Resistant Soils % Slope			Easily Eroded Soils % Slope		
	0-5	5-10	> 10	0-5	5-10	> 10
Bermuda Grass	8	7	6	6	5	4
Bahia Centipede Grass Tall Fescue Kentucky Bluegrass	7	6	5	5	4	3
Grass-legume Mixture	5	4	NR	4	3	NR

* Allow velocities over 5 ft/sec only where good cover and maintenance will be provided. If poor vegetation exists due to shade, climate, soils or other factors, reduce the permissible velocity.

NR = Not Recommended

For maximum water quality performance, grass channels are recommended to be off-line structures. If a grass channel is designed to be an online structure, it must be able to safely convey the runoff of the 10-year 24-hour storm event.

The following hydraulic design requirements will be met for all grass channel installations:

- Minimum channel slope of 0.5 percent.
- Maximum channel slope of 5%.
- Design a 2-foot minimum bottom width, with a level bottom.
- Design vegetated swales to have non-erosive peak runoff velocities and shear stresses for 10-year 24-hour storm event, and capable of conveying the 10-year 24-hour storm event without overtopping.
- Minimum length of 100 feet.
- The depth of flow for the water quality event should not exceed 4 inches.
- Provide a forebay at all inlets to grass channels.
- Side slopes no steeper than 3:1 (H:V).

1.5 Materials

1.5.1 Turf Reinforcement Matting (TRM)

Grass channels require non-erosive peak runoff velocities and shear stresses. Ensure the channel dimensions are capable of providing non-erosive flow rates and shear stresses. If non-erosive flow rates and shear stresses are not achieved, select an appropriate Permanent Turf Reinforcement Matting designed to provide non-erosive conditions. Do not use Temporary Erosion Control Blankets (ECBs) as they will degrade over time and lose their effectiveness.

Table 2: Material Specifications

Material	Specification
Turf Reinforcement Matting (TRM)	Use a TRM meeting appropriate design velocities and shear stresses.

1.5.2 Forebay

Provide pretreatment of runoff to grass channels with a Forebay. Forebays are typically provided by constructing a check dam at the inlet of the swale. Protect Forebay inlets to reduce erosive forces of the runoff. The preferable protective material is a Turf Reinforcement Mat (TRM).

1.5.3 Outlet Structures

Discharge stormwater runoff from grass channels to a storm drainage system on site, or discharge to a stable protected outlet point.

1.6 Construction Requirements

1.4.1 Site Preparation

Do not install grass channels when the contributing area is not completely stabilized or is periodically being disturbed.

1.4.2 Excavation

Ensure excavation minimizes the compaction of the bottom of grass channels. Operate excavators and backhoes on the ground adjacent to grass channels or use low ground-contact pressure equipment. Do not operate heavy equipment on the bottom of grass channels.

1.4.5 Surface

Install grass channels with a minimum bottom width of 2-feet where applicable to ensure an adequate filtration area. Install grass channel side slopes that are 3H:1V for ease of maintenance and for side inflow to remain as sheet flow. When site constraints are restrictive, the maximum side slopes are 2H:1V.

Install grass channels with an optimal surface channel slope ranging from 1% to 2%, forcing a slow and shallow flow. This aspect of grass channels allows particulates to settle out of the runoff and limits erosion.

Flow can enter a grass channel through a pretreatment Forebay or it may enter along the sides of the channel as sheet flow produced by a level spreader or other type of flow regulation trench along the top of the bank.

1.4.6 Grass

Plant all grass channels grasses to applicable standards and specifications.

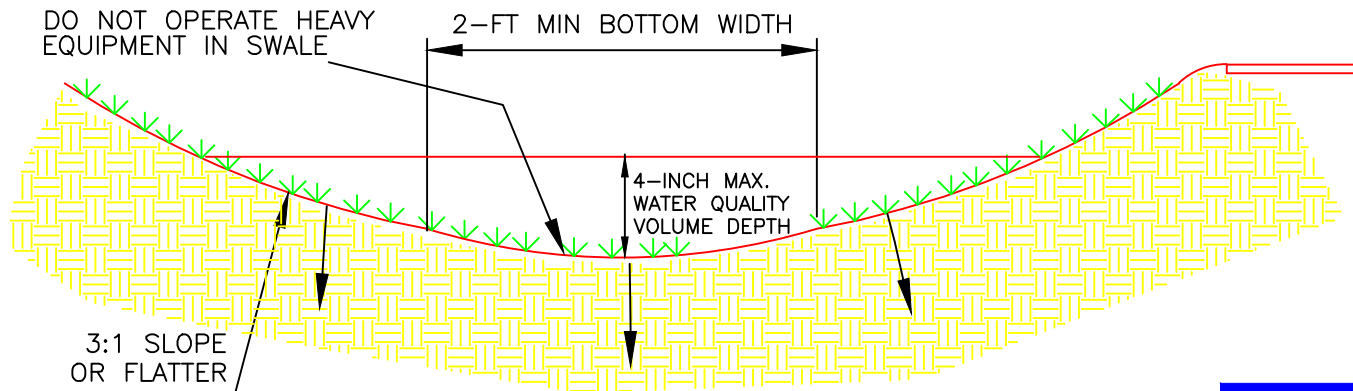
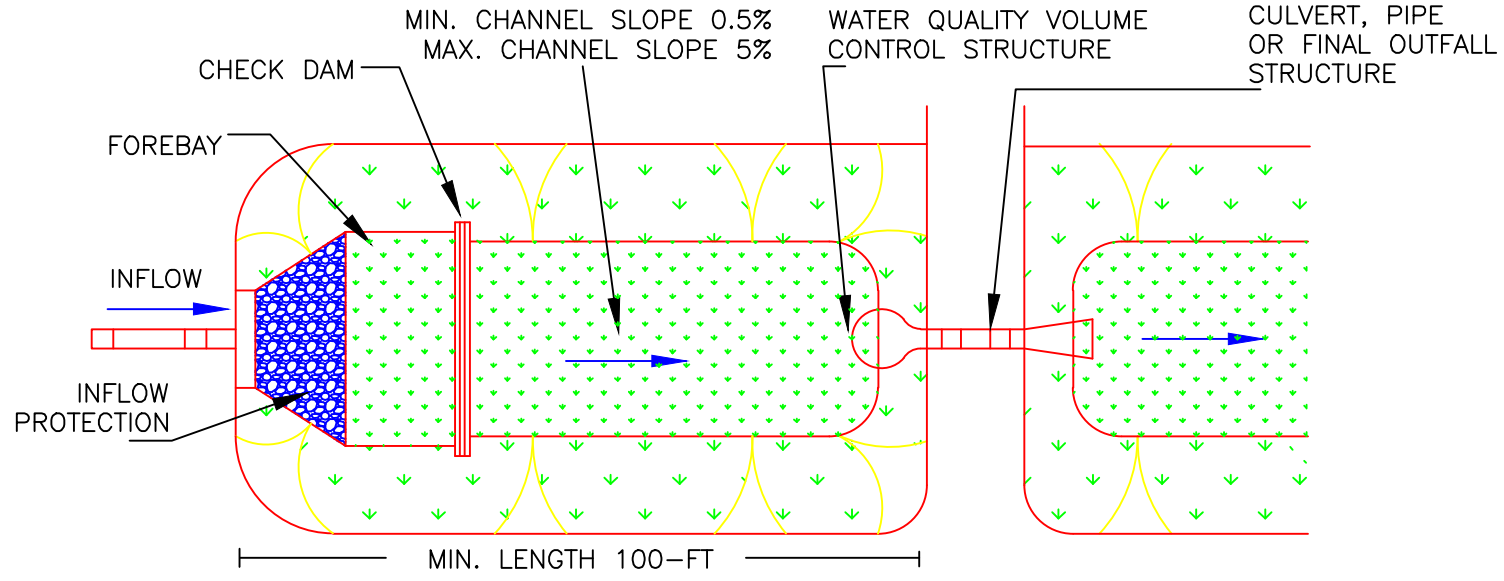
1.5 Inspection and Maintenance

Regular inspection and maintenance is critical to the effective operation of grass channels. Maintenance responsibility is vested with a responsible authority by means of an enforceable maintenance agreement that is executed as a condition of plan approval. Typical maintenance responsibilities include:

- Mow grass within swales at least twice during the growing season to maintain a maximum height of approximately 6 inches.
- Repair erosion, rills, and gullies.
- Remove accumulated sediment as necessary.
- Grass channels may periodically require aeration of the channel bed in order to increase the permeability of the system.

Table 3: Summary of Maintenance Requirements

Required Maintenance	Frequency
Mow grass to maintain design height and remove clippings.	As needed (frequent/seasonally)
Nutrient and pesticide management.	Annual, or as needed
Inspect side slopes for erosion and repair.	Annual, or as needed
Inspect channel bottom for erosion and repair.	Annual, or as needed
Remove trash and debris accumulated in Forebay.	Annual
Inspect vegetation. Plant an alternative grass species if original permanent cover is not established.	Annual (semi-annually first year)
Inspect for clogging and correct the problem.	Annual
Aeration of the surface of the bed when the grass channel does not draw down in 48 hours.	As needed
Remove sediment build-up within the bottom of the grass channel.	As needed, after 25% of the original design volume has filled.



Anderson County, SC

GRASS CHANNEL

STANDARD DRAWING NO. WQ-05

APPROVED BY: _____

JANUARY 2013
DATE

GRASS CHANNEL MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Grass Channels. Document Grass Channel deficiencies during **annual** inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as a Grass Channel.

Important Maintenance Procedures:

- Manage the drainage area of the Grass Channel to reduce the sediment load.
- After fertilizer is used to establish grass in the Grass Channel, only apply fertilizer according to the results of a soil test.
- Ensure the grass cover in the Grass Channel is dense and healthy. Re-sod or re-seed if necessary to ensure a dense stand of grass.

After the Grass Channel is established, perform inspections once a quarter and after every storm event greater than **1.0 inch** for the first year, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Periodic pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Every 6-months
Repair eroded areas. Re-seed or sod as necessary.	Every 6-months
Remove and replace dead or severely diseased vegetation.	Every 6-months
Removal of evasive vegetation.	Every 6-months
Nutrient and pesticide management.	Annual, or as needed

Perform trouble shooting activities as follows:

Field Condition	Common Solutions
Trash/ Debris is present	Remove trash/ debris
Sediment covers the grass at the bottom of the channel	Remove sediment manually if possible, and dispose of properly. Re-sod if necessary.
Areas of bare soil and/ or erosive gullies have formed	Re-grade the soil if necessary to remove the gully, then re-sod (or plant with other appropriate species) and water until established
Grass maintenance and weed control	Periodic mowing and weed control, watering during drought conditions, re-seeding of bare areas.
Nuisance vegetation is choking out desirable species	Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water (stream, pond, etc.).
Erosion or other signs of damage have occurred at the outlet	Re-grade if necessary to smooth it over and provide erosion prevention devices such as reinforced turf matting or riprap to avoid future problems with erosion.

WQ-06: BIOSWALES

1.0 Bioswales**1.1 Description**

A Bioswale is a shallow open-channel drainage way stabilized with turf grass or other vegetation used to convey runoff and filter pollutants. Use Bioswales in medians and drainage conveyance swales or ditches as an enhancement to vegetated swales. Bioswales are useful along roads that have driveway entrances crossing the swale. The maximum contributing drainage area for Bioswales is five (5) acres.

Bioswales capture, treat, and release the stormwater quality runoff volume. Bioswales are different from normal drainage swales in that they have structures implemented to enhance detention and stormwater pollutant removal. Bioswales are used primarily for stormwater quality and have a limited ability to provide stormwater runoff volume control. Bioswales are vegetated channels that include a filter media that overlays an underdrain system. Bioswales are sized to allow the entire water quality storage volume to filter or infiltrate through the swale bottom. Because Bioswales are sensitive to fine sediments, do not install them on sites where the contributing area is not completely stabilized or is periodically being disturbed.

Table 1: Average Pollutant Capability

Property	Value	Property	Value
Total Suspended Solids	70%-80%	Hydrocarbons	65%
Total Phosphorus	35%-50%	Lead	60%-70%
Pathogens/Bacteria	10%-60%	Copper	15%-45%
Total Nitrogen	40%-60%	Zinc	40%-65%

1.2 Design

Design Bioswales to treat the water quality volume of runoff from the entire drainage basin. Calculate the surface area of the Bioswale by dividing the water quality volume by the ponding depth (18 inches). Typical Bioswales have a minimum bottom width between 2- and 8-feet and minimum filter media depth of 2 feet. In order to allow for proper pollutant removal, design for the ponded runoff above the Bioswale surface to drain in a maximum of 12 hours. Design for runoff within the filter media to drain to a depth of 2-feet below the Bioretention area surface within 48 hours. Design the underdrain system to safely pass the peak draw down flow rate of the filter media.

1.3 Materials

Bioswales consist of an underdrain system, filter media, plantings/vegetation and a pre-treatment forebay.

Place berms, check dams, weirs, and other structures perpendicular to the Bioswale flow path to promote settling and infiltration.

1.3.1 Underdrain System

Use a minimum 4-inch diameter perforated PVC pipe in a 6-inch layer of No. 57 Aggregate gravel or equivalent filter material as the underdrain system. Place a permeable nonwoven geotextile filter fabric between the gravel and the overlaying permeable filter media.

Table 2: Material Specifications

Material	Specification
No. 57 Aggregate	Use course aggregate No. 57 consisting of crushed slag or gravel.
Pipe Underdrains	Use perforated pipe underdrains with a minimum diameter of 4-inches.
Non-Woven Geotextile Fabric	Use Type C non-woven geotextile fabric.
Turf Reinforcement Matting (TRM)	Use a TRM that conforms with the current <i>SCDOT Rolled Erosion Control Products (RECP) Specification</i> for Turf Reinforcement Matting (TRM) description, materials, and construction requirements.

1.3.2 Filter Media

The filter media for Bioswales consists of a permeable layer that is a minimum of 2.0-feet deep. Provide a filter media with a minimum infiltration rate of 1.0 in/hour and a maximum rate of 6 in/hr. The filter media provides a medium for physical filtration for the stormwater runoff with enough organic matter content to support provide water and nutrients for plant life.

The USDA textural classification of the filter media is Loamy Sand or Sandy Loam. The filter media is furnished, and on-site soils are not acceptable.

Test the filter media to meet the following criteria:

Table 3: Filter Media Material Specifications

Item	Percent of Total Planting Mix by Weight	ASTM Sieve Size	Percent Passing by Weight
Sand* Clean, Washed, Well Graded, No Organic Material <i>Aggregate No. FA-10</i> <i>ASTM C-33 Concrete Sand</i> <i>AASHTO M-6</i> <i>AASHTO M-43, No. 9 or No. 10</i>	80% Max	3/8 in.	100
		No. 4	95-100
		No. 8	80-100
		No. 16	50-85
		No. 30	25-60
		No. 50	10-30
		No. 100	2-10
Screened Topsoil <i>Loamy Sand or Sandy Loam</i> <i>ASTM D5268</i> <i>(imported or manufactured topsoil)</i> <i>Max 5% clay content</i>	15% Max.	No. 200	0-3
		2 in.	100
		1 in.	95- 100
		No. 4	75-100
		No. 10	60-100
		No. 200	10-50
Organic Matter in the form of Compost, Leaf Compost, Peat Moss or Pinebark Nursery Mix**	5% Min	0.002 mm	0-5
		3/8 in.	85-100
		No. 8	50-80
		No. 30	0-40

***Do not use lime stone screenings.**

**** Potting grade pine bark with no particles larger than 1/2 inches.**

Submit the source of the filter media and test results to the ENGINEER prior to the start of construction of Bioswales. Do not add material to a stockpile of filter media once a stockpile has been sampled. Allow sufficient time for testing. Utilize a filter media from a certified source or laboratory to reduce mobilization time and construction delays.

Use a filter media that is uniform, free of stones, stumps, roots or other similar objects larger than two inches excluding mulch. Do not mix or dump materials or substances within Bioswales that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations.

1.3.3 Forebay

Provide pretreatment of runoff to Bioswales with a forebay. Forebays are typically provided by constructing a check dam at the inlet to the Bioswale. Protect forebay inlets to reduce erosive forces of the runoff. The preferable protective material is a Turf Reinforcement Mat (TRM).

1.3.4 Outlet Structures

Discharge water from the underdrain system of Bioswales to a storm drainage system on site, or discharge to a stable protected outlet point.

1.3.5 Overflows

For maximum performance, Bioswales are recommended to be off-line structures. If a Bioswale is designed to be an online structure, the overflow structure must be able to safely pass runoff for the 10-year 24-hour storm event.

1.3.6 Plantings

Use plantings that conform to the standards of the current edition of *American Standard for Nursery Stock* as approved by the American Standards Institute, Inc.

Use plant materials that have normal, well developed stems or branches and a vigorous root system. Only use plantings that are healthy, free from physical defects, plant diseases, and insect pests.

Use plant species that are tolerant to wide fluctuations in soil moisture content. Use plantings capable of tolerating saturated soil conditions for the length of time anticipated for the water quality volume, as well as anticipated runoff constituents.

Use turfgrass species with a thick dense cover, slow growing, applicable to the expected moisture conditions (dry or wet), do not require frequent mowing, and have low nutrient requirements. The preferred method of establishing turf grass is sodding. Use temporary erosion control blankets to provide temporary cover when establishing turf grass by seeding.

1.4 Construction Requirements

1.4.1 Site Preparation

Do not install Bioswales on sites where the contributing area is not completely stabilized or is periodically being disturbed.

Separate Bioswales from the water table to ensure groundwater does not enter the facility leading to groundwater contamination or Bioswale failure. Ensure a vertical distance of 2 feet between the bottom of Bioswales and the seasonally high ground water table.

1.4.2 Excavation

Ensure excavation minimizes the compaction of the bottom of Bioswales. Operate excavators and backhoes on the ground adjacent to Bioswales or use low ground-contact pressure equipment. Do not operate heavy equipment on the bottom of Bioswales.

1.4.3 Underdrain System

Prior to placing the underdrain system, alleviated compaction on the bottom of the Bioswale by using a primary tilling operation such as a chisel plow, ripper, or subsoiler to a depth of 12 inches. Substitute methods must be approved by the RCE. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment.

Remove any ponded water from the bottom of the excavated area. Line the excavated area with a Class 2, Type C nonwoven geotextile fabric.

Place a layer of No. 57 Aggregate a minimum of 2-inches deep on top of the nonwoven filter fabric. Place the pipe underdrains on top of the underlying aggregate layer. Lay the underdrain pipe at a minimum 0.5 percent longitudinal slope. The perforated underdrain drain pipe may be connected to a stormwater conveyance system or stabilized outlet.

Place No. 57 Aggregate around the pipe underdrain system to a minimum depth of 6-inches. Place a Class 2, Type C nonwoven geotextile fabric between the boundary of the gravel and the filter media to prohibit the filter media from filtering down to the perforated pipe underdrain.

1.4.4 Filter Media

Place and grade the filter media using low ground-contact pressure equipment or excavators and/or backhoes operating on the ground adjacent to the Bioswale. Do not use heavy equipment within the perimeter of the Bioswale before, during, or after the placement of the filter media. Place the filter media in vertical layers with a thickness of 12 inches. Compact the filter media by saturating the entire Bioswale after each lift of filter media is placed until water flows from the underdrain system. Apply water for saturation by spraying or sprinkling. Perform saturation of each lift in the presence of the ENGINEER. Do not use equipment to compact the filter media. Use an appropriate sediment control BMP to treat any sediment-laden water discharged from the underdrain during the settling process.

Test the installed filter media to determine the actual infiltration rate after placement. Ensure the infiltration rate is within the range of 1 to 6 inches per hour.

