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8.0 Water Quality Best Management Practices

8.1 Non-Structural BMPs

8.1.1 Introduction

Best management practices (BMPs) are the basis for the prevention of pollution in Spalding County. Section 8.2 of this chapter presents the details of structural best management practices and their use within the county drainage system. The other major component of the Spalding County BMPs are -non-structural practices currently in place and future non-structural practices implemented through the County's General NPDES Permit Number GAG610000 for Small Municipal Separate Storm Sewer Systems (MS4)1, (hereinafter referred to as the Permit). The Permit is designed to assist in the prevention of pollution utilizing BMPs outlined in the following categories: Public Education and Outreach, Public Involvement/Participation, Illicit Discharge Detection and Elimination, Construction Site Stormwater Runoff Control, Post-construction Stormwater Management in New Development and Redevelopment, and Pollution Prevention/Good Housekeeping. Most non-structural BMPs are more effective and less costly than structural BMPs. These non-structural BMPs should be used within a "treatment train" containing structural BMPs and sound engineering practices. In addition, non-structural BMPs tend to be less costly, easier to design and implement and easier to maintain than structural BMPs. Nonstructural BMPs normally do not have technical or engineering designs associated with them but are measures that the County or other agencies or groups might require or implement to assist in the management water quality and the control of pollutants within the County. Following is a brief discussion of some non-structural BMPs that can be used within a stormwater quality management plan for different portions of the Spalding County Drainage System.

8.1.2 Public Education/Outreach and Public Involvement/Participation

Public Education and Outreach is a crucial component of a holistic approach to stormwater quality. . A public education and participation plan provides the County with a strategy for educating its employees, the public, and businesses about the importance of protecting stormwater from improper use, storage, and disposal of pollutants. Public education and outreach uses many programs and materials in a conscience effort to educate the public on stormwater management and water quality issues facing Spalding County. Spalding County maintains a library of educational materials available through the stormwater department, or on the stormwater department's website, which contains information on illicit discharges, site specific erosion and sediment control, construction information and recycling information. Spalding County is also active in the community conducting streamside cleanups, hosting a community stormwater hotline, and implementing a inlet stenciling program..

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[1] More information the Spalding County's NPDES Permit can be found online at http://www.spaldingcounty.com/storm-water/spaldingstormwaterhome.htm

8.1.3 Illicit Discharge Detection and Elimination

Illicit discharge detection and elimination is a curtail part of water quality not only in Spalding County but nation wide. The BMPs Spalding County has selected to address illicit discharge detection and elimination through the education of the public and various screening processes. Spalding County is always looking for new ways to better detect and eliminate illicit discharges throughout the County and is continually updated their procedures.

8.1.4 Construction Site Stormwater Runoff Control

Though the primary focus of this Manual is to address post construction stormwater management, actual construction site stormwater runoff can also contribute to the degradation of water quality. In order to address the issues of construction site stormwater runoff, the County has adopted a Soil Erosion and Sedimentation Control Ordinance. The ordinance adopts the Georgia Soil and Water Conservation Commissions Manual For Erosion and Sediment Control in Georgia, "The Green Book" to help prevent sediment from leaving construction sites. Spalding County has also implemented a better record keeping process to ensure all work sites are being inspected and adhere to the Soil Erosion and Sedimentation Control Ordinance. Along with the enhanced record keeping, a public hotline for Construction sites has been set up. The hotline is designed for the public to call and relay information about illicit discharges and or sedimentation leaving construction sites..

8.1.5 Post-Construction Stormwater Management

After using this Manual to design and construct stormwater conveyance systems and water quality BMPs, there is a need to inspect the installed stormwater systems and BMPs. The County has implemented a program for inspected detention/water quality ponds to insure these facilities are being maintained and are functioning as designed. These inspections are done on a yearly basis and encompass the urbanized area of Spalding County.

8.1.6 Pollution Prevention/ Good Housekeeping

Pollution Prevention and Good Housekeeping are vital parts of nonstructural BMPs. There are many BMPs used for the prevention of pollution in Spalding County including hazardous materials training for County employees, inspections of the current stormwater infrastructure and water quality ponds and several stormwater management pollution prevention plans.

8.2 Water Quality Performance Criteria

Total suspended solids (TSS) are primarily associated with sediment. These sediment partials also act as It also serves as a "carrier" of other pollutants such as organics and metals, and is often used as a key parameter for sizing BMPs for protecting water quality. Therefore, control of TSS may be used as a surrogate for the most important pollutants

that need to be controlled in order to meet the designated use and water quality standards in the stream.

This criterion represents a TSS loading rate from a developed site of 850 lb/ac/yr as computed using the protocol in the tool described below. The tool was developed by the Atlanta Regional Commission (ARC) to be used with the Georgia Stormwater Manual.

8.2.1 Performance Criterion Tool

An automated spreadsheet tool was developed to facilitate evaluation of developments in accordance with the TSS performance criterion (Figure 8-1). The tool was developed with the strategy of providing disincentives for installation of impervious surfaces, and incentives for leaving key areas (particularly riparian buffers) undisturbed.

The review protocol identifies four distinct types of land area on each site:

- **Impervious Area –** e.g., driveways, rooftops, parking lots, roads, sidewalks, etc.
- **Disturbed Pervious Area –** e.g., lawns, gardens, landscaped areas, any area that was cleared, grubbed or graded. Porous pavement will be treated as a land use BMP and should be included in the disturbed pervious areas.
- **Undisturbed Upland Area –** e.g., upland woods, meadows, and other areas not cleared, grubbed or graded
- **Undisturbed Stream Buffers –** e.g., undisturbed riparian buffers contiguous to streams, lakes, and wetlands. Undisturbed buffers are areas that are not cleared, grubbed, or graded. The area of land that can be used as a stream buffer to receive credit for TSS removal rates (see Table 8-1) is limited to the larger of 1) the stream buffer as determined by any state, county, or other regulation/ordinance or 2) the 100 year floodplain.

The tool estimates TSS loadings commensurate with potential contributions from land types (Table 8-1). The sum of the products of the areas and their corresponding TSS loading rates represent the total load from the site that is not managed or routed through a BMP.

The approach is simple to use and encourages site design that takes advantage of the natural site amenities and minimizes impervious surfaces.

Table 8-1Land Use Types and Their Respective TSS Removal Rates

Land Type	TSS Rate (lb/ac/yr)
Impervious Area (driveways, rooftops, parking lots, etc)	4000
Disturbed Pervious Area (lawns, gardens, porous pavement, etc)	1200
Undisturbed Upland Area (woods, preserves, etc)	500
Undisturbed Stream Buffers	125

The computerized spreadsheet form automatically calculates and graphs the loading value, and provides options for implementing BMPs on the site and designating the tributary drainage area to each BMP. BMPs available in the spreadsheet tool and the respective TSS removal efficiencies are listed in Table 8- 2. The form compares loading rates that are managed with and without BMPs to the TSS criterion. This tool can be used iteratively in the site design process.

An electronic copy of the worksheet can be found at http://www.spaldingcounty.com/storm-water/spaldingstormwaterhome.htm.

Table 8-2 BMPs and Their Respective TSS Removal Efficiencies

BMP	TSS Removal (%)
Wet and Dry Extended Detention Pond	80
Dry Detention Pond	50
Constructed Wetland	80
Vegetated Filter Strips	50
Sand Filters	80
Infiltration Trenches	80
Oil/Grit Separator	40
Grassed Swales (2% slope, dam)	15

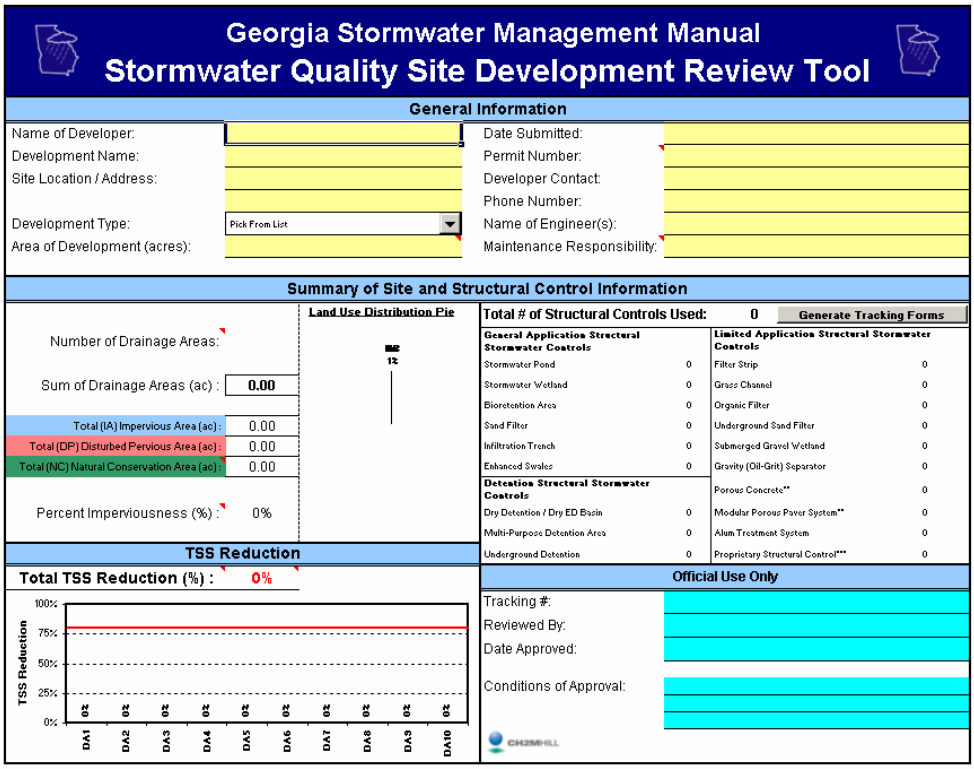

Figure 8-1 Storm Water Quality Performance Review Form

8.2.2 Stormwater Quality Performance Review Form-Instruction Guide

8.2.2.1 Main From

The Main form has 4 sections that are discussed in detail below (see Figure 8-2).

1) The first section requires user to fill out general information of the site. Inputs include: Name of Developer, Name of Development, Type of Development, Area of Development, and Name of Engineer.

2) The second section consists of the Land Use Distribution and Pollutant Loads. It is a summary of information from the different drainage areas in the BMP Distribution Component. Each computed cell in this section has popup notes that enable the user to understand the processing of data. This component provides a summary of the TSS loading rates (with and without BMPs) produced by the site. It then generates a graph to compare the two TSS loading rates with the New Development Criterion.

3) The third section functions as a tool to track the review process for all new developments.

4) The fourth section of the Main Form is a summary of all the different BMPs chosen for the given site. It summarizes the BMP information by drainage area from the BMP Distribution Sheet and displays them.

