CH. 3—STORMWATER MANAGEMENT PRACTICES

Contents

****The following stormwater management practices can be found in their entirety in Georgia's Stormwater Management Manuals, Coastal Stormwater Supplement, August 2009. For the purposes of this publication, practices profile sheets have been abbreviated.**

Soil Restoration

Description

Soil restoration refers to the process of tilling and adding compost and other amendments to soils to restore them to their pre-development conditions, which improves their ability to reduce post-construction stormwater runoff rates, volumes and pollutant loads. The soil restoration process can be used to improve the hydrologic conditions of pervious areas that have been disturbed by clearing, grading and other land disturbing activities. It can also be used to increase the reduction in stormwater runoff rates, volumes and pollutant loads provided by other low impact development practices.

(Source: http://www.towncountryltd.com)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Ideal for use in pervious areas that have been disturbed by clearing, grading and other land disturbing activities
- To properly restore disturbed pervious areas, soil amendments should be added to existing soils to a depth of 18 inches until an organic matter content of 8% to 12% is obtained
- Restored pervious areas should be protected from future land disturbing activities

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Promotes plant growth and improves plant health, which helps reduce stormwater runoff rates, volumes and pollutant loads

LIMITATIONS:

- Should not be used on areas that have slopes of greater than 10%
- To help prevent soil erosion, landscaping should be installed immediately after the soil restoration process is complete

SITE APPLICABILITY

☑	Rural Use	M	Construction Cost
☑	Suburban Use	L	Maintenance
☑	Urban Use	L	Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction

N/A[1] - Annual Runoff Volume
N/A[1] - Runoff Reduction Volume

Pollutant Removal

N/A[1] - Total Suspended Solids
N/A[1] - Total Phosphorus
N/A[1] - Total Nitrogen
N/A[1] - Metals
N/A[1] - Pathogens

1 = helps restore pre-development hydrology, which implicitly reduces post-construction stormwater runoff rates, volumes and pollutant loads

Discussion

Soil restoration can also be used to increase the stormwater management benefits provided by other low impact development practices, such as site reforestation/revegetation (Coastal Stormwater Supplement (CSS), Section 7.8.2), vegetated filter strips (CSS, Section 7.8.6), grass channels (CSS, Section 7.8.7) and simple downspout disconnection (CSS, Section 7.8.8), on sites that have soils with low permeabilities (i.e., hydrologic soil group C or D soils). The soil restoration process can be used to help increase soil porosity and improve soil infiltration rates on these sites, which improves the ability of these and other low impact development practices to reduce post-construction stormwater runoff rates, volumes and pollutant loads.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of soil restoration to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how soil restoration can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overbank flood protection, and extreme flood protection. For further details, see Section 7.8.1 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not soil restoration is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for soil restoration including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.1 of the CSS.

Site Applicability

Soil restoration can be used on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural, suburban and urban areas. When compared with other low impact development practices, it has a moderate construction cost, a relatively low maintenance burden and requires no additional surface area beyond that which will undergo the soil restoration process. It is ideal for use in pervious areas that have been disturbed by clearing, grading and other land disturbing activities. (See Table on Pages 3-13 through 3-14).

Planning and Design Criteria

It is *recommended* that the soil restoration process used on a development site meet all of the planning and design criteria provided in Section 7.8.1 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that the soil restoration process is successfully completed on a development site, site planning and design teams should consider construction recommendations listed in Section 7.8.1 of the CSS.

Maintenance Requirements

Restored pervious areas require some maintenance during the first few months following construction, but typically require very little maintenance thereafter. Table 7.7 in the CSS provides a list of the routine maintenance activities typically associated with restored pervious areas.

Site Reforestation/Revegetation

Description

Site reforestation/revegetation refers to the process of planting trees, shrubs and other native vegetation in disturbed pervious areas to restore them to their pre-development conditions. The process can be used to help establish mature native plant communities (e.g., forests) in pervious areas that have been disturbed by clearing, grading and other land disturbing activities, which improves their ability to reduce post-construction stormwater runoff rates, volumes and pollutant loads. The process can also be used to provide restored habitat for high priority plant and animal species (Appendix C).

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Ideal for use in pervious areas that have been disturbed by clearing, grading and other land disturbing activities
- Methods used for site reforestation/revegetation should achieve at least 75% vegetative cover one year after installation
- Reforested/revegetated areas should be protected in perpetuity as secondary conservation areas (Section 7.6.2)

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Helps restore habitat for priority plant and animal species

LIMITATIONS:

- Should have a minimum contiguous area of 10,000 square feet
- Should be managed in a natural state and protected from future land disturbing activities

SITE APPLICABILITY

☑ Rural Use	M Construction Cost
☑ Suburban Use	L Maintenance
✱ Urban Use	L Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
N/A[1] - Annual Runoff Volume
N/A[1] - Runoff Reduction Volume

Pollutant Removal
N/A[1] - Total Suspended Solids
N/A[1] - Total Phosphorus
N/A[1] - Total Nitrogen
N/A[1] - Metals
N/A[1] - Pathogens

1 = helps restore pre-development hydrology, which implicitly reduces post-construction stormwater runoff rates, volumes and pollutant loads

Discussion

Areas that have been reforested or revegetated should be maintained in an undisturbed, natural state over time. These areas should be designated as secondary conservation areas and protected in perpetuity through a legally enforceable conservation instrument (e.g., conservation easement, deed restriction). If properly maintained over time, these areas can help improve aesthetics on development sites, provide passive recreational opportunities and create valuable habitat for high priority plant and animal species.

To help create contiguous, interconnected green infrastructure corridors on development sites, site planning and design teams should strive to connect reforested or revegetated areas with one another and with other primary and secondary conservation areas through the use of nature trails, bike trails and other "greenway" areas.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of Site reforestation/revegetation to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how site reforestation/revegetation can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overbank flood protection, and extreme flood protection. For further details, see Section 7.8.2 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not site reforestation/revegetation is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for site reforestation/revegetation including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.2 of the CSS.

Site Applicability

Although it may be difficult to apply in urban areas, due to space constraints, site reforestation/ revegetation can be used on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, it has a moderate construction cost, a relatively low maintenance burden and requires no additional surface area beyond that which will undergo the reforestation/revegetation process. It is ideal for use in pervious areas that have been disturbed by clearing, grading and other land disturbing activities. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the site reforestation/revegetation process meet all of the planning and design criteria provided Section 7.8.2 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that the soil restoration process is successfully completed on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.2 of the CSS.

Maintenance Requirements

Reforested/revegetated areas require some maintenance during the first few months following construction, but typically require very little maintenance thereafter. Table 7.9 in the CSS provides a list of the routine maintenance activities typically associated with reforested/revegetated areas.

Green Roofs

Description

Green roofs represent an alternative to traditional impervious roof surfaces. They typically consist of underlying waterproofing and drainage materials and an overlying engineered growing media that is designed to support plant growth. Stormwater runoff is captured and temporarily stored in the engineered growing media, where it is subjected to the hydrologic processes of evaporation and transpiration before being conveyed back into the storm drain system.

(Source: http://www.greenroofs.com)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- The use of extensive green roof systems (2”-6” deep) should be considered prior to the use of more complex and expensive intensive green roof systems
- Engineered growing media should be a light-weight mix and should contain less than 10% organic material
- Waterproofing materials should be protected from root penetration by an impermeable root barrier

BENEFITS:

- Helps reduce post-construction stormwater runoff rates, volumes and pollutant loads without consuming valuable land
- Particularly well suited for use on urban development and redevelopment sites

LIMITATIONS:

- Can be difficult to establish vegetation in the harsh growing conditions found on rooftops in coastal Georgia
- Green roofs can be difficult to install on rooftops with slopes of 10% or greater

SITE APPLICABILITY

✱ Rural Use	H Construction Cost
☑ Suburban Use	M Maintenance
☑ Urban Use	L Area Required

STORMWATER MANAGEMENT “CREDITS”

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management “credits” that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

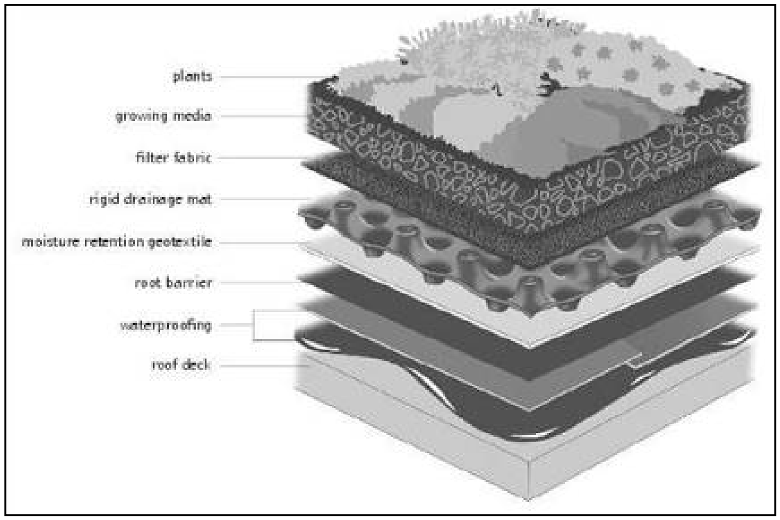
Runoff Reduction
50% - Annual Runoff Volume
60% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
50% - Total Phosphorus
50% - Total Nitrogen
N/A - Metals
N/A - Pathogens

1 = expected annual pollutant load removal

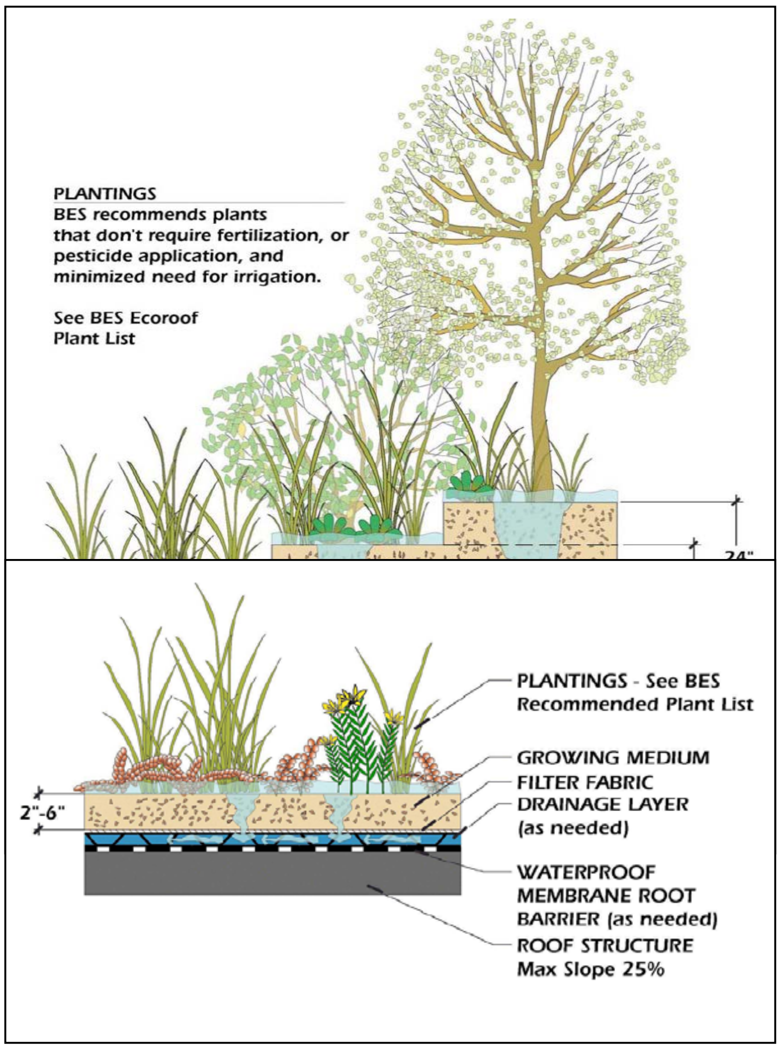
Discussion

There are two different types of green roof systems: intensive green roof systems and extensive green roof systems. Intensive green roof systems (also known as *rooftop gardens*) have a thick layer of engineered growing media (i.e., 12 to 24 inches) that supports a diverse plant community that may even include trees. Extensive green roof systems typically have a much thinner layer of engineered growing media (i.e., 2 to 6 inches) that supports a plant community that is comprised primarily of drought tolerant vegetation (e.g., sedums, succulent plants).



Components of a Green Roof System
(Source: Carter et al., 2007)

Extensive green roof systems, which can cost up to twice as much as traditional impervious roof surfaces, are much lighter and are less expensive than intensive green roof systems. Consequently, it is *recommended* that the use of extensive green roof systems be considered prior to the use of intensive green roof systems in coastal Georgia.



Extensive Green Roof System
(Source: City of Portland, OR, 2004)

Extensive green roof systems typically contain multiple layers of roofing materials, and are designed to support plant growth while preventing stormwater runoff from ponding on the roof surface. Green roof systems are designed to drain stormwater runoff vertically through the engineered growing media and then horizontally through a drainage layer towards an outlet. They are designed to require minimal long-term maintenance and, if the right plants are selected to populate the green roof, should not need supplemental irrigation or fertilization after an initial vegetation establishment period.

When designing a green roof, site planning and design teams must not only consider the stormwater storage capacity of the green roof, but also the structural capacity of the rooftop itself. To support a green roof, a rooftop must be designed to support an additional 15 to 30 pounds per square foot (psf) of load. Consequently, a structural engineer or other qualified professional should be involved with the design of a green roof to ensure that the rooftop itself has enough structural capacity sufficient to support the green roof system.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of green roofs to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how green roofs can be used to address can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overbank flood protection, and extreme flood protection. For further details, see Section 7.8.3 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not green roofs are appropriate for use on a particular development site. The Table on Pages 3-8 thorugh 3-12 provides design considerations for green roofs including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.3 of the CSS.

Site Applicability

Green roofs can be used on a wide variety of development sites in rural, suburban and urban areas. They are especially well suited for use on commercial, institutional, municipal and multi-family residential buildings on urban and suburban development and redevelopment sites. When compared with other low impact development practices, green roofs have a relatively high construction cost, a relatively low maintenance burden and require no additional surface area beyond that which will be covered by the green roof. Although they can be expensive to install, green roofs are often a component of "green buildings," such as those that achieve certification in the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. (Table ?, Appendix ?)

Planning and Design Criteria

It is *recommended* that green roofs meet all of the planning and design criteria provided in Section 7.8.3 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that green roofs are properly installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.3 of the CSS.

Maintenance Requirements

Maintenance is very important for green roofs, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.11 in the CSS provides a list of the routine maintenance activities typically associated with green roofs.