1.4.5 Bioswale Surface

Install Bioswales with a bottom width ranging between 2- and 8-feet where applicable to ensure an adequate filtration area. Where the site allows, increase the filtration area by using wider channels, giving consideration to prevent uncontrolled sub-channel formation. Install Bioswale surface side slopes that are 4H:1V for ease of maintenance and for side inflow to remain as sheet flow. The maximum Bioswale surface side slopes are 2H:1V.

Install Bioswales with a minimal surface channel slope ranging from 1% to 2%, forcing a slow and shallow flow. This aspect of the Bioswale allows particulates to settle out of the runoff and limits erosion. Place flow control structures (berms, check dams, weirs, and other structures) perpendicular to the Bioswale flow path to promote settling and infiltration. Space flow controls structures a minimum of 50-feet and install energy dissipation techniques on the downstream side of these structures.

Flow can enter the Bioswale through a pretreatment forebay or it may enter along the sides of the swale as sheet flow produced by level spreader trenches along the top of the bank.

1.4.6 Plantings

Plant all Bioswale grasses, native grasses, perennials, shrubs, and other plant materials specified to applicable landscaping standards.

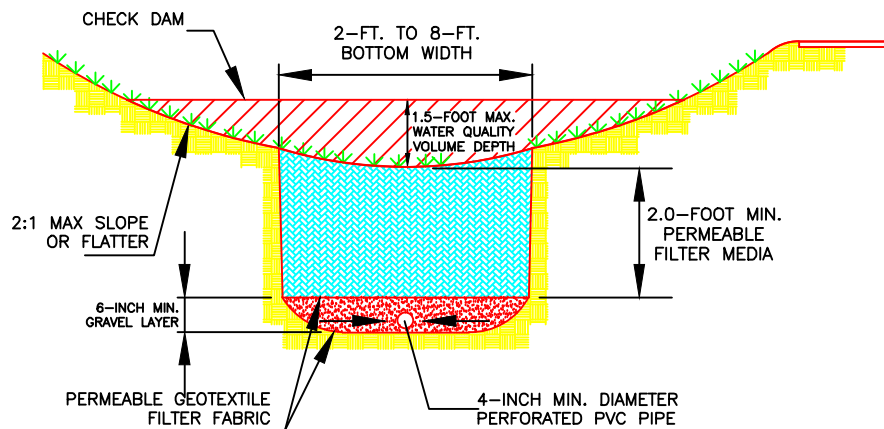
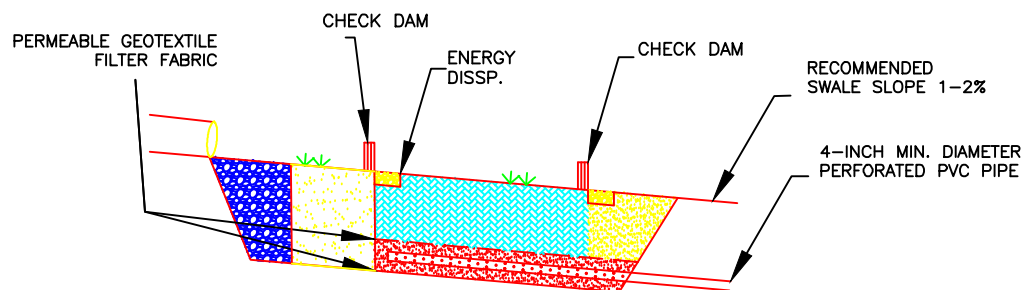
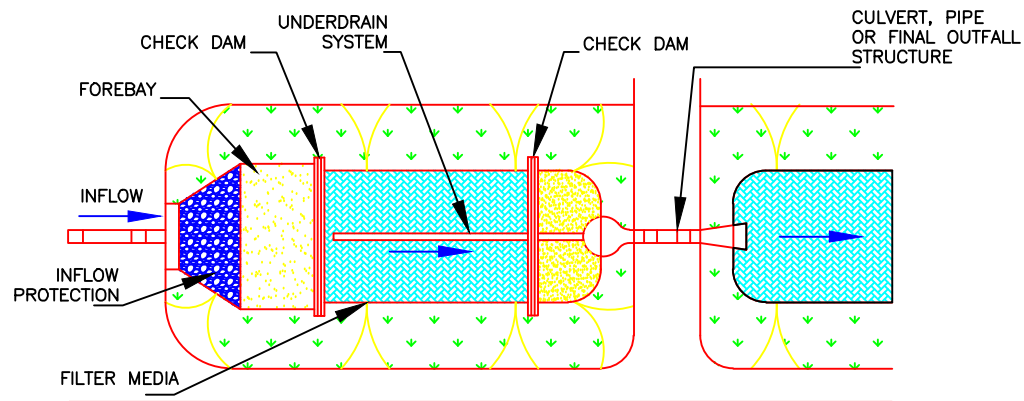
1.5 Inspection and Maintenance of Bioswales

Regular inspection and maintenance is critical to the effective operation of Bioswales. Maintenance responsibility is vested with a responsible authority by means of an enforceable maintenance agreement that is executed as a condition of plan approval. Typical maintenance responsibilities include:

- Keep a record of the average de-watering time of the infiltration trench to determine if maintenance is required.
- Perform light core aeration as required to ensure adequate filtration when the surface of the filter bed becomes clogged with fine sediments over.
- Perform mowing to maintain storage volume and to maintain appearance periodically as needed.
- Remove trash and debris periodically as needed.

Table 4: Summary of Maintenance Requirements

Required Maintenance	Frequency
Mow grass to maintain design height and remove clippings.	As needed (frequent/seasonally)
Nutrient and pesticide management.	Annual, or as needed
Inspect side slopes for erosion and repair	Annual, or as needed
Inspect channel bottom for erosion and repair	Annual, or as needed
Remove trash and debris accumulated in forebay	Annual
Inspect vegetation. Plant an alternative grass species if original cover is not established.	Annual (semi-annually first year)
Inspect for clogging and correct the problem	Annual
Roto-till or cultivate the surface of the bed when the Bioswale does not draw down in 48 hours.	As needed
Remove sediment build-up within the bottom of the Bioswale.	As needed, after 25% of the original design volume has filled.



Anderson County, SC

BIOSWALE

STANDARD DRAWING NO. WQ-06

APPROVED BY: _____ January 2012
DATE

BIOSWALE MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Bioswales. Document Bioswale deficiencies during **annual** inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as a Bioswale.

Important Maintenance Procedures:

- Manage the drainage area of the Bioswale to reduce the sediment load.
- After fertilizer is used to establish grass in the Bioswale, only apply fertilizer according to the results of a soil test.
- Ensure the grass cover in the Bioswale is dense and healthy. Re-sod or re-seed if necessary to ensure a dense stand of grass.

After the Bioswale is established, perform inspections once a quarter and after every storm event greater than 1.0 inch for the first year, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Periodic pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Every 6-months
Repair eroded areas. Re-seed or sod as necessary.	Every 6-months
Remove and replace dead or severely diseased vegetation.	Every 6-months
Removal of evasive vegetation.	Every 6-months
Nutrient and pesticide management.	Annual, or as needed

Perform trouble shooting activities as follows:

Field Condition	Common Solutions
Trash/ Debris is present	Remove trash/ debris
Sediment covers the grass at the bottom of the swale	Remove sediment manually if possible, and dispose of properly. Re-sod if necessary.
Areas of bare soil and/ or erosive gullies have formed	Re-grade the soil if necessary to remove the gully, then re-sod (or plant with other appropriate species) and water until established
Grass maintenance and weed control	Periodic mowing and weed control, watering during drought conditions, re-seeding of bare areas.
Nuisance vegetation is choking out desirable species	Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water (stream, pond, etc.).
Erosion or other signs of damage have occurred at the outlet	Re-grade if necessary to smooth it over and provide erosion prevention devices such as reinforced turf matting or riprap to avoid future problems with erosion.

WQ-07: Permeable Paving Systems

1.0 Permeable Paving Systems

1.1 Description

Permeable Paving Systems are a best management practice that captures stormwater through voids in the pavement surface and filters water through an underlying aggregate reservoir. The reservoir typically allows water to infiltrate into the soil subgrade. The reservoir can also be designed to detain and release the water to a surface conveyance system if the underlying soil is not suitable for infiltration.

The purpose of permeable pavement is to control the quality and quantity of stormwater runoff while accommodating pedestrians, parking and possibly traffic. Permeable pavement reduces runoff volumes and pollutants. Permeable pavement is especially useful in existing urban development where the need to expand parking areas is hindered by lack of space needed for stormwater management. Permeable pavement is also useful in new developments with limited space where land costs are high, and when nutrient reductions or green building certification programs are desired.

1.2 Paving System Selection

Permeable Paving Systems can be divided into a four primary paving system types including Permeable Pavers, Pervious Concrete, Pervious Asphalt and Reinforced Grid Systems. See the proceeding sections for guidance with paving system selection.

1.2.1 Permeable Pavers

These include modular blocks of plastic, concrete or other material which have wide joints or openings that can be filled with soil, gravel, or grass. The most common form of permeable pavers are Permeable Interlocking Concrete Pavers (PICP). This may also include cast in place concrete grids or concrete grid pavers with openings that can be filled with permeable materials. The pavers are placed on a thin aggregate bedding layer over a thicker choker course and base beneath. The choker course and aggregate base provide uniform support, water storage and drainage.

Advantages: Well suited for plazas, patios, small parking areas and stalls, parking lots, parking lot roadways, and roadside parking stalls. Permeable Interlocking Concrete Pavers can be designed for larger loads and does not require curing time. As compared to Pervious Concrete and Pervious Asphalt, permeable pavers are easier and less costly to renovate if it becomes clogged. The Interlocking Concrete Pavement Institute offers a design guide, construction specifications, design software, and a Certified PICP Specialist Course for contractors.

Disadvantages: Permeable Interlocking Concrete Pavers often have the highest initial cost for materials and installation. Regular maintenance of permeable pavers may be higher than Pervious Concrete and Pervious Asphalt because of the need to refill the joints with aggregate after cleaning and the greater occurrence of weeds. Cast in place concrete grids or concrete grid pavers are intended for very limited vehicular traffic such as overflow parking, emergency access fire lanes, or median crossovers. Cast in place concrete grids or concrete grid pavers are not recommended for regularly used parking areas.

1.2.2 Pervious Concrete

Pervious Concrete is produced by reducing the fines in a conventional concrete mix with other materials to create interconnected void spaces for drainage. Pervious concrete has a coarser appearance than standard concrete although mixtures can be designed to provide a denser, smoother surface profile than traditional pervious concrete mixtures.

Advantages: While not as strong as conventional concrete pavement, Pervious Concrete provides adequate structural support, making it a good choice for travel lanes in parking lots in addition to parking areas, and roadside parking stalls. The National Ready Mixed Concrete Association provides a contractor training and certification program. The American Concrete Institute publishes a construction specification and a report which provides guidance on structural, hydrological and hydraulic system and component design in addition to mix proportioning and maintenance.

Disadvantages: Mixing and installation must be done correctly or Pervious Concrete will not function properly. Pervious Concrete can be subject to surface raveling and deicing salt degradation if not designed and constructed properly. Restoring surface permeability after a significant loss of initial permeability may be difficult without removing and replacing the surface course for the affected area.

1.2.3 Pervious Asphalt

Pervious Asphalt is similar to conventional (impervious) asphalt except that less fine material is used in the mixture in order to provide for drainage. Pervious Asphalt has a courser appearance than conventional asphalt.

Advantages: While not as strong as conventional asphalt pavement, Pervious Asphalt offers sufficient structural strength for parking lots and roadside parking stalls.. The National Asphalt Pavement Association (NAPA) provides a Design, Construction and Maintenance Guide for Porous Asphalt titled *Porous Asphalt Pavement for Stormwater Management*.

Disadvantages: Mixing and installation must be done correctly or Pervious Asphalt will not function properly. The owner, contractor and designer will ensure that standard asphalt is not placed in lieu of pervious asphalt. Asphalt sealants or overlays that eliminate surface permeability cannot be used. Restoring surface permeability after a significant loss of initial permeability may be difficult without removing and installing a portion of the surface course.

1.2.4 Reinforced Grid Systems

Reinforced Grid Systems, often referred to as geocells, consists of flexible plastic or metal interlocking units that infiltrate water through large openings filled with aggregate or topsoil and turf grass. Reinforced Grid Systems are well suited for emergency vehicle access over lawn areas or overflow parking. They are not approved for regularly used vehicular areas such as parking lots.

Advantages: Reduces expenses and maximizes lawn area.

Disadvantages: Reinforced Grid Systems have less structural strength than the other pavement course options, especially when used under saturated conditions. When covered with vegetation, it requires mowing, fertilization and watering. Overuse can kill the turf grass or create ruts from displaced aggregates.

1.3 Design Components

The Wearing Course or Surface Layer - provides strength for the designed traffic loads while maintaining adequate infiltration capacity for stormwater runoff. This course may be cast-in place concrete, asphalt, concrete and plastic pavers, and plastic or metal grid systems. These courses generally have very high initial infiltration rates. Ensure that clogging rates are accounted for in the system design. While this layer allows for the infiltration of storm flows and provides some water quality benefits, the wearing course cannot be allowed to become saturated from excessive water volume stored in the aggregate base layer. For backup infiltration capacity, an unpaved stone edge hydraulically connected to the aggregate base or an overflow outlet is installed.

The Aggregate Base or Storage Bed - provides a stable base for the paver, a highly permeable layer for the infiltration of storm water into the underlying soil or under-drain system, and a temporary reservoir for storage of water prior to exfiltration through the underlying soil or under-drain system. In concrete and asphalt systems this layer is typically composed of a larger aggregate with a smaller stone (leveling or choker course) between the wearing course and the larger stone base course. The choker course is needed

to reduce rutting from construction traffic and to more evenly distribute the loading to the base material. Designs with partial or no exfiltration require under-drains. All installations are required to have an observation well installed at the furthest down slope area.

Ensure that the surrounding area is stabilized prior to installation. If the base course is being used for retention, the storage bed is excavated level to maximize infiltration across the entire area. If an under-drain is used, the bed is sloped to provide positive drainage at the desired rate for the under-drain. A non-woven filter fabric is installed along the bottom and sides of the excavation according to the manufacturer's specifications. Overlap adjacent strips at least 24 inches and secure fabric 4 feet outside of the storage bed. The aggregate is installed in 6 inch lifts and compacted to 95% modified proctor.

Subgrade – Analyze the subgrade conditions by a qualified geotechnical engineer for load bearing given the anticipated soil moisture conditions. A separation between the base course and the seasonal high water table of three feet is required.

1.3.1 General Design Requirements

The design of pervious pavements will depend on the application and location at each site. Locations where pervious pavements are not recommended include:

- Storm Water Hotspots, locations where concentrated pollutant spills are possible such as gas stations, and industrial chemical storage sites.
- Areas where maintenance is unlikely to be performed at appropriate intervals (residential and major roadways).
- In applications with no enforceable guidelines.
- Where heavy regular applications of sand are used for maintaining traction during winter.
- Areas with high seasonal groundwater or other conditions which create prolonged saturated conditions at or near the ground surface and within the pavement sections. Fill soils can become unstable when saturated.
- Locations where the estimated long term infiltration rate is less than 0.1 inch/hr.

1.3.2 Design Requirements

The use of pervious pavement, permeable pavers and grid systems is limited by slope conditions. Table 1, provides slope limitations for each BMP.

Table 1 – Slope limitations

BMP Type	Max. Slope
Pervious Asphalt	5%
Pervious Concrete	6%
Permeable Pavers	10%
Grid Systems	6%

In order to ensure adequate infiltration, it is important to estimate the long-term infiltration rate of the soil underlying a pervious pavement application. For small installations (patios, walkways, and driveways on individual lots) no infiltration field tests are necessary. However a soil grain size, texture analysis or soil pit excavation and infiltration tests may be prudent if highly variable soil conditions or seasonal high water tables are suspected. For large installations (parking lots, roadside parking stalls, and parking travel lanes) that include storage volume using base material below the surface, use the following methods to estimate the infiltration capacity of the underlying soil.

Method 1: USDA Soil Textural Classification (Rawls survey) every 200 feet of road or every 5,000 ft²

Method 2: ASTM D422 Gradation Testing at Full Scale Infiltration Facilities every 200 ft of road or 5,000 ft².

Method 3: Use small-scale infiltrometer tests every 200 feet of road or every 5,000 ft². These tests include the USEPA falling head or double ring infiltrometer tests (ASTM 3385-88). As these tests may not adequately measure variability of conditions in the test area they should be taken at several locations within the area of interest.

1.3.3 Pervious Asphalt Requirements

Table 2 – Pervious Asphalt Requirements

Design Component	Design Requirements & Considerations
The Wearing Course or Surface Layer	The top course is typically 2 to 4 inches thick. Permeable asphalt has similar strength and flow properties as conventional asphalt. Total void space is approximately 15-20%. The content of the asphalt cement ranges from 5.5 to 6.0 percent by weight dry aggregate. An elastomeric polymer can be added to reduce drain down. Also hydrated lime may be added at a rate of 1.0% by weight of the total dry aggregate to mixes using granite stone to prevent separation.
	The asphalt system is installed toward the end of construction activities to minimize sediment problems. Erosion and introduction of sediment is strictly controlled during and after construction. Test panels are recommended to determine asphalt cement grade and content compatibility with aggregate. In order to prevent rising water in the underlying aggregate base to saturate the pavement, a positive overflow will be installed.
The Aggregate Base or Storage	The minimum depth for structural support of this layer is 6 inches. The maximum depth is determined by the below grade storage volume. Aggregate base depths of 18 to 36 inches are common depending on storage needs. The coarse aggregate layer is 2.5 to 0.5 inch uniformly graded crushed (angular) thoroughly washed stone (AASHTO No. 3). The choker course is 1 to 2 inches in depth and consists of 1.5 inch to 0.0937 inch (No. 8 sieve) uniformly graded crushed washed stone for final grading of the base course. In applications with larger slopes, underground baffles may be used to make more efficient use of the storage layer. If baffles are used with an under-drain system, positive drainage to the under-drain will be provided along the baffles.
	Before installing the storage bed, stabilize the surrounding area to prevent runoff and sediment from entering the storage bed. A non-woven filter fabric is installed on the subsoil according to the manufacturer's specifications. Where the installation is adjacent to conventional paving surfaces, filter fabric is wrapped up the sides to the top of the base aggregate. Overlap adjacent strips of fabric at least 24 inches and secure 4 feet outside of the storage bed. Install the aggregate in maximum 8-inch lifts and lightly compact each lift. Install a 1 to 2-inch choker course evenly over the surface of the coarse aggregate layer. Filter fabric is folded over between the placement of the base and asphalt courses to protect installations from sediment inputs, and is trimmed when the site is fully stabilized.
Subgrade	After grading, ensure the existing subgrade is not compacted or subjected to excessive construction traffic. Immediately before base aggregate placement remove any accumulation of fine material from erosion with light equipment. Under-drains are required for soils where the estimated long-term infiltration rate is less than 0.5 in/hour. Ensure the draw-down time for the base does not exceed 24-hours.