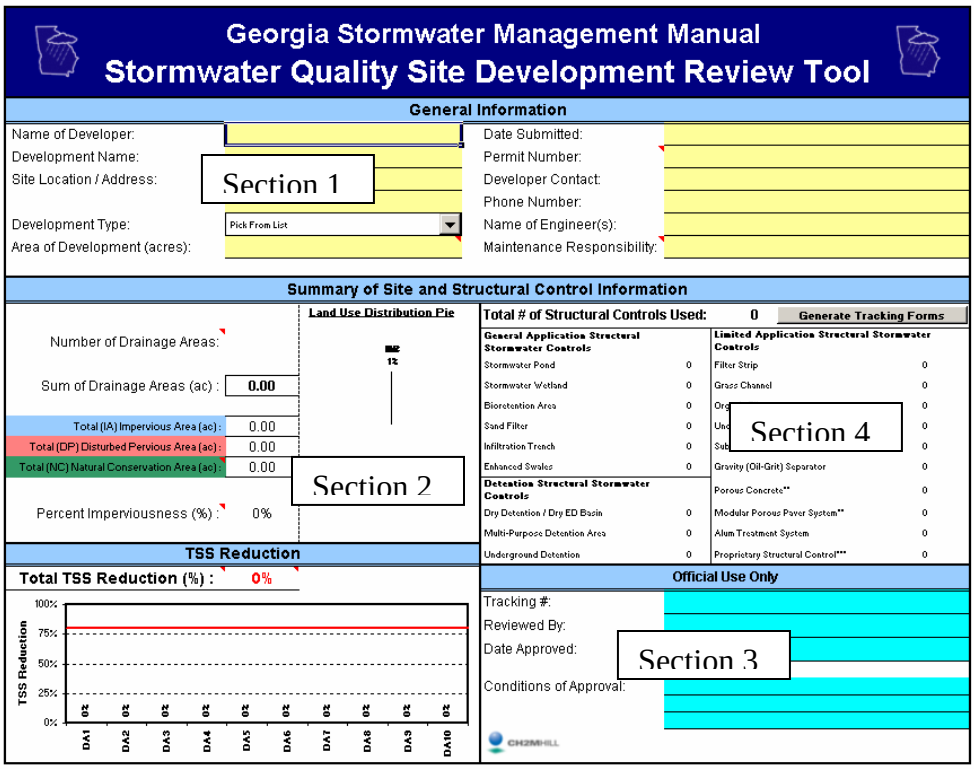

Figure 8-2 Section 1 through 4 of Storm Water Quality Performance Review Form

8.2.2.2 BMP Distribution

In most developments, it is not physically possible to treat the entire site with one BMP. The BMP Distribution Component aids in dividing up the development into several different drainage areas (Figure 8-3). For example, a particular development of 20.10 acres may have 10 acres treated by a sand filter while 10 acres are reducing the amount of removal needed by. The reduction efficiencies for the two BMPs are different (80% and 15% respectively). Hence the two areas should be entered into the BMP Distribution Component as Drainage Area 1 (30 acres) and Drainage Area 2 (10 acres), the BMPs in each drainage area should be chosen in the BMP Matrix section. The tool then computes the TSS loading rates for each drainage area. A weighted average is then computed to give an overall post treatment loading rate for the development and presented in the Main Form Component of this tool. Currently the BMP Distribution Component allows a particular development to be split into 20 drainage areas. There are four sections in the BMP Distribution Component (see Figure 8-3).

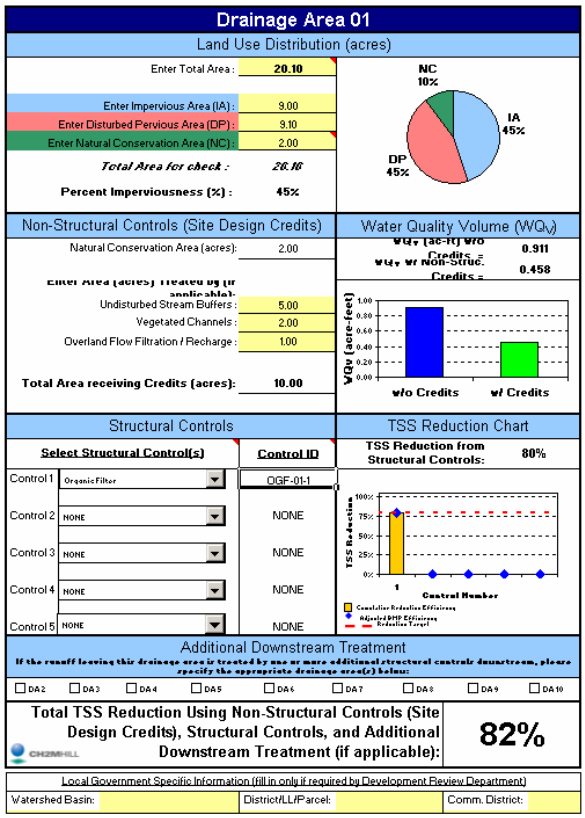

Figure 8-3 Sections 1 through 3 of the BMP Distribution Component of the Storm Water Quality Performance Review Form

The BMP distribution component of the tool has 3 main sections that are discussed in detail below.

1) Section 1 requires the user to input the different land area types within a given drainage area. Figure 8-3 provides an example for Drainage Area 2.
2) Section 2 is the BMP Matrix. The drop down menus in the BMP Matrix presents the types of BMPs and their removal efficiencies. This section requires the user to input the BMP that treats the given drainage area. The BMP Matrix allows the user to pick multiple combinations of BMPs or BMPs in sequence, i.e. if 10 acres of a given site are drained by a Constructed Wetland which in turn is drained by Grassed Swales, the 10 acres are being treated by a combination of the two BMPs. The user should indicate this scenario by picking the Constructed Wetland as BMP1 and the Grassed Swales as BMP2 in the BMP Matrix. However, one should note that if this scenario arises, the removal efficiency of the second BMP will be lower than its highest potential (i.e. the efficiency listed in the BMP Efficiency Component). The reason for the reduction is that most of the heavy (easily removed) solid matter will be reduced by the first BMP, and the smaller particles (which are much harder to treat) will be treated by the second BMP. These smaller particles would reduce the potential of the BMP to remove TSS at its utmost efficiency.

When BMPs are in a series, the following rules apply:

1) If a BMP follows a BMP with a reduction efficiency of greater than or equal to 80%, the second BMP's efficiency is reduced by 50%.
2) If a BMP follows a BMP with a reduction efficiency of greater than or equal to 50% and less than 80%, the second BMP's efficiency is reduced by 25%.
3) If a BMP follows a BMP with a reduction efficiency of less than 50%, the second BMP's efficiency does not get reduced.

Example Site: 10 acres drained by a Constructed Wetland followed by Grassed Swales

BMP1: Constructed Wetland Removal Efficiency: 80%
BMP2: Grassed Swales Removal Efficiency: 15%

Adjusted removal efficiency for BMP2:
= Removal Efficiency BMP2 X (Removal Efficiency Adjustment Rule 1)
= 15% X (1 - 50%)
= 7.5%

Another important note to keep in mind when the scenario of BMPs in series arises is that the tool recognizes the BMPs in their physical order. For example, there are 10 acres in a site being treated in the following order:

BMP1: Grassed Swales Removal Efficiency: 15%
BMP2: Constructed Wetland Removal Efficiency: 80%
BMP3: Filter Strip Removal Efficiency: 50%

The tool recognizes the sequence in the following order:

BMP1: Grassed Swale Removal Efficiency: 15%
BMP2: Constructed Wetland Removal Efficiency: 80%
BMP3: Filter Strip Removal Efficiency: 50%

The adjusted removal efficiencies can be estimated as follows:

Adjusted removal efficiency for BMP2 (Constructed Wetland):
= Removal Efficiency BMP2 * (1 – Adjustment Rule 3)
= 80% * (1 - 0%)
= 80%

Adjusted removal efficiency for BMP3 (Filter Strip):
= Removal Efficiency BMP3 * [1 - (Adjustement Rule 1)]
= 50% * [1 - 50%]
= 25%

3) Section 3 summarizes the TSS loading rates (with and without BMPs) for the drainage area. Popup notes are inserted in each cell to inform the user about the equations being used.
4) Section 4 requires the user to fill information on amount of Porous Pavement area present on the site, information on the District, Land Lot, and Parcel (if available), information in the Watershed Basin, and the Commission District. It should be noted that the Porous Pavement area is a part of the Disturbed Pervious Area and hence the Porous Pavement area should not be greater than the Disturbed Pervious Area.

8.2.2.3 BMP Efficiencies

The last component of the tool lists the types of BMPs that can be used for the New Development Review Protocol. It presents the BMP reduction efficiencies for TSS for each BMP type (see Table 8.2). It has links to the literature used in developing the removal effectiveness for each of the BMP types in this study.

8.2.2.4 Tracking Form

Spalding County must report annually to the Georgia Environmental Protection Division on activities that we are taking to protect water quality. We also inspect existing structural BMPs to ensure that they are being properly maintained. To that end, Spalding County requires that the designer of a structural BMP provide a BMP Tracking Form. This form is found at the end of this chapter. To aid the designer in this effort, the form is incorporated into the spreadsheet. In the upper right hand corner of Form 2 is a button labeled “Print BMP Tracking Forms for Structural BMPs”. When the design of all of the structural BMPs has been finalize, the designer should select this button and the required BMP Tracking form will be printed for each structural BMP.

8.3 Stormwater Site Design Credits

8.3.1 Introduction

Non-structural stormwater control practices are increasingly recognized as a critical feature in every site design. As such, a set of stormwater "credits" has been developed that allows a community to provide developers and site designers an incentive to implement better site design practices that can reduce the volume of stormwater runoff and minimize the pollutant loads from a site. The credit system directly translates into cost savings to the developer by reducing the size of structural stormwater control and conveyance facilities. The basic premise of the credit system is to recognize the water quality benefits of certain site design practices by allowing for a reduction in the water quality treatment volume (WQv). If a developer incorporates one or more of the credited practices in the design of the site, the requirement for capture and treatment of the water quality volume will be reduced. The better site design practices that provide stormwater credits are listed in Table 4.5-1. Site-specific conditions will determine the applicability of each credit. For example, stream buffer credits cannot be taken on upland sites that do not contain perennial or intermittent streams. It should be noted that better site design practices and techniques that reduce the overall impervious area on a site already implicitly reduce the total amount of stormwater runoff generated by a site (and thus reduce WQv) and are not further credited under this system.

Table 4.5-1 Summary of Better Site Design Practices that Provide for Site Design Stormwater

Credit	Practice Description
Natural area conservation	Undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics.
Stream buffers	Stormwater runoff is treated by directing sheet flow runoff through a naturally vegetated or forested buffer as overland flow.
Use of vegetated channels	Vegetated channels are used to provide stormwater treatment.
Overland flow filtration/infiltration zones	Overland flow filtration/infiltration zones are incorporated into the site design to receive runoff from rooftops and other small impervious areas.
Environmentally sensitive large lot subdivisions	A group of site design techniques are applied to low and very low density residential development.

For each potential credit, there is a minimum set of criteria and requirements which identify the conditions or circumstances under which the credit may be applied. The intent of the suggested numeric conditions (e.g., flow length, contributing area, etc.) is to avoid situations that could lead to a credit being granted without the corresponding

reduction in pollution attributable to an effective site design modification. Site designers should be encouraged to utilize as many credits as they can on a site. Greater reductions in stormwater storage volumes can be achieved when many credits are combined (e.g., disconnecting rooftops and protecting natural conservation areas). However, credits cannot be claimed twice for an identical area of the site (e.g. claiming credit for stream buffers and disconnecting rooftops over the same site area).

Due to local safety codes, soil conditions, and topography, some of these site design credits may be restricted by a community.

8.3.2 Site Design Credit #1: Natural Area Conservation

A stormwater credit may be granted when undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics. Under this credit, a designer would be able to subtract conservation areas from total site area when computing water quality volume requirements. An added benefit will be that the postdevelopment peak discharges will be smaller, and hence water quantity control volumes (CPv, Qp25, and Qf) will be reduced due to lower post-development curve numbers or rational formula "C" values.

Rule: Subtract conservation areas from total site area when computing water quality volume requirements.

Recommended Local Criteria:

- Conservation area cannot be disturbed during project construction
- Shall be protected by limits of disturbance clearly shown on all construction drawings
- Shall be located within an acceptable conservation easement instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked [Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management], and
- Shall have a minimum contiguous area requirement of 10,000 square feet

8.3.3 Site Design Credit #2: Stream Buffers

This credit may be granted when stormwater runoff is effectively treated by a stream buffer. Effective treatment constitutes treating runoff through overland flow in a naturally vegetated or forested buffer. Under the proposed credit, a designer would be able to subtract areas draining via overland flow to the buffer from total site area when computing water quality volume requirements. In addition, the volume of runoff draining to the buffer can be subtracted from the channel protection volume. The design of the stream buffer treatment system must use appropriate methods for conveying flows above the annual recurrence (1-yr storm) event.

Rule: Subtract areas draining via overland flow to the buffer from total site area when computing water quality volume requirements.