Permeable Pavements

Description

Permeable pavements represent an alternative to traditional impervious paving surfaces. They typically consist of an underlying drainage layer and an overlying permeable surface layer. A permeable pavement system allows stormwater runoff to pass through the surface course (i.e., pavement surface) into an underlying stone reservoir, where it is temporarily stored and allowed to infiltrate into the surrounding soils or conveyed back into the storm drain system through an underdrain.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Permeable pavement systems should be designed to completely drain within 48 hours of the end of a rainfall event
- If the infiltration rate of the native soils located beneath a permeable pavement system do not meet or exceed 0.25 in/hr, an underdrain should be included in the design
- Permeable pavement systems should generally not be used to "receive" any stormwater runoff generated elsewhere on the development site

BENEFITS:

- Helps reduce post-construction stormwater runoff rates, volumes and pollutant loads without consuming valuable land
- Particularly well suited for use on urban development sites and in low traffic areas, such as overflow parking lots

LIMITATIONS:

- Relatively high construction costs, which are typically offset by savings on stormwater infrastructure (e.g., storm drain system)
- Permeable pavement systems should be installed only by experienced personnel

SITE APPLICABILITY

✱ Rural Use	H Construction Cost
☑ Suburban Use	H Maintenance
☑ Urban Use	L Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

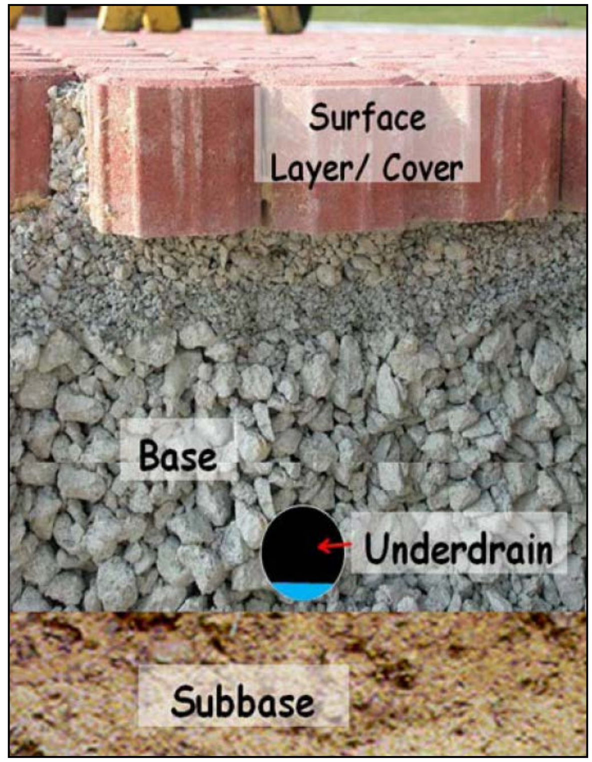
Runoff Reduction
45%-75% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
50% - Total Phosphorus
50% - Total Nitrogen
60% - Metals
N/A - Pathogens

1 = varies according to storage capacity of the permeable pavement system
2 = expected annual pollutant load removal

Discussion

There are a variety of permeable pavement surfaces available in the commercial marketplace, including pervious concrete, porous asphalt, permeable interlocking concrete pavers, concrete grid pavers and plastic grid pavers. Each of these permeable pavement surfaces is briefly described below:



Components of a Permeable Pavement System
(Source: Hunt and Collins, 2008)

- Pervious Concrete: Pervious concrete (also known as *porous concrete*) is similar to conventional concrete in structure and form, but consists of a special open-graded surface course, typically 4 to 8 inches thick, that is bound together with portland cement. This open-graded surface course has a void ratio of 15% to 25% (conventional concrete pavement has a void ratio of between 3% and 5%), which gives it a high permeability that is often many times more than that of the underlying native soils, and allows rainwater and stormwater runoff to rapidly pass through it and into the underlying stone reservoir. Although this particular type permeable pavement surface may not require an underlying base layer to support traffic loads, site planning and design teams may wish to provide it to increase the stormwater storage capacity provided by a pervious concrete system.

- Porous Asphalt: Porous asphalt is similar to pervious concrete, and consists of a special open-graded surface course bound together by asphalt cement. The open-graded surface course in a typical porous asphalt installation is 3 to 7 inches thick and has a void ratio of between 15% and 20%. Porous asphalt is thought to have a limited ability to maintain its structure and permeability during hot summer months and, consequently, is currently *not recommended* for use in coastal Georgia. If it is used on a development site in the 24-county coastal region, it should be carefully monitored and maintained over time.

- Permeable Interlocking Concrete Pavers: Permeable interlocking concrete pavers (PICP) are solid structural units (e.g., blocks, bricks) that are installed in a way that provides regularly spaced openings through which stormwater runoff can rapidly pass through the pavement surface and into the underlying stone reservoir. The regularly spaced

Pervious Concrete

Concrete Grid Pavers

Permeable Interlocking Concrete Pavers

Plastic Grid Pavers

Various Permeable Pavement Surfaces

openings, which generally make up between 8% and 20% of the total pavement surface, are typically filled with pea gravel (i.e., ASTM D 448 Size No. 8, 3/8" to 1/8"). Typical PICP systems consist of the pavers, a 1.5 to 3 inch thick fine gravel bedding layer and an underlying stone reservoir.

- Concrete Grid Pavers: Concrete grid pavers (CGP) are precast concrete units that allow rainfall and stormwater runoff to pass through large openings that are filled with gravel, sand or topsoil and turf. CGP are typically 3.5 inches thick and have between a void ratio of between 20% and 50%, which means that the material used to fill the spaces between the grids has a large influence on the overall permeability (i.e., void space) of a CGP system. A typical CGP installation consists of the pavers, 1 to 1.5 inch sand or pea gravel bedding layer and an underlying stone reservoir.

- Plastic Grid Pavers: Plastic grid pavers (PGP) are similar to CGP. They consist of flexible, interlocking plastic units that allow rainfall and stormwater runoff to pass through large openings that are filled with gravel, sand or topsoil and turf. Since the empty plastic grids have a void ratio of between 90% and 98%, the material used to fill the spaces between the grids has a large influence on the overall permeability (i.e., void space) a PGP system.

When designing a permeable pavement system, planning and design teams must not only consider the storage capacity of the system, but also the structural capacity of the underlying soils and the underlying stone reservoir. The infiltration rate and structural capacity of the native soils found on a development site directly influence the size of the stone reservoir that is needed to provide structural support for a permeable pavement system and measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads. Site planning and design teams should strive to design permeable pavement systems that can accommodate the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using permeable pavement systems in combination with other runoff reducing low impact development practices.

Although permeable pavement systems have seen some use in coastal Georgia, there is still limited experience with the design and installation of this low impact development within the region. On the national scale, permeable pavement installations have had high failure rates due to poor design, poor installation, underlying soils with low infiltration rates and poor maintenance practices (ARC, 2001). Consequently, if a permeable pavement system is used on a development site, it should be carefully monitored and maintained over time.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of permeable pavement systems in the reduction of stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how permeable pavement systems can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.4 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not permeable pavement is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for permeable pavement including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.4 of the CSS.

<u>Feasibility in Coastal Georgia</u>

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using permeable pavement on a development site. The following table identifies these common site characteristics and describes how they influence the use of permeable pavement systems on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Permeable Pavement Systems in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Permeable Pavement**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of permeable pavement systems to reduce stormwater runoff rates, volumes and pollutant loads.	• An underdrain should be included in permeable pavement systems that will be installed development sites that have soils with infiltration rates of less than 0.25 inches per hour (i.e., hydrologic soil group C and D soils). • Use additional low impact development practices to supplement the stormwater management benefits provided by underdrained permeable pavement systems.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of permeable pavement systems to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based low impact development practices, including non-underdrained permeable pavement systems, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. • Use permeable pavement systems with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• Does not influence the use of permeable pavement systems. In fact, permeable pavement systems should be designed with slopes that are as close to flat as possible.	
• *Shallow water table*	• May cause stormwater runoff pond at the bottom of the permeable pavement system.	• Ensure that the distance from the bottom of the permeable pavement system to the top of the water table is at least 2 feet. • Use stormwater ponds (CSS, Section 8.6.1) and stormwater wetlands (CSS, Section 8.6.2) to

Challenges Associated with Using Permeable Pavement Systems in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Permeable Pavement**	**Potential Solutions**
		intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a permeable pavement system, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS, Section 7.8.12) to "receive" stormwater runoff in these areas.

Site Applicability

Permeable pavement systems can be used on a wide range of development sites in rural, suburban and urban areas. They are especially well suited for use on urban development and redevelopment sites to construct sidewalks, parking lots, overflow parking areas, private streets and driveways and parking lanes on public streets and roadways. When compared with other low impact development practices, permeable pavement systems have a relatively high construction cost, a relatively high maintenance burden and require no additional surface area beyond that which will be covered by the permeable pavement system. (See Table on Pages 313 through 3-14.

Planning and Design Criteria

It is *recommended* that permeable pavement systems site meet all of the planning and design criteria provided in Section 7.8.4 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that permeable pavement systems are properly installed on a development site, site planning and design teams should consider the construction recommendations in Section 7.8.4 in the CSS.

Maintenance Requirements

Maintenance is very important for permeable pavement systems, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.14 in the CSS provides a list of the routine maintenance activities typically associated with permeable pavement systems.

Undisturbed Pervious Areas

Description

Undisturbed pervious areas, including primary and secondary conservation areas, can be used to "receive" the post-construction stormwater runoff generated elsewhere on a development site. If stormwater runoff can be evenly distributed over them as overland sheet flow, undisturbed pervious areas can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Stormwater runoff should enter undisturbed pervious areas as overland sheet flow
- Length of flow path in contributing drainage areas should be 150 feet or less in pervious drainage areas and 75 feet or less in impervious drainage areas
- Length of flow path in undisturbed pervious areas used to "receive" post-construction stormwater runoff must be 50 feet or more

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Helps protect valuable aquatic and terrestrial resources from the direct impacts of the land development process

LIMITATIONS:

- Should be managed in a natural state and protected from future land disturbing activities by an acceptable conservation instrument

SITE APPLICABILITY

☑	Rural Use	L	Construction Cost
☑	Suburban Use	L	Maintenance
	Urban Use	H	Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction

50%-75% - Annual Runoff Volume
60%-90% - Runoff Reduction Volume

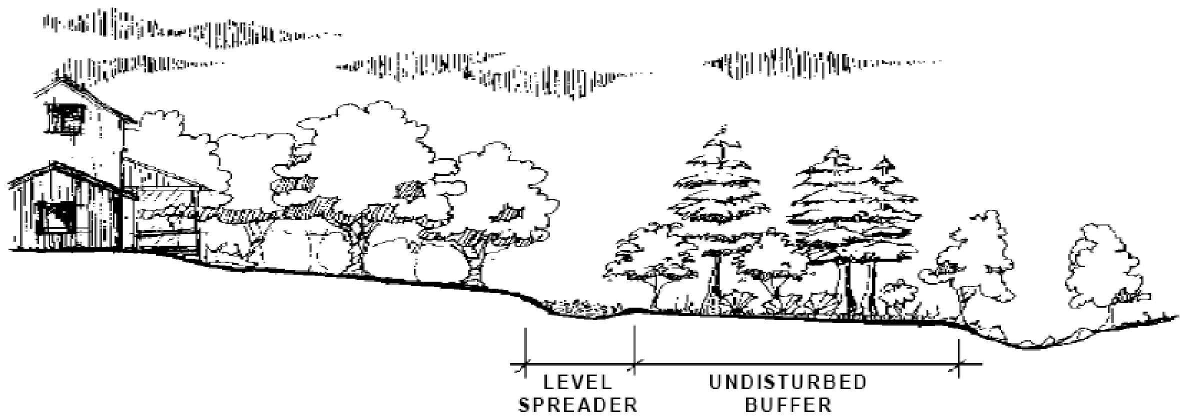
Pollutant Removal[1]

80% - Total Suspended Solids
50% - Total Phosphorus
50% - Total Nitrogen
N/A - Metals
N/A - Pathogens

1 = expected annual pollutant load removal

Discussion

If concentrated stormwater runoff is allowed to enter an undisturbed pervious area, it can cause soil erosion and can significantly reduce the stormwater management benefits that the undisturbed pervious area provides. Consequently, stormwater runoff needs to be intercepted and distributed evenly, as overland sheet flow, across an undisturbed pervious area that will be used to "receive" post-construction stormwater runoff. This can be accomplished by limiting the length of the flow path within the contributing drainage area and by using a level spreader at the upstream end of the undisturbed pervious area that will "receive" post-construction stormwater runoff.



Use of a Level Spreader Upstream of an Undisturbed Pervious Area
(Source: North Carolina Department of Environment and Natural Resources, 1998)

Since the undisturbed pervious areas that are used to "receive" stormwater runoff on a development site are typically designed to be on-line stormwater management practices, consideration should be given to the stormwater runoff rates and volumes generated by larger storm events (e.g., 25-year, 24-hour storm event) to help ensure that they do not cause significant damage within the undisturbed pervious areas.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of undisturbed pervious areas that "receive" stormwater runoff to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how undisturbed pervious areas can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, see Section 7.8.5 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not undisturbed pervious areas should be used to "receive" stormwater runoff on a development site. The Table on Pages 3-8 through 3-12 provides design considerations for undisturbed pervious areas including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.5 of the CSS.

Site Applicability

Although it may be difficult to use undisturbed pervious areas to "receive" stormwater runoff in urban areas, due to space constraints, undisturbed pervious areas can be used to "receive" stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, undisturbed pervious areas have a relatively low construction cost, a relatively low maintenance burden and require a relatively large amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the undisturbed pervious areas used on a development site meet all of the planning and design criteria provided in Section 7.8.5 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that undisturbed pervious areas are properly used to "receive" stormwater runoff on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.5 of the CSS.

Maintenance Requirements

Undisturbed pervious areas used to "receive" post-construction stormwater runoff typically require very little long-term maintenance, but a legally binding inspection and maintenance agreement and plan should be created to help ensure that they are properly maintained after construction is complete. Table 7.16 in the CSS provides a list of the routine maintenance activities typically associated with undisturbed pervious areas.