1.3.4 Pervious Concrete Requirements

Table 3 – Pervious Concrete Requirements

Design Component	Design Requirements & Considerations
The Wearing Course or Surface Layer	<p>Typically 4 to 12 inches thick depending upon design loads. Permeable concrete is approximately 70 to 80 percent of the unit weight of conventional concrete and uses Portland cement type I or II conforming to ASTM C 150 or Type IP or IS conforming to ASTM C 595. The void space is 15 to 20% according to ASTM C 138 with a water cement ratio of 0.27-0.35, and an aggregate to cement ratio of 4:1 to 4.5:1. Admixtures including water reducing/retarding admixture (ASTM C 494 Type D) and hydration stabilizer (ASTM C 494 Type B), and fiber mesh may be used. Use potable water. Permeable concrete is similar to conventional concrete without the fine aggregate (sand component).</p>
	<p>Use the cement mix within 1 hour after water is introduced and within 90 minutes if an admixture is used and the temperature of the mix does not exceed 90° Fahrenheit. Base aggregate is wetted to improve the working time of the cement. A mechanical or manual screen can be used to level concrete at ½ inch above a form. The surface is covered with a 6-mil plastic and a static drum roller used for final compaction (roller should provide approx. 10 psi vertical force). Cover the Cement with plastic within 20 minutes and it remains covered for a minimum curing time of 7 days with no truck traffic for 10 days. Do not use high frequency vibrators as they can seal the surface of the concrete. Placement widths do not exceed 15 feet unless the contractor can demonstrate competence to install greater widths. Shrinkage associated with drying is less than that of conventional concrete. A conservative design can include control joints at 60-ft spacing cut to ¼ of the pavement thickness.</p>
	<p>The following tests are conducted to ensure proper performance</p> <ul style="list-style-type: none"> i. Have the contractor place and cure two test panels covering a minimum of 225 ft² at the required thickness to demonstrate that specified unit weights and permeability can be achieved on site. The test panels have two cores taken from each panel in accordance with ASTM C 42 at least 7 days after placement. ii. Untrimmed cores measured for thickness (ASTM C 42), within ¼ inch of specified thickness iii. Cores trimmed and measured for unit weight (ASTM C 140), within 5 lbs/ft³ of design specification iv. Void Structure tested (ASTM C 138) providing an infiltration rate greater than underlying soil <p>If the test panel meets the requirements, the panel can be left in place as part of the completed installation. Collect and sample material once per day to measure unit weight per ASTM C 172 and C 29.</p>
The Aggregate Base or Storage	<p>The minimum depth for structural support of this layer is 6 inches. The maximum depth is determined by the below grade storage volume. Aggregate base depths of 18 to 36 inches are common depending on storage needs. The coarse aggregate layer is 2.5 to 0.5 inch uniformly graded crushed (angular) thoroughly washed stone (AASHTO No. 3). The choker course is 1 to 2 inches in depth and consists of 1.5 inch to 0.0937 inch (No. 8 sieve) uniformly graded crushed washed stone for final grading of the base course. In applications with larger slopes, underground baffles may be used to make more efficient use of the storage layer. If baffles are used with an under-drain system, positive drainage to the under-drain will be provided along the baffles.</p>

	<p>Before installing the storage bed, the surrounding area is stabilized to prevent runoff and sediment from entering the storage bed. A non-woven filter fabric is installed on the subsoil according to the manufacturer's specifications. Where the installation is adjacent to conventional paving surfaces, filter fabric is wrapped up the sides to the top of the base aggregate. Overlap adjacent strips of fabric at least 24 inches and secure 4 feet outside of the storage bed. Install the aggregate in maximum 8-inch lifts and lightly compact each lift. Install a 1 to 2-inch choker course evenly over the surface of the coarse aggregate layer. Filter fabric is folded over between the placement of the base and asphalt courses to protect installations from sediment inputs, and is trimmed when the site is fully stabilized.</p>
Subgrade	<p>After grading, do not compact the existing subgrade or subject it to excessive construction traffic. Immediately before base aggregate placement remove any accumulation of fine material from erosion with light equipment and scarify the soil to a minimum depth of 6 inches. The estimated long-term infiltration rate may be as low as 0.1 inch/hour. Install under-drains for soils with lower infiltration rates to prevent prolonged saturated conditions at or near the ground surface within the pavement section.</p>

1.3.5 Permeable Paver Requirements

Table 4 – Permeable Paver Requirements

Design Component	Design Requirements & Considerations
The Wearing Course or Surface Layer	Design specifications for these systems are generally provided by the manufacturer. These systems provide adequate infiltration and load bearing capacity for the application. Directing surface flows to these systems from adjacent areas is not recommended without pretreatment
The Aggregate Base or Storage	The minimum thickness for the aggregate base for aggregate or plastic pavers depends on anticipated loadings, soil type and storm water storage requirements. Follow the Interlocking Concrete Paver Institute or the manufacturer's provided guidelines for base thickness when available. Typical depths range from 6 to 22 inches though larger depths may be used if greater storage capacity is desired. The minimum base depth for pedestrian and bicycle applications is 6 inches. An ASTM No. 57 crushed aggregate or similar is recommended for the coarse layer while a 3-inch layer of ASTM No. 8 is recommended for the choker course.
	Stabilizer the surrounding area prior to installation of the aggregate base. If the base course is being used for retention, the storage bed is excavated level to maximize infiltration across the entire area. If an under-drain is used, the bed is sloped to provide positive drainage at the desired rate for the under-drain. A non-woven filter fabric is installed along the bottom and sides of the excavation according to the manufacturer's specifications. Where the installation is adjacent to conventional practices, the fabric is wrapped up the sides to the top of the base aggregate. Install the No. 57 aggregate in 4 to 6 inch lifts compacting with at least 4 passes of a 10-ton steel drum roller. Initial passes can be with vibration but the final two will be static. Install the choker course in a similar manner. Ensure both courses are moist to facilitate compaction.
Subgrade	Under-drains are required for soils where the estimated long-term infiltration rate is less than 0.5 in/hour. Ensure the draw-down time for the base does not exceed 24-hours. For vehicle traffic areas, grade and compact the subgrade to 95 percent modified proctor density (ASTM D 1557). For pedestrian areas, compact to 95 percent standard proctor density (ASTM D698). The majority of soils in Anderson County will not retain useful infiltration rates when compacted and will require the use of under-drains.

1.3.6 Grid Systems

Table 5 – Grid System Requirements

Design Component	Design Requirements & Considerations
The Wearing Course or Surface Layer	Design specifications for these systems are generally provided by the manufacturer. These systems provide adequate infiltration and load bearing capacity for the application. Directing surface flows to these systems from adjacent areas is not recommended without pretreatment.
The Aggregate Base or Storage	The minimum thickness of this layer depends on anticipated loadings, underlying soil type and storage requirements. A typical minimum depth for driveways, alleys and parking lots is 4 to 6 inches. Increased depths can be used to increase storage capacity. The base aggregate is made up of a sandy gravel material typical for road base construction.
Subgrade	After grading, do not compact the existing subgrade or subject it to excessive construction traffic. Immediately before base aggregate placement remove any accumulation of fine material from erosion with light equipment. Under-drains are required for soils where the estimated long-term infiltration rate is less than 0.5 in/hour. The draw-down time for the base will not exceed 24-hours.

1.4 General Construction Requirements

Porous pavements are specialty applications and are installed by contractors who have been trained and have experience with the type of pavement being used. If the installation contractor does not have adequate experience they will retain a qualified consultant to monitor the production, handling and placement of the porous pavement.

Avoid the introduction of sediment and runoff from surrounding unpaved areas where possible to prevent clogging of the pavement pore spaces. When this is unavoidable, use pre-treatment practices to allow for filtering or settling of sediments before the runoff reaches the porous pavement. Use filter fabric between the underlying soil and the base course of the pavement to prevent fines from migrating up into the base. Ensure that muddy vehicles do not drive on the base material or surface layer during construction. This is especially true of fine soils such as those found in Anderson County. Under-drains are required in these applications where the long-term infiltration rate of the underlying soil is less than 0.1 inch/hr. These precautions enhance the operation and extend the operational life of the pavement.

1.4.1 Site Preparation

Do not begin construction on permeable pavement until acceptable conditions are present. This includes the following items:

- Pervious surfaces are graded and do not discharge to the permeable pavement, except for instances when this is unavoidable, such as redevelopment projects.
- Impervious areas that drain to the permeable pavement are completed.
- Areas of the site adjacent to the permeable pavement are stabilized with vegetation, mulch, straw, seed, sod, fiber blankets or other appropriate cover in order to prevent erosion and possible contamination with sediments.
- Construction access to other portions of the site is established so that no construction traffic passes through the permeable pavement site during installation. Install barriers or fences as needed.
- The forecast calls for a window of dry weather to prevent excess compaction or smearing of the soil subgrade while it is exposed.
- All permeable pavement areas are clearly marked on the site.

1.4.2 Excavation and Subgrade Preparation

Clear and excavate the area for pavement and base courses while protecting and maintaining subgrade infiltration rates using following these steps:

- Excavate in dry subgrade conditions and avoid excavating immediately after storms without a sufficient drying period.
- Do not allow equipment to cross the pavement area after excavation has started.
- Operate excavation equipment from outside the pavement area or from unexcavated portions of the area using an excavation staging plan.
- Use equipment with tracks rather than tires to minimize soil compaction when equipment on the subgrade surface is unavoidable.
- Dig the final 9 to 12 inches by using the teeth of the excavator bucket to loosen soil and do not smear the subgrade soil surface. Final grading or smoothing of the subgrade will be done by hand if possible.
- Minimize the time between excavation and placement of the aggregate.
- Ensure the final subgrade slope does not exceed 0.5%. Inspect and verify the subgrade slope before proceeding.

After verifying the subgrade slope, scarify, rip or trench the soil subgrade surface (while the soil is dry) of infiltrating pavement systems to maintain the soil's pre-disturbance infiltration rate. To scarify the pavement, use backhoe bucket's teeth to rake the surface of the subgrade. To rip the subgrade, use a subsoil ripper to make parallel rips 6 to 9 inches deep spaced 3 feet apart along the length of the permeable pavement excavation. In silty or clayey soils, place clean coarse sand over the ripped surface to keep it free-flowing. The sand layer should be adequate to fill the rips.

An alternative to scarification and ripping is trenching. When trenching, install parallel trenches 12 inches wide by 12 inches deep along the length of the permeable pavement excavation. Excavate trenches every 6 feet (measured from center to center of each trench) and fill with ½ in. of clean coarse sand and 1 ½ in. of ASTM No. 67 aggregate. Ripped or trenched (uncompacted) soil subgrade can settle after aggregate base and surface course installation and compaction. Therefore, base compaction requires special attention to means and methods in the construction specifications and during construction inspection to minimize future settlement from ripped or trenched soil subgrades.

1.4.3 Subgrade Soil Test for Infiltration

Perform infiltration testing as specified in Section 1.3.2

1.4.4 Place Geotextiles and Geomembrane (If Applicable)

If using geotextiles or geomembranes, follow the manufacturer's recommendations for the appropriate overlap between rolls of material. Secure geotextile or geomembrane so it will not move or wrinkle when placing aggregate.

1.4.5 Place Catch Basin, Observation Wells, and Underdrain System

Place catch basins and observation wells according to the design plans and verify that the elevations are correct. If an upturned elbow design is used, then the underdrains are placed first. In such case, verify the following:

- Elevations of the underdrains and upturned elbows are correct.
- Dead ends of pipe underdrains are closed with a suitable cap placed over the end and held firmly in place.
- Portions of the underdrain system are within 1-foot of the outlet structure are solid and not perforated.

1.4.6 Place Aggregate Base

Inspect all aggregates to insure they are clean, free of fines and conform to the plans and specifications. If aggregates delivered to the site cannot be immediately placed into the excavation, stockpile the aggregate on an impervious surface, geotextile, or on an impervious material to keep the aggregate free of sediment. If aggregate becomes contaminated with sediment, replace it with clean materials.

Before placing the aggregate base, remove any accumulation of sediments on the finished soil subgrade. Use light, tracked equipment. If the excavated subgrade surface is subjected to rainfall before placement of the aggregate base, excavate the resulting surface crust to at least an additional 2 inches of depth, raked or scarified to break up the crust. For sites with an impermeable liner or geotextiles, remove any accumulated sediments and check placement. Check slopes and elevations on the soil subgrade and the finished elevation of base (after compaction) or bedding materials to ensure they conform to the plans and specifications.

Spread all aggregate (not dump) by a front-end loader or from dump trucks depositing from near the edge of the excavated area or resting directly on deposited aggregate piles. Moisten and spread the washed stone without driving on the soil subgrade. Be careful not to damage under-drains and their fittings, catch basins, or observation wells during compaction. Follow compaction recommendations by the permeable pavement manufacturer or from industry guidelines. Be sure that corners, areas around utility structures and observation wells, and transition areas to other pavements are adequately compacted. Do not crush aggregates during compaction as this generates additional fines that may clog the soil subgrade.

1.4.7 Install Curb Restraints and Pavement Barriers

Install edge restraints and barriers between permeable and impervious pavement per the design plans.

1.4.8 Install Surface Layer

The bedding and pavement course installation procedures depend on the permeable pavement surface. It is important to follow the specifications and manufacturer's installation instructions. Install the bedding course in accordance with manufacturer or industry guide specifications. Improper bedding materials or installation can cause significant problems in the performance of the pavers and stone jointing materials between them.

If constructing a PICP pavement, use a contractor that holds a PICP Specialist Certificate from the Interlocking Concrete Pavement Institute. A list of contractors can be obtained from the Interlocking Concrete Pavement Institute.

1.5 Site Protection

It is preferable to have the permeable pavement installed at the end of the site construction timeline. If that is not possible, protect the permeable pavement until project completion. Route construction access through other portions of the site so that no construction traffic passes through or over the permeable pavement site. Install barriers or fences as needed.

- If this is not possible, protect the pavement per the construction documents.
- Protection techniques include mats, plastic sheeting, barriers to limit access, or moving the stabilized construction entrance
- Schedule street sweeping during and after construction to prevent sediment from accumulating on the pavement.

1.6 Maintenance

Permeable Paving Systems require maintenance to provide long term functioning. A majority of the maintenance efforts involve efforts to prevent the surface from clogging. Consider long term maintenance when using permeable paving systems

Permeable Paving System	Maintenance Requirements
Pervious Asphalt and Concrete	Clean surfaces using suction and sweeping, or high-pressure wash and suction. Hand held pressure washers are effective for cleaning void spaces and are appropriate for smaller areas. Smaller utility cuts can be repaired with conventional pavers is desired.
Permeable Pavers	Do not use washing. Only suction and sweeping is used when debris are dry. Pavers can be removed individually and replaced during utility work. Replace broken pavers to prevent structural instability.
Grid Systems	Remove and replace top course aggregate if clogged or contaminated using vacuum trucks or other techniques. Remove and replace broken grid segments where three or more adjacent grid cells are broken or damaged. Replenish the top course aggregate as needed.

1.6.1 Preventive Maintenance

The following list of preventive maintenance guidelines is required for Permeable Paving Systems.

- Clean the surface with portable blowers frequently, especially during the fall and spring to remove leaves and pollen before they irreversibly reduce the pavement's surface permeability.
- Do not stockpile soil, sand, mulch or other materials on the permeable pavement.
- Do not wash vehicles parked on the permeable pavement.
- Place tarps to collect any spillage from soil, mulch, sand or other materials transported over the pavement.
- Cover stockpiles of soil near the permeable pavement.
- Bag grass clippings or direct them away from the permeable pavement.
- Do not blow materials onto the permeable pavement from adjacent areas.
- Do not apply sand during winter storms.
- Immediately remove any material deposited onto the permeable pavement during maintenance activities.
- Remove large materials by hand. Remove smaller organic material using a hand-held blower machine.
- Remove weeds growing in the joints of pavers by spraying them with a systemic herbicide such as glyphosate and then return within the week to pull them by hand.

1.6.2 Surface Cleaning

At a minimum, surface cleaning is required when runoff pools or puddles for extended periods longer than 24-hrs. Owners are required to clean pervious concrete and pervious asphalt systems once annually, but more frequent cleaning are recommended, because surface infiltration is very difficult to restore after it has become clogged, and surface replacement is expensive.

The three main types of street cleaners are: mechanical, regenerative air and vacuum. Vacuum or regenerative air street sweepers are required because they are effective at cleaning the pore spaces in the pavement surface.

Mechanical sweepers are the most common. Mechanical sweepers come in various sizes for cleaning pedestrian or vehicular pavements, and generally do not use a vacuum. Mechanical sweepers employ brushes that initially move litter toward the machine center and lift trash onto a conveyor belt for temporary storage inside the machine. The brush bristles can penetrate some pavers, but not other types of permeable pavement. For other pavement types, mechanical sweepers may be used for removing trash, leaves, and other organic material, but the mechanical sweeper is not likely to be effective in removing sediment.

Regenerative air cleaners are the second most common. Regenerative air cleaners work by directing air at a high velocity within a confined box the rides across the pavement. The uplift from the high velocity effectively loosens dust and other fine particles on and near the pavement surface and lifts them into a hopper at the back of the truck. This equipment removes surface-deposited sediments from all pavement types. This equipment is recommended for regular preventive maintenance for permeable pavement.

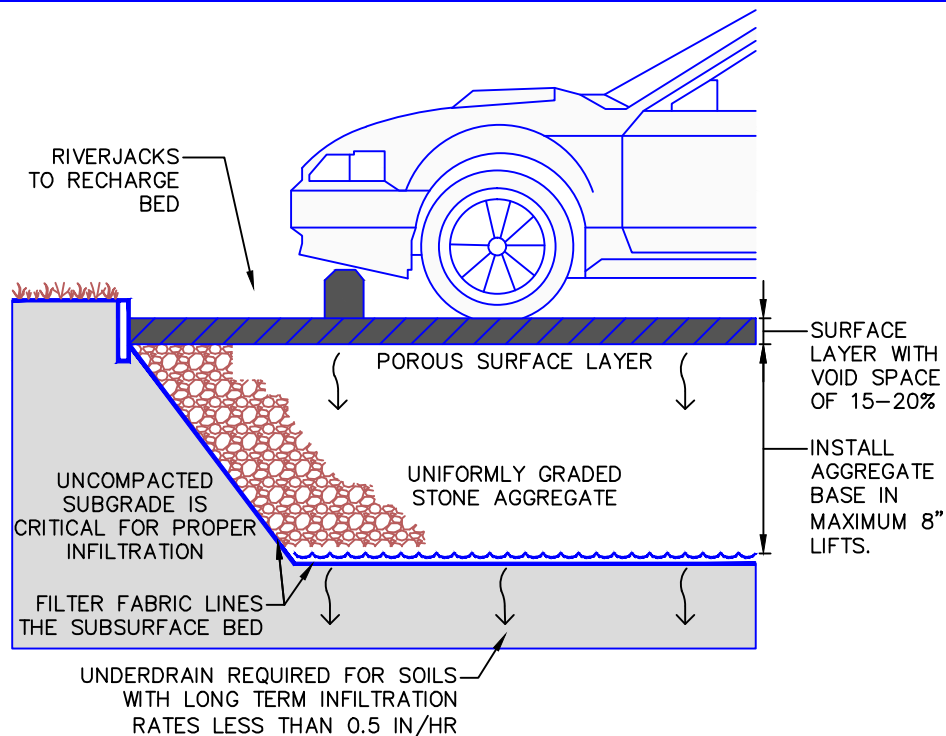
Vacuum street cleaners are the least common and most expensive. Vacuum street cleaners apply a strong vacuum to a relatively narrow area that lifts particles both at and below the surface of the pavement. Vacuum sweepers have demonstrated the ability to suction 3 to 4 inches of gravel from PICP and have the ability to restore infiltration to some pavements that have been neglected.

1.7 References

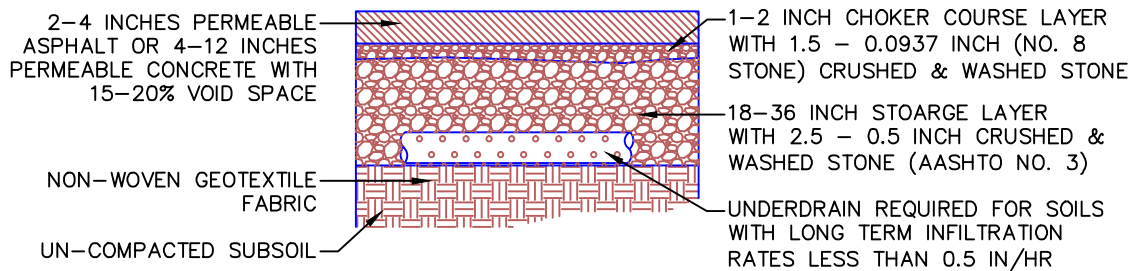
NCDENR Stormwater BMP Manual, Chapter 18 Permeable Pavement, Chapter Revised 10-16-12

Pennsylvania Stormwater Best Management Practices Manual, Section 6 Comprehensive Stormwater Management: Structural BMPs. January 2005.