Recommended Local Criteria:

- The minimum undisturbed buffer width shall be 50 feet
- The maximum contributing lenght shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces (ex. If there is a 50 foot stream buffer, off set the stream buffer 150 feet for pervious surfaces and 75 for impervious surfaces and that off set area is the credit area)
- The average contributing slope shall be 3% maximum unless a flow spreader is used
- Runoff shall enter the buffer as overland sheet flow. A flow spreader can be supplied to ensure this, or if average contributing slope criteria cannot be met
- Not applicable if overland flow filtration/groundwater recharge credit is already being taken
- Buffers shall remain unmanaged other than routine debris removal

8.3.4 Site Design Credit #3: Vegetated Channels

This credit may be granted when vegetated (grass) channels are used for water quality treatment. Under the proposed credit, a designer would be able to subtract the areas draining to a grass channel from total site area when computing water quality volume requirements. A vegetated channel may be able to fully meet the water quality volume requirements for certain kinds of low density residential development (see low impact development credit). An added benefit will be that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

Note: This credit should not be granted if grass channels are being used as a limited application structural stormwater control towards meeting the 80% TSS removal goal for WQv treatment.

Rule: Subtract the areas draining to a vegetated (grass) channel from total site area when computing water quality volume requirements

Recommended Local Criteria:

- The credit shall only be applied to moderate or low density residential land uses (3 dwelling units per acre maximum)
- The maximum flow velocity for water quality design storm shall be less than or equal to feet per second
- The minimum residence time for the water quality storm shall be 5 minutes
- The bottom width shall be a maximum of 6 feet. If a larger channel is needed use of a compound cross section is required
- The side slopes shall be 3:1 (horizontal:vertical) or flatter
- The channel slope shall be 3 percent or less

8.3.5 Site Design Credit #4: Overland Flow Filtration/Groundwater Recharge Zones

This credit may be granted when “overland flow filtration/infiltration zones” are incorporated into the site design to receive runoff from rooftops or other small

impervious areas (e.g., driveways, small parking lots, etc). This can be achieved by grading the site to promote overland vegetative filtering or by providing infiltration or "rain garden" areas. If impervious areas are adequately disconnected, they can be deducted from total site area when computing the water quality volume requirements. An added benefit will be that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

Rule: If impervious areas are adequately disconnected, they can be deducted from total site area when computing the water quality volume requirements.

Recommended Local Criteria:

- Relatively permeable soils (hydrologic soil groups A and B) should be present
- Runoff shall not come from a designated hotspot
- The maximum contributing impervious flow path, directly adjacent to Overland Flow Filtration/Groundwater Recharge Zone, length shall be 75 feet
- Downspouts shall be at least 10 feet away from the nearest impervious surface to discourage "re-connections"
- The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or structural stormwater control
- The length of the "disconnection" shall be equal to or greater than the contributing length
- The entire vegetative "disconnection" shall be on a slope less than or equal to 3 percent
- The surface imperviousness area to any one discharge location shall not exceed 5,000 square feet
- For those areas draining directly to a buffer, either the overland flow filtration credit –or the stream buffer credit can be used

8.3.6 Site Design Credit #5: Environmentally Sensitive Large Lot Subdivisions

This credit may be granted when a group of environmental site design techniques are applied to low and very low density residential development (e.g., 1 dwelling unit per 2 acres [du/ac] or lower). The credit can eliminate the need for structural stormwater controls to treat water quality volume requirements. This credit is targeted towards large lot subdivisions and will likely have limited application.

Rule: Targeted towards large lot subdivisions (e.g. 2 acre lots and greater). The requirement for structural practices to treat the water quality volume treatment requirements shall be waived.

Recommended Local Criteria:
For Single Lot Development:

- Total site impervious cover (including roadways/driveway) is less than 15%
- Lot size shall be at least two acres
- Rooftop runoff is disconnected in accordance with the criteria in Credit #4
- Grass channels are used to convey runoff versus curb and gutter

For Multiple Lots:

- Total impervious cover footprint (including streets) shall be less than 15% of the area
- Lot areas should be at least 2 acres, unless clustering is implemented. Open space developments should have a minimum of 25% of the site protected as natural conservation areas and shall be at least a half-acre average individual lot size.
- Grass channels should be used to convey runoff versus curb and gutter (see Credit #3)
- Overland flow filtration/infiltration zones should be established (see Credit #4)

8.4 Structural BMP Specifications

8.4.1 Introduction

To provide some guidance in the design and use of different structural BMP's this section gives specifications and performance standards for several BMP's that could find application within the Spalding County.

Following are the general specifications, recommended specifications, and operation and maintenance requirements, for eight different structural BMP's. For the design of extended detention ponds and retention ponds refer to the Storage Facilities Chapter for examples of storage design.

For grassed swales refer to the Open Channel Design Chapter for examples of channel design. For example designs of the infiltration facilities included in this chapter, see the publication Stormwater Infiltration Structure Design, 1994.

Extended Detention Ponds	Retention Ponds
Sand Filters	Constructed Wetlands
Infiltration Trenches	Filter Strips and Flow Spreaders
Grassed/Biofiltration Swales	Oil/Grit Separators

The general design criteria for Spalding County is to design for the runoff from the first 1.2 inches of rainfall, from the development site or drainage area that drains through the BMP.

8.4.2 Sediment Forebay

For many of the BMPs included in this chapter, especially ponds and infiltration facilities, sediment forebays or equivalent upstream pretreatment should be included. Following are the general criteria to be used for sediment forebay design.

- The forebay should consist of a separate cell, formed by an acceptable barrier.

- The forebay should be sized to contain 0.1 inches of runoff per impervious acre of contributing drainage. The forebay storage volume counts toward the total water quality storage requirements.
- Exit velocities from the forebay should be non-erosive.
- Direct maintenance access for appropriate equipment should be provided to the forebay.
- The bottom of the forebay may be hardened (e.g., using concrete, paver blocks, etc.) to make sediment removal easier.
- A fixed vertical sediment depth maker should be installed in the forebay to measure sediment deposition over time.
- Forebay sediment removal should occur when 50% of the total capacity has been lost.

8.4.3 Dry Extended Detention Ponds, Dry Detention Ponds, and Dry Water Quality Ponds

Information contained within the following section provides specifications and standards for dry detention ponds, dry water quality ponds and dry extended detention ponds. Dry Extended Detention Ponds and Dry Detention ponds must provide detention for the 1-year storm. Dry Detention ponds do not provide water quality. Dry Water Quality Ponds provide detention for water quality only.

8.4.3.1 Standard Specifications for Dry Extended Detention Ponds and Dry Detention Ponds

Required Specifications

- **Dry detention ponds** shall be designed to capture the runoff from the 1-year storm (channel protection) for the entire basin draining to the pond with a minimum detention time of 24 hours.
- **Dry water quality ponds** shall be designed to capture the runoff from the first 1.2 inches of rainfall from the site (water quality volume) with a minimum detention time of 24 hours.
- **Dry extended detention ponds** shall be designed to capture the runoff from the first 1.2 inches of rainfall from the site (water quality volume) with a minimum detention time of 24 hours and these ponds are also designed to capture the runoff from the 1-year storm for the entire basin draining to the pond (channel protection) with a detention time of 24 hours.

    - All facilities with a drainage area larger than 20-acres should be designed as a wet facility unless the engineer can show that the pond will not remain wet.
    - Side slopes shall be no steeper than 3:1 if a fill slope.
    - Inlet and outlet located to maximize flow length.
    - Design for full development upstream of control.

- Rip-rap protection (or other suitable erosion control means) for the outlet and all inlet structures into the pond.
- One and one-half (1-1/2) foot minimum freeboard above peak stage for top of embankment.
- Emergency spillway designed to pass the 100-year storm event (must be paved in fill areas).
- Maintenance access minimum of 25 feet wide.
- Trash racks, filters or other debris protection or control.
- Anti-vortex plates.
- Insure no outlet leakage.
- Benchmark for sediment removal.
- Place grouted rip-rap at channel inlets to ponds.
- Retaining walls over 4 feet tall used as dams must have some safety treatment such as Detail 630 titled, "Retaining wall Safety Treatments".

Recommended Specifications

- Pilot channel of paved or concrete material for erosion control (alternately use turf if there is little low flow). Size such that any event runoff will overflow the low flow channel onto the pond floor.
- Two stage design for dry extended detention pond only (top stage - dry during the 1.2 inch rainfall event, bottom stage - inundated during storms equal to or less than the 1.2 inch storm event.)
- Top stage shall have slopes between 2% and 5% and a depth of 2 to 5 feet.
- Bottom stage maintained as shallow wetland (6 to 12 in.).
- Manage buffer and pond as meadow.
- Minimum 25-foot wide buffer around pool.
- On-site disposal areas for two sediment removal cycles.
- Impervious soil boundary.
- Design as off-line pond to bypass larger flows.
- Design as sediment settling basin for pretreatment of the larger particles.

8.4.3.2 Operation and Maintenance Recommendations

A storm water management easement and maintenance agreement shall be required for each facility.

- Dry extended detention ponds are used where lack of water or other multi-use considerations preclude the use of wet ponds or constructed wetlands.
- Operation and maintenance is the same as for detention ponds (see storage chapter).
- Maintenance activities include keeping the outlets unclogged, control of vegetation, removal of sediment deposits, keeping aesthetics of area acceptable.

8.4.3.3 Performance Standards

- Soluble pollutant removal rates are low for dry extended detention ponds but can be enhanced either with greatly increased detention time, through the use of shallow marshes to increase biological uptake, or through using an infiltration device downstream from the outlet orifice.
- Dry extended detention ponds are presumed to be able to remove 80% of the total suspended solids load in typical urban post-development runoff (see Table 8-2).
- Dry detention ponds are presumed to be able to remove 50% of the total suspended solids load in typical urban post-development runoff (see Table 8-2).

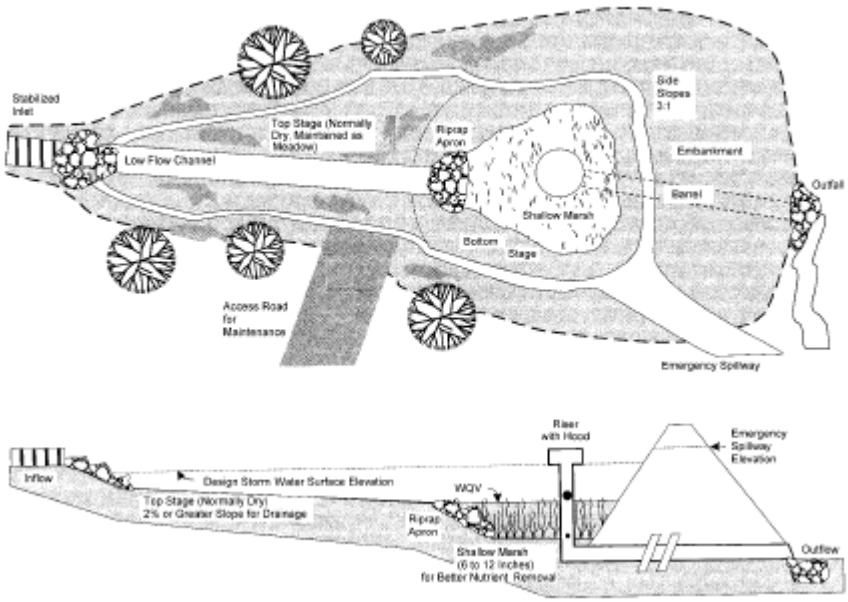

Figure 8-4 Dry Extended Detention Pond
(Source: Controlling Urban Runoff)

8.4.4 Wet Extended Detention Ponds

8.4.4.1 Standard Specifications for Wet Extended Detention Ponds

Required Specifications

- **Wet detention ponds** shall be designed to capture the runoff from the 1-year storm for the entire basin draining to the pond (channel protection) with a minimum detention time of 24 hours.
- **Wet water quality ponds** shall be designed to capture the runoff from the first 1.2 inches of rainfall from the site (water quality volume).
- **Wet extended detention ponds** shall be designed to capture the runoff from the first 1.2 inches of rainfall from the site (water quality volume) and these ponds are

also designed to capture the runoff from the 1-year storm for the entire basin draining to the pond (channel protection) with a detention time of 24 hours.