Vegetated Filter Strips

Description

Vegetated filter strips are uniformly graded, densely vegetated areas of land designed to slow and filter stormwater runoff. They are typically installed in areas that have been disturbed by clearing, grading and other land disturbing activities and are typically vegetated with managed turf. If stormwater runoff can be evenly distributed over them as overland sheet flow, vegetated filter strips can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Merrill et al., 2006)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Stormwater runoff should enter vegetated filter strips as overland sheet flow
- Length of flow path in contributing drainage areas should be 150 feet or less in pervious drainage areas and 75 feet or less in impervious drainage areas
- Length of flow path in vegetated filter strip should be 25 feet or more
- Vegetated filter strips should have a slope of at least 0.5% to ensure adequate drainage

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Relatively low construction cost and long-term maintenance burden

LIMITATIONS:

- Can be difficult to maintain overland sheet flow within a vegetated filter strip, which needs to be provided to prevent soil erosion and ensure practice performance

SITE APPLICABILITY

☑ Rural Use	L Construction Cost
☑ Suburban Use	L Maintenance
✱ Urban Use	H Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
25%-50% - Annual Runoff Volume
30%-60% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
25% - Total Phosphorus
25% - Total Nitrogen
40% - Metals
N/A - Pathogens

1 = expected annual pollutant load removal

Discussion

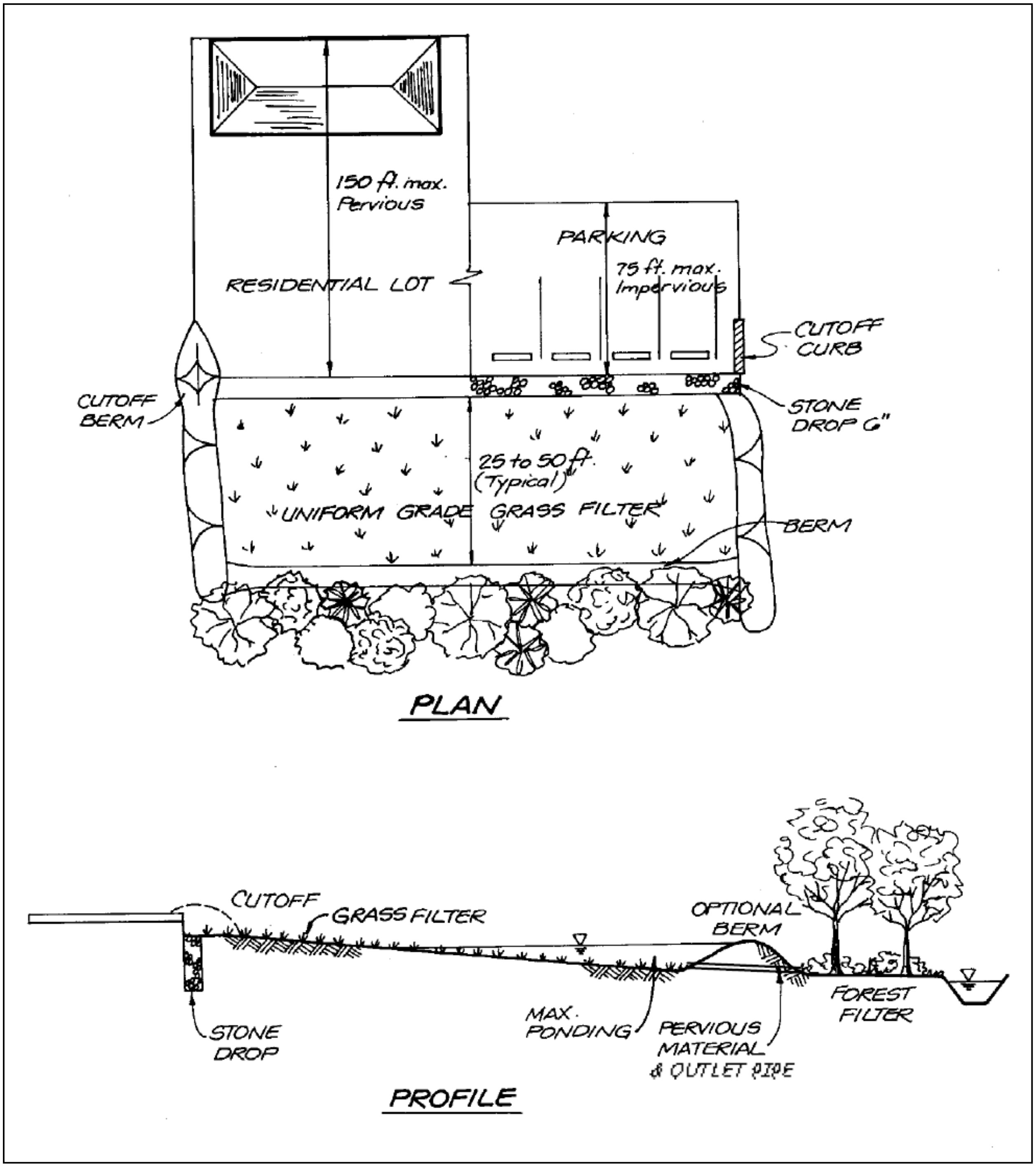
Filter Strip Around the Perimeter of a Parking Lot
(Source: Atlanta Regional Commission, 2001)

Vegetated filter strips can be attractively integrated into development sites as landscaping features and are well suited to "receive" stormwater runoff from local streets and roadways, highways, roof downspouts, small parking lots and disturbed pervious surfaces (e.g., lawns, parks, community open spaces). They are particularly well suited for use in the "outer zone" of aquatic buffers, in the landscaped areas commonly found between adjoining properties (e.g., setbacks) and incompatible land uses (e.g., residential and commercial land uses) and around the perimeter of parking lots. They can also be used to pretreat stormwater runoff before it enters other low impact development practices, such as undisturbed pervious areas (CSS, Section 7.8.5), bioretention areas (CSS, Section 7.8.13) and infiltration practices (CSS, Section 7.8.14), which increases the reductions in stormwater runoff rates, volumes and pollutant loads that these other low impact development practices provide.

If concentrated stormwater runoff is allowed to enter a vegetated filter strip, it can cause soil erosion and can significantly reduce the stormwater management benefits that the filter strip provides. Consequently, stormwater runoff needs to be intercepted and distributed evenly, as overland sheet flow, across a vegetated filter strip. This can be accomplished by limiting the length of the flow path within the contributing drainage area and by using a level spreader at the upstream end of the vegetated filter strip that will "receive" post-construction stormwater runoff.

There are two different filter strip designs that can be used on a development site. The first is a simple design, while the second is more advanced, and includes a permeable berm at the downstream end of the filter strip. The permeable berm is used to temporarily store stormwater runoff within the filter strip, which increases the residence time that it provides and reduces the required width of the filter strip.

Since the vegetated filter strips that are used to "receive" stormwater runoff on a development site are typically designed to be on-line stormwater management practices, consideration should be given to the stormwater runoff rates and volumes generated by larger storm events (e.g., 25-year, 24-hour storm event) to help ensure that they do not cause significant damage to a vegetated filter strip.



Vegetated Filter Strip
(Source: Atlanta Regional Commission, 2001)

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of vegetated filter strips to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how filter strips can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.6 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for filter strips including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.6 of the CSS.

<u>Feasibility in Coastal Georgia</u>

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using vegetated filter strips to “receive” post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of vegetated filter strips on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Vegetated Filter Strips in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Vegetated Filter Strips**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of vegetated filter strips to reduce stormwater runoff rates, volumes and pollutant loads.	• Use soil restoration (CSS, Section 7.8.1) to improve soil porosity and the ability of vegetated filter strips to reduce stormwater runoff rates, volumes and pollutant loads. • Place buildings and other impervious surfaces on poorly drained soils or preserve them as secondary conservation areas (CSS, Section 7.6.2). • Use additional low impact development practices to supplement the stormwater management benefits provided by vegetated filter strips.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of vegetated filter strips to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based low impact development practices, including vegetated filter strips, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them.
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond on the surface of a vegetated filter strip.	• Design vegetated filter strips with a slope of at least 0.5% to help ensure adequate drainage.

Challenges Associated with Using Vegetated Filter Strips in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Vegetated Filter Strips**	**Potential Solutions**
		• Where soils are well drained, use non-underdrained bioretention areas (CSS, Section 7.8.13) and infiltration practices • (CSS, Section 7.8.14), to reduce stormwater runoff rates, volumes and pollutant loads and prevent ponding in these areas. • Where soils are poorly drained, use small stormwater wetlands (i.e., pocket wetlands) (CSS, Section 8.6.2) to intercept and treat stormwater runoff.
• *Shallow water table*	• May occasionally cause stormwater runoff to pond on the surface of a vegetated filter strip.	• Use small stormwater wetlands (i.e., pocket wetlands) (CSS, Section 8.6.2) or wet swales CSS, (Section 8.6.6) to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a vegetated filter strip, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS, Section 7.8.12) to "receive" stormwater runoff in these areas.

Site Applicability

Although it may be difficult to use them to "receive" stormwater runoff in urban areas, due to space constraints, vegetated filter strips can be used to "receive" stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, vegetated filter strips have a relatively low construction cost, a relatively low maintenance burden and require a relatively large amount of surface area.
(See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that vegetated filter strips used on a development site meet all of the planning and design criteria provided and Section 7.8.6 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that vegetated filter strips are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.6 of the CSS.

Maintenance Requirements

Maintenance is very important for vegetated filter strips, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.19 in the CSS provides a list of the routine maintenance activities typically associated with vegetated filter strips. It is important to note that vegetated filter strips have maintenance requirements that are very similar to those of other vegetated low impact development practices.

Grass Channels

Description

Where site characteristics permit, grass channels, which are densely vegetated stormwater conveyance features, can be used to "receive" and convey post-construction stormwater runoff. They are typically installed in areas that have been disturbed by clearing, grading and other land disturbing activities, and are typically vegetated with managed turf. If properly designed, grass channels can provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS	STORMWATER MANAGEMENT "CREDITS"
DESIGN CRITERIA: • Grass channels should be designed to accommodate the peak discharge generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event) • Grass channels should be designed to able to safely convey the overbank flood protection rainfall event (e.g., 25-year, 24-hour event) • Grass channels may be designed with a slope of between 0.5% and 3%, although a slope of between 1% and 2% is recommended	☑ Runoff Reduction ☑ Water Quality Protection ☑ Aquatic Resource Protection ☑ Overbank Flood Protection ☑ Extreme Flood Protection ☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria
BENEFITS: • Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads • Relatively low construction cost and long-term maintenance burden **LIMITATIONS:** • Should not be used on development sites with slopes of less than 0.5% • Provides greater stormwater management benefits on sites with permeable soils (i.e., hydrologic soil group A and B soils)	**STORMWATER MANAGEMENT PRACTICE PERFORMANCE** **Runoff Reduction** 10%-20% - Annual Runoff Volume 12%-25% - Runoff Reduction Volume **Pollutant Removal[1]** 60% - Total Suspended Solids 25% - Total Phosphorus 30% - Total Nitrogen 30% - Metals

SITE APPLICABILITY		N/A - Pathogens 1 = expected annual pollutant load removal
☑ Rural Use	L Construction Cost	
☑ Suburban Use	M Maintenance	
Urban Use	M Area Required	

Discussion

Conventional storm drain systems are designed to quickly and efficiently convey stormwater runoff away from buildings, roadways and other impervious surfaces and into rivers, streams and other aquatic resources. When these conventional systems are used to “receive” and convey stormwater runoff on development sites, opportunities to reduce post-construction stormwater runoff rates, volumes and pollutant loads are lost. To take better advantage of these opportunities, grass channels can be used in place of conventional storm drain systems (e.g., curb and gutter systems, storm sewers, concrete channels) to “receive” and convey stormwater runoff.

Grass channels (also known as *vegetated open channels*) are densely vegetated stormwater conveyance features designed to slow and filter stormwater runoff. They differ from the old, unvegetated roadside ditches of the past, which often suffered from erosion and standing water and occasionally worked to undermine the roadway itself. If grass channels are properly designed (e.g., sufficient channel widths, relatively flat slopes, dense vegetative cover), they can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads, particularly when they are located on areas with permeable soils (i.e., hydrologic soil group A and B soils).

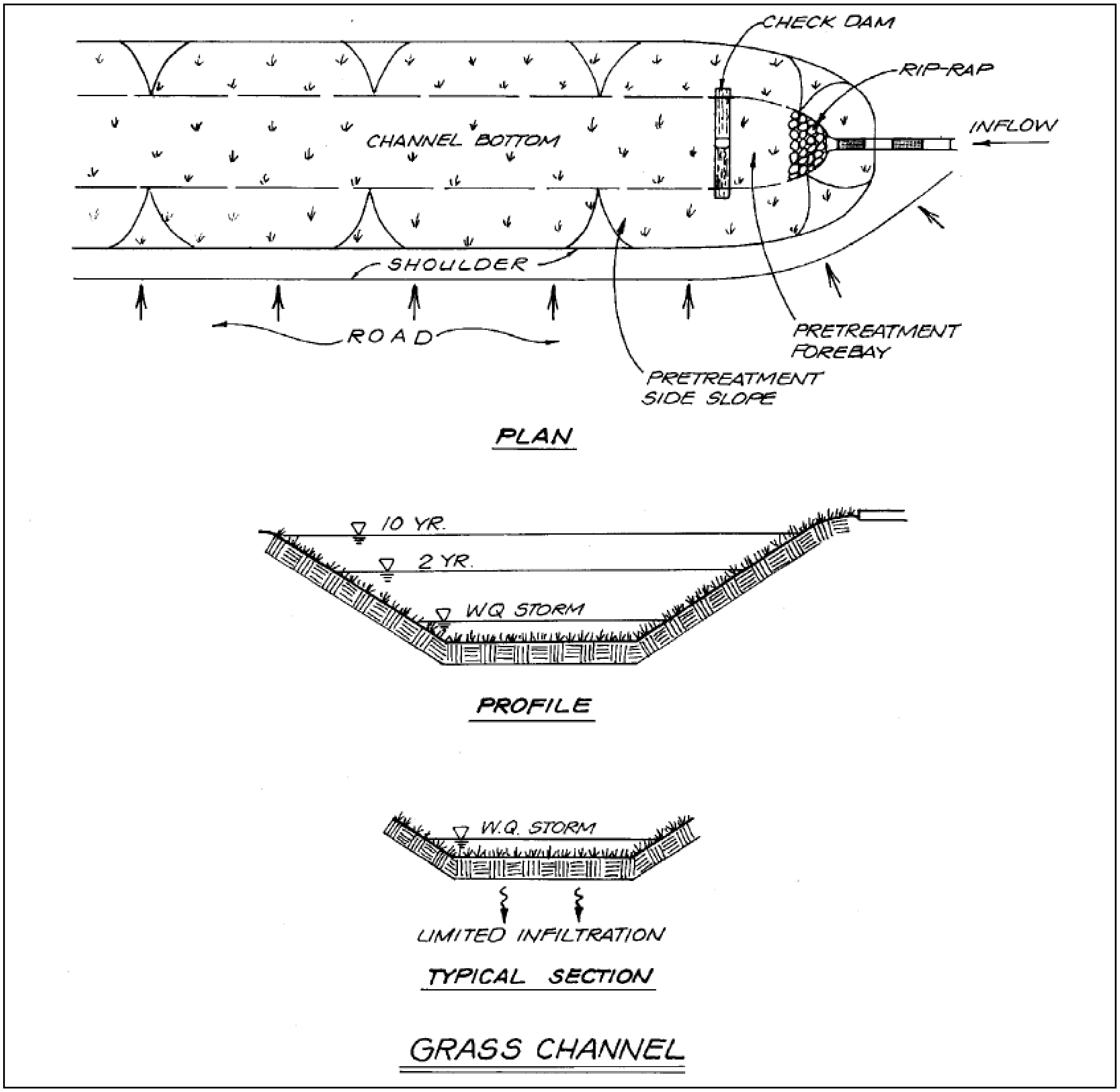
Grass Channel
Along a Local Roadway
(Source: Atlanta Regional Commission, 2001)

Grass channels can be integrated into development sites as landscaping features and are well suited to “receive” stormwater runoff from local streets and roadways, highways, small parking lots and disturbed pervious surfaces (e.g., lawns, parks, community open spaces). They are typically installed in areas that have been disturbed by clearing, grading and other land disturbing activities and are particularly well suited for use in roadway rights-of-way. Grass channels are typically less expensive to install than conventional storm drain systems and can be used to pretreat stormwater runoff before it enters other low impact development practices, such as undisturbed pervious areas (CSS, Section 7.8.5), bioretention areas (CSS, Section 7.8.13) and infiltration practices (CSS, Section 7.8.14), which increases the reductions in stormwater runoff rates, volumes and pollutant loads that these other low impact development practices provide.