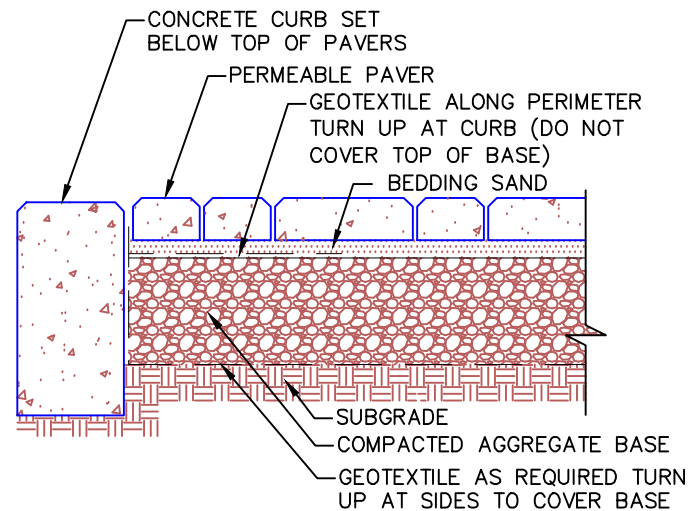
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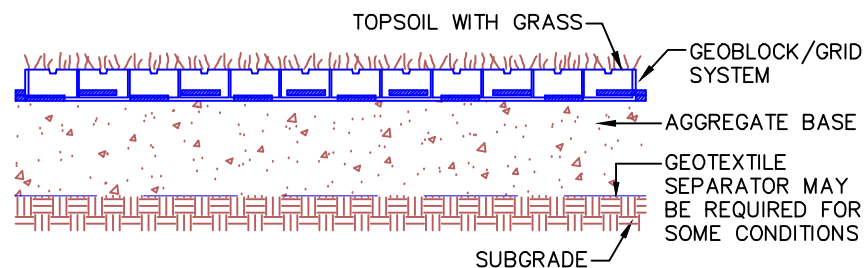
PERVIOUS PAVING SYSTEMS
NTS



POROUS ASPHALT & CONCRETE DETAIL
NTS



PERMEABLE PAVERS
NTS



REINFORCED GRID SYSTEMS
NTS

Anderson County, SC

PERMEABLE PAVEMENTS

STANDARD DRAWING NO. WQ-07

APPROVED BY: _____
Anderson County, SC

January, 2013
DATE

PERMEABLE PAVEMENT MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Permeable Pavement. Document Permeable Pavement deficiencies during annual inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as Permeable Pavement.

Important operation and maintenance procedures:

- Maintain a stable groundcover in the drainage area to reduce sediment load.
- Stabilize and mow the area around the perimeter of the permeable pavement with clippings removed.
- Spray weeds that grow in the permeable pavement with pesticide immediately. Do not pull weeds, as this could damage the media.
- Clean the Permeable Pavement surface using suction and sweeping (vacuum sweep) or high-pressure wash and suction. Sweeping alone without suction is ineffective.
- Do not repair Permeable Pavement surfaces with other types of pavement surfaces. Conduct all repairs to Permeable Pavement surfaces utilizing permeable pavement meeting the original pavement specifications. Ensure any utility cuts adhere to this requirement.
- Ensure concentrated runoff from roof drains, piping, swales or other point sources, to not directly discharge to Permeable Pavement surface.
- Inspect the surface for damage deterioration.
- Perform high pressure hosing to free pores in the top layer from clogging.

After the installation of Permeable Pavement, perform inspections once a quarter and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Clean the Permeable Pavement surface.	Semi-Annual to Annual, or as needed
Mow adjacent vegetated areas and remove clippings	Quarterly, or as needed
Remove leaves, trash, and debris.	As needed
Removal of weeds and vegetation.	As needed
High pressure hosing to free pores	As needed
Inspect for damage or deterioration	Annual
Inspect to ensure surface dewatering	Semi-Annual to Annual
High pressure hosing to free pores	As needed

Perform trouble shooting activities as follows:

BMP Component	Problem	Solution
Perimeter	Areas of bare soil and/or erosive gullies have formed.	Repair the erode areas immediately and re-establish permanent groundcover. Install temporary erosion prevention and sediment control measures during the establishment of permanent groundcover. Clean impacted Permeable Pavement areas by vacuum sweeping.
Surface	Rutting / uneven settlement	This indicates inadequate compaction of the Permeable Pavement base / sub-base. If rutting or uneven settlement is ½ inch or greater, remove the section of Permeable Pavement, re-compact and smooth or replace the base / sub-base, and re-install the Permeable Pavement. Monitor base / sub-base compaction by a licensed geotechnical engineer to ensure that infiltration capacity of base and sub-base are not compromised by the compaction processes.
	Surface is deteriorating or damaged.	Consult an appropriate professional. Remove and repair damaged areas.
	The pavement does not dewater between storms, or water is running off.	Vacuum sweep the pavement. If the pavement still does not dewater, consult a professional. Remove and repair permanently clogged pavement.
	Sediment is present on the surface.	Vacuum sweep the pavement.
	Weeds are growing on the surface.	Do not pull the weeds (may pull out media as well). Spray them with pesticide.
	Trash/debris is present.	Remove the trash/debris.

WQ-08: PERMANENT WATER QUALITY STREAM BUFFERS

1.0 Permanent Water Quality Stream Buffers

1.1 Description

A Permanent Water Quality Stream Buffer (Stream Buffer) is the area along a shoreline, wetland or stream meant to protect the waterbody. Development is restricted or prohibited in the stream buffer to prevent impacts to the waterbody. In addition, the stream buffer provides the following:

- Protection to the overall stream quality by providing shade for the stream,
- Natural habit for wildlife,
- Removal of pollutants (sediments, bacteria, and nutrients) from stormwater runoff through infiltration and filtering, and
- A setback from the stream to prevent damage to structures or improved property due to flooding or changes in the stream channel.

When a buffer must be disturbed, promptly stabilize it with a dense cover of strong rooted natural grasses, native plants, and native trees.

1.2 When and Where to Use

The most effective Stream Buffers for protecting water quality are those that consist of undisturbed natural vegetation including maintaining the original tree line along the stream, channel banks, or other waterbody to protect the waterbody. The buffer remains undisturbed to the maximum extent practicable. Immediately stabilize any stream buffer area that is temporarily disturbed with a dense cover of strong rooted natural grasses, native plants, and native trees.

1.3 Classification

Major streams, drainage ways and water bodies have Stream Buffer requirements based on the following three (3) classifications:

Class 1: Streams with a drainage area greater than or equal to 100 acres.

Class 2: Streams with a drainage area greater than or equal to 300 acres.

Class 3: Streams with a drainage area greater than or equal to 640 acres.

In addition, Stream Buffers are divided into different sections. The section widths vary depending on the stream classification. The sections include:

Stream Side Zone: Undisturbed area; adjacent to stream.

Managed Use Zone: Disturbance limited; adjacent to stream side zone.

Upland Zone: Some disturbance; farthest from stream.

Table 1 specifies the required buffer and section widths based on stream classification.

Table 1: Minimum Stream Buffer Section Widths

Stream Class	Stream Side Zone (ft)	Managed Use Zone (ft)	Upland Zone (ft)	Minimum Buffer Width on Each Side of Stream (ft)
1	30	None	15	45
2	30	20	15	65
3	30	45	25	100

All buffer measurements are from the top of the stream bank.

1.3.1 Stream Side Zone

The Stream Side Zone is directly adjacent to the stream and remains undisturbed. The vegetative target consists of mature forest. This zone is used to protect water quality and the ecosystem of the stream. In addition, the area is expected to hold flood waters during large storm events. Clearing, grading, or cutting of vegetation is prohibited in this zone, and natural vegetation is preferred. In the event stabilization measures are needed, use natural vegetation.

Allowable disturbances of the Stream Side Zone include:

- Flood control structures,
- Stabilized conveyance channels,
- Stream bank stabilization and restoration,
- Footpaths that do not require tree removal,
- Utility crossings, and
- Road crossings.

1.3.2 Managed Use Zone

The Managed Use Zone is between the Stream Side Zone and Upland Zone. The vegetative target for this zone is managed forest. This zone is used to store floodwaters and help remove pollutants through infiltration. Vegetation removal and tree cutting is limited. Grading activities and fill are prohibited. Maintain a minimum tree density of eight healthy trees at least six inches in diameter per 1,000 square feet. If the minimum tree density is not naturally present, reforestation is encouraged. Native grasses are appropriate in this zone.

Allowable disturbances of the Managed Use Zone include:

- Flood control structures,
- Stormwater best management practices (BMPs) provided that no other practicable alternative location exists on-site and minimal disturbance will take place,
- Engineered vegetated filter areas (that do not require the cutting of trees),
- Stabilized conveyance channels, and
- Walking trails and bike paths that result in no net tree removal of trees a minimum of 6 inches in diameter. When implementing walking trails or bike paths, utilize utility crossings or previously cleared areas when possible.

1.3.3 Upland Zone

The Upland Zone filters runoff and protects the stream. This zone is located farthest from the actual stream banks and grading and certain disturbances are allowed when performed in a manner that does not damage the roots of the trees located in the adjacent Managed Use Zone. Do not place fill material in the Upland Zone unless the replacement of deficient soil is required. Ensure the volume of fill material does exceed the volume of deficient soil removed. Commercial buildings and homes are not permitted in the upland zone. Forest cover is encouraged, but lawns, gardens, and other ground cover is permissible.

Allowable disturbances of the Upland Zone include:

- Stormwater best management practices (BMPs),
- Level spreaders,
- Engineered vegetated filter areas,
- Stabilized conveyance channels,
- Walking trails and bike paths,
- Personal gardens,
- Decks,
- Gazebos, and
- Storage buildings smaller than 150 square feet.

1.4 Design Requirements

Determine the required Stream Buffer width based on the watershed drainage areas.

Design the Upland Zone to have a level spreader to manage the water quality runoff volume. Ensure the water quality runoff from the level spreader discharges to a 35-foot minimum vegetated filter area width (or a width that achieves 80% TSS removal through the use of a pollutant loading model acceptable to County) before entering the Managed Use Zone.

For Stream Classes Type 2 and Type 3, the Managed Use Zone may be used as the vegetated filter area when:

- The Managed Use Zone consists of an existing dense herbaceous buffer,
- The herbaceous buffer has an existing minimum ground cover of 70%,
- The area is validated by Anderson County during a field site visit, and
- In no cases, trees are cut in the Managed Use Zone to create the required vegetated filter area.

For water quality control, design the level spreader to capture the water quality volume from the site and bypass larger storm flows directly to the receiving water body through a stabilized flow bypass conveyance channel.

For outlet applications, design the level spreader to capture the peak flow for the 10-year, 24-hour storm up to 10 cfs, and bypass larger storm flows directly to the receiving water body through a stabilized flow bypass conveyance channel.

If stormwater quantity management is not addressed by other stormwater controls, then a stabilized stormwater conveyance channel is required for all buffers.

1.5 Maintenance

Stabilize all deposited sediment as soon as possible. Maintain the level spreader and vegetated filter areas as needed.

1.6 Buffer Impacts

Often times, impacts to buffers are unavoidable. In some cases, mitigation is needed to compensate for the impact and in other cases, mitigation is not required. Activities that require mitigation must be approved by Anderson County.

1.6.1 Buffer Impacts Not Requiring Mitigation

- Flood control structures.
- Road crossings.
- Utility crossings.
- Paths and trails in the Managed Use Zones that result in no net tree removal for trees a minimum of 6 inches in diameter.
- Stabilized conveyance channels.
- Stabilized drainage improvements or repairs.
- Domesticated animal trails lost by action beyond farmers control. Fencing is required to limit and direct animal movement.
- Activities with mitigation or approval by a State or Federal Agency for Sections 401 or 404 of the Federal Clean Water Act

1.6.2 Buffer Impacts Requiring Mitigation

- Filling of the Stream Side or Managed Use Zone.
- Vegetation removal in the Stream Side or Managed Use zones that do not meet the requirements in section 1.3.
- Paved paths in Stream Side Zone.
- Fences and walls requiring tree removal in the Stream Side or Managed Use Zones.

1.6.3 On-Site Mitigation Techniques

In the event that a stream side buffer is impacted, there are several on-site mitigation options that are acceptable upon request. Review and approval is required by Anderson County on a case by case basis.

1.6.3.1 Re-vegetation

For temporary Stream Buffer zone impacts or disturbance, re-vegetate the impacted area with native vegetation species to the pre-disturbed condition for specific vegetation size and species.

1.6.3.2 Installation of Structural BMPs.

Structural BMPs reduce the amount of pollutants that are released into the stream, and are used when impacts to the stream buffer reduce the effectiveness of the buffer. Install the BMPs outside of the Stream Side Zone when practicable. A long term maintenance plan for the BMP is required.

1.6.3.3 Stream Restoration.

Restoration, enhancement, or stabilization of the existing Stream Side Zone on-site may be used when impacts to the stream buffer reduce the effectiveness of the buffer. Restoration, enhancement, or stabilization improvements must be equal to the Stream Buffer footage in need of mitigation.

1.6.3.4 Controlled Impervious Cover.

Limit the impervious cover on the overall development to 24% or less when impacts to the Stream Buffer reduce the effectiveness of the buffer.

1.6.3.5 Open Space Development.

Preserve 50% of the total development area as undisturbed open space when impacts to the Stream Buffer reduce the effectiveness of the buffer.

1.7 Marking Permanent Water Quality Stream Buffer and Final Plat Requirements

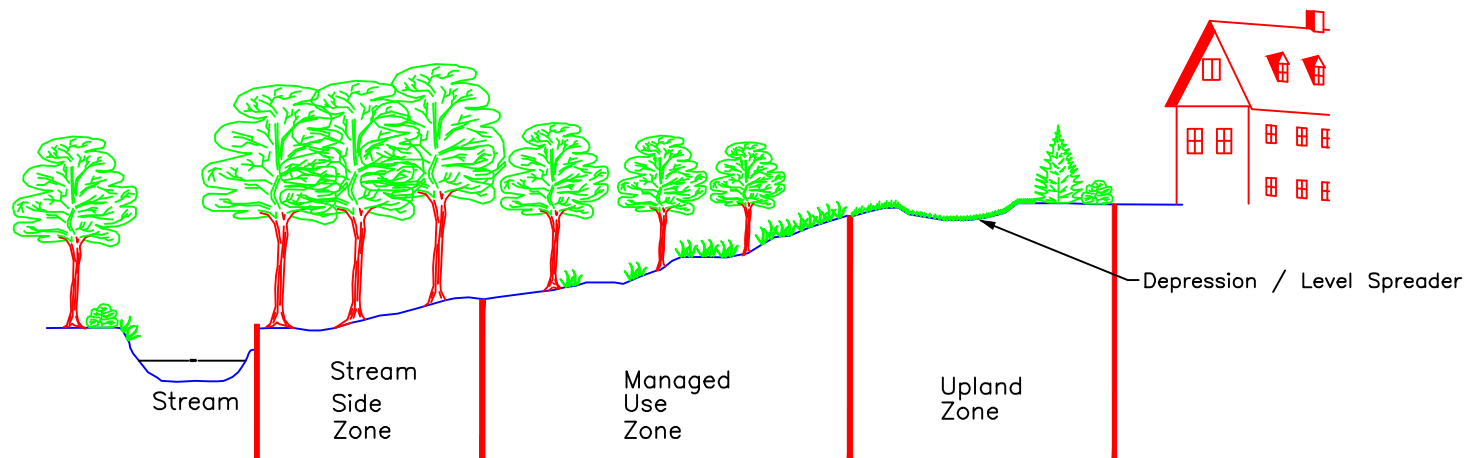
Clearly mark the different buffer zones during construction to protect the Stream Buffer and prevent unnecessary disturbance. Prior to the initiating of land disturbing activities, ensure construction layout surveys include staking and labeling of the Stream Buffer. Use a combination of staking, flagging, and/or other methods to ensure adequate visibility of the Stream Buffer during construction activities.

Ensure the final plat shows the exact boundary of all Permanent Water Quality Stream Buffers prepared by a registered surveyor.

Provide visible permanent Stream Buffer boundary markers approved by Anderson County prior to recording the final plat for the property. Ensure the boundary markers are installed in a visible area located on the landward edge of the Stream Buffer. Place boundary markers a minimum of one every 100 linear feet of Stream Buffer. Ensure permanent Stream Buffer boundary markers include the statement “*Water Quality Buffer – Do Not Disturb*”. Where possible, attach the permanent boundary markers to trees larger than 6-inches in diameter. Where it is not possible to attach the marker to a tree, use treated wood, steel, or plastic signposts.

Ensure the final plat contain the following statement:

“This property contains a Permanent Water Quality Stream Buffer that must be maintained in perpetuity in accordance with the recorded Operations and Maintenance Agreement by the responsible property owner. No clearing, grading, construction or disturbance is permitted in the Permanent Water Quality Stream Buffer except as permitted by the Permanent Water Quality Stream Buffer Technical Specification and permitted by Anderson County.”



Stream Class	Stream Side Zone (ft)	Managed Use Zone (ft)	Upland Zone (ft)	Total Buffer Width on Each Side of the Stream (ft)
1	30	None	15	45
2	30	20	15	65
3	30	45	25	100

** All buffer widths are measured from the top of the stream bank.

Class 1: Streams that have a drainage area greater than or equal to 100 acres.

Class 2: Streams that have a drainage area greater than or equal to 300 acres.

Class 3: Streams that have a drainage area greater than or equal to 640 acres.

Three Zoned Water Quality Stream Buffer

NTS

ANDERSON COUNTY, SC

WQ STREAM BUFFER

STANDARD DRAWING NO. WQ-08

APPROVED BY: _____ January, 2013
DATE

WQ STREAM BUFFERS MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including WQ Stream Buffers. Document WQ Stream Buffer deficiencies during annual inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as a WQ Stream Buffer.

Important maintenance procedures:

- Immediately after the installation, water newly planted vegetation twice weekly as needed until the vegetation becomes established (typically six weeks).
- Ensure the grass cover is dense and healthy. Re-sod or re-seed if necessary to ensure a dense stand of grass.
- Maintain stable groundcover in the drainage area to reduce the sediment load.
- Two to three times per year, grass filter strips will be mowed and the clippings harvested to promote the growth of thick vegetation with optimum pollutant removal efficiency. Turf grass should not be cut shorter than 3 to 5 inches and may be allowed to grow as tall as 12 inches depending on the aesthetic requirements. Forested filter strips do not require this type of maintenance.
- Once a year, the soil will be aerated if necessary.
- Once a year, soil pH will be tested and lime will be added if necessary.
- Annually inspect the BMP to ensure proper function and effectiveness as a stormwater best management practice.