- Wet extended detention ponds and wet water quality ponds must be design with a minimum detention time of 24 hours of any Water Quality Volume not retained. A minimum of 50% of the Water Quality Volume must be retained.
- All facilities with a drainage area larger than 20-acres should be designed as a wet facility unless the designer can show that the pond will not remain wet. A wet micro-pool designed in accordance with the Georgia Stormwater Management Manual Section 3.2.1.6 with a minimum volume of 25% of the Water Quality Volume may be used.
- Minimum length to width ratio of 2:1 (preferably expanding outward toward the outlet). Irregular shorelines for larger ponds provide visual variety.
- Inlet and outlet located to maximize flow length. Use baffles if short-circuiting cannot be prevented with inlet-outlet placement.
- Minimum depth of permanent pool 2 to 3 feet, maximum depth of 9 to 12 feet. Average depth should be 3 to 7 feet.
- Design for full development upstream of control.
- Fill side slopes shall be no greater than 3:1.
- Rip-rap protection (or other suitable erosion control means) for the outlet and all inlet structures into the pond. Individual boulders or baffle plates can work for this.
- One and one-half (1-1/2) foot minimum freeboard above peak stage for top of embankment.
- Emergency drain; i.e. sluice gate, drawdown pipe; capable of draining pond within 24 hours.
- Emergency spillway designed to pass the 100-year storm event.
- Minimum 25 foot wide buffer around pool.
- Trash racks, filters, hoods or other debris control on riser.
- A cleared and graded maintenance access easement that is a minimum of 25 feet wide.
- Benchmark for sediment removal.
- Provide forebay designed with 10 percent of the required volume. Forebay should have separate drain for de-watering. Provide grass biofilters for smaller ponds.
- Provide maintenance access drive/roadway with a minimum width of 15 feet.
- Place grouted rip-rap at channel inlets to ponds.
- Retaining walls over 4 feet tall used as dams must have some safety treatment such as Detail 630 titled, “Retaining wall Safety Treatments”.

Recommended Specifications

- Multi-objective use such as amenities or flood control.

- Minimum drainage area of 20 acres.
- Landscaping management of buffer.
- Design for multi-function as flood control and extended detention.
- Minimum length to width ratio of 3:1 to 4:1 (preferably wedge shaped).
- Use reinforced concrete instead of corrugated metal.
- Consider artificial mixing for small sheltered ponds.
- Impervious soil boundary to prevent drawdown.
- Shallow marsh area around fringe 25 to 50 percent of area (including aquatic vegetation).
- A safety bench with a minimum width of 10 feet should be provided around the permanent pool.
- On-site disposal areas, for two sediment removal cycles, protected from runoff.
- An oil and grease skimmer for sites with high production of such pollutants.

8.4.4.2 Operation and Maintenance Recommendations

- Sediment to be removed when 20% of storage volume of the facility is filled (design storage volume must account for volume lost to sediment storage).
- Sediment traps shall be cleaned out when filled.
- No woody vegetation shall be allowed on the embankment without special design provisions.
- Other vegetation over 18 inches high shall be cut unless it is part of planned landscaping.
- Debris shall be removed from blocking inlet and outlet structures and from areas of potential clogging.
- The control shall be kept structurally sound, free from erosion, and functioning as designed.
- Periodic removal of dead vegetation shall be accomplished.
- No standing water is allowed within wet extended detention pond unless specifically designed for.
- Inspection requirements should be outlined in the maintenance agreement.
- The site should be inspected and debris removed after every major storm.
- All special maintenance responsibilities will be listed in the maintenance agreement.
- Mow embankment and side slopes at least twice a year.
- Consider chemical treatment by alum if algal blooms are a problem.

8.4.4.3 Performance Standards

- Wet extended detention ponds are very effective in removal of both the soluble and particulate fractions of pollution.
- Wet extended detention ponds are presumed to be able to remove 80% of the total suspended solids load in typical urban post-development runoff (see Table 8-2).

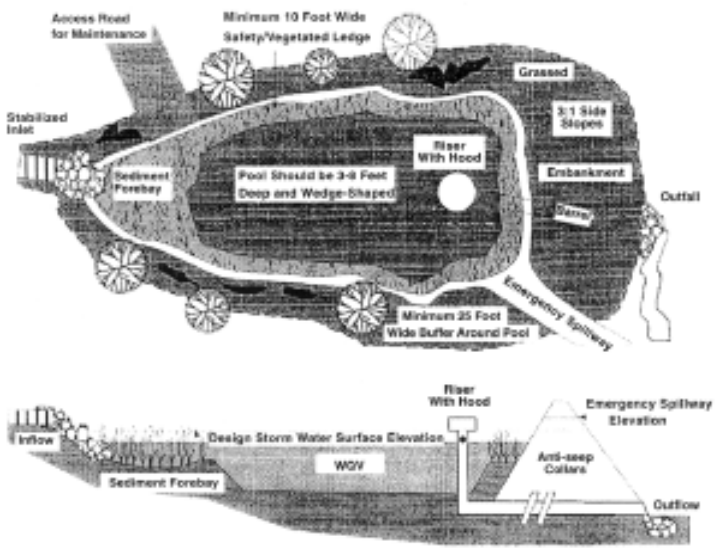

Figure 8-5
Wet Extended Detention Pond
Source: Controlling Urban Runoff

Figure 8-5 Wet Extended Detention Pond
(Source: Controlling Urban)

8.4.5 Sand Filters

Specifications for Sand Filters

General Specifications

- Maximum contributing drainage area to an individual stormwater filtering system is usually less than 10 acres.
- Accommodate the runoff from the first 1.2 inches of rainfall from the development site or drainage area that drains through the BMP.
- Adequate pretreatment (e.g., filter strips) is required to prevent sediment from overloading the filters.
- Most stormwater filters normally require one to six feet of head.
- Designed to completely empty in 36 hours.
- Inlet structure should be designed to spread the flow uniformly across the surface of the filter media.
- Stone riprap or other dissipation devices should be installed to prevent gouging of the sand media and to promote uniform flow.
- Final sand bed depth should be at least 18 inches.

- Underdrain pipes should consist of main collector pipes and perforated lateral branch pipes.
- The underdrain piping should be reinforced to withstand the weight of the overburden.
- Internal diameters of lateral branch pipes should be 4 inches or greater (6 inches preferred) and perforations should be 3/8 inch.
- Maximum spacing between rows of perforations should not exceed 6 inches.
- All piping should be schedule 40 polyvinyl chloride or greater strength.
- Minimum grade of piping should be 1/8 inch per foot (1% slope).
- Access for cleaning all underdrain piping should be provided.
- Surface filters may have a grass cover to aid in pollution adsorption.
- Vegetation should be established over the contributing drainage areas before runoff can be accepted into the facility.

Recommended Specification

- Two sand bed configurations are recommended for use:

1) Sand Bed with Gravel Layer;
    - Top layer of sand should be a minimum of 18 inches of 0.02 - 0.04 inch diameter sand (smaller sand size is acceptable).
    - A layer of one-half to 2-inch diameter gravel under the sand should be provided for a minimum of 2 inches of cover over the top of the under-drain lateral pipes.
    - No gravel is required under the lateral pipes.
    - The sand and gravel should be separated by a layer of geotextile fabric (permeable filter fabric).
2) Sand Bed with Trench Design;
    - Top layer of sand is to be 12-18 inches of 0.02 - 0.04 inch diameter sand (smaller size is acceptable).
    - Laterals to be placed in trenches with a covering of one-half to 2-inch gravel and geotextile fabric.

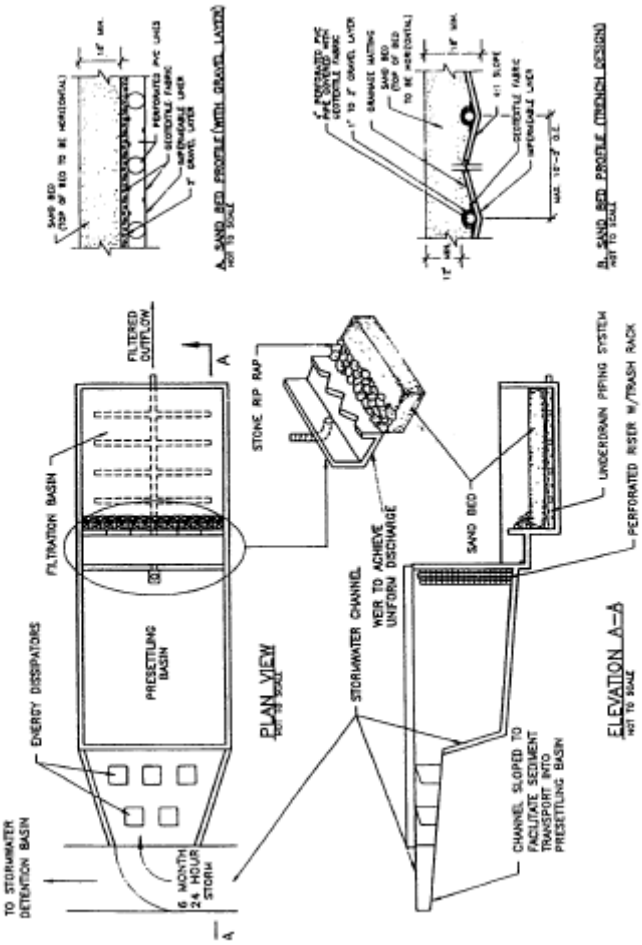

Figure 8-3 Sand Filtration Basin
Source: Stormwater Management Manual For The Puget Sound Basin

Figure 8-6 Sand Filtration Basin
(Source: Stormwater Management Manual for the Puget Sound Basin)

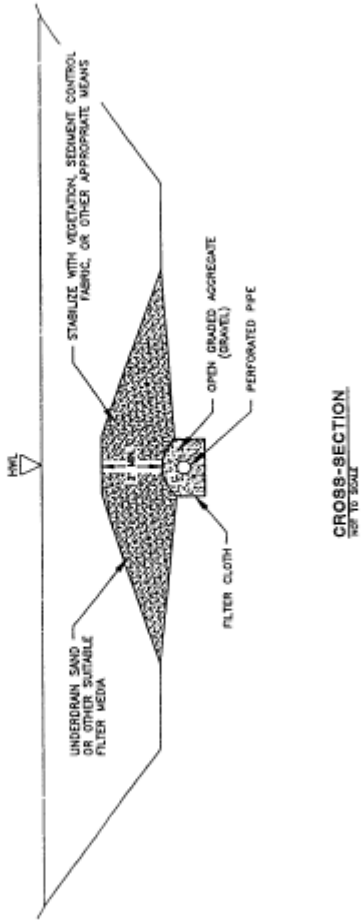

Figure 8-4 Cross-Section Of Elevated Sand Filter

Figure 8-7 Cross-Section of Elevated Sand Filter
(Source: Florida Erosion and Sediment Control Handbook)

- The lateral pipes are to be underlain by a layer of drainage matting.
- A pre settling basin and/or biofiltration swale is recommended to pre treat runoff discharging to the sand filter.
- A maximum spacing of 10 feet between lateral underdrain pipes is recommended.

Operation and Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc.
- Scrape off sediment layer buildup during dry periods with steel rakes or other devices.
- Replace some or all of the sand when permeability of the filter media is reduced to unacceptable levels which should be specified in the design of the facility. A

minimum infiltration rate of 0.5 inches per hour should be used for all infiltration designs.

8.4.6 Bioretention Systems

Information for Bioretention filters was taken from the Draft Georgia Stormwater Management Manual, Volume 2 (ARC, 2000).

8.4.6.1 Standard Specifications for Bioretention Systems

Required Specifications

General Requirements

• Capture the runoff from the first 1.2 inches of rainfall from the site.
• Minimum detention time of 24 hours.
• Bioretention areas should have a maximum contributing drainage area of 5 acres or less; 0.5 to 2 acres are preferred.
• Site slope must be no more than 6 percent
• Minimum elevation difference needed at a site from the inflow to the outflow of five feet.
• The maximum recommended ponding depth of a bioretention area is 6 inches.
• A well-designed bioretention filter area includes (1) ponding area containing vegetation with a planting soil bed and organic/mulch layer, (2) a grass filter strip between the contributing drainage area and the ponding area, and (3) a gravel and perforated pipe underdrain system to collect runoff that has filtered through the soil layer.
• Outlet pipe is to be provided from the underdrain system to the facility discharge. Due to the slow rate of filtration, outlet protection is generally unnecessary.
• Minimum depth to water table of two feet required between the bottom of the bioretention facility and the elevation of the seasonably high water table.