Two of the primary concerns associated with grass channels are channel capacity and erosion control. In order to address these two concerns, site planning and design teams should work to ensure that the peak discharge rate generated by the target runoff reduction rainfall event (e.g., 85^{th} percentile rainfall event) does not flow through the grass channel at a velocity greater than 1.0 foot per second (ft/s). Site planning and design teams should also work to ensure that grass channels provide at least 10 minutes of residence time for the peak discharge rate generated by the target runoff reduction rainfall event (Claytor and Schueler, 1996). Check dams can be placed across grass channels to help slow post-construction stormwater runoff and increase residence times.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of grass channels to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how grass channels can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.7 of the CSS.



Grass Channel
(Source: Atlanta Regional Commission, 2001)

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not site grass channels are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for grass channels including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.7 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using grass channels to “receive” and convey post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of grass channels on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Grass Channels in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Grass Channels**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of grass channels to reduce stormwater runoff rates, volumes and pollutant loads.	• Use soil restoration (CSS, Section 7.8.1) to improve soil porosity and the ability of grass channels to reduce stormwater runoff rates, volumes and pollutant loads. • Use wet swales (i.e., linear wetland systems) (CSS, Section 8.6.6) to intercept, convey and treat stormwater runoff in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of grass channels to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based low impact development practices, including grass channels, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them. • Use dry swales (CSS, Section 7.8.15) with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• May be difficult to provide positive drainage and may cause stormwater runoff to pond in the bottom of the grass channel.	• Design grass channels with a slope of at least 0.5% to help ensure adequate drainage. • Where soils are sufficiently permeable, use infiltration practices (CSS, Section 7.8.14) and non-underdrained bioretention areas (CSS, Section 7.8.13)and dry swales (CSS, Section 7.8.15), to reduce stormwater runoff volumes and prevent ponding in these areas. • Where soils have low permeabilities, use wet swales (CSS, Section 8.6.6) instead of grass channels to intercept, convey and treat stormwater runoff.

Challenges Associated with Using Grass Channels in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Grass Channels**	**Potential Solutions**
• *Shallow water table*	• May occasionally cause stormwater runoff to pond in the bottom of the grass channel.	• Use wet swales (i.e., linear wetland systems) (CSS, Section 8.6.6) to intercept, convey and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a grass channel, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS, Section 7.8.12) to "receive" stormwater runoff in these areas.

Site Applicability

Although it may be difficult to use them to "receive" stormwater runoff in urban areas, due to space constraints, grass channels can be used to "receive" stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, grass channels have a relatively low construction cost, a moderate maintenance burden and require only a moderate amount of surface area.

Planning and Design Criteria

It is *recommended* that the grass channels used on a development site meet all of the planning and design criteria provided Section 7.8.7 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that grass channels are successfully installed on a development site, site planning and design teams should consider the following construction recommendations in Section 7.8.7 in the CSS.

Maintenance Requirements

Maintenance is very important for grass channels, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.22 in the CSS provides a list of the routine maintenance activities typically associated with grass channels. It is important to note that grass channels have maintenance requirements that are very similar to those of other vegetated low impact development practices.

Simple Downspout Disconnection

Description

Where site characteristics permit, simple downspout disconnections can be used to spread rooftop runoff from individual downspouts across lawns and other pervious areas, where it is slowed, filtered and allowed to infiltrate into the native soils. They are typically used in areas that have been disturbed by clearing, grading and other land disturbing activities and are typically vegetated with managed turf. If properly designed, simple downspout disconnections can provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Length of flow path in contributing drainage areas should be 75 feet or less
- Length of flow path in pervious areas below simple downspout disconnections should be at least 15 feet long and equal to or greater than the length of the flow path in their contributing drainage areas
- Downspout disconnections should be designed to convey stormwater runoff away from buildings to prevent damage to building foundations

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Relatively low construction cost and long-term maintenance burden

LIMITATIONS:

- Can only be used to "receive" runoff from small drainage areas of 2,500 square feet or less
- Provides greater stormwater management benefits on sites with permeable soils (i.e., hydrologic soil group A and B soils)

SITE APPLICABILITY

☑ Rural Use	L Construction Cost
☑ Suburban Use	L Maintenance
✱ Urban Use	M Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
25%-50% - Annual Runoff Volume
30%-60% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
25% - Total Phosphorus
25% - Total Nitrogen
40% - Metals
N/A - Pathogens

1 = expected annual pollutant load removal

Discussion

As the name implies, a simple downspout disconnection is the most basic of all of the low impact development practices that can be used to "receive" rooftop runoff. Where site characteristics permit, they can be used to spread rooftop runoff from individual downspouts across lawns and other pervious areas, where it is slowed, filtered and allowed to infiltrate into the native soils. If properly designed, simple downspout disconnections can provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites and, consequently, can be used to help satisfy the SWM Criteria presented in this CSS.

Simple Downspout Disconnections to Pervious Areas
(Source: Center for Watershed Protection)

In order to use simple downspout disconnections to "receive" post-construction stormwater runoff, downspouts must be designed to discharge to a lawn or other pervious area. The pervious area located below the simple downspout disconnection should slope away from buildings and other impervious surfaces to prevent damage to building foundations and discourage rooftop runoff from "reconnecting" with the storm drain system.

The primary concern associated with a simple downspout disconnection is the length of the flow path in the lawn or other pervious area located below the disconnection point. In order to provide adequate residence time for stormwater runoff, the length of the flow path in the pervious area located below a simple downspout disconnection should be equal to or greater than the length of the flow path of the contributing drainage area. If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using other low impact development practices, such as vegetated filter strips (CSS Section 7.8.6), rain gardens (CSS Section 7.8.9), dry wells (CSS Section 7.8.11) and rainwater harvesting (CSS Section 7.8.12), on the development site.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of simple downspout disconnections to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how simple downspout disconnections can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.8 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not simple downspout disconnections are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for simple downspout disconnections including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.8 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using simple downspout disconnections to "receive" post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of simple downspout disconnections on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Simple Downspout Disconnections in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Downspout Disconnections**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of simple downspout disconnections to reduce stormwater runoff rates, volumes and pollutant loads.	• Use soil restoration (CSS Section 7.8.1) to improve soil porosity and the ability of simple downspout disconnections to reduce stormwater runoff rates, volumes and pollutant loads. • Use additional downspout disconnection practices, such as rain gardens (CSS Section 7.8.9), dry wells (CSS Section 7.8.11) and rainwater harvesting (CSS Section 7.8.12) to supplement the stormwater management benefits provided by simple downspout disconnections.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of simple downspout disconnections to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Rooftop runoff is relatively clean, so this should not prevent the use of simple downspout disconnections, even at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. However, rooftop runoff should not be allowed to comingle with runoff from other impervious surfaces in these areas if it will be "received" by a simple downspout disconnection.

Challenges Associated with Using Simple Downspout Disconnections in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Downspout Disconnections**	**Potential Solutions**
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the pervious area located below a simple downspout disconnection.	• Design the pervious area located below the simple downspout disconnection with a slope of at least 0.5% to help ensure adequate drainage. • Where soils are well drained, use rain gardens (CSS Section 7.8.9), non-underdrained bioretention areas (CSS Section 7.8.13) and infiltration practices (CSS Section 7.8.14), to reduce stormwater runoff rates, volumes and pollutant loads and prevent ponding in these areas. • Where soils are poorly drained, use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of simple downspout disconnection to intercept and treat stormwater runoff.
• *Shallow water table*	• May occasionally cause stormwater runoff to pond in the pervious area located below a simple downspout disconnection.	• Use rainwater harvesting (CSS Section 7.8.9), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of downspout disconnection to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through the pervious area located below a simple downspout disconnection, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) to “receive” stormwater runoff in these areas.

Site Applicability

Although it may be difficult to use them to "receive" stormwater runoff in urban areas, due to space constraints, simple downspout disconnections can be used to "receive" stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, simple downspout disconnections have a relatively low construction cost, a relatively low maintenance burden and require only a moderate amount of surface area. (See Table Pages 3-8 through 3-12)

Planning and Design Criteria

It is *recommended* that simple downspout disconnections used on a development site meet all of the planning and design criteria provided in CSS Section 7.8.8 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure simple downspout disconnections are properly installed on a development site, site planning and design teams should consider the construction recommendations listed in CSS Section 7.8.8 of the CSS.

Maintenance Requirements

Simple downspout disconnections typically require very little long-term maintenance. Table 7.25 in the CSS provides a list of the maintenance activities typically associated with simple downspout disconnections.

Rain Gardens

Description

Rain gardens are small, landscaped depressional areas that are filled with amended native soils or an engineered soil mix and are planted with trees, shrubs and other herbaceous vegetation. They are designed to capture and temporarily store stormwater runoff so that it may be subjected to the hydrologic processes of evaporation, transpiration and infiltration. This allows rain gardens to provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: R. Bannerman)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Rain gardens should be designed to completely drain within 24 hours of the end of a rainfall event
- A maximum ponding depth of 6 inches is recommended within rain gardens to help prevent the formation of nuisance ponding conditions
- Unless a shallow water table is found on the development site, rain garden planting beds should be at least 2 feet deep

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be integrated into development plans as attractive landscaping features

LIMITATIONS:

- Can only be used to "receive" runoff from small drainage areas of 2,500 square feet or less
- Provides greater stormwater management benefits on sites with permeable soils (i.e., hydrologic soil group A and B soils)

SITE APPLICABILITY

☑	Rural Use	L	Construction Cost
☑	Suburban Use	M	Maintenance
✱	Urban Use	M	Area Required

STORMWATER MANAGEMENT "CREDITS"

- ☑ Runoff Reduction
- ☑ Water Quality Protection
- ☑ Aquatic Resource Protection
- ☑ Overbank Flood Protection
- ☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction

80% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]

80% - Total Suspended Solids
80% - Total Phosphorus
80% - Total Nitrogen
N/A - Metals
80% - Pathogens

1 = varies according to storage capacity of the rain garden
2 = expected annual pollutant load removal

Discussion

The primary concern associated with the design of a rain garden is its storage capacity, which directly influences its ability to reduce stormwater runoff rates, volumes and pollutant loads. Site planning and design teams should strive to design rain gardens that can accommodate the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using rain gardens in combination with other runoff reducing low impact development practices, such as dry wells (CSS Section 7.8.11) and rainwater harvesting (CSS Section 7.8.12), to provide more substantial reductions in stormwater runoff rates, volumes and pollutant loads.

Various Rain Gardens

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of rain gardens to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how rain gardens can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.9 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not rain gardens are appropriate for use on a particular development site. The Table ? on Pages 3-8 through 3-12 provides design considerations for rain gardens including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.9 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using rain gardens to "receive" post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of rain gardens on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Rain Gardens in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Rain Gardens**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of rain gardens to reduce stormwater runoff rates, volumes and pollutant loads.	• Use an engineered soil mix instead of amended native soils to create rain garden planting beds in these areas. • Use additional downspout disconnection practices, such as rainwater harvesting (CSS Section 7.8.12) to supplement the stormwater management benefits provided by rain gardens in these areas. • Use rainwater harvesting (CSS Section 7.8.9), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of rain gardens to intercept and treat stormwater runoff in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of rain gardens to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Rooftop runoff is relatively clean, so this should not prevent the use of rain gardens, even at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. However, rooftop runoff should not be allowed to comingle with runoff from other impervious surfaces in these

Challenges Associated with Using Rain Gardens in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Rain Gardens**	**Potential Solutions**
		areas if it will be “received” by a rain garden. • Use bioretention areas (CSS Section 7.8.13) and dry swales (CSS Section 7.8.15) with liners and underdrains to intercept and treat non rooftop runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the rain garden for extended periods of time.	• Ensure that the underlying native soils will allow the rain garden to drain completely within 24 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the rain garden and the top of the water table. • May occasionally cause stormwater runoff to pond in the rain garden.	• Ensure that the distance from the bottom of the rain garden to the top of the water table is at least 2 feet. • Reduce the depth of the planting bed to 18 inches. • Use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of rain gardens to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a rain garden, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) to “receive” stormwater runoff in these areas.

Site Applicability

Although it may be difficult to use them to “receive” stormwater runoff in urban areas, due to space constraints, rain gardens can be used to “receive” stormwater management on a wide variety of development sites, including residential, commercial and institutional development sites in rural and suburban areas. Although they are particularly well suited to “receive” rooftop runoff, they can also be used to “receive” stormwater runoff from other small drainage areas, such as local streets and roadways, driveways, small parking areas and disturbed pervious areas (e.g., lawns, parks, community open spaces). When compared with other low impact development practices, rain gardens have a relatively low construction cost, a moderate maintenance burden and require only a moderate amount of surface area. (See Table on Pages 8-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the rain gardens used on a development site meet all of the planning and design criteria provided Section 7.8.9 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that rain gardens are successfully installed on a development site, site planning and design teams should consider the construction recommendations in Section 7.8.9 in the CSS.