After vegetation is established, perform inspections once a quarter and after every storm event greater than 1.0 inch, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Periodic pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Every 6-months
Repair eroded areas. Re-seed or sod as necessary.	Every 6-months
Inspect trees and shrubs to evaluate their health.	Every 6-months
Remove and replace dead or severely diseased vegetation.	Every 6-months
Removal of evasive vegetation.	Every 6-months
Nutrient and pesticide management.	Annual, or as needed
Water vegetation, shrubs, and trees.	Every 6-months

Perform trouble shooting activities as follows:

Field Condition	Common Solutions
Trash/ Debris is present	Remove trash/ debris
Water is channelizing and causing erosion.	Re-grade if necessary to smooth it over and Provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Too much sediment has accumulated.	Remove accumulated sediment to recover capacity. A sediment forebay may be required. Remove sediment that exceeds 2 inches on more than 10% of the vegetated treatment area, or anywhere that it is interfering with performance.
The flow control device is clogged or damaged	Unclog and properly dispose of any sediment off site. Make any necessary repairs or replace device if necessary.
Grass is too long or too short.	Maintain grass at a height of approximately three to six inches.
Plants are desiccated, dead, diseased or dying	Determine the source of the problem (soils, hydrology, disease, etc.). Remedy the problem and replace plants. Provide a one-time fertilizer application. Provide additional irrigation and fertilizer as needed.
Nuisance vegetation is choking out desirable species	Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water (stream, pond, etc.).

WQ-09: LEVEL SPREADERS

1.0 Level Spreaders

1.1 Description

Use Level Spreaders to disperse concentrated runoff uniformly over ground surfaces as sheet flow. Use Level Spreaders for peak design flow rates up to 10 cubic feet per second (cfs). Level Spreaders are constructed at a zero percent grade across a slope consisting of a permanent concrete weir structure used to disperse or spread concentrated flow thinly over a Vegetated Filter Area. The main purpose is to spread potentially erosive concentrated flow over a wide area so that erosion does not occur at the outlet. Added benefits include increased infiltration and increased pollutant and nutrient removal.

Level Spreader components include:

- High Flow Splitter
- Forebay
- Level Spreader Swale
- Underdrain
- Level Spreader Lip
- Vegetated Filter Area
- Bypass Conveyance Channel

Use Level Spreaders to convey runoff from impervious surfaces and pipe outfalls, uniformly onto vegetated filter areas or onto stream buffers. Level Spreaders are applicable:

- At outlets for diversion structures.
- Where uniform, sheet flow can be achieved down slope of the Level Spreaders.
- In areas requiring a Vegetated Filter Area to treat runoff.
- As a segment of a stormwater BMP treatment series.
- Where runoff from an impervious surface is uneven and/or runoff is released as concentrated flow, such as through curb cuts or slope drains.

Do not use Level Spreaders:

- Where discharge slopes exceed 6% for wooded/forested filter areas or 8% for thick ground cover/grass filter areas.
- Where there is a draw located within the Vegetated Filter Area down slope of a proposed level spreader.
- Where the runoff water will re-concentrate after release from the level spreader before reaching an outlet designed for concentrated flow.
- Where there will be traffic over the level spreader.

1.2 Design

Depending on the site layout and flows, Level Spreader components may include a high flow splitter, and a forebay system. Level Spreaders not discharging to a specific stormwater BMP or designed stormwater conveyance system must discharge to a Vegetated Filter Area.

Use Level Spreaders as a stand-alone BMP, or in a series to treat stormwater runoff. Flow, slope, site constraints, and design considerations dictate which method is used.

For Stream Buffer applications, determine the capacity of the Level Spreader by calculating the peak flow for the water quality volume.

For water quality control applications, design the Level Spreader to manage the water quality runoff volume. Ensure the water quality runoff from the Level Spreader discharges to a 35-foot minimum vegetated filter area width or a width that achieves 80% TSS removal through pollutant modeling software acceptable to Anderson County. Bypass larger storm flows directly to the receiving water body through a stabilized flow bypass conveyance channel.

For diversion outlet applications, determine the capacity of the level spreader using the peak flow for the 10-year, 24-hour storm.

Ensure the Level Spreader design accounts for runoff at ultimate build-out, including off-site drainage.

Flows to the Level Spreader must not exceed 10 cfs in any application. Bypass all flows greater than 10 cfs.

Level Spreader dimensions are derived from the design flow (cfs). Table 1 shows the minimum depth and minimum length of the level spreader lip based on design flows.

Table 1: Level Spreader Dimensions

Design Flow (cfs)	Minimum Level Spreader Swale Depth (ft)	Minimum Level Spreader Swale Top Width (ft)	Level Spreader Lip Length (ft)	Minimum Lip Length (ft)
0-10	1.0	3.0	10 feet per cfs	30

Design the Level Spreader Swale to handle the expected peak flow rates with a minimum bottom width of 1-foot with side slopes of 1H:1V or flatter and a minimum top width of 3 feet.. The Level Spreader Swale has a maximum grade of 0.5%. Tie the ends of the level spreader into higher ground to prevent flow around the spreader.

A Forebay is used to collect the runoff before the water is sent to the Level Spreader Swale. Design the forebay to be 0.5% of the contributing impervious surface area. The depth is 3 feet at the deepest point, and decrease to 1 foot as the forebay approaches the level spreader swale.

1.3 Components

1.3.1 Forebay

Use a Forebay for the preliminary treatment of stormwater allowing sediment to settle out. Excavate the Forebay as a bowl shaped feature to slow the influent before it reaches the Level Spreader Lip. Reinforce the Forebay with turf reinforcement matting (TRM) or Class A riprap.

1.3.2 Level Spreader Swale

Immediately upslope of the Level Spreader Lip, stormwater is discharged into the Level Spreader Swale (which is terminated at either end to ensure flow goes over the level spreader lip). Within the Level Spreader Swale, water rises and falls evenly over the Level Spreader Lip, distributing flow evenly over its length. Whenever practical, convey stormwater to the level Spreader Swale parallel to the Level Spreader Lip to avoid short circuiting.

1.3.2 Underdrain Pipe

Use underdrain pipe when soils are not capable of infiltrating water detained within the Forebay and Level Spreader Swale. Install an underdrain when the Level Spreader is installed on soil with an infiltration rate

less than 2 in/hr. The underdrain drains the Forebay and Level Spreader Swale between storm events to provide capacity for the next storm event, allows the turf to dewater and avoids mosquito risks. The underdrain discharges to the Stabilized Flow Bypass Conveyance Channel.

1.3.3 Level Spreader Lip

Use a Level Spreader Lip made of a poured concrete weir set at a 0% grade. The Level Spreader Lip is the main body of the level spreader that receives water from the forebay, directly from a BMP, or directly from a pipe outlet. Construct the lip so it is level along the entire length. Ensure the lip is a minimum of 6 inches higher than the existing ground on the downslope side, and anchored into the ground with an appropriately sized concrete footer. Install earthen or concrete berms at each end of the Level Spreader to prevent bypass of runoff.

The Level Spreader must be straight or convex in Plan view. Ensure Level Spreaders are not concave in Plan view because this concentrates flow downslope of the Level Spreader. To minimize the grading needed to install the Level Spreader, ensure it is placed so that it is parallel to contour lines.

1.3.4 Turf Reinforcement Matting (TRMs)

The Level Spreader Swale and Forebay may be stabilized with TRMs.

1.3.5 Non-woven Geotextile

Place and anchor a Class 2, Type C nonwoven geotextile on the downslope side of the Level Spreader Lip a minimum of 3 feet and place a 3- to 4-inch layer of #57 stone on top of the geotextile to minimize erosion.

1.3.6 Vegetated Filter Area

After passing over the Level Spreader Lip, stormwater enters a Vegetated Filter Area. The slope of the Vegetated Filter Area should not exceed 8%. The minimum width of the Vegetated Filter Area is **35 feet**.

For Stream Classes Type 2 and Type 3, the Managed Use Zone of the Permanent Water Quality Stream Buffer may be used as the Vegetated Filter Area when:

- The Managed Use Zone consists of an existing dense herbaceous buffer,
- The herbaceous buffer has an existing minimum ground cover of 70%,
- The area is validated by Greenville County during a field site visit, and
- In no cases, trees are cut in the Managed Use Zone to create the required vegetated filter area.

It is crucial that the slope and vegetation of the proposed natural herbaceous Vegetated Filter Area be surveyed in the field to ensure that the vegetation and slopes comply with requirements of this Specification.

Do not use Permanent Water Quality Stream Buffers as a Vegetated Filter Area if any natural draws or channels are present. If the buffer is herbaceous in nature but does not contain a thick stand of vegetation, then add additional plantings to stabilize the ground surface.

For an effective Vegetated Filter Area, it is essential to prepare the soils properly and plant and maintain a dense, vigorous stand of turfgrass Sod. Use Tall Fescue or Common Bermuda grass for Vegetated Filter Areas.

Vegetation must be established prior to receiving flow. A temporary stormwater diversion is necessary until the vegetation in the Vegetated Filter Area is stabilized. The Vegetated Filter Area must retain the capacity to pass flow without erosion. Since stable vegetation must be established in the Vegetated Filter Area before the Level Spreader can be put on-line, consider the time of year as construction may be limited to the growing season in order to ensure that a vegetated cover is established.

1.3.7 Flow Bypass Conveyance Channel

Use a Flow Bypass splitter or diversion box to pass all excess flow around the Level Spreader and into a stabilized Flow Bypass Conveyance Channel. The Flow Bypass splitter must be capable of diverting all flows above the Level Spreader design event.

Use a TRM in place of riprap when possible to stabilize the Flow Bypass Conveyance Channel. Add check dams and energy dissipaters, as needed, to stabilize the Flow Bypass Conveyance Channel. When discharging to a receiving water body, design the discharge point of the Flow Bypass Conveyance Channel at a 30 degree angle downstream into the receiving waterway to minimize erosion and bank degradation. Discharge the Flow Bypass Conveyance Channel into a deep section of the stream when practicable, and protect stream banks with a TRM or riprap at the discharge point. Other options include discharging to a velocity dissipater, a plunge pool, or a culvert. Site conditions and/or water quality requirements will guide design decisions for discharging bypass flow.

1.4 Construction Requirements

Construct Level Spreaders on undisturbed soil whenever possible. If the use of fill is unavoidable, compact the fill material to 95% of standard proctor tests. Protect the Level Spreader and downstream Vegetated Filter Area from sediment and stormwater flows during construction. Ensure flows bypass the Vegetated Filter Area until vegetation is established. Avoid driving heavy equipment in the footprint of the Level Spreader. Remove excavated materials from the level spreader and forebay and dispose of them properly.

1.4.1 Site Preparation

Before Level Spreader construction, verify that ground contours are parallel to the Level Spreader location, Vegetated Filter Area slopes are less than 8%, and no draws are located in the Vegetated Filter Area downstream of the Level Spreader. Use only sites with topography that allows a smooth transition from the Level Spreader Lip to the downstream Vegetated Filter Area. Avoid drops or irregular areas that allow water to re-concentrate and erode the Vegetated Filter Area, stream buffer, and possibly the receiving stream.

Ensure there is adequate access around the Level Spreader site to accommodate for post construction inspection and maintenance. Regular maintenance is required for the Level Spreader to function as designed.

1.4.2 Installation

Install Level Spreaders with the following construction sequence when appropriate:

- Install Flow Bypass Conveyance Channel.
- Grade Vegetated Filter Area.
- Excavate Vegetated Filter Strip Swale and Underdrain Area.
- Install Concrete Level Spreader Lip.
- Install Underdrain.
- Install Leveled Spreader Swale.
- Install Forebay.
- Install Flow Bypass Device.

1.4.2.1 Flow Bypass Conveyance Channel

Install the flow bypass diversion box according to the design Plans. This structure is installed at the outlet of the watershed and splits flow between the Forebay and the Flow Bypass Conveyance Channel. Install the Flow Bypass Conveyance Channel and install stabilization measures as shown on the Plans. Direct all flows to the Flow Bypass Conveyance Channel until the Level Spreader and any associated vegetation is fully stabilized.

1.4.2.2 Vegetated Filter Area

Grade the Vegetated Filter Area (if required) to the design slope using a box blade or similar equipment. Avoid driving heavy equipment through the Vegetated Filter Area to prevent compaction.

Vegetated Filter Area soils must not be compacted. Loosen the soil by raking, tilling or using a field cultivator. After the Vegetated Filter Area soils have been loosened, add topsoil or compost. Add lime and fertilizer based on the results of a soil test. Establish a permanent stand of vegetation by Sodding.

1.4.2.3 Excavation

Excavate the area for the Level Spreader Swale and Level Spreader Lip as shown on the Plans. Remove excavated materials and dispose of them properly.

1.4.2.4 Level Spreader Lip

Install an appropriately sized concrete footer to stabilize the concrete Level Spreader Lip. Install a 1-foot wide cast in place concrete Level Spreader Lip at 0% grade. Ensure that the top of the forms are level.

Install the Level Spreader Lip a minimum of 6 inches higher than the existing downstream ground. Place and anchor a Class 2, Type C nonwoven geotextile on the downslope side of the Level Spreader Lip a minimum of 3 feet and place a 3 to 4-inch layer of #57 stone on top of the geotextile to minimize erosion.

1.4.2.5 Underdrains

Install perforated pipe underdrains beneath the Forebay and Level Spreader Swale with a minimum diameter of 4-inches conforming to the requirements of *SCDOT Technical Specification Section 802, Pipe Underdrains* when the underlying soil has an infiltration rate less than 2 in/hr. Ensure the underdrain discharges to the Flow Bypass Conveyance Channel.

1.4.2.6 Level Spreader Swale

The Level Spreader Swale is typically constructed from earth and is stabilized with turfgrass Sod TRMs, concrete or lined with rip rap. Install the Level Spreader Swale with dimensions as shown on the design Plans. Tie the ends of the Level Spreader Swale into higher ground to prevent flow around the level spreader lip

Place top soil in the excavated trench over the underdrain system, and Sod the swale. Sod is strongly preferred for the Level Spreader Swale. In urban applications, the Level Spreader Swale may be concrete. An advantage of a concrete channel is the relative ease in removing accumulated debris.

1.4.2.7 Forebay

Construct a Forebay upstream of the Level Spreader Swale using a small excavator. Excavate the Forebay to the dimensions, side slopes, and elevations shown on the site Plans. The minimum depth of the Forebay ranges from 1 to 3 feet.

1.4.3 Inspection and Maintenance of Level Spreaders

Regular inspection and maintenance is critical to the effective operation of Level Spreaders. During the first year after construction, inspect Level Spreaders for proper distribution of flows and signs of erosion during and after all major rainfall events. After the first year, inspect Level Spreaders annually.

Summary of maintenance requirements:

- Maintain Level Spreaders annually and after all major storm events.
- Check the Level Spreader and downstream vegetated area for signs of erosion.

- Address erosion that is discovered in the vegetated area through the application of turf reinforcement matting (TRM) and through re-grading if necessary.
- Remove sediment and debris from the Forebay and from behind the Level Spreader Lip.
- Maintain the vegetation in the Forebay and around the Level Spreader to a height of approximately 3 to 6 inches.

Other required maintenance includes, but is not limited to:

- Mowing and trimming as needed.
- Replacing or replenishing vegetation and plants as needed.
- Removing trash and debris periodically as needed.
- Re-grading and re-seeding Level Spreader upslope edges and the forebay as a result of deposited sediment. (Depositing sediment may kill grass and change the level spreader elevation.)

1.4.4 Acceptance

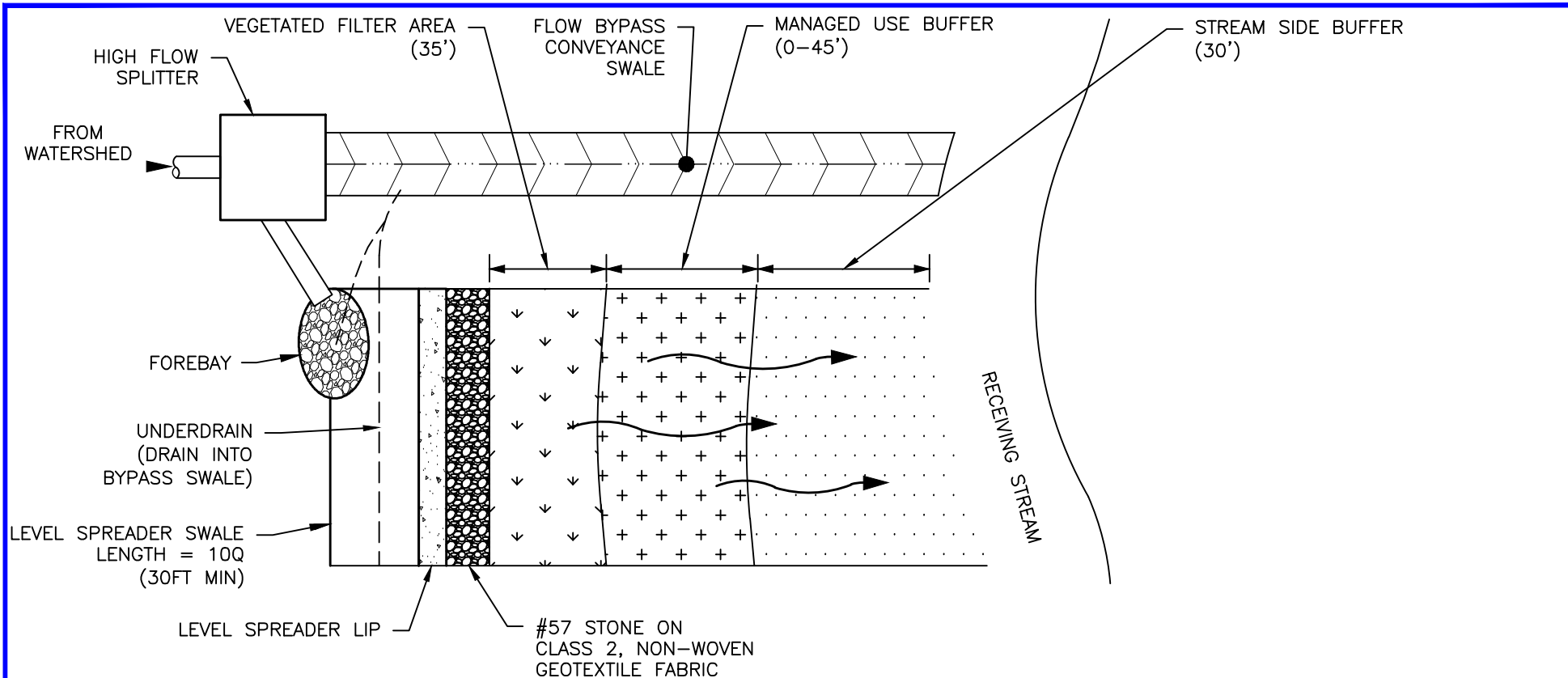
Obtain ENGINEER acceptance and approval for all Level Spreader installations.

1.5 References

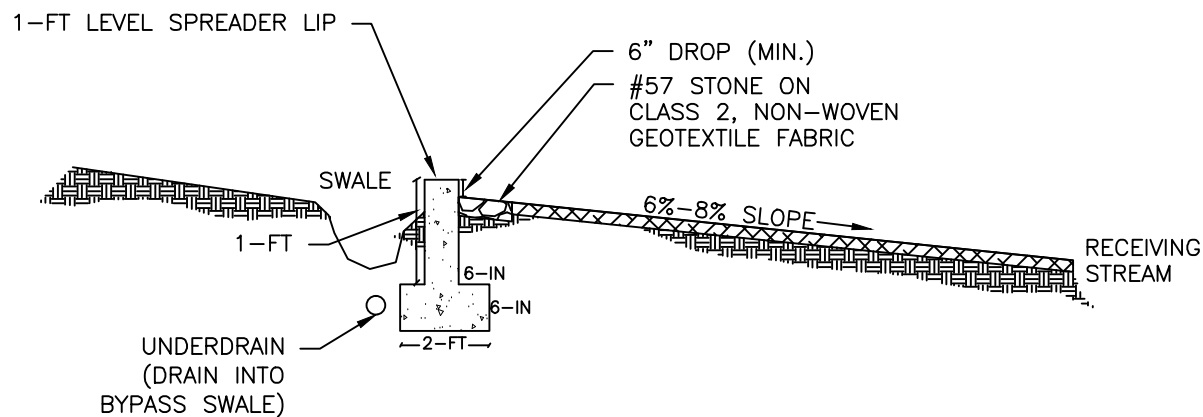
North Carolina DENR Stormwater BMP Manual, March 9, 2010.