Soil Bed Requirements

• The planting soil bed should be four feet in depth. Planting soils should be sandy loam, loamy sand, or loam texture with clay content ranging from 10 to 25 percent. The soil should have an infiltration rate of 0.5 inches per hour and a pH between 5.5 and 6.5. In addition, the planting soil should have a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.
• The soil layer should be capped with a 2 to 3 inch layer of commercially-available fine shredded mulch or shredded hardwood chips.
• The underdrain collection system should consist of 6 inch perforated pipe in the gravel layer and the planting soil bed.

Landscape Requirements

• A dense and vigorous vegetative cover should be established over the contributing pervious drainage areas before runoff can be accepted into the facility.
• The bioretention area should be vegetated to resemble a terrestrial forest ecosystem, with a mature tree canopy, subcanopy of understory trees, scrub layer, and herbaceous ground cover.
• The tree-to-shrub ratio should be 2:1 to 3:1. On average, the trees should be spaced 8 feet apart. Plants should be placed at regular intervals to replicate a natural forest. Woody vegetation should not be specified at inflow locations.
• After trees and shrubs are established, the ground cover and mulch should be established.
• Choose plants based on factors such as whether native or not, resistance to drought and inundation, cost, aesthetics, maintenance, etc.

Recommended Specifications

General Recommendations

• Bioretention filters are well suited for highly impervious areas in commercial, residential, and industrial developments.
• Bioretention is also well suited for small lots, including those of one acre or less.
• Recommended minimum dimensions of a bioretention area are 15 feet wide by 40 feet in length.

Landscape Recommendations

• Three species each of both trees and scrubs are recommended to be planted.
• Native plant species should be specified over non-native species.
• Vegetation should be selected based on a specified zone of hydric tolerance.
• A selection of trees with an understory of shrubs and herbaceous materials should be provided.

8.4.6.2 Operation and Maintenance Recommendations

• A storm water management easement and maintenance agreement shall be required for each facility. The maintenance covenant shall require the owner of the bioretention facility to periodically clean the structure in order to maintain design performance.
• The bioretention facility shall be monitored after every large storm (>1 inch in 24 hours) for the first year after completion of construction and be monitored quarterly thereafter.
• The site should be inspected and debris removed after every major storm.
• Periodic pruning and weeding shall be performed to maintain appearance.
• Replace mulch as needed when erosion is evident.
• Trees and shrubs should be inspected semi-annually to evaluate their health and remove any dead or severely diseased vegetation.

• Replace mulch over the entire area every two to three years.
• Other vegetation over 18 inches high shall be cut unless it is part of planned landscaping.

8.4.6.3 Performance Standards

A bioretention design can also include the following:

• An optional sand filter layer to spread flow, filter runoff, and aid in the aeration and\ drainage of the planting soil.
• A stone diagram at the beginning of the grass filter strip to reduce runoff velocities and spread flow into the grass filter.
• A gravel curtain drain overflow on the opposite side of the bioretention area.
• Multiple bioretention areas can be utilized for larger areas.

Pretreatment:

• Pretreat with grass filter strip. Adequate pretreatment for bioretention systems is provided when all of the following are provided: (a) grass filter strip below a level spreader, (b) gravel diaphragm and (c) a mulch layer.

Pollutant removal:

• Bioretention facilities are presumed to be able to remove 80% of the total suspended solids load in typical urban post-development runoff.

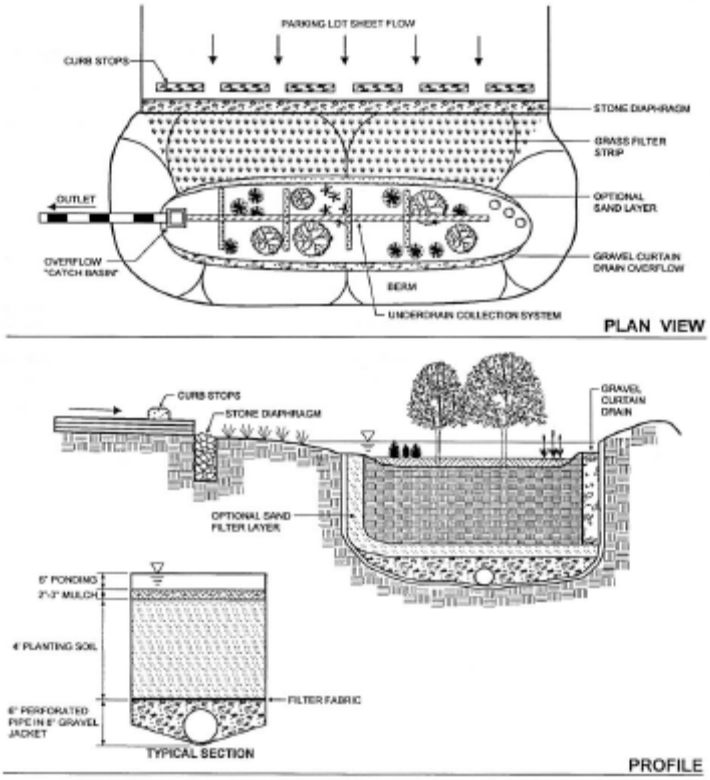

Figure 8-8 Schematic of a Bioretention Facility
Source: Draft Georgia Storm Water Management Manual, Atlanta Regional Commission

8.4.7 Constructed Wetlands

Specifications for Constructed Wetlands

General Specifications

- Inflow of water must be greater than that leaving the basin by infiltration or exfiltration.
- A water balance should be performed to demonstrate that the wetland can withstand a thirty day drought at summer evaporation rates without completely drawing down.
- Designed for an extended detention time of 24 hours or discharge the runoff through a filtering device (e.g., rock covered perforated pipe) for the design volume of runoff from the first 1.2 inches of rainfall.
- The orifices used for extended detention will be vulnerable to blockage from plant material or other debris that will enter the basin with stormwater runoff. Therefore, some form of protection against blockage should be installed (such as some type of noncorrodible wire mesh).

- Surface area of the wetland should account for a minimum of 1 percent of the area of the watershed draining into it (1.5 percent for a shallow marsh design).
- The length to width ratio should be at least 2 to 1.
- A soil depth of at least 4 inches should be used for shallow wetland basins.
- A minimum of 35 percent of the total surface area should have a depth of six inches or less and at least 65 percent of the total surface area should be shallower than 18 inches.
- The deeper area of the wetland should include the outlet structure so outflow from the basin is not interfered with by sediment buildup.
- A forebay should be established at the pond inflow points to capture larger sediments and be 4 to 6 feet deep. Direct maintenance access to the forebay should be provided. Sediment depth markers should be provided.
- If high water velocity is a potential problem, some type of energy dissipation device should be installed.
- The designer should maximize use of existing- and post-grading pondscaping design to create both horizontal and vertical diversity and habitat.
- A minimum of 2 aggressive wetland species (primary species - Figure 8-5) of vegetation should be established in quantity on the wetland.
- Three additional wetland species (secondary species- Figure 8-5) of vegetation should be planted on the wetland, although in far less numbers than the two primary species.
- 30 to 50 percent of the shallow (12 inches or less) area of the basin should be planted with wetland vegetation. The optimal depth requirements for several common species of emergent wetland plants are often six inches of water or less.
- Approximately 50 individuals of each secondary species should be planted per acre; set out in 10 clumps of approximately 5 individuals and planted within 6 feet of the edge of the pond in the shallow area leading up to the ponds edge; spaced as far apart as possible, but no need to segregate species to different areas of the wetland.
- Wetland mulch, if used, should be spread over the high marsh area and adjacent wet zones (-6 to +6 inches of depth) to depths of 3 to 6 inches.
- A buffer zone, for all but pocket wetlands, should be established and planted with riparian and upland vegetation (50 foot buffer if wildlife habitat value required in design). In addition, an additional 15 feet setback to structures should be included.
- Surrounding slopes should be stabilized by planting in order to trap sediments and some pollutants and prevent them from entering the wetland.
- The wetland should be maintained to prevent loss of area of ponded water available for emergent vegetation due to sedimentation and/or accumulation of plant material.
- Local assistance should be obtained for information concerning plants to be used, planting schedule, soil requirements, mulch requirements, etc.

Recommended Specification

- It is recommended that the frequently flooded zone surrounding the wetland be located within approximately 10 to 20 feet from the edge of the permanent pool.
- Soil types conducive to wetland vegetation should be used during construction.
- The wetland should be designed to allow slow percolation of the runoff through the substrate (add a layer of clay for porous substrates).
- The depth of the forebay should be in excess of 3 feet and contain approximately 10 percent of the total volume of the normal pool.
- As much vegetation as possible and as much distance as possible should separate the basin inlet from the outlet.
- Of the 75 percent of the wetland that should be 12 inches deep or less, it is recommended that approximately 25 percent range from 6 inches deep to 12 inches deep, and that the remaining 50 percent be 6 inches or less in depth.
- The water should gradually get shallower about 10 feet from the edge of the pond.
- The planted areas should be made as square as possible within the overall design of the wetland, rather than long and narrow.
- The only site preparation that is necessary for the actual planting (besides flooding the basin) is to ensure that the substrate is soft enough to permit relatively easy insertion of the plants.

Operation and Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc., with more intense activity for the first three years after construction.
- The wetland should be maintained to prevent loss of area of ponded water available for emergent vegetation due to sedimentation and/or accumulation of plant material.
- Sediment forebays should be cleaned every 2 to 5 years except for pocket wetlands without forebays which are cleaned after a six inch accumulation of sediment.

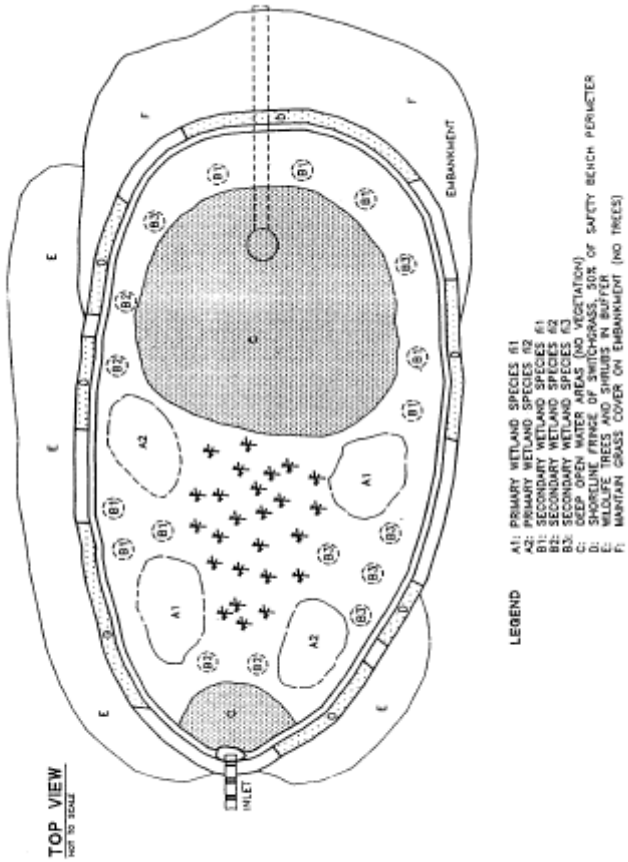

Figure 8-9 Shallow Marsh Planting Strategies
(Source: Controlling Runoff)

- The ponded water area may be maintained by raising the elevation of the water level in the permanent pond, by raising the height of the orifice in the outlet structure, or by removing accumulated solids by excavation.
- Water levels may need to be supplemented or drained periodically until vegetation is fully established.
- It may be desirable to remove contaminated sediment bottoms or to harvest above ground biomas and remove it from the site in order to permanently remove pollutants from the wetland.