Maintenance Requirements

Maintenance is very important for rain gardens, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Consequently, a legally binding inspection and maintenance agreement and plan should be created to help ensure that they are properly maintained after construction is complete. Table 7.28 in the CSS provides a list of the routine maintenance activities typically associated with rain gardens. It is important to note that rain gardens have maintenance requirements that are very similar to those of other vegetated low impact development practices.

Stormwater Planters

Description

Stormwater planters are landscape planter boxes that are specially designed to "receive" post-construction stormwater runoff. They consist of planter boxes that are equipped with waterproof liners, filled with an engineered soil mix and planted with trees, shrubs and other herbaceous vegetation. Stormwater planters are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where it is subjected to the hydrologic processes of evaporation and transpiration before being conveyed back into the storm drain system through an underdrain.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Stormwater planters should be designed to completely drain within 24 hours of the end of a rainfall event
- A maximum ponding depth of 6 inches is recommended within stormwater planters to help prevent the formation of nuisance ponding conditions
- Unless a shallow water table is found on the development site, stormwater planter planting beds should be at least 2 feet deep

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be integrated into development plans as attractive landscaping features
- Particularly well suited for use on urban development sites

LIMITATIONS:

- Can only be used to "receive" runoff from small drainage areas of 2,500 square feet or less

SITE APPLICABILITY

Rural Use
☑ Suburban Use
☑ Urban Use

H Construction Cost
M Maintenance
L Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
40% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
60% - Total Phosphorus
60% - Total Nitrogen
N/A - Metals
80% - Pathogens

1 = varies according to storage capacity of the stormwater planter
2 = expected annual pollutant load removal

Discussion

The primary concern associated with the design of a stormwater planter is its storage capacity, which directly influences its ability to reduce stormwater runoff rates, volumes and pollutant loads. Site planning and design teams should strive to design stormwater planters that can accommodate the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using stormwater planters in combination with other runoff reducing low impact development practices, such dry wells (CSS Section 7.8.11) and rainwater harvesting (CSS Section 7.8.12), to supplement the stormwater management benefits provided by the planters.

Various Stormwater Planters

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of stormwater planters to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how stormwater planters can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, and extreme flood protection. For further details, refer to Section 7.8.10 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not stormwater planters are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for stormwater planters including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.10 of the CSS.

<u>Feasibility in Coastal Georgia</u>

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using stormwater planters to "receive" post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of stormwater planters on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Stormwater Planters in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Stormwater Planters**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are equipped with waterproof liners and underdrains, the presence of poorly drained soils does not influence the use of stormwater planters on development sites.	
• *Well drained soils*, such as hydrologic soil group A and B soils	• Since they are equipped with waterproof liners and underdrains, the presence of poorly drained soils does not influence the use of stormwater planters on development sites.	
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the stormwater planter for extended periods of time.	• Ensure that the underdrain will allow the stormwater planter to drain completely within 24 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the stormwater planter and the top of the water table. • May cause stormwater runoff to pond in the stormwater planter.	• Reduce the depth of the planting bed to 18 inches. • Reduce the distance between the bottom of the stormwater planter and top of the water table to 12 inches and provide an adequately sized underdrain. • Use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of stormwater planters to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a stormwater planter, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) to “receive” stormwater runoff in these areas.

Site Applicability

Stormwater planters are typically used on commerical, institutional and industrial development sites and, because they can be constructed immediately adjacent to buildings and other structures, they are ideal for use in urban areas. Although they are well suited to "receive" rooftop runoff, they can also be used to "receive" stormwater runoff from other small impervious and pervious drainage areas, such as sidewalks, plazas and small parking lots. When compared with other low impact development practices, stormwater planters have a relatively high construction cost, a moderate maintenance burden and require a relatively small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the stormwater planters used on a development site meet all of the planning and design criteria provided Section 7.8.10 of the CSS to be eligible for the stormwater management "credits.

Construction Considerations

To help ensure that stormwater planters are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.10.

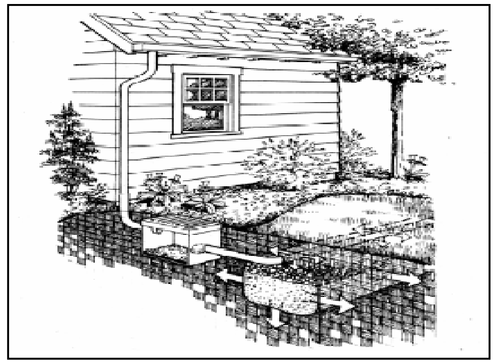
Maintenance Requirements

Maintenance is very important for stormwater planters, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.31 in the CSS provides a list of the routine maintenance activities typically associated with stormwater planters. It is important to note that rain gardens have maintenance requirements that are very similar to those of other vegetated low impact development practices.

Dry Wells

Description

Dry wells are low impact development practices that are located below the surface of development sites. They consist of shallow excavations, typically filled with stone, that are designed to intercept and temporarily store post-construction stormwater runoff until it infiltrates into the underlying and surrounding soils. If properly designed, they can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.



(Source: City of Portland, OR, 2008)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Dry wells should be designed to completely drain within 24 hours of the end of a rainfall event
- The distance from the bottom of a dry well to the top of the water table should be least 2 feet
- Dry wells should be designed with slopes that are as close to flat as possible to help ensure that stormwater runoff is evenly distributed throughout the stone reservoir

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Particularly well suited for use on urban development sites

LIMITATIONS:

- Can only be used to "receive" runoff from small drainage areas of 2,500 square feet or less
- Should not be used on development sites that have soils with infiltration rates of less than 0.5 inches per hour

SITE APPLICABILITY

☑ Rural Use	M Construction Cost
☑ Suburban Use	M Maintenance
☑ Urban Use	L Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

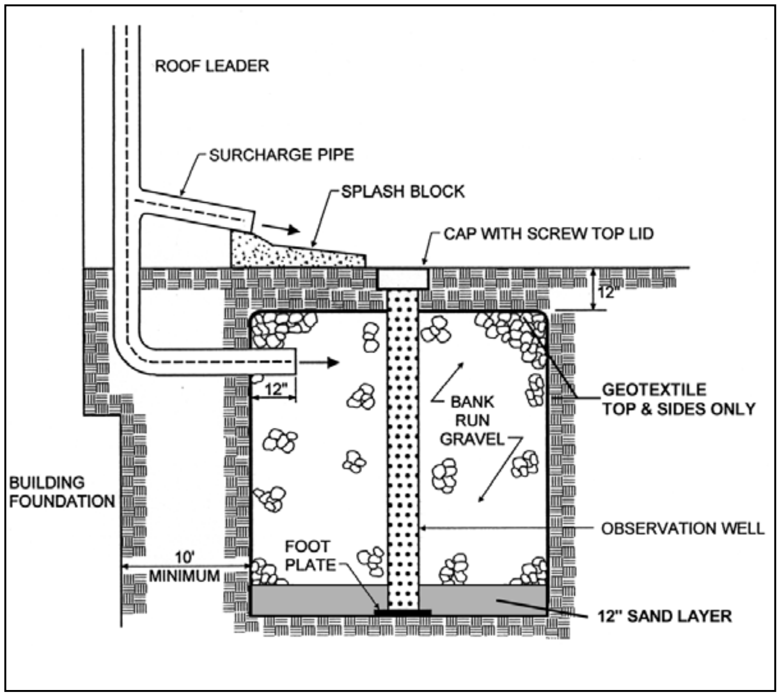
Runoff Reduction
80% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
80% - Total Phosphorus
80% - Total Nitrogen
80% - Metals
80% - Pathogens

1 = varies according to storage capacity of the dry well
2 = expected annual pollutant load removal

Discussion

As infiltration-based low impact development practices, dry wells are limited to use in areas where the soils are permeable enough and the water table is low enough to provide for the infiltration of stormwater runoff. They should only be considered for use on development sites where fine sediment (e.g., clay, silt) loads will be relatively low, as high sediment loads will cause them to clog and fail. In addition, dry wells should be carefully sited to avoid the potential contamination of water supply aquifers.



Dry Well
(Source: Maryland Department of the Environment, 2000)

The primary concern associated with the design of a dry well is its storage capacity, which directly influences its ability to reduce stormwater runoff rates, volumes and pollutant loads. Site planning and design teams should strive to design dry wells that can accommodate the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85^{th} percentile rainfall event). If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using dry wells in combination with other runoff reducing low impact development practices, such as rain gardens (CSS Section 7.8.9) and rainwater harvesting (CSS Section 7.8.12), to supplement the stormwater management benefits provided by the dry wells.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of dry wells to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how dry wells can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.11 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not dry wells are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for dry wells including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.11 of the CSS.

<u>Feasibility in Coastal Georgia</u>

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using dry wells to "receive" post-construction stormwater runoff on a development site. The Table identifies these common site characteristics and describes how they influence the use of dry wells on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Dry Wells in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Dry Wells**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of dry wells to reduce stormwater runoff rates, volumes and pollutant loads.	• Dry wells should not be used on development sites that have soils with infiltration rates of less than 0.5 inches per hour (i.e., hydrologic soil group C and D soils). • Use other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) and underdrained bioretention areas (CSS Section 7.8.13), to "receive" stormwater runoff in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of dry wells to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Rooftop runoff is relatively clean, so this should not prevent the use of dry wells, even at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. However, rooftop runoff should not be allowed to comingle with runoff from other impervious surfaces in these areas if it will be "received" by a dry well. • Use bioretention areas (CSS Section 7.8.13) and dry swales (CSS Section 7.8.15) with liners and underdrains to intercept and treat non rooftop runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• Does not influence the use of dry wells. In fact, dry wells should be designed with slopes that are as close to flat as possible.	

Challenges Associated with Using Dry Wells in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Dry Wells**	**Potential Solutions**
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the dry well and the top of the water table. • May occasionally cause stormwater runoff to pond in the bottom of the dry well.	• Ensure that the distance from the bottom of the dry well to the top of the water table is at least 2 feet. • Reduce the depth of the stone reservoir in dry wells to 18 inches. • Use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of dry wells to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• Does not influence the use of dry wells.	

Site Applicability

Dry wells can be used to “receive” stormwater runoff on a wide variety of development sites, including residential, commercial and institutional development sites in rural, suburban and urban areas. Although they are particularly well suited to “receive” rooftop runoff, they can also be used to “receive” stormwater runoff from other small drainage areas, such as local streets and roadways, driveways, small parking areas and disturbed pervious areas (e.g., lawns, parks, community open spaces). When compared with other low impact development practices, dry wells have a moderate construction cost, a moderate maintenance burden and require only a small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the dry wells used on a development site meet all of the planning and design criteria provided Section 7.8.11 of the CSS to be eligible for the stormwater management “credits”.

Construction Considerations

To help ensure that dry wells are successfully installed on a development site, site planning and design teams should consider the construction recommendations in Section 7.8.11 in the CSS.

Maintenance Requirements

Maintenance is important for dry wells, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.34 in the CSS provides a list of the routine maintenance activities typically associated with dry wells.

Rainwater Harvesting

Description

Rainwater harvesting is the ancient stormwater management practice of intercepting, diverting and storing rainfall for later use. In a typical rainwater harvesting system, rainfall is collected from a gutter and downspout system, screened and "washed," and conveyed into an above- or below-ground storage tank or cistern. Once captured in the storage tank or cistern, it may be used for non-potable indoor or outdoor uses. Rainwater harvesting also helps reduce the demand on public water supplies, which, in turn, helps protect aquatic resources, such as groundwater aquifers, from drawdown and seawater intrusion.

(Source: Jones and Hunt, 2008)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Rainwater harvesting systems should be sized based on the size of the contributing drainage area, local rainfall patterns and the projected demand for the harvested rainwater
- Pretreatment should be provided upstream of all rainwater harvesting systems to prevent leaves and other debris from clogging the system

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be used on nearly any development site
- Reduces demand on public water supplies, which helps protect groundwater aquifers from drawdown and seawater intrusion

LIMITATIONS:

- Rain barrels may not be used except on small drainage areas of 2,500 square feet or less
- Stored rainwater should be used on a regular basis to maintain system storage capacity

SITE APPLICABILITY

☑	Rural Use	M	Construction Cost
☑	Suburban Use	H	Maintenance
☑	Urban Use	L	Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

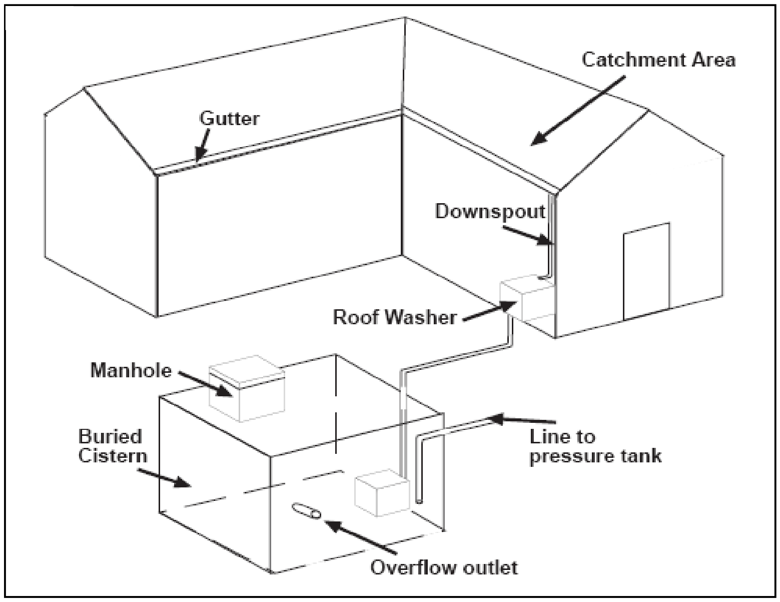
Runoff Reduction
Varies[1] - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
Varies[1] - Total Suspended Solids
Varies[1] - Total Phosphorus
Varies[1] - Total Nitrogen
Varies[1] - Metals
N/A - Pathogens

1 = varies according to storage capacity of the rainwater harvesting system
2 = expected annual pollutant load removal

Discussion

There are two basic types of rainwater harvesting systems: (1) systems that are used to supply water for non-potable outdoor uses, such as landscape irrigation, car and building washing and fire fighting; and (2) systems that are used to supply water for non-potable indoor uses, such as laundry and toilet flushing. Rainwater harvesting systems used to supply water for non-potable indoor uses are more complex and require separate plumbing, pressure tanks, pumps and backflow preventers. Additionally, the use of harvested rainwater for non-potable indoor uses may be restricted in some areas of coastal Georgia, due to existing "development rules." Developers and their site planning and design teams are encouraged to consult with the local development review authority if they are interested in using harvested rainwater for non-potable indoor uses.