North Carolina Division of Water Quality, Level Spreader Design Guidance, January 1, 2007.

Natural Resources Conservation Service, Conservation Practice Standard for Level Spreader, January 1999.



PLAN VIEW



PROFILE VIEW

SCALE: NONE

Anderson County, SC

WQ LEVEL SPREADER

STANDARD DRAWING NO. WQ-09

APPROVED BY: _____
Anderson County, SC

January, 2013
DATE

LEVEL SPREADER MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Level Spreaders. Document Level Spreaders deficiencies during **annual** inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as Level Spreaders.

Important maintenance procedures:

- Immediately after the installation, water newly planted vegetation twice weekly as needed until the vegetation becomes established (typically six weeks).
- Ensure the grass cover is dense and healthy. Re-sod or re-seed if necessary to ensure a dense stand of grass.
- Maintain stable groundcover in the drainage area to reduce the sediment load.
- Two to three times per year, grass filter strips will be mowed and the clippings harvested to promote the growth of thick vegetation with optimum pollutant removal efficiency. Turf grass should not be cut shorter than 3 to 5 inches and may be allowed to grow as tall as 12 inches depending on the aesthetic requirements. Forested filter strips do not require this type of maintenance.
- Once a year, the soil will be aerated if necessary.
- Once a year, soil pH will be tested and lime will be added if necessary.
- Annually inspect the BMP to ensure proper function and effectiveness as a stormwater best management practice.

After vegetation is established, perform inspections once a quarter and after every storm event greater than 1.0 inch, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Periodic pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Every 6-months
Repair eroded areas. Re-seed or sod as necessary.	Every 6-months
Inspect trees and shrubs to evaluate their health.	Every 6-months
Remove and replace dead or severely diseased vegetation.	Every 6-months
Removal of evasive vegetation.	Every 6-months
Nutrient and pesticide management.	Annual, or as needed
Water vegetation, shrubs, and trees.	Every 6-months

Perform trouble shooting activities as follows:

Field Condition	Common Solutions
Trash/ Debris is present	Remove trash/ debris
Water is channelizing and causing erosion.	Re-grade if necessary to smooth it over and Provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Too much sediment has accumulated.	Remove accumulated sediment to recover capacity. A sediment forebay may be required. Remove sediment that exceeds 2 inches on more than 10% of the vegetated treatment area, or anywhere that it is interfering with performance.
The flow control device is clogged or damaged	Unclog and properly dispose of any sediment off site. Make any necessary repairs or replace device if necessary.
Grass is too long or too short.	Maintain grass at a height of approximately three to six inches.
Plants are desiccated, dead, diseased or dying	Determine the source of the problem (soils, hydrology, disease, etc.). Remedy the problem and replace plants. Provide a one-time fertilizer application. Provide additional irrigation and fertilizer as needed.
Nuisance vegetation is choking out desirable species	Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water (stream, pond, etc.).

WQ-10: OP LEVEL SPREADERS (Outlet Pipe Discharges)

1.0 Level Spreaders

1.1 Description

Use Level Spreaders for Outlet Pipe Discharges as an energy dissipater to disperse concentrated runoff uniformly. Use Level Spreaders for peak design flow rates up to 30 cubic feet per second (cfs). Level spreaders are constructed at a virtually zero percent grade across a slope consisting of a permanent structure used to disperse or “spread” concentrated flow thinly over the Level Spreader lip. The main purpose is to spread potentially erosive concentrated flow over a wide area to reduce erosion at the outlet.

Use Level Spreaders for Outlet Pipe Discharges to convey runoff from pipe outfalls uniformly onto downstream areas. Level Spreaders are applicable:

- As outlets for diversion structures.
- Where uniform, sheet flow can be achieved down slope of Level Spreaders.
- As a segment of a stormwater BMP treatment series.
- Where runoff from an impervious surface is uneven and/or runoff is released as concentrated flow, such as through curb cuts or slope drains.

Do not use Level Spreaders:

- Where discharge slopes exceed 6% for wooded/forested areas or 8% for thick ground cover/grass areas.
- Where there are draws or concentrated flow channels located within the down slope area of a proposed Level Spreader.
- Where the runoff water will re-concentrate after release from the level spreader before reaching an outlet designed for concentrated flow.
- Where there will be traffic over the Level Spreader.

Depending on the use, Level Spreader elements may include a forebay, Level Spreader lip, pipe drain and turf reinforcement matting (TRM) or Class A or B riprap. Ensure Level Spreaders not discharging to a specific stormwater BMP or designed stormwater conveyance system discharge to a stabilized area.

Level Spreader dimensions are derived from the design peak flow rates (cfs). Table 1 shows the minimum depth and minimum length of the level spreader lip based on the discharge pipe size.

Table 1: Level Spreader Dimensions

Pipe Size (inches)	Minimum Depth (ft)	Minimum Lip Length (ft)
12	1.0	11.0
18	1.5	16.5
24	2.0	22.0
30	2.5	27.5
36	3.0	33.0

1.2 Materials

1.2.1 Forebay / Excavated Swale

Use a forebay or excavated swale for the preliminary treatment of stormwater. Excavate the forebay as a bowl shaped feature to slow the influent before it reaches the level spreader lip. Reinforce the forebay with a turf reinforcement matting (TRM), Class A or B riprap, or transition mats

1.2.2 Level Spreader Lip

User a Level Spreader lip made of earth, gravel, or concrete. When the lip is constructed of earth or gravel, reinforce the level spreader lip with turf reinforcement matting. The level spreader lip is the main body of the Level Spreader that receives water from the forebay, directly from a BMP, or directly from a pipe outlet. Construct the lip so it is level along the entire length.

1.2.3 Drainage Pipe

Use Level Spreader drainage pipe when the underlying soil has an infiltration rate less than 2 in/hr or when water detained within the Level Spreader does not drain. Use a non-perforated PVC pipe underdrain with a minimum diameter of 4-inches.

1.2.4 Turf Reinforcement Matting (TRMs)

Stabilize the Level Spreader with turf reinforcement matting.

1.3 Construction Requirements

Construct Level Spreaders on undisturbed soil whenever possible. If the use of fill is unavoidable, compact the fill material to 95% of standard proctor tests. Protect the level spreader and downstream vegetated area from sediment and stormwater flows during construction.

1.3.1 Site Preparation

Before Level Spreader construction, ensure the ground contours are parallel to the Level Spreader location, slopes are less than 6 to 8 percent, and no draws are located downstream of the level spreader. Assess the downstream area and ensure the area stabilized prior to the construction of the Level Spreader. Ensure Level Spreader is actually level.

1.3.2 Installation

Install the Level Spreader with no greater than 0.05 percent grade on the spreader lip to ensure a uniform distribution of flow. A temporary stormwater diversion may be necessary until the Level Spreader is fully stabilized.

1.3.2.1 Forebay / Excavated Swale

Construct an excavation upstream of the Level Spreader lip acting as a stilling basin allowing runoff to pond. Excavate the forebay to the dimensions, side slopes, and elevations shown on the contract plans or as directed by the Engineer. The minimum depth of the forebay ranges from 1 to 3 feet. Do not operate heavy equipment for the excavation of the Level Spreader. Remove excavated materials from the Level Spreader and forebay and dispose of them properly.

1.3.2.2 Level Spreader Lip

Install the Level Spreader lip with a minimum top width of 6-inches. Install the Level Spreader lip with a minimum 6-inch drop to the existing downstream ground allowing water to pass over the lip without interference from vegetation. Extend a TRM a minimum of 3 feet downstream of the Level Spreader lip,

then anchor and trench the TRM into place as required. The TRM limits erosion from occurring as water discharges from the top of the level spreader to the downstream vegetated area.

1.3.3 Inspection and Maintenance of Level Spreaders

Regular inspection and maintenance is critical to the effective operation of Level Spreaders. During the first year after construction, inspect Level Spreaders for proper distribution of flows and signs of erosion during and after all major rainfall events. After the first year, inspect Level Spreaders annually or biannually.

Summary of maintenance requirements:

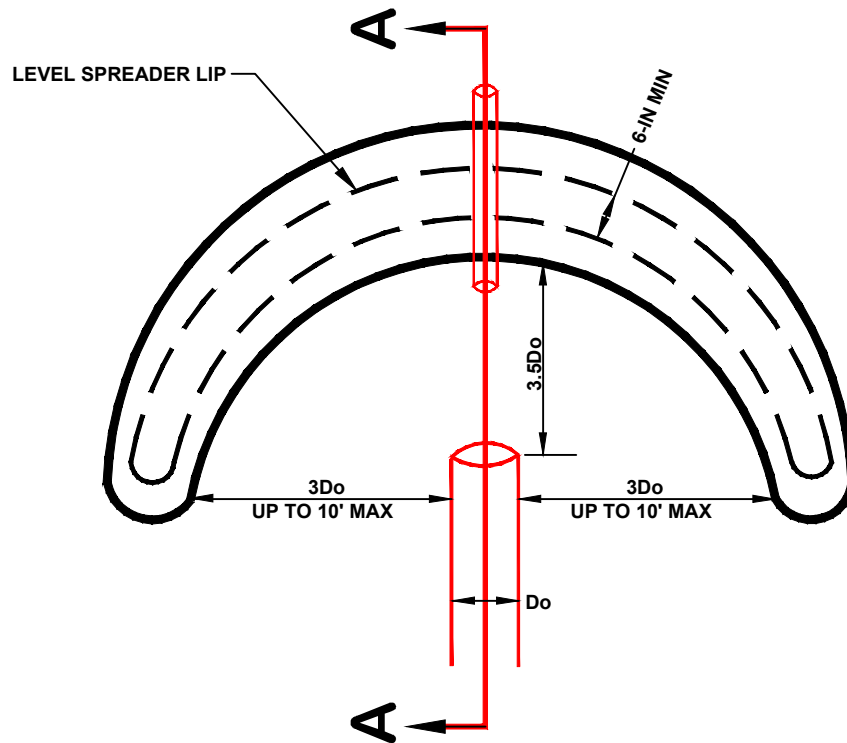
- Maintain Level Spreaders annually and after all major storm events.
- Check the Level Spreader and downstream areas for signs of erosion.
- Address erosion that is discovered in downstream areas through the application of turf reinforcement matting (TRM) and through re-grading if necessary.
- Remove sediment and debris from the forebay and from behind the Level Spreader lip.
- Maintain the grass in the forebay and around the Level Spreader to a height of approximately 3 to 6 inches.

Other required maintenance includes, but is not limited to:

- Mowing and trimming as needed.
- Replacing or replenishing vegetation as needed.
- Removing trash and debris periodically as needed.
- Re-grade and re-seed Level Spreader upslope edges and the forebay as a result of deposited sediment. (Depositing sediment may kill grass and change the Level Spreader elevation.)

1.3.4 Acceptance

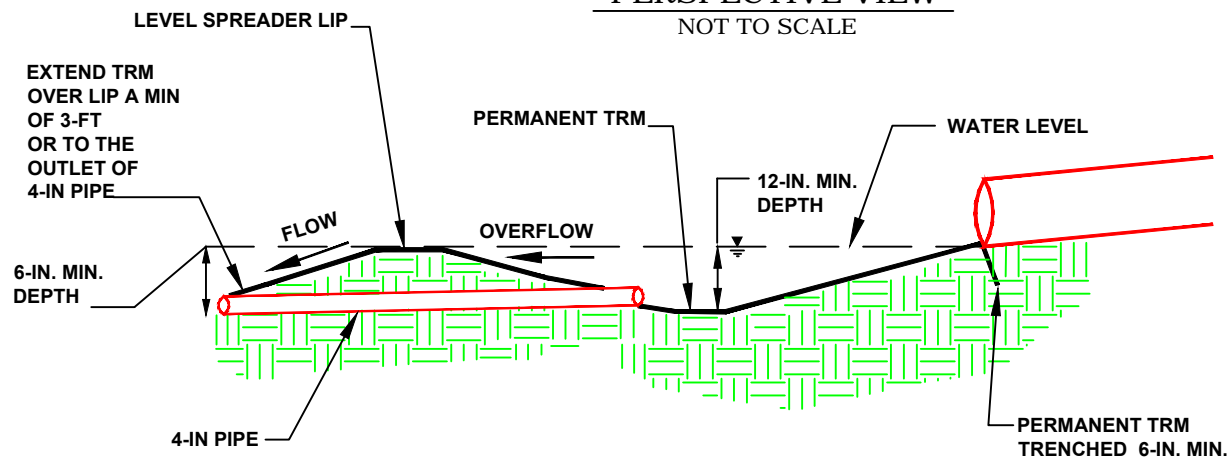
Obtain Engineer acceptance and approval for all Level Spreader installations.



OUTLET PROTECTION LEVEL SPREADER

NOTE;
Install TRM per RECP specifications.

PERSPECTIVE VIEW
NOT TO SCALE



SECTION A-A
NOT TO SCALE

Anderson County, SC

OP LEVEL SPREADER

STANDARD DRAWING NO. WQ-10

APPROVED BY: _____
Anderson County, SC

January, 2013
DATE

LEVEL SPREADER MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Level Spreaders. Document Level Spreaders deficiencies during **annual** inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as Level Spreaders.

Important maintenance procedures:

- Immediately after the installation, water newly planted vegetation twice weekly as needed until the vegetation becomes established (typically six weeks).
- Ensure the grass cover is dense and healthy. Re-sod or re-seed if necessary to ensure a dense stand of grass.
- Maintain stable groundcover in the drainage area to reduce the sediment load.
- Two to three times per year, grass filter strips will be mowed and the clippings harvested to promote the growth of thick vegetation with optimum pollutant removal efficiency. Turf grass should not be cut shorter than 3 to 5 inches and may be allowed to grow as tall as 12 inches depending on the aesthetic requirements. Forested filter strips do not require this type of maintenance.
- Once a year, the soil will be aerated if necessary.
- Once a year, soil pH will be tested and lime will be added if necessary.
- Annually inspect the BMP to ensure proper function and effectiveness as a stormwater best management practice.

After vegetation is established, perform inspections once a quarter and after every storm event greater than 1.0 inch, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Periodic pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Every 6-months
Repair eroded areas. Re-seed or sod as necessary.	Every 6-months
Inspect trees and shrubs to evaluate their health.	Every 6-months
Remove and replace dead or severely diseased vegetation.	Every 6-months
Removal of evasive vegetation.	Every 6-months
Nutrient and pesticide management.	Annual, or as needed
Water vegetation, shrubs, and trees.	Every 6-months

Perform trouble shooting activities as follows:

Field Condition	Common Solutions
Trash/ Debris is present	Remove trash/ debris
Water is channelizing and causing erosion.	Re-grade if necessary to smooth it over and Provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Too much sediment has accumulated.	Remove accumulated sediment to recover capacity. A sediment forebay may be required. Remove sediment that exceeds 2 inches on more than 10% of the vegetated treatment area, or anywhere that it is interfering with performance.
The flow control device is clogged or damaged	Unclog and properly dispose of any sediment off site. Make any necessary repairs or replace device if necessary.
Grass is too long or too short.	Maintain grass at a height of approximately three to six inches.
Plants are desiccated, dead, diseased or dying	Determine the source of the problem (soils, hydrology, disease, etc.). Remedy the problem and replace plants. Provide a one-time fertilizer application. Provide additional irrigation and fertilizer as needed.
Nuisance vegetation is choking out desirable species	Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water (stream, pond, etc.).

WQ-11: VEGETATED FILTER STRIP

1.0 Vegetated Filter Strip

1.1 Description

Vegetated Filter Strips are gently sloping, densely vegetated areas that filter, slow, and infiltrate sheet flowing stormwater. Filter strips are best utilized to treat runoff from roads, highways, roof drainage, and pervious surfaces. In highly impervious areas, filter strips should be used for pretreatment for other BMPs such as a Bioretention Area. Vegetated Filter Strips can consist of turf grasses, or natural vegetation.

The use of indigenous vegetated areas that have surface features that disperse runoff is encouraged, as the use of these areas will also reduce overall site disturbance and soil compaction. Indigenous areas that have surface features that concentrate flow are not acceptable. Runoff must be distributed as sheet flow so that erosive conditions cannot develop. The vegetation in Vegetated Filter Strips must be dense and healthy.

1.2 Design

1.2.1 General Design Requirements

The slope of the Vegetated Filter Strip should not exceed 8%. The minimum width (flow length) of the Vegetated Filter Strip is **35 feet**. Ensure the water quality runoff discharges to a 35-foot minimum vegetated filter area width (or a width that achieves 80% TSS removal through the use of a pollutant loading model acceptable to County).

For an effective Vegetated Filter Strip, it is essential to prepare the soils properly and plant and maintain a dense, vigorous stand of turfgrass sod. Use Tall Fescue or Common Bermuda grass as the main permanent turf-type vegetation for engineered Vegetated Filter Strips.

Natural vegetation can be used as cover for Vegetated Filter Strips when:

- The natural vegetation consists of an existing dense herbaceous buffer,
- The herbaceous buffer has an existing minimum ground cover of 90%,
- The area is validated by Anderson County during a field site visit, and

Vegetated Filter Strips will not contain any natural draws or channels. If the buffer is herbaceous in nature but does not contain a thick stand of vegetation, then add additional turf-type vegetation species to stabilize the ground surface.

A shallow or seasonally high groundwater table will inhibit the opportunity for infiltration. Therefore, the lowest elevation in the Vegetated Filter Strip should be at least 2 feet above the water table

Do not remove trees to create the necessary Vegetated Filter Strip area.

Vegetated Filter Strips may be designed to discharge to a variety of features, including natural buffer areas, vegetated swales, infiltration basins, or other structural BMPs.

Vegetation must be established prior to receiving flow. A temporary stormwater diversion is necessary until the vegetation in the Vegetated Filter Strip is stabilized. The Vegetated Filter Strip must retain the capacity to pass flow without erosion. Since stable vegetation must be established in the Vegetated Filter Strip before it can be put on-line, consider the time of year as construction may be limited to the growing season in order to ensure that a vegetated cover is established.

It is crucial that the slope and vegetation of the proposed natural herbaceous Vegetated Filter Area be surveyed in the field to ensure that the vegetation and slopes comply with requirements of this Specification.

1.2.2 Sheet Flow Requirements

Level spreading devices or other measures are required to provide uniform sheet flow conditions at the interface of the Vegetated Filter Strip and the adjacent land cover. Ensure concentrated flows do not discharge to the Vegetated Filter Strip, as they lead to erosion and failure of the system. Completely impervious drainage areas with flow lengths greater than 25-ft discharging directly to Vegetated Filter Strips require a level spreader meeting the requirements of the *Level Spreader Specification*. Other level spreading applications can be used for flow lengths less than 25-ft when contributing drainage areas are graded to provide sheet flow runoff into the Vegetated Filter Strip. Examples of level spreader applications with flow lengths less than 25-ft include:

- A gravel-filled trench, installed along the entire up gradient edge of the Vegetated Filter Strip. Use gravel having a size range of ASTM D 448 size No. 6 (1/8-in – 3/8-in). Trenches are typically 12-inches wide and 24-inches to 36-inches deep, and are lined with a nonwoven geotextile. When placed directly adjacent to an impervious surface, provide a drop (between the pavement edge and the trench) of 1 to 2-inches in order to inhibit the formation of the initial deposition barrier.
- Curb stops with cut outs. The cut out height is no greater than 1-in with a maximum length of 6-in. Space cutouts no less than 6-ft apart on center.