8.4.8 Infiltration Trenches

Specifications for Infiltration Trenches

General Specifications

- Used in small drainage areas less than 5 acres.

- Designed to drain the water volume from the first 1.2 inches of rainfall in 24 hours or discharge the runoff through a filtering device (e.g., rock covered perforated pipe).
- A minimum of one soils boring is required for every 50 feet of trench length, and no less than 2 soils logs for each proposed trench location. Borings should be taken to a depth of at least five feet below the trench depth.
- Each soils boring should extend a minimum of 3 feet below the bottom of the trench, describe the NRCS series of the soil, the textural class of the soil horizon(s) through the depth of the log, and note any evidence of high ground water level, such as mottling. In addition, the location of impermeable soil layers or dissimilar soil layers should be determined.
- For runoff treatment, the soil infiltration rate should be between 0.5 and 2.4 inches per hour.
- Soil textures with minimum infiltration rates of 0.5 inches per hour or less are not suitable for infiltration trenches.
- Soils should have a clay content of less than 15 percent and a silt/clay content of less than 40 percent.
- Soils that have a 30 percent or greater clay content are not suitable for infiltration trenches.
- Soils that are suitable for infiltration systems are silt loam, loam, sandy loam, loamy sand, and sand.
- The use of infiltration systems on fill is not allowed due to the possibility of creating an unstable subgrade.
- A minimum of 3 feet difference is required between the bottom of the infiltration trench and the groundwater table and to bedrock.
- Site slope must be less than 20 percent, and the trench must be horizontal.
- The proximity of building foundations should be at least 25 feet horizontally.
- A minimum distance of 100 feet from water supply wells should be maintained when the runoff is from industrial or commercial areas.
- The design infiltration rate should be equal to one-half the infiltration rate found from the soil textural analysis.
- Water quality infiltration trenches must be preceded by a pretreatment BMP.
- If the trench is preceded by a presettling basin, then the combination of both BMPs must be designed to drain the design water volume within 48 hours.
- The aggregate material for the trench should consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches.
- Stone aggregate backfill material for the trench should have a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. For design purposes, void space for these aggregates may be assumed to be in the range of 30 percent to 40 percent. Void ratio of 0.40 should be used to design stone reservoirs for infiltration practices.
- The aggregate should be completely surrounded with an engineering filter fabric. If the trench has an aggregate surface, filter fabric should surround all aggregate fill material except for the top one foot.
- Runoff must infiltrate through at least 18 inches of soil.

- An observation well should be installed for every 50 feet of trench length.
- The observation well should consist of perforated PVC pipe, 6 inches in diameter, located in the center of the structure, and be constructed flush with the ground elevation of the trench.
- The top of the observation well should be capped to discourage vandalism and tampering.
- Bypass larger flows.

Recommended Specifications

- Infiltration trenches work well for residential lots, commercial areas, parking lots, and open space areas.
- Can be installed under a swale to increase the storage of the infiltration system.
- Infiltration systems should not be constructed until all construction areas draining to them are fully stabilized.
- An analysis should be made to determine any possible adverse effects of seepage zones when there are nearby building foundations, basements, roads, parking lots, or sloping sites.

Operation and Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc.
- The trench should be monitored after every large storm (rainfall greater than 1 inch in 24 hours) for the first year after completion of construction and be monitored quarterly thereafter.
- Sediment buildup in the top foot of stone aggregate or the surface inlet should be monitored on the same schedule as the observation well.

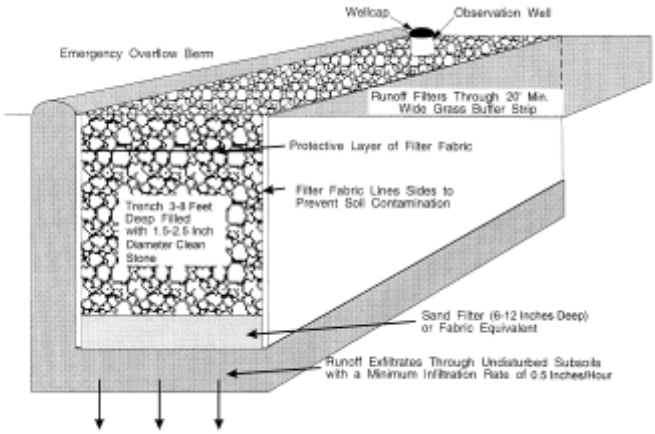

Figure 8-10 Infiltration Trench
(Source: Stormwater Management Manual for the Puget Sound Basin)

8.4.9 Filter Strips and Flow Spreaders

Standard Specifications for Filter Strips and Flow Spreaders

General Specifications

- The use of filter strips and flow spreaders should be limited to drainage areas of 10 acres or less with the optimal size being less than 5 acres.
- Capacity of the spreader and/or filter strip length (perpendicular to flow) should be determined by estimating the volume of flow that is diverted to the spreader for water quality control.
- Drainage area into spreader should be restricted so that maximum flow will not exceed 30 cfs.
- Channel grade for the last 20 feet of the dike or diversion entering the level spreader should be less than or equal to 1% and designed to provide a smooth transition into spreader.
- Grade of a level spreader should be 0%.
- Depth of a level spreader as measured from the lip should be at least 6 inches.
- Appropriate length, width, and depth of flow spreader should be selected from the following table.

Design Flow (cfs)	Entrance Width (ft)	Depth (ft)	End Width (ft)	Length (ft)
0 - 10	10	0.5	3	10
10 - 20	16	0.6	3	20
20 - 30	24	0.7	3	30

- The level spreader lip should be constructed on undisturbed soil (not fill material) to uniform height and zero grade over length of the spreader.
- The released runoff to the outlet should be on undisturbed stabilized areas in sheet flow and not allowed to reconcentrate below the structure.
- Slope of the filter strip from a level spreader should not exceed 10 percent.
- All disturbed areas should be vegetated immediately after construction.
- Filter strip width to be a minimum of 20 feet.

Recommended Specifications

- Top edge of filter strip should directly abut the contributing impervious area and follow the same contour elevation line.
- Runoff water containing high sediment loads to be treated in a sediment trapping device before release in a flow spreader.
- Spreader lip to be protected with erosion resistant material, such as fiberglass matting or a rigid non-erodible material for higher flows, to prevent erosion and allow vegetation to be established.

- Wooded filter strips are preferred to gravel strips.

Operation and Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc. The maintenance considerations should require the owner of the filter strip/flow spreader to periodically clean the structure.
- Flow spreader should be inspected after every rainfall until vegetation is established, and needed repairs made promptly.
- After area is stabilized, inspections should be made quarterly.
- Vegetation should be kept in a healthy, vigorous condition.
- Filter strip and flow spreader should be maintained in a manner to achieve sheet flow.

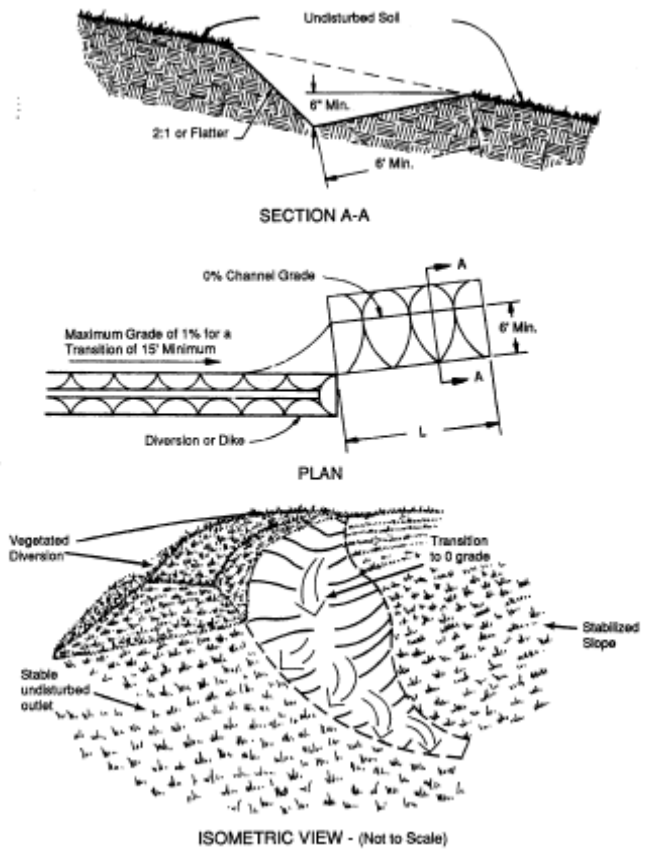

Figure 8-11 Flow Spreader
Source: North Carolina Erosion and Sediment Control Planning and Design Manual, 1988

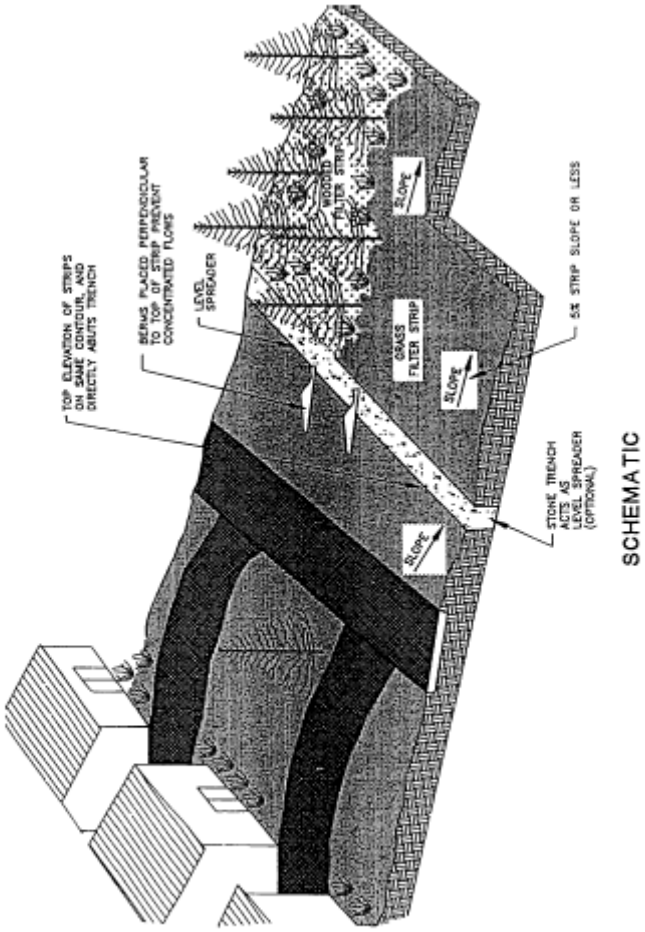

Figure 8-12 Schematic of a Filter Strip
Source: Controlling Urban Runoff

8.4.10 Grassed/Biofiltration Swales

Standard Specifications for Grassed Swales

Grassed swales are also described as biofiltration swales with the major difference being that grassed swales often have check dams where biofiltration swales do not.

General Specifications

- Grassed swale should only convey standing or flowing water following a storm.
- As a water quality BMP, grass swales should be designed for the water quality volumes that can be expected from the first 1.2 inches of rainfall.
- Limited to peak discharges generally less than 5 to 10 cfs.
- Limited to runoff velocities less than 2.5 ft/s.
- Maximum design flow depth to be 1 foot.

- Swale slopes should be graded as close to zero as drainage will permit.
- Swale slope should not exceed 4 percent (2 percent is preferred).
- Swale cross-section should have side slopes of 3:1 (h:v) or flatter.
- Underlying soils should have a high permeability (f_c > 0.5 inches per hour).
- Swale area should be tilled before grass cover is established.
- Dense cover of a water tolerant, erosion resistant grass should be established.
- To obtain credit as a water quality BMP, grassed swales must have a minimum length of 100 feet.