Rainwater Harvesting System
(Source: Rupp, 1998)

Whether it is used to supply water for non-potable indoor or outdoor uses, a well-designed rainwater harvesting system typically consists of five major components, including the collection and conveyance system (e.g., gutter and downspout system), pretreatment devices (e.g., leaf screens, first flush diverters, roof washers), the storage tank or cistern, the overflow pipe (which allows excess stormwater runoff to bypass the storage tank or cistern) and the distribution system (which may or may not require a pump, depending on site characteristics). When designing a rainwater harvesting system, site planning and design teams should consider each of these components, as well as the size of the contributing drainage area, local rainfall patterns and the projected water demand, to determine how large the cistern or storage tank must be to provide enough water for the desired non-potable indoor or outdoor use.

Major Components of a Rainwater Harvesting System
(Source: Jones and Hunt, 2008)

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of rainwater harvesting systems to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how rainwater harvesting systems can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.12 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not rainwater harvesting systems are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for rainwater harvesting systems including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.12 of the CSS.

Site Applicability

Rainwater harvesting systems can be used on a wide variety of development sites in rural, suburban and urban areas. They are especially well suited for use on commercial, institutional, municipal and multi-family residential buildings on urban and suburban development and redevelopment sites. When compared with other low impact development practices, rainwater harvesting systems have a moderate construction cost, a relatively high maintenance burden and require a relatively small amount of surface area. Although they can be expensive to install, rainwater harvesting systems are often a component of "green buildings," such as those that achieve certification in the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the rainwater harvesting systems used on a development site meet all of the planning and design criteria provided Section 7.8.12 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that rainwater harvesting systems are successfully installed on a development site, site planning and design teams should consider the following construction recommendations listed in Section 7.8.12 of the CSS.

Maintenance Requirements

Maintenance is important for rainwater harvesting systems, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.36 in the CSS provides a list of the routine maintenance activities typically associated with rainwater harvesting systems.

Bioretention Areas

Description

Bioretention areas, which may also be classified as a low impact development practice (CSS Section 7.8.13), are shallow depressional areas that are filled with an engineered soil mix and are planted with trees, shrubs and other herbaceous vegetation. They are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where it is subjected to the hydrologic processes of evaporation and transpiration, before being conveyed back into the storm drain system through an underdrain or allowed to infiltrate into the surrounding soils. This allows them to provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Bioretention areas should be designed to completely drain within 48 hours of the end of a rainfall event
- A maximum ponding depth of 9 inches is recommended within bioretention areas to help prevent the formation of nuisance ponding conditions
- Unless a shallow water table is found on the development site, bioretention area planting beds should be at least 3 feet deep

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be integrated into development plans as attractive landscaping features

LIMITATIONS:

- Can only be used to manage runoff from relatively small drainage areas of 5 acres in size

SITE APPLICABILITY

☑ Rural Use	M Construction Cost
☑ Suburban Use	M Maintenance
☑ Urban Use	L Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
40%/80% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
60% - Total Phosphorus
60% - Total Nitrogen
N/A - Metals
80% - Pathogens

1 = varies according to storage capacity of the bioretention area
2 = expected annual pollutant load removal

Discussion

Bioretention areas are one of the most effective stormwater management practices that can be used in coastal Georgia to reduce post-construction stormwater runoff rates, volumes and pollutant loads. They also provide a number of other benefits, including improved aesthetics, wildlife habitat, urban heat island mitigation and improved air quality. Bioretention areas differ from rain gardens (CSS Section 7.8.9), in that they are designed to receive stormwater runoff from larger drainage areas and may be equipped with an underdrain.


(Source: Center for Watershed Protection)


(Source: Merrill et al., 2006)


(Source: Center for Watershed Protection)


(Source: Center for Watershed Protection)

Various Bioretention Areas

Stormwater Management "Credits"

Bioretention areas have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how bioretention can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.3 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not bioretention is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for bioretention including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.3 of the CSS.

<u>Feasibility in Coastal Georgia</u>

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using bioretention areas to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of bioretention areas on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Bioretention Areas in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Bioretention Areas**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of bioretention areas to reduce stormwater runoff rates, volumes and pollutant loads.	• Use underdrained bioretention areas to manage post-construction stormwater runoff in these areas. • Use additional low impact development and stormwater management practices to supplement the stormwater management benefits provided by bioretention areas in these areas. • Use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of bioretention areas to intercept and treat stormwater runoff in these areas.

Challenges Associated with Using Bioretention Areas in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Bioretention Areas**	**Potential Solutions**
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of bioretention areas to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based stormwater management practices, including non-underdrained bioretention areas, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them. • Use bioretention areas and dry swales (CSS Section 8.6.6) with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the bioretention area for extended periods of time.	• Ensure that the underlying native soils will allow the bioretention area to drain completely within 48 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the bioretention area and the top of the water table. • May occasionally cause stormwater runoff to pond in the bioretention area.	• Ensure that the distance from the bottom of the bioretention area to the top of the water table is at least 2 feet. • Reduce the depth of the planting bed to 18 inches. • Use stormwater ponds (CSS Section 8.6.1), stormwater wetlands (CSS Section 8.6.2) and wet swales (CSS Section 8.6.6), instead of bioretention areas to intercept and treat stormwater runoff in these areas.

Challenges Associated with Using Bioretention Areas in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Bioretention Areas**	**Potential Solutions**
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a bioretention area, particularly during high tide.	• Investigate the use of other low impact development and stormwater management practices, such as rainwater harvesting (CSS Section 7.8.12) to manage post-construction stormwater runoff in these areas.

Site Applicability

Bioretention areas can be used to manage post-construction stormwater runoff on a wide variety of development sites, including residential, commercial and institutional development sites in rural, suburban and urban areas. They are well suited to "receive" stormwater runoff from nearly all small impervious and pervious drainage areas, including local streets and roadways, highways, driveways, small parking areas and disturbed pervious areas (e.g., lawns, parks, community open spaces). When compared with other stormwater management practices, bioretention areas have a moderate construction cost, a moderate maintenance burden and require a relatively small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the bioretention areas used on a development site meet all of the planning and design criteria provided in Section 8.6.3 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that bioretention areas are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.3 of the CSS.

Maintenance Requirements

Maintenance is very important for bioretention areas, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.12 in the CSS provides a list of the routine maintenance activities typically associated with bioretention areas.

Infiltration Practices

Description

Infiltration practices, which may also be classified as a runoff reducing low impact development practice (Section 7.8.14), are shallow excavations, typically filled with stone or an engineered soil mix, that are designed to intercept and temporarily store post-construction stormwater runoff until it infiltrates into the underlying and surrounding soils. If properly designed, they can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Pretreatment should be provided upstream of all infiltration practices
- Infiltration practices should be designed to completely drain within 48 hours of the end of a rainfall event
- Underlying native soils should have an infiltration rate of 0.5 in/hr or more
- The distance from the bottom of an infiltration practice to the top of the water table should be 2 feet or more

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be integrated into development plans as attractive landscaping features

LIMITATIONS:

- Can only be used to manage runoff from relatively small drainage areas of 2-5 acres in size
- Should not be used to "receive" stormwater runoff that contains high sediment loads

SITE APPLICABILITY

☑ Rural Use	M Construction Cost
☑ Suburban Use	H Maintenance
☑ Urban Use	L Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credit" that can be used to address this SWM Criteria

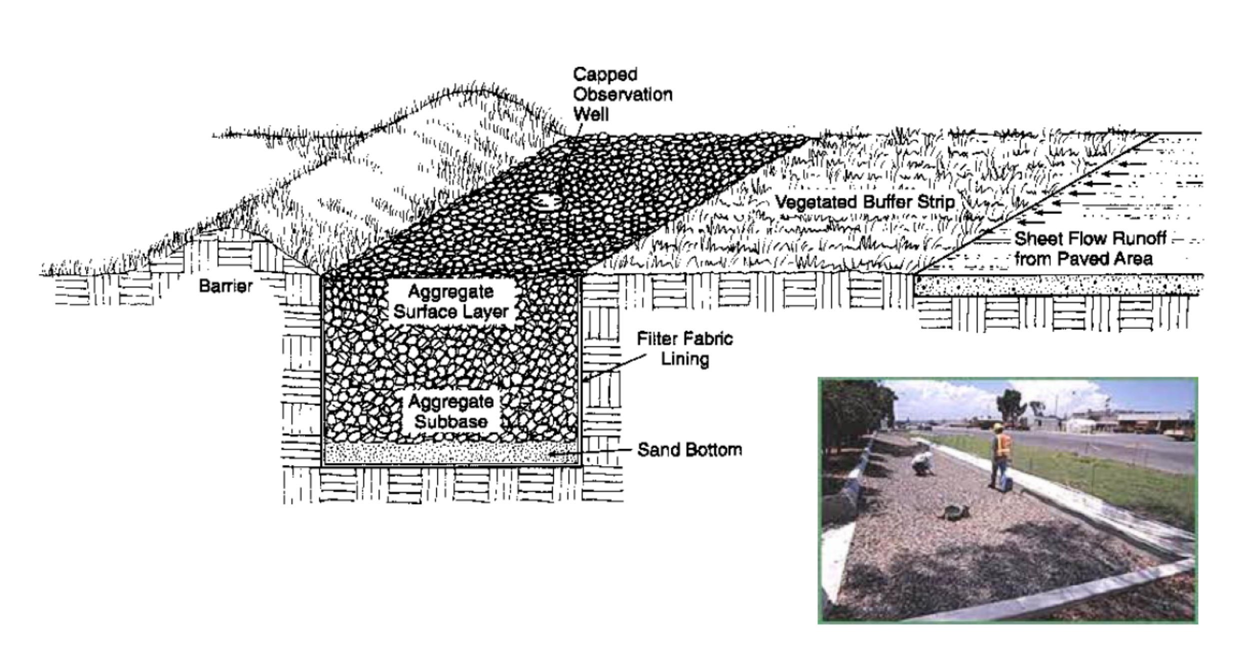
STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
80% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
60% - Total Phosphorus
60% - Total Nitrogen
N/A - Metals
80% - Pathogens

1 = varies according to storage capacity of the infiltration practice
2 = expected annual pollutant load removal

Discussion



Infiltration Trench
(Source: Center for Watershed Protection)

Although infiltration practices can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads, they have historically experienced high rates of failure due to clogging caused by poor design, poor construction and neglected maintenance. If infiltration practices are to be used on a development site, great care should be taken to ensure that they are adequately designed, carefully installed and properly maintained over time. They should only be applied on development sites that have permeable soils (i.e., hydrologic soil group A and B soils) and that have a water table and confining layers (e.g., bedrock, clay lenses) that are located at least 2 feet below the bottom of the trench or basin. Additionally, infiltration practices should always be designed with adequate pretreatment (e.g., vegetated filter strip, sediment forebay) to prevent sediment from reaching them and causing them to clog and fail.

There are two major variations of infiltration practices, namely infiltration trenches and infiltration basins. A brief description of each of these design variants is provided below:

- Infiltration Trenches: Infiltration trenches are excavated trenches filled with stone. Stormwater runoff is captured and temporarily stored in the stone reservoir, where it is allowed to infiltrate into the surrounding and underlying native soils. Infiltration trenches can be used to manage post-construction stormwater runoff from contributing drainage areas of up to 2 acres in size and should only be used on development sites where sediment loads can be kept relatively low.
- Infiltration Basins: Infiltration basins are shallow, landscaped excavations filled with an engineered soil mix. They are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where it is subjected to the hydrologic processes of evaporation and transpiration, before being allowed to infiltrate into the surrounding soils. They are essentially non-underdrained bioretention areas (CSS Section 8.6.3), and should also only be used on development sites where sediment loads can be kept relatively low.

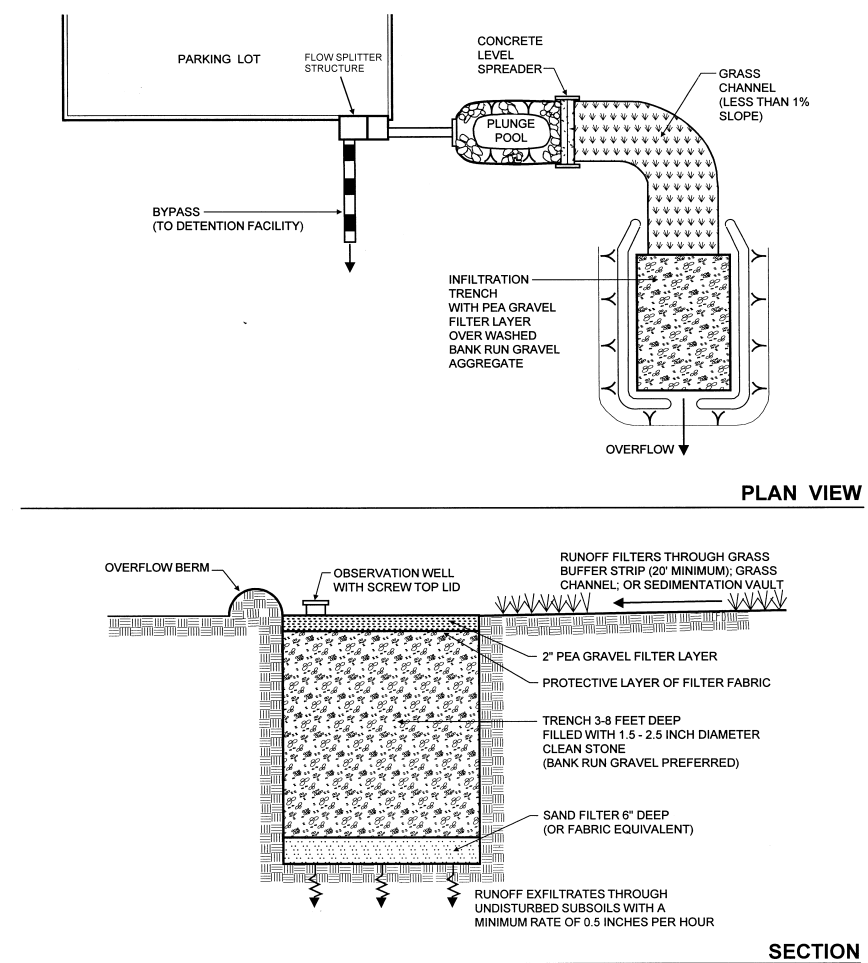
Infiltration Trench

Infiltration Basin (During Installation)

Infiltration Practices

Stormwater Management "Credits"

Infiltration practices have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how infiltration practices can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, and extreme flood protection. For further details, refer to Section 8.6.5 of the CSS.



Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not infiltration practices is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for infiltration including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.5 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using infiltration practices to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of infiltration practices on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Infiltration Practices in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Infiltration Practices**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of infiltration practices to reduce stormwater runoff rates, volumes and pollutant loads.	• Infiltration practices should not be used on development sites that have soils with infiltration rates of less than 0.25 inches per hour (i.e., hydrologic soil group C and D soils). • Use other low impact development and stormwater management practices, such as rainwater harvesting (CSS Section 7.8.12) and underdrained bioretention areas (CSS Section 8.6.3), to manage post-construction stormwater runoff in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of infiltration practices to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based stormwater management practices, including infiltration practices, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them. • Use bioretention areas (CSS Section 8.6.3) and dry swales (CSS Section 8.6.6) with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.

Challenges Associated with Using Infiltration Practices in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Infiltration Practices**	**Potential Solutions**
• *Flat terrain*	• Does not influence the use of infiltration practices. In fact, infiltration practices should be designed with slopes that are as close to flat as possible.	
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the infiltration practice and the top of the water table. • May occasionally cause stormwater runoff to pond in the bottom of the infiltration practice.	• Ensure that the distance from the bottom of the infiltration practice to the top of the water table is at least 2 feet. • Reduce the depth of the stone reservoir in infiltration trenches to 18 inches. • Reduce the depth of the planting bed in infiltration basins to 18 inches. • Use stormwater ponds (CSS Section 8.6.1), stormwater wetlands (Section 8.6.2) and wet swales (CSS Section 8.6.6), instead of infiltration practices to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• Does not influence the use of infiltration practices.	

Site Applicability

Infiltration practices can be used to manage post-construction stormwater runoff on development sites in rural, suburban and urban areas where the soils are permeable enough and the water table is low enough to provide for the infiltration of stormwater runoff. While infiltration trenches are particularly well-suited for use on small, medium-to-high density development sites, infiltration basins can be used on larger, lower density development sites. Infiltration practices should only be considered for use on development sites where fine sediment (e.g., clay, silt) loads will be relatively low, as high sediment loads will cause them to clog and fail. In addition, infiltration practices should be carefully sited to avoid the potential contamination of water supply aquifers. When compared with other stormwater management practices, infiltration practices have a moderate construction cost, a moderate maintenance burden and require a relatively small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that infiltration used on a development site meet all of the planning and design criteria provided in Section 8.6.5 of the CSS to be eligible for the stormwater management "credits.

Construction Considerations

To help ensure that infiltration practices are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.5 of the CSS.

Maintenance Requirements

Maintenance is very important for infiltration practices, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.18 in the CSS provides a list of the routine maintenance activities typically associated with infiltration practices.

Swales

Description

Swales are vegetated open channels that are designed to manage post-construction stormwater runoff within wet or dry cells formed by check dams or other control structures (e.g., culverts). They are designed with relatively mild slopes to force stormwater runoff to flow through them slowly and at relatively shallow depths, which encourages sediment and other stormwater pollutants to settle out. Swales differ from grass channels (CSS Section 7.8.7), in that they are designed with specific features that enhance their ability to manage stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Maximum contributing drainage area of 5 acres or less
- Swales should be designed to safely convey the overbank flood protection rainfall event (e.g., 25-year, 24-hour event)
- Swales may be designed with a slope of between 0.5% and 4%, although a slope of between 1% and 2% is recommended
- Swales should be designed to be between 2 and 8 feet wide to prevent channel braiding

BENEFITS:

- Provides moderate to high removal of many of the pollutants of concern typically contained in post-construction stormwater runoff
- Less expensive than traditional drainage (e.g., curb and gutter, storm drain) systems

LIMITATIONS:

- Can only be used to manage runoff from relatively small drainage areas of 5 acres in size
- Should not be used on development or redevelopment sites with slopes of less than 0.5%
- Potential for nuisance ponding to occur in wet swales

SITE APPLICABILITY

☑ Rural Use	M Construction Cost
☑ Suburban Use	M Maintenance
✱ Urban Use	M Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
0%[1]/40%-80%[2] - Annual Runoff Volume
0%[1]/Varies[3] - Runoff Reduction Volume

Pollutant Removal[4]
80%[1]/80%[2] - Total Suspended Solids
30%[1]/50%[2] - Total Phosphorus
30%[1]/50%[2] - Total Nitrogen
20%[1]/40%[2] - Metals
N/A - Pathogens

1 = wet swale
2 = dry swale
3= varies according to storage capacity of the dry swale
4 = expected annual pollutant load removal

Discussion

There are several variations of swales that can be used to manage post-construction stormwater runoff on development sites, the most common of which include dry swales and wet swales. A brief description of each of these design variants is provided below:

- *Dry Swales*: Dry swales (also known as *bioswales*), which may also be classified as a low impact development practice (CSS Section 7.8.15), are vegetated open channels that are filled with an engineered soil mix and are planted with trees, shrubs and other herbaceous vegetation. They are essentially linear bioretention areas (Section 8.6.3), in that they are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where it is subjected to the hydrologic processes of evaporation and transpiration, before being conveyed back into the storm drain system through an underdrain or allowed to infiltrate into the surrounding soils. This allows them to provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

- *Wet Swales*: Wet swales (also known as *wetland channels* or *linear stormwater wetlands*) are vegetated channels designed to retain water and maintain hydrologic conditions that support the growth of wetland vegetation. A high water table or poorly drained soils are necessary to maintain a permanent water surface within a wet swale. The wet swale essentially acts as a linear wetland treatment system, where the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event) is intercepted and treated over time.

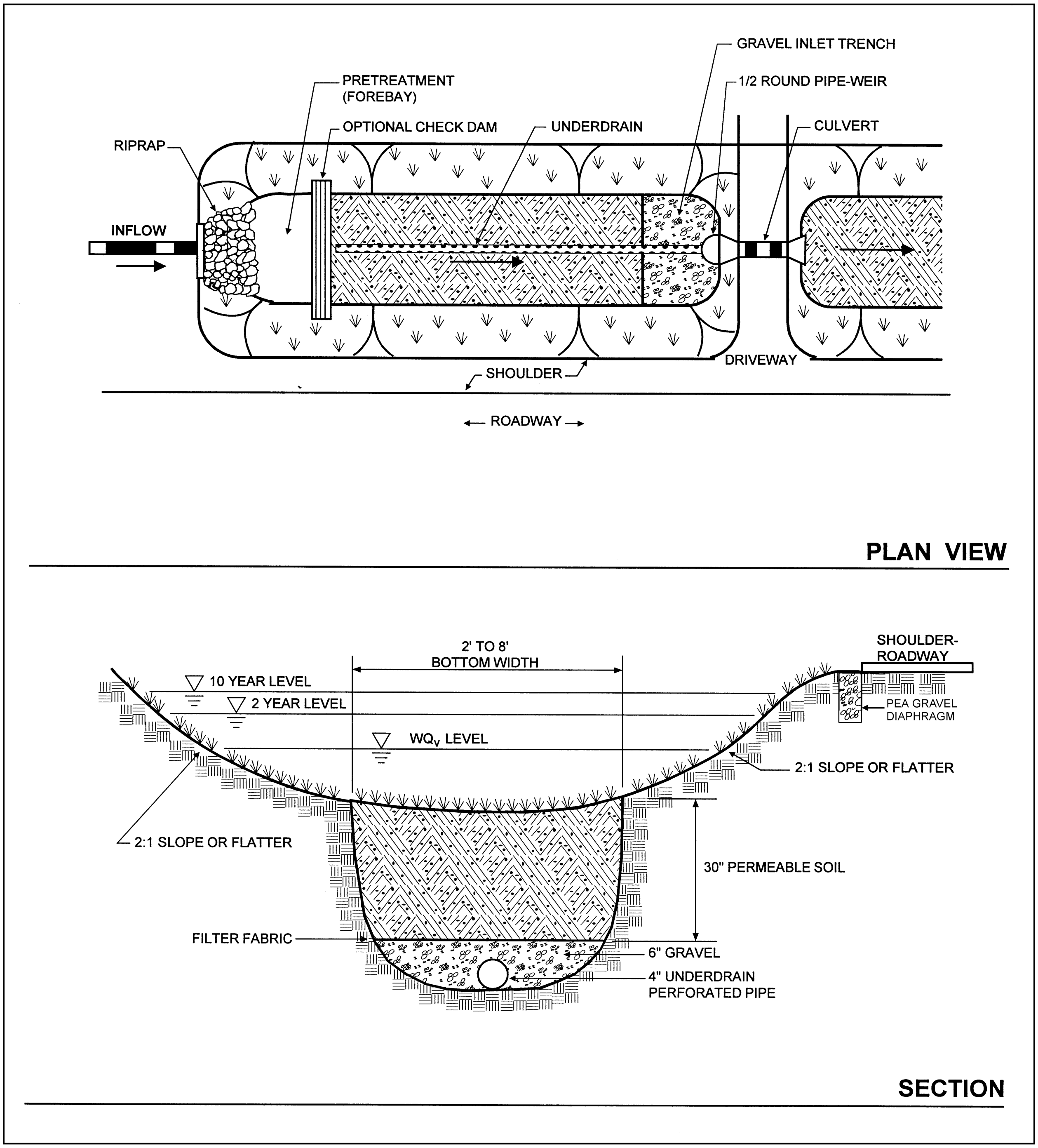
(Source: Atlanta Regional Commission, 2001)

Dry Swale

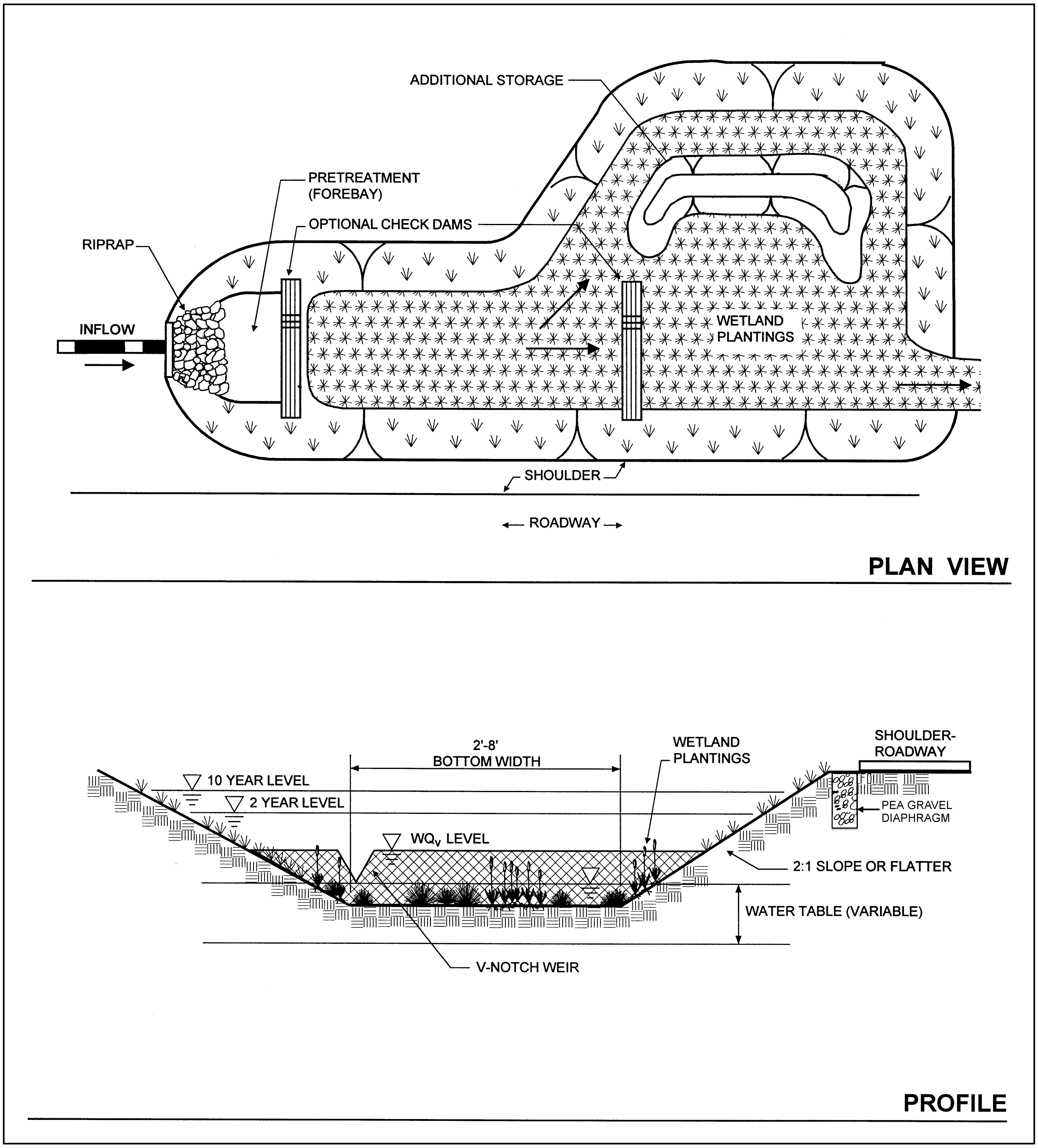
(Source: Atlanta Regional Commission, 2001)

Wet Swale

Various Swales



Schematic of a Typical Dry Swale
(Source: Center for Watershed Protection)



Schematic of a Typical Wet Swale
(Source: Center for Watershed Protection)

Stormwater Management "Credits"

Swales have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how swales can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.6 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not swales are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for swales including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.6 of the CSS.

<u>Feasibility in Coastal Georgia</u>

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using swales to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of swales on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Swales in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Swales**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are designed to have a permanent water surface, the presence of poorly drained soils does not influence the use of wet swales on development sites. In fact, the presence of poorly drained soils may help maintain a permanent water surface within a wet swale. • Reduces the ability of dry swales to reduce stormwater runoff rates, volumes and pollutant loads.	• Use wet swales or underdrained dry swales to intercept, convey and treat post-construction stormwater runoff in these areas. • Use additional low impact development and stormwater management practices, such as rainwater harvesting (CSS Section 7.8.12) to supplement the stormwater management benefits provided by swales in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• May be difficult to maintain a permanent water surface within a wet swale. • Enhances the ability of dry swales to reduce stormwater runoff rates, volumes and pollutant loads. • May allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based stormwater management practices, including non-underdrained dry swales, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them. • Use dry swales and bioretention areas (CSS Section 8.6.3) with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.