1.3 Variations

Vegetated Filter Strip effectiveness may be enhanced through the addition of a pervious berm at the toe of the slope. A pervious berm allows for greater runoff velocity and volume reduction resulting in better pollutant removal ability, by providing a very shallow, temporarily ponded area.

The berm has a height of 6 to 12 inches and is constructed of sand, gravel, and sandy loam to encourage vegetative cover. Provide an outlet pipe(s) or overflow weir to ensure that the area drains within 24 hours, or to convey larger storm events. The berm is erosion resistant under the full range of storm events. The ponded area is planted with vegetation that is resistant to frequent inundation. Check dams may be implemented on Vegetated Filter Strip with slopes exceeding 5%.

Construct check dams of durable, nontoxic materials such as rock, brick, wood, not more than 6-inches in height, and placed at appropriate intervals to encourage ponding and prevent erosion. Care must be taken to prevent erosion around the ends of the check dams.

1.4 Installation

Begin Vegetated Filter Strip construction only when the upgradient site has been sufficiently stabilized and temporary erosion and sediment control measures are in place. The Vegetated Filter Strip will be installed at a time of the year when successful establishment without irrigation is most likely. However, temporary irrigation may be needed in periods of little rain or drought.

Grade the Vegetated Filter Strip (if required) to the design slope using a box blade or similar equipment. Avoid driving heavy equipment through the Vegetated Filter Strip to prevent compaction.

Vegetated Filter Strip soils must not be compacted. Loosen the soil by raking, tilling or using a field cultivator. After the Vegetated Filter Strip soils have been loosened, add topsoil or compost. Add lime and fertilizer based on the results of a soil test. Establish a permanent stand of vegetation by Sodding.

Construct level spreader device at the upgradient edge of the Vegetated Filter Strip. For gravel trenches, do not compact the subgrade.

The preferred installation of surface cover for Vegetated Filter Strip is Sodding with turf grass sod. The Vegetated Filter Strip may be seeded and protected with an Erosion Control Blanket, but Sodding is the preferred installation methods. Additional vegetation such as trees and shrubs may be planted, if proposed. Follow these steps to install sod for filter strips:

1. Make sure the soil is moist (but not overly wet) before laying Sod. Irrigating the soil several days before delivery is often adequate.
2. Install the Sod within 24 hours of delivery. Plan to un-stack and unroll the sod if it cannot be laid within 48 hours.
3. While installing, keep Sod in the shade to lessen the chance of heat buildup.
4. Start Sodding from a straight edge (driveway or sidewalk), and butt strips together, staggering them in a bricklike pattern
5. Avoid stretching Sod. Use a knife or sharp spade for trimming to fit irregularly shaped areas.
6. Lay Sod lengthwise across the face of slopes, and peg or stake the pieces to prevent slippage. After the sod has been placed, roll the lawn to ensure good sod-to-soil contact.
7. Begin watering.

Once the Vegetated Filter Strip is sufficiently stabilized, remove temporary erosion and sediment controls. It is very important that Vegetated Filter Strip vegetation be fully established before receiving upland stormwater flow. One full growing season is the recommended minimum time for sod establishment.

Frequent watering is essential for the first week after placing Sod. Ensure the short roots on the Sod does not dry out. After root establishment, watering becomes less frequent but longer, encouraging the roots to grow deeper without stressing the plant. Any drought at this point can severely diminish the health of the placed Sod. Gradually increasing the length of time between watering is important to develop a deep root system that can reach the moisture and nutrients needed to sustain long-term growth. Frequent light applications of watering results in a shallow-rooted plant, that is vulnerable to drought.

1.5 Maintenance

1.5.1 Preventive Maintenance and Operation Activities

The following list included reoccurring maintenance and operation activities that are required to maintain a functional filter strip.

- Once a year, re-seed the Vegetated Filter Strip with primary turf- type vegetation to maintain a dense growth of vegetation
- Maintain a stable ground cover in the drainage area to reduce the sediment load to the vegetation.
- Mow Vegetated Filter Strip as needed during the growing season. Turf grass should not be cut shorter than 3 to 5 inches and may be allowed to grow as tall as 12 inches depending on aesthetic requirements
- Aerate the Vegetated Filter Strip once a year.
- Once a year perform a soil test and add lime and fertilizer as required.

1.5.2 Intermittent Maintenance and Repairs

Table 1 includes typical intermittent maintenance needs and repairs with remediation suggestions for each potential problem.

Table 1: Intermittent Maintenance and Repairs

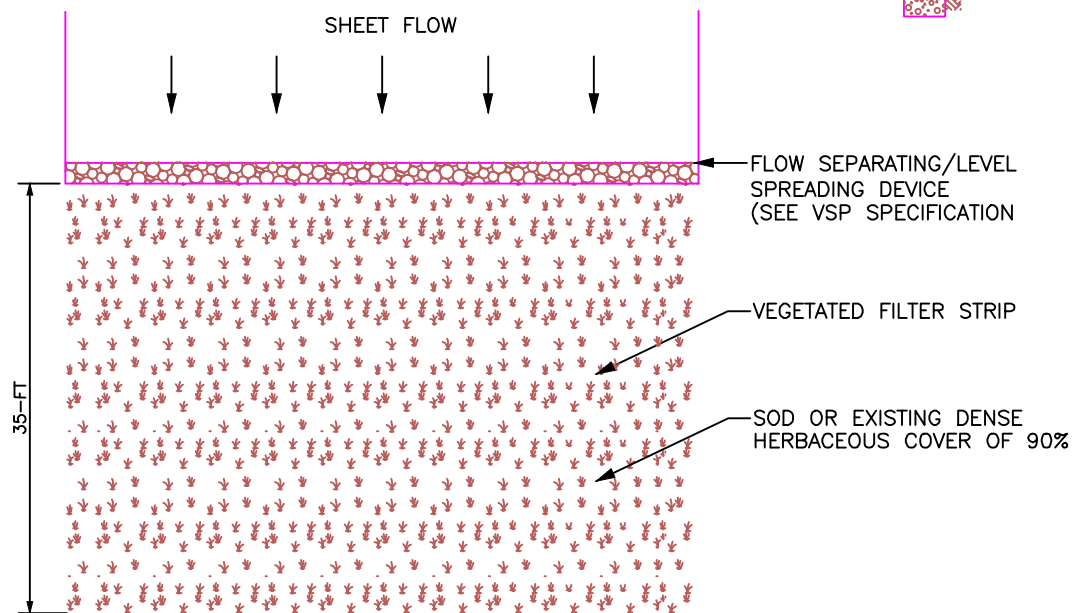
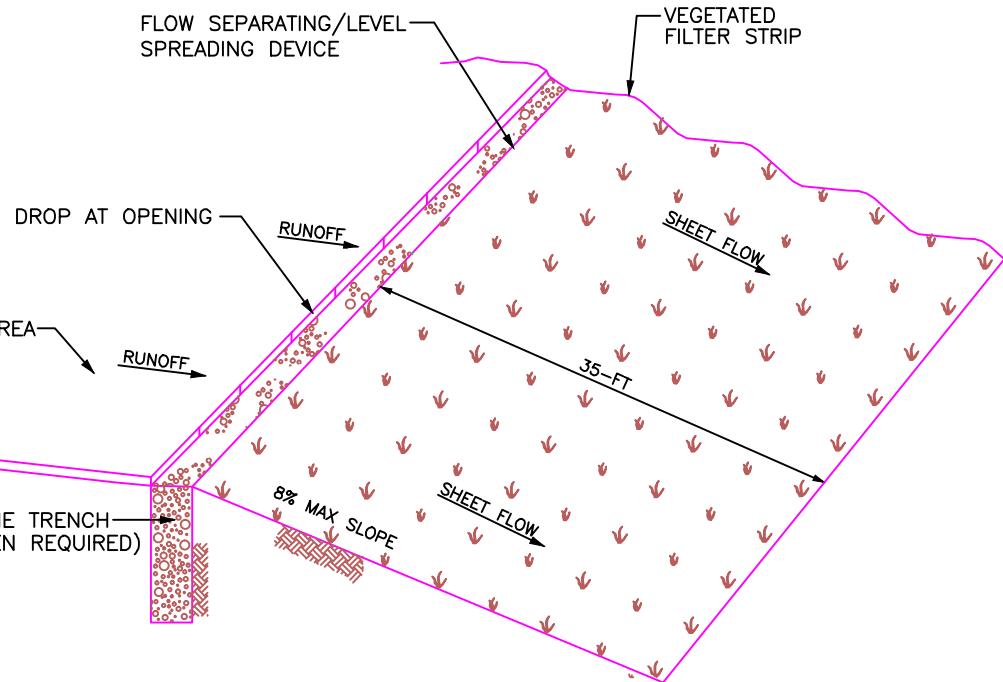
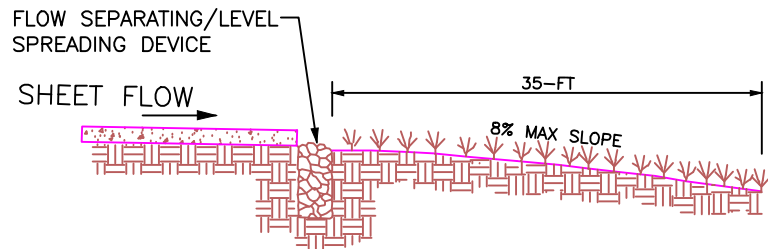
BMP Element:	Potential problem:	How to remediate the problem:
Level Spreader-VFS system	Trash/debris is present.	Remove the trash/debris.
Flow splitter device (if applicable)	The flow splitter device is clogged.	Unclog the conveyance and dispose of any sediment off-site.
	The flow splitter device is damaged.	Make any necessary repairs or replace if damage is too large for repair.
Level Spreader	The swale is overgrown with vegetation.	Mow vegetation. Re-grade and vegetate if the swale has become silted in.
	The level lip is cracked, settled, undercut, eroded or otherwise damaged.	Repair or replace lip.
	There is erosion around the end of the level spreader that shows stormwater has bypassed it.	Re-grade the soil to create a berm that is higher than the level lip, and then plant a ground cover and water until it is established. Provide lime and a one-time fertilizer application.
	Trees or shrubs have begun to grow on the swale or just downslope of the level lip.	Remove them.
Bypass channel	Areas of bare soil and/or erosive gullies have formed.	Re-grade the soil if necessary to remove the gully, and then reestablish proper erosion control.
	Turf reinforcement is damaged or riprap is rolling downhill.	Study the site to see if a larger bypass channel is needed (enlarge if necessary). After this, reestablish the erosion control material.
Vegetated Filter Strip	Grass is too short or too long (if applicable).	Maintain grass at a height of approximately three to six inches.
	Areas of bare soil and/or erosive gullies have formed.	Re-grade the soil if necessary to remove the gully, and then plant a ground cover and water until it is established. Provide lime and a one-time fertilizer application.
	Sediment is building up on the filter strip.	Remove the sediment and re-stabilize the soil with vegetation if necessary. Provide lime and a one-time fertilizer application.
	Grass is dead, diseased, or dying.	Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a one-time fertilizer application.
	Nuisance vegetation is choking out grass.	Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water.

1.6 References.

NCDENR Stormwater BMP Manual, Chapter 8 Level Spreader Grass Filter, Chapter Revised 03-09-10

City of Pennsylvania, Stormwater Best Management Practices Manual, Chapter 6 – Vegetated Filter Strip

New Jersey Stormwater Best Management Practices Manual, Chapter 9.10 – Standards for Vegetative Filters



NTS

Anderson County, SC

VEGETATED FILTER STRIP

STANDARD DRAWING NO. WQ-11

APPROVED BY: _____
Anderson County, SC

January, 2013
DATE

VEGETATED FILTER STRIP MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Vegetated Filter Strips. Document Vegetated Filter Strips deficiencies during annual inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as Vegetated Filter Strips.

Important maintenance procedures:

- Immediately after the installation, water newly planted vegetation twice weekly as needed until the vegetation becomes established (typically six weeks).
- Ensure the grass cover is dense and healthy. Re-sod or re-seed if necessary to ensure a dense stand of grass.
- Maintain stable groundcover in the drainage area to reduce the sediment load.
- Two to three times per year, grass filter strips will be mowed and the clippings harvested to promote the growth of thick vegetation with optimum pollutant removal efficiency. Turf grass should not be cut shorter than 3 to 5 inches and may be allowed to grow as tall as 12 inches depending on the aesthetic requirements. Forested filter strips do not require this type of maintenance.
- Once a year, the soil will be aerated if necessary.
- Once a year, soil pH will be tested and lime will be added if necessary.
- Annually inspect the BMP to ensure proper function and effectiveness as a stormwater best management practice.

After vegetation is established, perform inspections once a quarter and after every storm event greater than 1.0 inch, and annually thereafter. Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Periodic pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Every 6-months
Repair eroded areas. Re-seed or sod as necessary.	Every 6-months
Inspect trees and shrubs to evaluate their health.	Every 6-months
Remove and replace dead or severely diseased vegetation.	Every 6-months
Removal of evasive vegetation.	Every 6-months
Nutrient and pesticide management.	Annual, or as needed
Water vegetation, shrubs, and trees.	Every 6-months

Perform trouble shooting activities as follows:

Field Condition	Common Solutions
Trash/ Debris is present	Remove trash/ debris
Water is channelizing and causing erosion.	Re-grade if necessary to smooth it over and Provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Too much sediment has accumulated.	Remove accumulated sediment to recover capacity. A sediment forebay may be required. Remove sediment that exceeds 2 inches on more than 10% of the vegetated treatment area, or anywhere that it is interfering with performance.
The flow control device is clogged or damaged	Unclog and properly dispose of any sediment off site. Make any necessary repairs or replace device if necessary.
Grass is too long or too short.	Maintain grass at a height of approximately three to six inches.
Plants are desiccated, dead, diseased or dying	Determine the source of the problem (soils, hydrology, disease, etc.). Remedy the problem and replace plants. Provide a one-time fertilizer application. Provide additional irrigation and fertilizer as needed.
Nuisance vegetation is choking out desirable species	Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water (stream, pond, etc.).

WQ-12: Stormwater Manufactured Treatment Devices (MTDs)

1.0 Stormwater Manufactured Treatment Devices

Stormwater Manufactured Treatment Devices (MTDs) function as stormwater treatment devices before stormwater runoff is discharged off-site or to receiving water bodies, and may be incorporated into a series of water quality best management practices to remove pollutants from stormwater runoff. MTDs are not designed, or intended to store a volume of water for water quality treatment. When the storage of a water quantity volume is required, additional or separate BMPs must be implemented. MTD Pollutant removal efficiencies are variable and are highly dependent on storm size, influent pollutant concentrations, rainfall intensity and other factors.

Use MTDs that minimize the long term water quality impacts from stormwater runoff to the Maximum Extent Practicable (MEP). Use MTDs designed to filter and trap trash, sediment, totals suspended solids (TSS), oil and grease, metals, hydrocarbons and other pollutants. Provide MTDs that combine settling, filtration, and various biological processes into one controlled system.

MTDs are classified in to three Types:

- MTD Type 1 - Separation Devices (Standard Stormwater MTD). Contains a sump for sediment deposition with a series of chambers, baffles or weirs to trap trash, oil, grease, and other contaminants.
- MTD Type 2 - Filtration Devices (Impaired Water Bodies, TMDL Requirements). Contains a sedimentation chamber and a filtering chamber. MTD Type 2 contains filter materials or vegetation to remove specific pollutants such as nitrogen, phosphorus, copper, lead, zinc, and bacteria.
- MTD Type 3 - Catch Basin Inserts (Limited Space). May contain filter media including polypropylene, porous polymers, treated cellulose, and activated carbon designed to absorb specific pollutants such as oil, grease, hydrocarbons, and heavy metals. MTD Type 3 must provide overflow features that do not reduce the original hydraulic capacity of the catch basin.

1.1 Design Criteria

MTDs are applicable for a maximum drainage area of 3.0 acres.

Size MTD Type 1 and MTD Type 2 to treat at a minimum the entire water quality event (WQE) with no by pass.

Use MTDs designed to treat the entire water quality event (WQE) with no by pass for a minimum **80%** Total Suspended Solids (TSS) removal efficiency.

The WQE flow rate is a separate flow rate from the Level of Service (LOS) flow rate. In addition to meeting the required treatment efficiency for the WQE, the MTD must be capable of passing the specified LOS flow rate (i.e. 10-year storm event) without causing adverse hydraulic impact to upstream portions of the drainage system and without causing any re-suspension or scour of previously trapped pollutants, or the MTD may be required to be placed off-line.

Ensure site constraints (available right of way and available depth) allow the installation of a single MTD for design peak water quality flow rates up to 8 cfs. Additional MTDs may be required for water quality event flow rates greater than 8 cfs.

Ensure tail water conditions are accounted for in the MTD design.

When applicable, use MTDs designed to meet any other additional watershed, TMDL, or site-specific water quality requirements.

1.1.1 Water Quality Event (WQE) Design

Size MTDs to treat, at a minimum, the peak flow rate of the stormwater runoff from the **1.8-inch, 24-hour Type II storm event**, from the entire drainage area to the MTD. This is defined as the water quality event (WQE). When applicable, use the 1-year 24-hour storm hydrograph and input 1.8 inches as the rainfall depth when performing hydrologic modeling. This water quality event is distributed into the rainfall intensities in Table 1.

Table 1: Water Quality Event (WQE) Design Intensities

Frequency	i (t _c 5 min) (in/hr)	i (t _c 10 min) (in/hr)	i (t _c 15 min) (in/hr)	i (t _c 30 min) (in/hr)
Water Quality Design Storm 1.8 in 24-hr Type II storm event	2.16	1.93	1.74	1.34

When used as a stand-alone BMP that is not part of a treatment train, design MTDs to trap a minimum of 80% TSS based on annual loadings.

Where MTDs are not able to meet the annual 80% TSS removal efficiency, they can provide excellent pre-treatment in a series of water quality control BMPs or inlet to permanent pool detention basins or storm water wetlands. When used as a part of a treatment series, design MTDs to trap TSS based on annual loadings by particle class (clay, silt, small aggregate, sand, large aggregate). In this situation, the MTD is not required to trap 80% TSS on annual loadings, but the entire treatment series must trap 80% TSS based on annual loadings.

1.2 Materials

1.2.1 Material Design Specifications

- Use MTD Type 1 and 2 designed in accordance with the requirements of the latest *AASHTO LRFD Bridge Design Specifications*. Use MTDs with a HL-93 design live loading.
- Use Class 4000 concrete (minimum) for all MTD precast concrete elements.
- Use reinforcing bars conforming to the requirements of ASTM A706, Grade 60.
- Use welded wire fabric meeting the requirements of AASHTO M55 and AASHTO M221, ASTM A185, or ASTM A497.
- Ensure all materials, manufacturing, testing and product performance for precast concrete components and accessories are in accordance with AASHTO M199 and accepted by the Engineer.

1.2.2 Detailing Requirements

- Ensure the base slab and any required separation slab concrete is poured monolithically with the wall or a water-stop cast into the bottom for the joint to the wall.
- Use tongue and groove joints. Ensure the size and amount of sealant is in accordance with the manufacturer's recommendations.

- Use an appropriate Steel manhole supplied by the manufacturer engraved with the unique MTD markings including the MTD Name and Model number.

1.2.3 Stormwater Manufactured Treatment Devices (MTDs) Type 1

Use MTD Type 1 (separation devices, also referred to as hydrodynamic separators) designed and sized to treat, at a minimum, the stormwater runoff from the applicable Water Quality Event (WQE) to prevent pollutants from being transported downstream.

Use MTD Type 1 as the standard Stormwater MTD for pollutant removal. Use MTD Type 1 that contains a sump for sediment deposition with a series of chambers, baffles or weirs to trap trash, oil, grease and other contaminants. MTD Type 1 may include a high flow bypass mechanism for rainfall events larger than the water quality event to prevent scouring and re-suspension of previously trapped pollutants.