Recommended Specifications

- As a BMP, grassed swales are limited to residential or institutional areas where percentage of impervious area is relatively small.
- Seasonally high water table to be greater than 3 feet below the bottom of the swale.
- Check dams can be installed in swales to promote additional infiltration. Recommended method is to sink a railroad tie halfway into the swale. Riprap stone should be placed on the downstream side to prevent erosion.
- Maximum ponding time behind check dam to be less than 48 hours. Minimum ponding time of 30 minutes is recommended to meet water quality goals.

Operation and Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc. The maintenance considerations should require the owner of the grassed swale to periodically clean the structure.
- Grass swale should be maintained to keep grass cover dense and vigorous.
- Maintenance should include periodic mowing, occasional spot reseeding, and weed control.
- Swale grasses should never be mowed close to the ground. Grass heights in the 4 to 6 inch range are recommended.
- Fertilization of grass swale should be done when needed to maintain the health of the grass, with care not to over-apply the fertilizer.

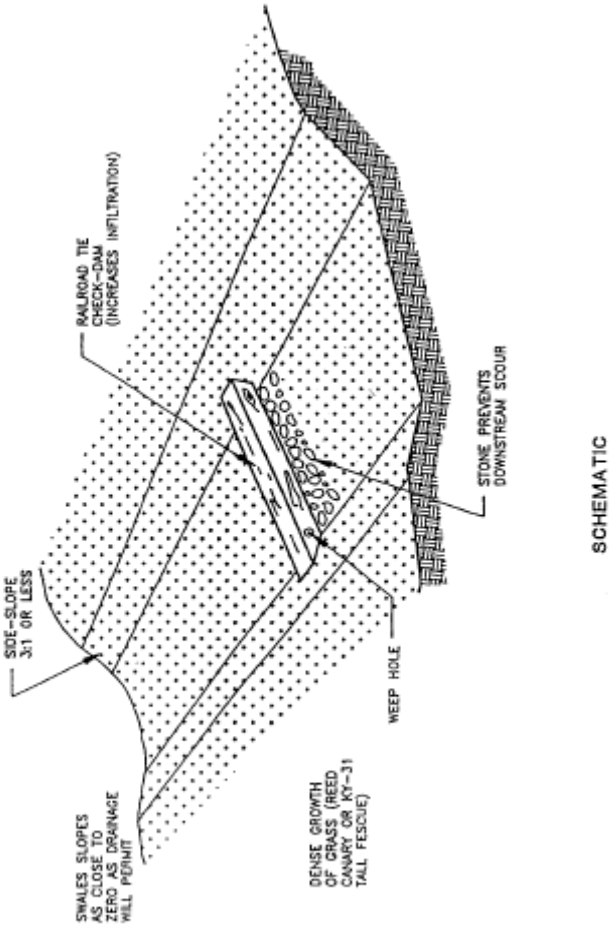

Figure 8-13 Schematic of a Grass Swale
Source: Controlling Urban Runoff

8.4.11 Porous Pavement

8.4.11.1 Porous Pavement

Porous pavement does not receive credits as a water quality BMP, instead credit is obtained as a land use BMP as designated by the "disturbed pervious area" classification using the New Development Review Tool.

8.4.11.2 Standard Specifications for Porous Pavement

Required Specifications

- Geotechnical investigation shall be required prior to design including a minimum of one soil boring (to a depth of 4 feet below the anticipated bottom of the stone

reservoir) for each 5,000 square feet of infiltration surface area, with a minimum of three borings per BMP.

- Soil infiltration rate shall be greater than 0.27 inch per hour and clay content less than 30 percent for partial exfiltration system and greater than 0.52 inch per hour for full exfiltration system.
- Porous pavement shall be designed to exfiltrate a minimum of runoff volume equal to the first 1.2 inches of runoff from the contributing drainage area.
- Only feasible on sites with gentle slopes (less than 5%).
- Design infiltration rate shall be equal to 1/2 of the infiltration rate associated with the soil below the proposed porous pavement.
- Minimum of 3 feet of clearance between stone reservoir level and bedrock.
- Minimum of 3 feet between stone reservoir level and seasonally high water table.
- Shall not be constructed over fill soils.
- Vegetative strip or diversion berm required to protect pavement area from off-site runoff before, during, and after construction.
- If porous pavement areas receive runoff from off-site areas, a pretreatment facility shall be constructed to remove oil, grit, and sediments before entering the porous pavement.
- Dry subgrade shall be covered with engineering filter fabric such as Mirafi #14N or equal on bottom and sides.
- Pavement section consisting of 4 layers as shown on Figure 8-14.
- Stone shall be clean, washed stone meeting roadway standards.
- Reservoir base course shall consist of 1" to 3" crushed stone aggregate compacted lightly at the depth required to achieve design storage.
- Filter courses to be 1/2" crushed stone aggregate at a 1" to 2" thickness.
- Surface course shall be laid in 1 lift at the design depth with compaction done while the surface is cool enough to resist a 10-ton roller. Only 1 or 2 passes are required.
- After final rolling, no vehicular traffic shall be permitted on pavement until cooling and hardening, a minimum of 1 day.
- Stone reservoir shall be designed for a 1.2-inch design storm and a maximum residence time of 24 hours.
- The porous pavement site shall be posted with signs indicating the nature of the surface and warning against resurfacing, using abrasive, and parking heavy equipment.
- An observation well shall be installed on the downslope end of the porous pavement area to monitor runoff clearance rates.
- The observation well shall consist of perforated PVC pipe, 4 to 6 inches in diameter, constructed flush with the ground.
- The top of the observation well shall be capped to discourage vandalism and tampering.

Recommended Specifications

- Limited in application to parking lots, service roads, emergency and utility access lanes, and other low traffic areas.
- Limited to sites between 1/4 acre and 10 acres.
- Should not be constructed near groundwater drinking supplies.
- Heavy equipment should be prevented from compacting the underlying soils before and during construction.
- Other porous pavement types such as concrete lattice blocks, perforated concrete grid slabs, reinforced plastic pavers, etc. placed over a porous subgrade and filled with soil may be used in lieu of the asphalt surface course.

8.4.11.3 Operation and Maintenance Recommendations

- A storm water management easement and maintenance agreement shall be required for each facility. The covenant shall require the owner of the porous pavement to periodically clean the structure.
- Sediment shall be kept off of the pavement before, during, and after construction to prevent premature clogging.
- Surface of the porous pavement shall be vacuum swept at least 4 times a year, followed by high pressure jet hosing, to keep the pores free from clogging.
- Sand or ash shall never be applied to porous pavement.
- Spot clogging of the porous pavement layer can be relieved by drilling 1/4" holes through the porous asphalt layer every few feet.
- The observation well shall be monitored several times during the first few months after construction and be monitored quarterly thereafter. Water depth in the well shall be measured at 0-, 24-, and 48-hour intervals after a storm to determine the clearance rate.

8.3.10.3 Performance Standards

- Porous Pavement Performance
    - An underground drainage system is installed to help dispose of excess runoff.

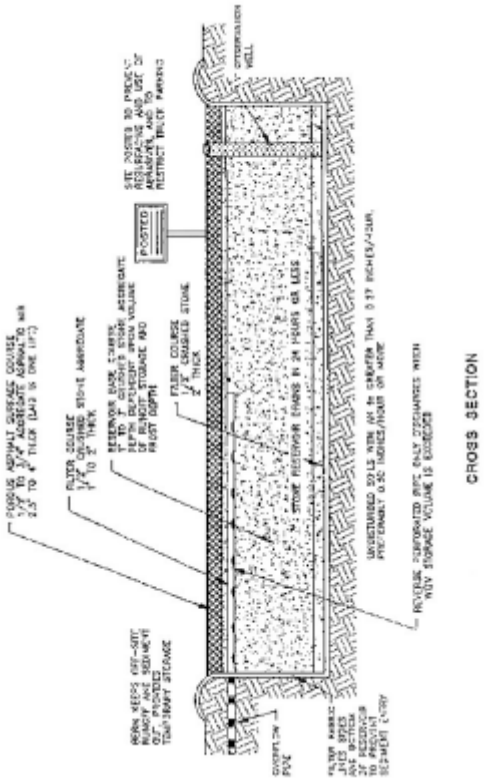

Figure 8-14 Design Schematic for Porous Pavement
Source: Controlling Urban Runoff

8.4.12 Oil/Grit Separators

Standard Specifications for Oil/Grit Separators

General Specifications

- Separators should be sized for the design water volume from the first 1.2 inches of rainfall.
- Separator should be structurally sound and designed for acceptable traffic loadings where subject to traffic loadings.
- Separator should be designed to be water tight.
- Volume of separator should be at least 400 cubic feet per acre tributary to the facility (first two chambers).
- Forebay or first chamber should be designed to collect floatables and larger settleable solids. Its surface area should not be less than 20 square feet per 10,000 square feet of drainage area.
- Oil absorbent pads, oil skimmers, or other approved methods for removing accumulated oil should be provided.
- Separator pool should be at least 4 feet deep.

- Weirs, openings, and pipes should be sized to pass as a minimum a 25-year storm.
- Manholes should be provided to each chamber to provide access for cleaning.

Recommended Specifications

- Oil absorbent pads, oil skimmers, or other approved methods for removing accumulated oil should be provided.
- Separator to be located close to the source before pollutants are conveyed to storm sewers or other BMPs.
- Use only on sites of less than one acre.
- Provide perforated covers as trash racks on orifices leading from first to second chamber.
- Use three chambers for treatment similar to Figure 8-10.
- Center chamber may contain a coalescing medium to enhance the gravity separating process.
- Storm drain inlet in third chamber to be located above floor to permit additional settling.
- Stormwater from rooftops and other impervious areas not likely to be polluted with oil should not discharge to the separator.
- Design to bypass flows above 400 cubic feet per acre.

Operation and Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc.
- The maintenance considerations should require the owner to periodically clean the structure.
- Cleaning quarterly should be a minimum schedule with more intense land uses such as gas stations requiring cleaning as often as monthly.
- Cleaning should include pumping out waste water and grit and having the water processed to remove oils and metals.

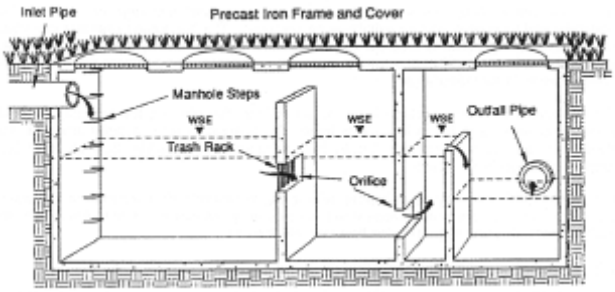

Figure 8-15 Oil/Grit Separator
Source: City of Rockville, MD

8.4.13 Alternate Structural BMPs

Prior to the submittal of a development permit with a structural BMP not included in the manual, written approval that the use of the alternate BMP is allowed must be received from the Director of the Department of Public Utilities.

The number of requests for approval as an alternate BMP is more than we can process in a timely manner. We are hopeful that a regional review and approval process will be developed in the near future so that alternate BMPs are used uniformly though the metropolitan Atlanta area. Until this structure is developed, Gwinnett will be using the guidance provided by the Washington State Department of Ecology (Ecology) Sampling for "Emerging Technologies".

Ecology has established an Emerging Technology Committee, and they have developed protocols for gaining approval of emerging technologies for use in Washington State. They have also reviewed and approved some treatment technologies. Several categories of approvals can be granted.

Links to this Ecology information are below:

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/02-10-037%20TAPE.pdf

Gwinnett County encourages manufacturers of emerging technologies to seek approval through the Ecology review and approval process. Approval by Ecology does not guarantee approval by Gwinnett County, however.

Requests for approval to an alternate BMP in Gwinnett County must be made in writing and shall include the following information. Developer may be required to pay a fee so that the County can have the design reviewed by an independent expert or panel of experts.