MTD Type 1 not providing a high flow bypass mechanism must provide specific lab testing results verifying no re-suspension or scour of previously trapped pollutants during the Level of Service (LOS) design event for the MTD. Use MTD Type 1 with treatment elements or other upstream BMPs to remove trash, debris and other gross pollutants.

Use MTD Type 1 sized using acceptable scaling methodologies based on the results of laboratory testing with a maximum Hydraulic Loading Rate of **25 gpm/sf (0.0557 cfs/sf)**. MTDs scaled with higher Hydraulic Loading Rates must provide specific lab results verifying the required removal efficiency for the water quality event at the higher Hydraulic Loading Rate.

Use MTD Type 1 with the following properties:

- Designed for a minimum **80%** Total Suspended Solids (TSS) removal efficiency (ASTM D-3977-97 SSC) of coarse sand (125-micron-mean size, OK-110, or F-95 Silica Sand) for the peak flow rate from the water quality event for average influent concentrations ranging from 100 mg/L to 300 mg/L.
- Use settling, separation, swirling, and centrifugal force techniques to remove pollutants from storm water runoff.
- Contain no moving components that require an external power source such as electricity, gas powered engines or generators.

1.2.4 Stormwater Manufactured Treatment Devices (MTDs) Type 2

Use MTD Type 2 (filtration devices) designed and sized to treat, at a minimum, the stormwater runoff from the applicable Water Quality Event (WQE) to prevent pollutants from being transported downstream.

MTD Type 2 may be required for unique Project constraints such as impaired water body's or TMDL watersheds. Use MTD Type 2 that contains a sedimentation chamber and a filtering chamber. Use MTD Type 2 that contains filter materials or vegetation to remove specific pollutants.

MTD Type 2 may include a high flow bypass mechanism for rainfall events larger than the water quality event to prevent scouring and re-suspension of previously trapped pollutants.

MTD Type 2 not providing a high flow bypass mechanism must provide specific lab testing results verifying no re-suspension or scour of previously trapped pollutants during the Level of Service (LOS) design event for the MTD. Use MTD Type 2 with treatment elements or other upstream BMPs to remove trash, debris and other gross pollutants.

Use MTD Type 2 sized using acceptable scaling methodologies based on the results of laboratory testing with a maximum Hydraulic Loading Rate of **25 gpm/sf (0.0557 cfs/sf)**. MTDs scaled with higher

Hydraulic Loading Rates must provide specific lab results verifying the required removal efficiency for the water quality event at the higher Hydraulic Loading Rate.

Typical pollutant removal efficiencies are variable and are highly dependent on storm size, influent pollutant concentrations, rainfall intensity and other factors.

Use MTD Type 2 with the following properties:

- Designed for a minimum **80%** Total Suspended Solids (TSS) removal efficiency (ASTM D-3977-97 SSC) of Sil-Co-Sil 106 ground silica, or the NJDEP particle size distribution with a D50 of 67 microns for the peak flow rate from the water quality event for average influent concentrations ranging from 100 mg/L to 300 mg/L.
- Use filtering techniques to remove pollutants from storm water runoff.
- Are capable of removing the pollutants of concern for the receiving water body.
- Have typical removal capability for the pollutant of concern from test results as shown in Table 2.

Table 2: MTD Type 2 Typical Pollutant Removal Capability

PROPERTY	VALUE	PROPERTY	VALUE
Total Suspended Solids	≥ 80%	Metals	≥ 50%
Copper	≥ 50%	Lead	≥ 50%
Zinc	≥ 50%	Total Phosphorus	≥ 40%
Total Nitrogen	≥ 30%	Pathogens/Bacteria	≥ 75%
Oil & Grease	≥ 80%	Total Petroleum Hydrocarbons	≥ 80%

1.2.5 Stormwater Manufactured Treatment Devices (MTDs) Type 3

MTD Type 3 (catch basin inserts) may be required for unique Project constraints. Use MTD Type 3 designed for direct installation into storm drain catch basins. Use MTD Type 3 sized for the specific catch basin they are inserted. Use MTD Type 3 designed to treat stormwater runoff before it enters the primary storm sewer network or water quality treatment system.

Use MTD Type 3 that may contain filter media including polypropylene, porous polymers, treated cellulose, and activated carbon designed to absorb specific pollutants.

Use MTD Type 3 that provides overflow features that do not reduce the original hydraulic capacity of the catch basin. Pollutant removal efficiencies vary and are highly dependent on storm size, influent pollutant concentrations, rainfall intensity and other factors.

Use MTD Type 3 with the following properties:

- Designed for a minimum **80%** Total Suspended Solids (TSS) removal efficiency (ASTM D-3977-97 SSC) for:
 - Coarse sand (125-micron-mean size, OK-110, or F-95 Silica Sand) with average influent concentrations ranging from 1,500 mg/L to 2,000 mg/L (6% target sediment to water concentration) using ASTM 7351 or equivalent laboratory testing methods.
 - Street sweeping sediment load (average particle size of 200 micron) with average influent concentrations ranging from 24,000 mg/L to 26,000 mg/L (2.5% target sediment to water concentration) using ASTM 7351 or equivalent laboratory testing methods.

- Use separation, settling, swirling, centrifugal force, and filtering techniques to remove pollutants from stormwater runoff.
- Contain no moving components that require external power sources such as electricity, gas powered engines or generators.
- Are capable of removing the pollutants of concern for the receiving water body.

1.2.6 Quality Assurance

Provide MTDs Type 1 and 3 from a manufacturer listed on the most recent edition of *SCDOT Qualified Product List 78 Stormwater Manufactured Treatment Devices* in the appropriate category.

Provide MTD Type 2 from a manufacturer listed on the most recent edition of *Anderson County Qualified Product List for Type 2 MTDs*:

Table 3: Anderson County Qualified Product List for Type 2 MTDs

Manufacturer	Treatment Device	Website	Contact Number
AquaShield, Inc.	AquaFilter Filtration Chamber	www.aquashieldinc.com/	423-870-8888
BaySaver Technologies, Inc.	Bayfilter	www.baysaver.com/	1-800-BAYSAVER
Imbrium Systems Corporation	Jellyfish Filter	www.imbriumsystems.com/	416-960-9900
CONTECH Stormwater Solutions, Inc.	StormFilter	www.conteches.com/	800-338-1122
Hydro International	Up-Flo Filter	www.hydro-international.biz/us/	207-756-6200

At the time of delivery, provide the Engineer with a MTD packing list containing complete identification including, but not limited to, the following:

- Manufacturer's name and location.
- Manufacturer's telephone number and fax number.
- Manufacturer's e-mail address and web address.
- MTD name, model, and/or serial number.
- Certification that the specific MTD meets the physical and performance criteria of this specification.

Ensure that each MTD delivered bears identification including, but not limited to, the following:

- MTD name, model, and/or serial number.
- MTD structure number.

1.3 Construction Requirements

1.3.1 Working Drawings

Submit Working Drawings and Certification that the MTD meets the requirements of this *Specification* to the Engineer. Ensure the Working Drawings contain at a minimum the project name, MTD name and model and/or serial number, MTD dimensioning, MTD and storm sewer invert elevations, installation drawings, and instructions that completely describe the MTD. Do not perform any work on the MTD until the Working Drawings are accepted by the Engineer.

1.3.2 Site Preparation

Proper site preparation is essential for MTD installation. Prepare the site per the Plans, Specifications, and the manufacturer's instructions.

1.3.3 Precast MTD Installation

Perform precast MTD excavation, bed preparation, backfilling and compaction as required on the Plans, Specifications, manufacturer's instructions, or as directed by the Engineer for precast items.

Prepare and compact the MTD bed.

Ensure the elevation of the bedding material accommodates the elevation of all pipes connected to the MTD and the required MTD top elevation.

Place and level the MTD according to the manufacturer's requirements and to the elevations shown on the Working Drawings and Plans.

Install pipes and grout in place according to the storm sewer elevations, outfall elevations, pipe sizes, and the layout of the MTD as shown on the Plans. Ensure all lifting methods meet OSHA regulations.

Backfill and compact the MTD and all pipes as required on the Plans, Specifications, manufacturer's instructions, or as directed by the Engineer.

1.3.4 Assembly

Assemble MTDs in accordance with the manufacturer's written assembly instructions and in compliance with all OSHA, AASHTO, local, state, and federal codes and regulations. Erect shoring, bracing, or other devices necessary to achieve safe working conditions. Ensure the MTD bedding is protected from scour or movement during MTD installation.

Ensure that MTDs are designed and constructed in a manner that will not impact the integrity of the overall Project design and features such as grades, pedestrian facilities and other structures.

A manufacturer's representative is required to provide specific MTD assembly instructions to the Contractor and verify the assembly for each of the manufacturer's specific MTD according to the manufacturer's design and assembly instructions.

Ensure proper site stabilization is achieved so MTDs function as designed. Do not use MTDs to trap eroded sediment from construction operations, unless the manufacturer has approved such use in writing. Install MTDs as the last stormwater runoff structures installed on site, or keep these MTDs off-line or isolated until final stabilization is achieved.

If MTDs are used for sediment control, provide written certification from the manufacturer that the device is clean and operating properly at the time a Notice of Termination is filed for the site.

1.3.5 Inspection and Maintenance

- Inspect and maintain all MTDs in accordance with the manufacturer's written recommendations.
- Prepare specific maintenance requirements and maintenance schedules for each MTD.
- Inspect MTDs at least bi-annually to ensure that the MTD is working properly.
- Maintain MTDs as required to maximize pollutant removal.
- Keep a maintenance log to track all MTD inspections and maintenance with the quantities of materials removed from each MTD. Lack of maintenance is the most common cause of failure for MTDs.
- Remove accumulated sediment and other trapped pollutants when the MTD becomes full. Typical removal of pollutants requires the use of a vacuum truck.

1.3.6 Acceptance

Obtain Engineer acceptance and approval of all MTD installations. Obtain a letter from the manufacturer verifying the MTD assembly. When requested by the Engineer, ensure that a manufacturer's representative is on-site to provide MTD assembly instructions or ensure the manufacturer has provided assembly training to the contractor for each manufacturer specific MTD.

ANDERSON COUNTY
SUBMITTAL POLICY FOR
STORMWATER MANUFACTURED TREATMENT DEVICES (MTDs)

1. General

This policy covers Stormwater Manufactured Treatment Devices (MTDs) for use as post construction water quality management. Only use Manufacturers for MTD Type 1 and Type 3 that appear on *Qualified Products List 78* by the SCDOT Office of Materials and Research. Prior to approval on Anderson County projects, provide the ENGINEER with the following information from the Manufacturer for each specific Type of MTD (Type 1, Type 2, or Type 3):

- Written Quality Control program conforming to the requirements of the specification.
- Documentation of laboratory testing that quantifies the water quality performance of the MTD conforming to the requirements of the specification.
 - Independent 3rd party testing evaluator identification ((EPA ETV Program, ASTM, NJCAT, USGS, or other private, federal, state, local or university entities etc.) The evaluator cannot be the manufacturer.
 - Test facility name and location,
 - Signature of responsible person or party certifying the test results,
 - MTD manufacturer,
 - MTD name and model number tested,
 - Test ID number, and
 - Test date.
- Standard Details for each specific MTD showing MTD dimensions, estimated quantities and material specifications bearing the seal and signature of a *South Carolina* registered Professional Engineer meeting the requirements of the Anderson County *Technical Specification for MTDs*.
- Structural design calculations indicating design criteria, reinforcing steel schedule, and material specifications bearing the seal and signature of a *South Carolina* registered Professional Engineer meeting the requirements of the Anderson County *Technical Specification for MTDs*.
- Detailing Requirements
 - Base slab and any required separation slab concrete poured monolithically with the wall or a water-stop cast into the bottom for the joint to the wall.
 - Tongue and groove joints. Ensure the joint sealant meets all pipe specifications. Provide size and amount of joint sealant required.
 - Use an appropriate Heavy Duty steel manhole cover supplied by the manufacturer engraved with the unique MTD markings including the specific MTD Name and Model number. It is acceptable to vary the size, location of the manhole cover, and markings from typical manhole cover standards.
- Certification that the specific MTD performs to the minimum performance standards under the specific conditions stated in the Anderson County *Technical Specification for MTDs*.
- Instructions on the proper assembly and maintenance of the MTD.

When requested by Anderson County, the manufacture will provide field maintenance and cleaning recommendations based on MTD sizing models, MTD performance curves, MTD load reduction curves or from maintenance records on at least five installations showing a minimum of two years performance data in South Carolina or similar climatological area.

2. Acceptance

- 2.1. Complete the MTD Submittal Form supplied with this policy and provide the required information highlighted in the Form. This Form is used in the evaluation to ensure compliance with the MTD Technical Specifications. The information required in this Form is the minimum acceptable requirements for compliance with the MTD Technical Specification. Any deviations from this form are considered grounds for rejection of the submittal
- 2.2. Provide third party test documentation and test data demonstrating 80% TSS removal is achieved for the specified Particle Size Distribution and particle concentration as specified in the MTD Technical Specification.
- 2.3. Provide a detailed drawing of the typical MTD supplied. Indicate bypass flow route around the treatment and storage area if this is provided. A drawing for each size of a typical MTD model is not required.
- 2.4. If no bypass flow route around the treatment and storage area is provided, submit third party test documentation demonstrating at what flow rate that re-suspension and loss of trapped sediments occurs for the test Particle Size Distribution. Include this flow rate in the table, chart, or graph required in Section 2.5.
- 2.5. Provide a table, chart or graph indicating the maximum flow rate where 80% TSS removal is achieved for the specified Particle Size Distribution and particle concentration for each specific MTD model that is supported by the third party test data.
- 2.6. Provide a table indicating the maximum flow rate where 80% TSS removal is achieved for the specified Particle Size Distribution and particle concentration and the maximum sediment storage capacity for each specific MTD Type 3 that is supported by the third party test data.

3. Identification

Mark each specific MTD produced and delivered by the Manufacturer, by either stamping or etching, with the following minimum information:

- MTD name, model, and/or serial number
- Project Specific Structure Number

4. Shipment

- 4.1 Submit a completed material certification form for each shipment to a project site. The form includes a statement certifying the products were manufactured, tested, and accepted in accordance with the MTD Technical Specification.
- 4.2 Do not ship MTDs from the fabrication plant/stockyard to project sites until they have met all acceptance criteria.

MTD SUBMITTAL FORM

Manufacturer Information	
Name:	
Address/location:	
Web page:	
Contact Name:	
Telephone Number:	
Fax Number:	
e-mail address:	
MTD Information (Submit a separate form for each specific MTD)	
Submittal Type:	MTD Type 1 <input type="checkbox"/> MTD Type 2 <input type="checkbox"/> MTD Type 3 <input type="checkbox"/>
Specific MTD Name:	
Written description of the Manufacturer's Quality Control program:	Yes <input type="checkbox"/> No <input type="checkbox"/>
Instructions on the proper assembly and maintenance of the MTD:	Yes <input type="checkbox"/> No <input type="checkbox"/>
Certification that the MTD performs to the minimum performance standards under the specific conditions stated in the MTD specification:	Yes <input type="checkbox"/> No <input type="checkbox"/>
Detail drawing for each MTD submitted signed by registered SC PE:	Yes <input type="checkbox"/> No <input type="checkbox"/>
Structural design calculations for each MTD submitted signed by registered SC PE:	Yes <input type="checkbox"/> No <input type="checkbox"/>
Internal high flow bypass capability around treatment/storage area (required for Type 3):	Yes <input type="checkbox"/> No <input type="checkbox"/>
If Yes, detailed drawing must show this flow path:	Yes <input type="checkbox"/> No <input type="checkbox"/>
If No, provide 3 rd party test results demonstrating when scour/re-suspension occurs:	Yes <input type="checkbox"/> No <input type="checkbox"/>
Performance Evaluation Testing	
Independent 3 rd party testing evaluator:	
Test facility name:	
Test facility location:	
Test ID:	
Test Date:	
Report Date:	
Signature of responsible 3 rd party evaluator included on test report:	Yes <input type="checkbox"/> No <input type="checkbox"/>
Performance Evaluation Laboratory Testing Data	
Max Flow Rate at which 80% removal efficiency is achieved:	
Testing Hydraulic Loading Rate (NA for Type 3):	
Particle Size Distribution (PSD) used:	
<input type="checkbox"/> 125-micron-mean size <input type="checkbox"/> OK-110 <input type="checkbox"/> F-95 Silica Sand <input type="checkbox"/> Sil-Co-Sil 106 <input type="checkbox"/> NJDEP PSD <input type="checkbox"/> Other (describe)	
Concentration of PSD (100 mg/l to 300 mg/l for MTD Type1) (1,500 mg/l to 2,000 mg/l for Type 3 6% concentration) (24,000 mg/l to 26,000 mg/l for Type 3 Street Sweepings 2.5% concentration):	mg/L
Total Suspended Solids (TSS) removal efficiency (ASTM D-3977-97 SSC):	%
Scaling	
Table, chart, or graph indicating maximum water quality flow rate (WQE) for 80% TSS removal and indicating max peak flow rate (LOS) of MTD (Section 2.5 and 2.6):	Yes <input type="checkbox"/> No <input type="checkbox"/>
MTD Type 1 Hydraulic loading rate used in MTD scaling (if > 25 gpm/SF, specific 3 rd party laboratory testing must verify removal efficiency at the higher loading rate):	gpm/SF
Manufacturer's Signature:	

MTD TYPE 1 & Type 2 SUBMITTAL FORM

Maximum Water Quality Event (WQE) and Maximum Level of Service (LOS) Flow Rate Table

[illegible]

Maximum Water Quality Flow Rate and Maximum Sediment Storage Table

5

MTD MAINTENANCE AND RESPONSIBILITY AGREEMENT

The Permanent *Stormwater System Maintenance and Responsibility Agreement* requires adequate maintenance for stormwater management/Best Management Practices (BMP) facilities including Stormwater Manufactured Treatment Devices (MTDs). Document Stormwater Manufactured Treatment Devices (MTDs) deficiencies during **semi-annual** inspections. Complete any necessary repairs and/or preventive maintenance procedures in a timely manner to ensure proper functioning as a Stormwater Manufactured Treatment Devices (MTDs).

Important maintenance procedures:

- Inspect and maintain all MTDs in accordance with the manufacturer's written recommendations.
- Prepare specific maintenance requirements and maintenance schedules for each MTD.
- Inspect MTDs at least semi-annually to ensure that the MTD is working properly.
- Maintain MTDs as required to maximize pollutant removal.
- Keep a maintenance log to track all MTD inspections and maintenance with the quantities of materials removed from each MTD. Lack of maintenance is the most common cause of failure for MTDs.
- Remove accumulated sediment and other trapped pollutants when the MTD becomes full. Typical removal of pollutants requires the use of a vacuum truck.
- Ensure proper site stabilization is achieved so MTDs function as designed.
- Do not use MTDs to trap eroded sediment from construction operations, unless the manufacturer has approved such use in writing.
- Install MTDs as the last stormwater runoff structures installed on site, or keep these MTDs off-line or isolated until final stabilization is achieved.

After the installation of Stormwater Manufactured Treatment Devices (MTDs), perform inspections once a quarter. **Long term inspection and maintenance frequency is dependent on land use, accumulated solids, weather conditions, and specific design of the specific MTD.** Keep operation and maintenance records in a known location and make them available upon request.

Perform recommended maintenance activities as follows:

Required Maintenance	Frequency
Clean and remove trapped sediments, oil and grease, and other pollutants.	As needed.
Inspect for damage to MTD components	Semi-Annual Minimum
Inspect for sediment and pollutant accumulation	Semi-Annual Minimum
Inspect for operational inlet and outlet structures	Semi-Annual Minimum