1) Justification for the proposed BMP facility
2) Summary of BMP submitted for approval
3) Description of design
4) Minimum and maximum flows (drainage area) that BMP can handle
5) Pollutants that are removed by the BMP
6) Pollutant removal efficiency
7) BMP design drawings
8) BMP design calculations
9) Research data supporting water quality efficiencies
10) Monitoring program to document removal efficiencies
11) Maintenance program
12) Safety and aesthetic considerations

A request for approval should be submitted to a review committee. The review committee shall be selected by the County. Members on the committee should be representatives of the following groups:

1) County
2) Site design engineer consultant
3) Environmental engineer consultant
4) Environmentalist
5) Contractor
6) Developer

The BMP shall be evaluated based on the following criteria:

1) Independent test results/studies
2) Maintenance requirements
3) Design theory
4) Reliability
5) History of use
6) Other factors determined by the review committee

Approval of alternates will require a monitoring program. A monitoring period of at least three years with quarterly samples is recommended. The program should be in accordance with Gwinnett County's Municipal NPDES Storm water permit sampling requirements.

Approval of alternates should require a surety to cover replacement of the alternative with a BMP included in the Design Manual.

The surety should be required during the period of testing. The developer shall provide a plan using BMPs included in the Design Manual and reserve space on the proposed development plan to implement these BMPs should the alternative BMP fail. The County can use the surety to install the BMPs included in the Design Manual if the sampling program is not followed, maintenance requirements are greater than anticipated, the results do not meet the claims of the approved design, or the Director of the Department of Public Utilities determines that the BMP is not functioning satisfactorily.

Approval of alternatives will require reporting to include maintenance activities and test results.

The review committee shall recommend approval or denial of the BMP, monitoring requirements, maintenance requirements, and surety requirements. The Director of the Department of Public Utilities shall decide if the BMP should be approved. Appeals of the Director's decision can be made in accordance with the appeals process in Section 13.4 of the Development Regulations.

The County will maintain a record of alternative BMP designs that have been submitted or are under testing. BMPs that meet design claims will be included in the Design Manual.

8.5 Streambank Restoration

Although effective watershed runoff controls are needed to eliminate the root causes of stream degradation, stream health can also benefit from restoration efforts that directly target the stream channel and stream banks. Stream bank erosion needs to be halted, and both in-stream and riparian habitats restored. Such a program requires expertise in areas such as stream forming processes, slope stabilization, plant science, and aquatic biology. Local Soil Conservation Service and U.S. Fish and Wildlife Service staff may be able to provide some of this expertise. Stream restoration includes three major activities:

- Riparian reforestation.
- Streambank stabilization.
- Streambed restoration.

8.5.1 Riparian Reforestation

The contribution of trees and woody understory vegetation to the maintenance of stream health cannot be overstated. Streamside forested areas not only provide habitat, shade, and forage for both aquatic and land-based species, but their ability to filter pollutants and rainfall provides a buffer, a last line of defense, from watershed runoff. A program to restore forested streamside areas should receive early consideration, because it can be one of the most cost-effective steps that a community takes in its stream restoration efforts. The objective should be to replicate or mimic the natural ecosystem as much as possible, so mixed-age native plant and tree species are preferred. The cost-effectiveness of the program can be increased by encouraging participation by citizen volunteers. Though most revegetation efforts focus on streambanks, the hydrologic characteristics of the watershed can be improved by upland reforestation as well.

8.5.2 Streambank Stabilization

Anyone faced with an eroding or collapsing streambank needs first to determine the cause of the problem. Streambank erosion occurs for a number of reasons, including increased stream velocity, obstacles in the stream, floating debris, wave action, and direct rainfall. Streambank failure occurs when a large section of streambank collapses into the stream channel. Among the causes of streambank failure are changes in channel cross-section through down-cutting of the streambed and undercutting of the bank, increased load on the top of the bank, and internal pressure from uneven water absorption.

Selection of an appropriate bank stabilization method requires careful analysis of each site. No single method is appropriate in all situations. Technical advice will often be

needed, and is available from sources such as the local Soil Conservation Service and Cooperative Extension Service offices, or from private consultants. One important note: a Corps of Engineers permit may be needed before any material is placed in a stream or adjacent wetlands. The Corps of Engineers Savannah District office should be contacted (1-800-448-2402 or 1-912-652-5347.)

Detailed discussion of the many possible stream and streambank stabilization techniques is beyond the scope of this Manual, but one general approach needs to be mentioned because of growing realization of its contribution to the overall health of streams. The approach has been called the bioengineering or biotechnical approach. Its aim is to replicate or reintroduce natural stream and slope stabilization processes as much as possible. The biotechnical approach to slope protection combines the use of mechanical (or structural) elements with biological elements (plants), functioning together and mutually reinforcing each other (Gray and Leiser, 1982). Biotechnical techniques in which plant materials are the primary structural components have come to be identified by the term "soil bioengineering". Techniques include installing plantings of woody vegetation such as willows, either as individual live cuttings, or in bundles of cuttings. If planted correctly and given time to establish root systems, the cuttings can grow into a dense network of protective vegetation that can bend but not break under stress and that is self repairing. The vegetation's root matrix provides resistance to the sliding and shear displacement forces involved in slope erosion.

Although "living construction" methods have been systematically studied and used in Europe for more than half a century, technical information on such methods became easily available in the United States only recently. The Pennsylvania Scenic Rivers Program's 1986 guidebook for landowners is an attractive, reader-friendly publication (Pennsylvania Scenic Rivers Program, 1986). The Izaak Walton League of America has published a 21-page survey of stream-bank stabilization methods (Izaak Walton League of America, 1989). The Washington Department of Ecology's draft Storm Water Management Manual for the Puget Sound Basin includes bioengineering methods among the many groups of protection measures that it describes (Washington Department of Ecology, 1992). Also, the Georgia Soil and Water Conservation Commission plans to include a detailed description of the concepts in a new guidebook titled Controlling Streambank Erosion which will soon be available.

Gray and Leiser (1982) list four reasons to prefer biotechnical approaches:

- Their cost-effectiveness. Lower cost vegetative treatments can reduce the amount of higher cost structural treatments that may be needed.
- Their environmental compatibility. Biotechnical systems tend to blend into the landscape and are less visually intrusive. Examples include log or timber cribs gabion and rock breast walls, and reinforced earth. In addition, wherever possible, vegetation is incorporated into the structures, for example by planting in the spaces between structural members.

- Their use of indigenous, natural materials. Wherever possible, natural locally available materials are used: earth, rock, timber, vegetation - in contrast to man-made materials such as steel and concrete.
- Their labor- and skill-intensiveness. Well-supervised, skilled labor can often be substituted for high-cost, energy-intensive materials.

Most importantly, biotechnical methods contribute to the support and protection of the ecology of a stream in ways that purely structural techniques do not.

If possible, a qualified bioengineer should be consulted to evaluate site conditions and determine the appropriate mix of measures that will adequately solve the problem and stand up to the test of time. In some cases, a solely vegetative approach may be all that is needed. In others, conditions such as excessive stream velocities or poor soil conditions may require a combination of vegetative and structural elements. And in still others, space limitations or other conditions may require a solely structural approach such as stone walls or bulkheads. Some of the most common conditions that may preclude the soil bioengineering preference for vegetative measures include inadequate space, heavy pedestrian traffic, the need for an unobstructed view, or too much shade.

8.5.3 Streambed Restoration

Prior to any streambed restoration, upstream conditions should be assessed. Without corrective measures or retrofitting upstream, storm water flows could quickly destroy any restoration work. If the steam is in equilibrium, or if appropriate corrective measures are in place, streambed restoration can recreate the habitat conditions needed to support aquatic life. Several factors may need to be addressed in streambed restoration:

- Replacement of pools and riffles.
- Velocity control.
- Restoration of the stream gradient and normal flow channel.
- Removal of major stream obstructions.
- Restoration of suitable channel patterns. There are three major channel patterns: meandering - which is characterized by repetitive bends, (2) irregular - which is more or less straight; and (3) braided - which separates and rejoins around islands. Which pattern is appropriate depends upon surrounding soil and slope conditions, as well as the original stream patterns (Dunne, 1978).
- Restoration of the substrate (removal of sediment and replacement with gravel and cobbles, as appropriate for the streams).
- Restoration of adjacent wetlands and floodplains.

The number of factors affected by restoration and the extent of the measures taken will depend upon individual stream conditions. Some techniques permit the stream flows themselves to work to restore healthier streambed conditions; others require excavation and physical realignment of the stream channel. Three basic techniques include

deflectors, in-stream boulders and drop structures. With many variations, these techniques are used throughout the country.

8.5.3.1 Deflectors

Deflectors can be easily constructed of common, local material such as cobbles, boulders and logs, and are adaptable to a variety of conditions and stream sizes. They are sited in the channel with the intent of deflecting the current into a more narrow channel. Deflectors can use the stream flow for a variety of purposes, including deepening channels, developing downstream pools, enhancing pool riffle ratios and assisting in the restoration of meander patterns with channelized reaches. There are several deflector designs, such as a simple double "wing deflector" that consists of rock structures on each bank deflecting the streamflow to a central channel, single deflectors along one bank, deflectors offset on opposite banks of a stream to imitate meanders, and V-type deflectors, which are placed in the middle of channels with the point of the "V" pointing upstream to deflect water towards both banks. This type of deflector helps re-establish riffles and pools downstream. An underpass deflector is a log placed across a small stream several inches off the bottom. Water is deflected under the log which helps remove sediment deposits and restore pools (Gore, ed., 1985; Kumble, 1990).

8.5.3.2 Drop Structures

Drop structures include a number of variations such as weirs, check dams, sills and plunges. They can serve a variety of functions in streambed restoration depending upon their design, including: slowing streamflow; deepening existing pools; and creating new pools upstream and downstream. Structures with notches can be used to control heavy storm water flows and can help re-establish deep pools immediately downstream. Drop structures can be made of concrete, logs or boulders. Log or boulders structures can be used to replicate small falls or rapids. Single log dams across a streambed are simple and effective in restoring plunge pools. The K-dam is a variant of the single log dam, so named by added downstream bracing. In some areas, especially headwater areas, reintroducing beavers has been effective in restoring habitat (Gore, ed., 1985). Their dams function as drop structures in headwaters and on small streams.

8.5.3.3 Boulder Placement

Boulder placement is a third in-channel treatment that can assist streambed restoration. Boulders can be used to reduce velocity, restore pools and riffles, restore meanders, provide cover and protect eroded banks by deflecting flow (Gore, ed., 1985). Boulders can be placed randomly or in a pattern. Placing them in a "V" pointed upstream produces eddies that replicate riffles and restore downstream pools. Combined with placement of cobbles and gravels, boulder placement can also help restore the stream substrate.

Excavation and fill may also be necessary to restore the stream gradient, the normal flow channel and the stream channel pattern, including meanders and braids, where appropriate. Channel pattern restoration should be combined with streambank restoration and re-vegetation. Streams that have been severely degraded by large amounts of sediment or heavy storm water flows may require greater restoration work. Sediment may have to be removed mechanically and replaced with gravel and cobbles to replicate the original streambed. Major debris accumulation that is obstructing flows may also need to be removed.

Restoration of riparian wetlands and floodplains can also be included in re-vegetation projects with special consideration given to planting species appropriate to the specific site conditions, including soil types and degree of saturation. The following sources can provide further information on streambed restoration:

- Guidelines for Streambank Restoration. State Soil & Water Conservation Commission, 1994
- Soil Conservation Service Engineering Field Book, Part 650, 1992
- The Restoration of Rivers and Streams. James A. Gore, Editor, 1985.
- Stream Restoration Along the Greenways in Boulder, Colorado. John L. Barnett, 1991
- The State of the Anacostia 1989 Status Report, Peter A. Kumble, 1990.
- A Streambank Stabilization and Management Guide for Pennsylvania Landowners. Commonwealth of Pennsylvania, Department of Environmental Resources, 1986.
- Stream Obstruction Removal Guidelines. Wildlife Society and American Fisheries Society, 1983.

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American Association of State Highway and Transportation Officials, *Model Drainage Manual*, 1992.

Maryland Department of Natural Resources, Water Resources Administration, Stormwater Management Division, Standards and Specifications for Infiltration Practices, 1984.

State of North Carolina, Erosion and Sediment Control Planning and Design Manual, North Carolina Sedimentation Control Commission, North Carolina Department of Natural Resources and Community Development, 1988.

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