Challenges Associated with Using Swales in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Swales**	**Potential Solutions**
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the swale for extended periods of time.	• Design swales with a slope of at least 0.5% to help ensure adequate drainage. • Where soils are well drained, use non-underdrained dry swales, non-underdrained bioretention areas (CSS Section 8.6.3) and infiltration practices (CSS Section 8.6.5), to reduce stormwater runoff rates, volumes and pollutant loads and prevent ponding in these areas. • Ensure that the underlying native soils or underdrain system will allow a dry swale to drain completely within 48 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the swale for extended periods of time.	• Where soils are poorly drained, use wet swales and small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) to intercept and treat stormwater runoff.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of a dry swale and the top of the water table. • May occasionally cause stormwater runoff to pond in a dry swale.	• Ensure that the distance from the bottom of a dry swale to the top of the water table is at least 2 feet. • Reduce the depth of the planting bed in a dry swale to 18 inches. • Use wet swales to intercept, convey and treat post-construction stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a swale, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) to manage post-construction stormwater runoff in these areas.

Site Applicability

Swales can be used to manage post-construction stormwater runoff on a wide variety of development sites, including residential, commercial and institutional development sites in rural, suburban and urban areas. They are well suited for use on residential and institutional development sites that have low to moderate development densities. They can be used to "receive" stormwater runoff from nearly all small impervious and pervious drainage areas, including local streets and roadways, highways, driveways, small parking areas and disturbed pervious areas (e.g., lawns, parks, community open spaces). When compared with other stormwater management practices, swales have a moderate construction cost, a moderate maintenance burden and require a moderate amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that swales meet all of the planning and design criteria provided in Section 3.2.6 of Volume 2 of the *Georgia Stormwater Management Manual* (ARC, 2001) to be eligible for the stormwater management "credits" described above.

Construction Considerations

To help ensure that swales are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Table 8.6.6 of the CSS.

Maintenance Requirements

Maintenance is very important for swales, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.21 in the CSS provides a list of the routine maintenance activities typically associated with swales.

Stormwater Ponds

Description

Stormwater ponds are stormwater detention basins that have a permanent pool of water. Post-construction stormwater runoff is conveyed into the pool, where it is detained and treated over an extended period of time, primarily through gravitational settling and biological uptake, until it is displaced by stormwater runoff from the next rain event. Temporary storage (i.e., live storage) can be provided above the permanent pool for stormwater quantity control. This allows stormwater ponds to both *treat* stormwater runoff and *manage* the stormwater runoff rates and volumes generated by larger, less frequent rainfall events on development sites.

(Source: Atlanta Regional Commission, 2001)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Contributing drainage area of 25 acres or more typically needed for wet and wet extended detention ponds; 10 acres or more typically needed for micropool extended detention pond
- A sediment forebay (or equivalent pretreatment) should be provided upstream of all ponds
- Permanent pools should be designed to be between 3 and 8 feet deep
- Length to width ratio should be at least 1.5:1 (L:W), although a length to width ratio of 3:1 (L:W) or greater is preferred
- Side slopes should not exceed 3:1 (H:V)

BENEFITS:

- Provides moderate to high removal of many of the pollutants of concern contained in post-construction stormwater runoff
- Can be attractively integrated into a development site and designed to provide some wildlife habitat

LIMITATIONS:

- Provides minimal reduction of post-construction stormwater runoff volumes
- Stormwater pond design can be challenging in flat terrain

SITE APPLICABILITY

☑ Rural Use	L Construction Cost
☑ Suburban Use	L Maintenance
☑ Urban Use	H Area Required

STORMWATER MANAGEMENT "CREDITS"

☐ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
0% - Annual Runoff Volume
0% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
50% - Total Phosphorus
30% - Total Nitrogen
50% - Metals
70% - Pathogens

1 = expected annual pollutant load removal

Discussion

Stormwater ponds (also known as *retention ponds*, *wet ponds*, or *wet extended detention ponds*) are stormwater detention basins that are designed to have a permanent pool of water (i.e., dead storage) throughout the year. Post-construction stormwater runoff is conveyed into the pool, where it is detained and treated over an extended period of time, primarily through gravitational settling and biological uptake, until it is displaced by stormwater runoff from the next rain event. The permanent pool also helps protect deposited sediments from resuspension. Above the permanent pool, temporary storage (i.e., live storage) can be provided for stormwater quantity control.

Stormwater ponds treat post-construction stormwater runoff through a combination of physical, chemical and biological processes. The primary pollutant removal mechanism at work is gravitational settling, which works to remove particulate matter, organic matter, metals and bacteria as stormwater runoff is conveyed through the permanent pool. Another primary pollutant removal mechanism at work in stormwater ponds is biological uptake of nutrients by algae and wetland vegetation. Volatilization and other chemical processes also work to break down and eliminate a number of other stormwater pollutants (e.g., hydrocarbons) in stormwater ponds.

Stormwater ponds are among the most common stormwater management practices used in coastal Georgia and the rest of the United States. They are typically created by excavating a depressional area to create “dead storage” below the water surface elevation of the receiving storm drain system, stream or other aquatic resource. A well-designed pond can be attractively integrated into a development site as a landscaping feature and, if appropriately designed, sited and landscaped, can provide some wildlife habitat. However, site planning and design teams should use caution when siting a stormwater pond. They should use the results of the natural resources inventory (CSS Section 6.3.3), to ensure that the pond will not negatively impact any existing primary conservation areas on the development site (e.g., freshwater wetlands, bottomland hardwood forests). Site planning and design teams should also consider the other potential drawbacks associated with stormwater ponds, including their potential to become a source of mosquitoes and harmful algal blooms.

There are several variations of stormwater ponds that can be used to manage post-construction stormwater runoff on development sites, the most common of which include wet ponds, wet extended detention ponds and micropool extended detention ponds. In addition, multiple stormwater ponds can be placed in series or parallel to increase storage capacity or address specific site characteristics or constraints (e.g., flat terrain). A brief description of each of these design variants is provided below:

- Wet Ponds: Wet ponds are stormwater detention basins that are designed to have a permanent pool that provides enough storage for the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). Stormwater runoff is conveyed into the pool, where it is detained and treated over an extended period of time, primarily through gravitational settling and biological uptake, until it is displaced by stormwater runoff from the next rain event. Additional temporary storage (i.e., live storage) can be provided above the permanent pool for stormwater quantity control.

- Wet Extended Detention (ED) Ponds: Wet extended detention ponds are wet ponds that are designed to have a permanent pool that provides enough storage for approximately 50% of the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). The remainder of the stormwater runoff volume generated by the target runoff reduction rainfall event is managed in an extended detention zone provided immediately above the permanent pool. During wet weather, stormwater runoff is detained in the extended detention zone and released over a 24-hour period.

Wet Pond

Wet Extended Detention Pond

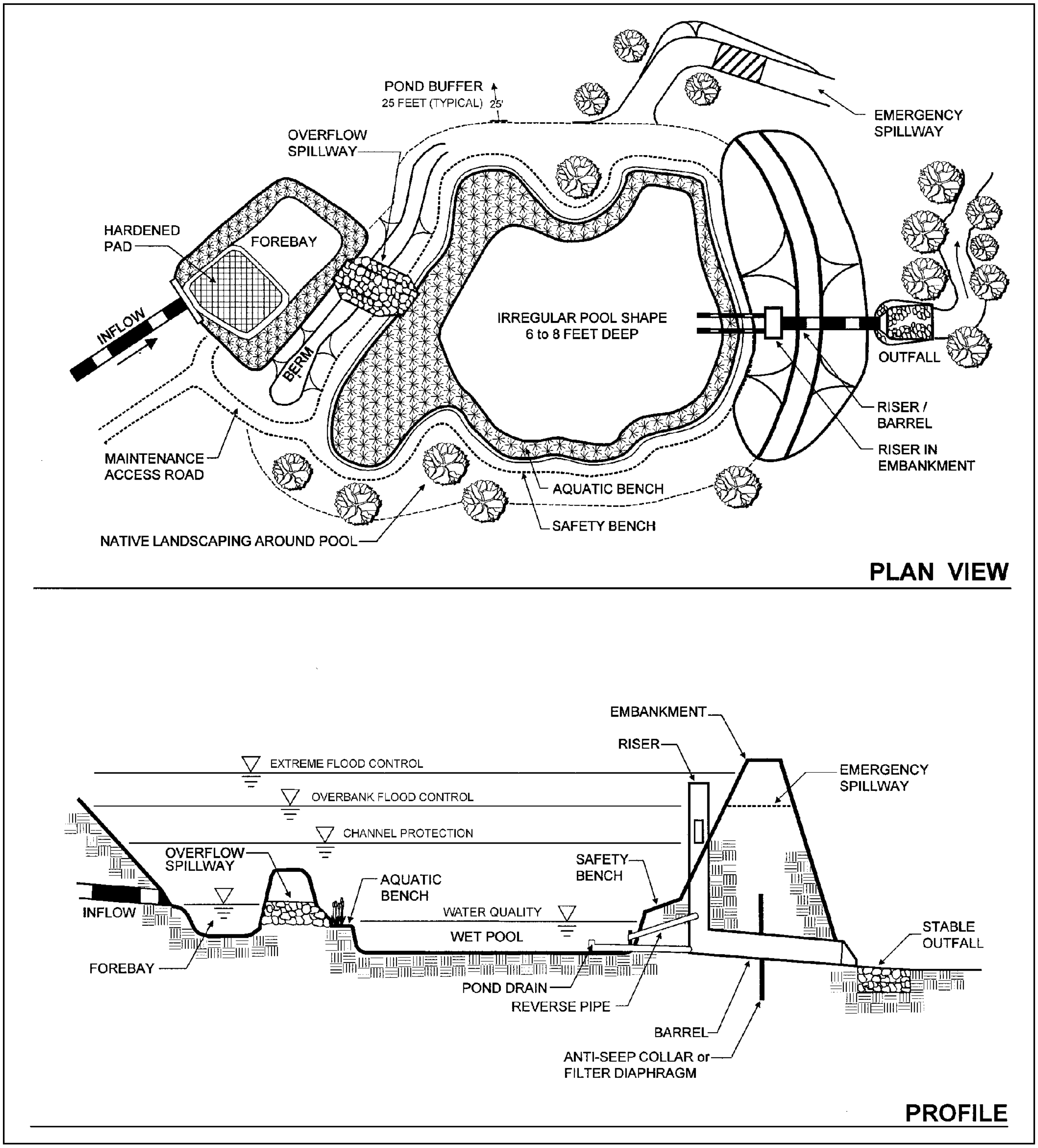
Micropool Extended Detention Pond

Wet Pond

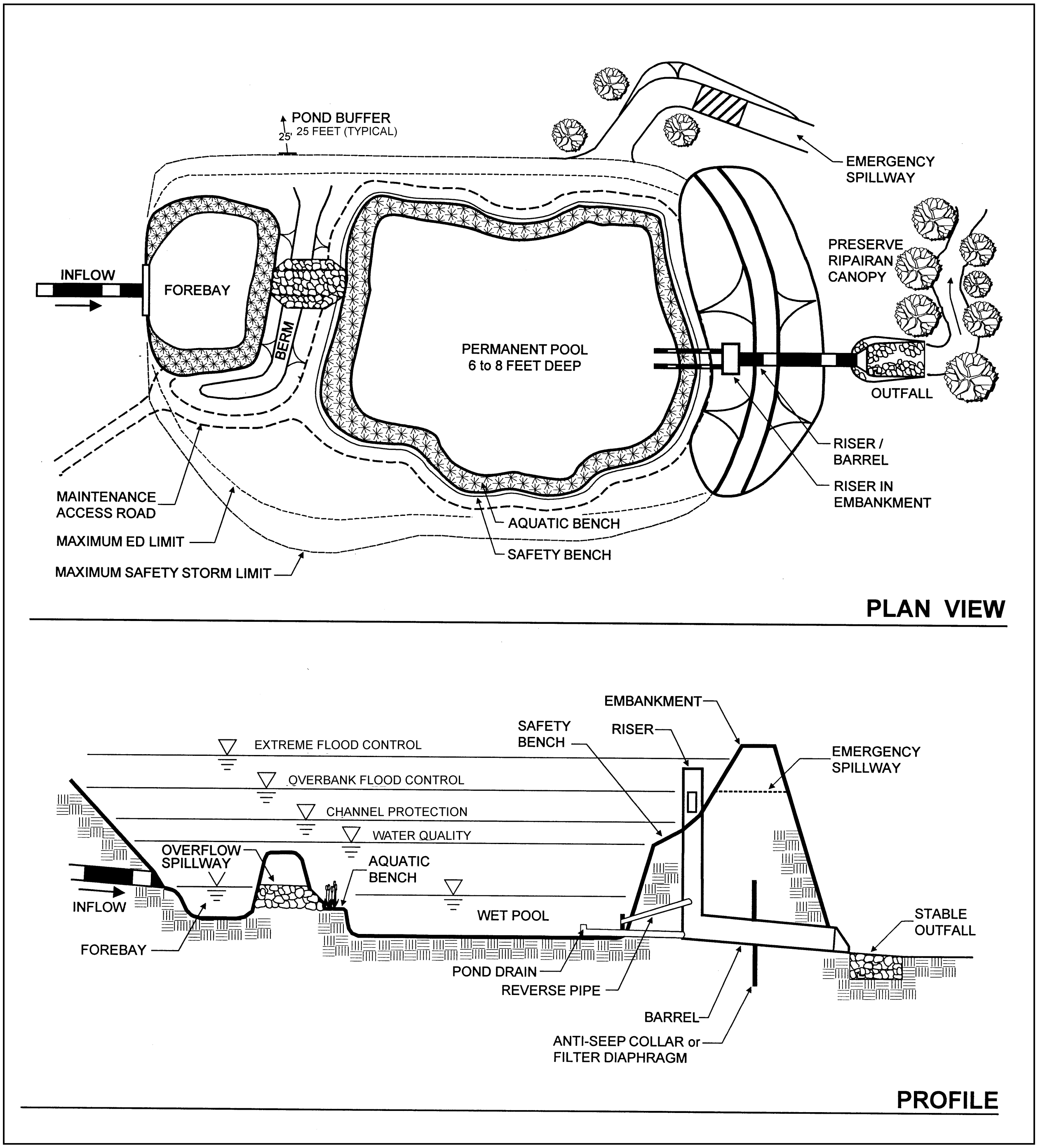
Various Stormwater Ponds

- Micropool Extended Detention (ED) Ponds: Micropool extended detention ponds are a variation of the standard wet extended detention pond that have only a small permanent pool (i.e., micropool). The “micropool” provides enough storage for approximately 10% of the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). The remainder of the stormwater runoff volume generated by the target runoff reduction rainfall event is managed in an extended detention zone provided immediately above the “micropool” and released over an extended 24-hour period.

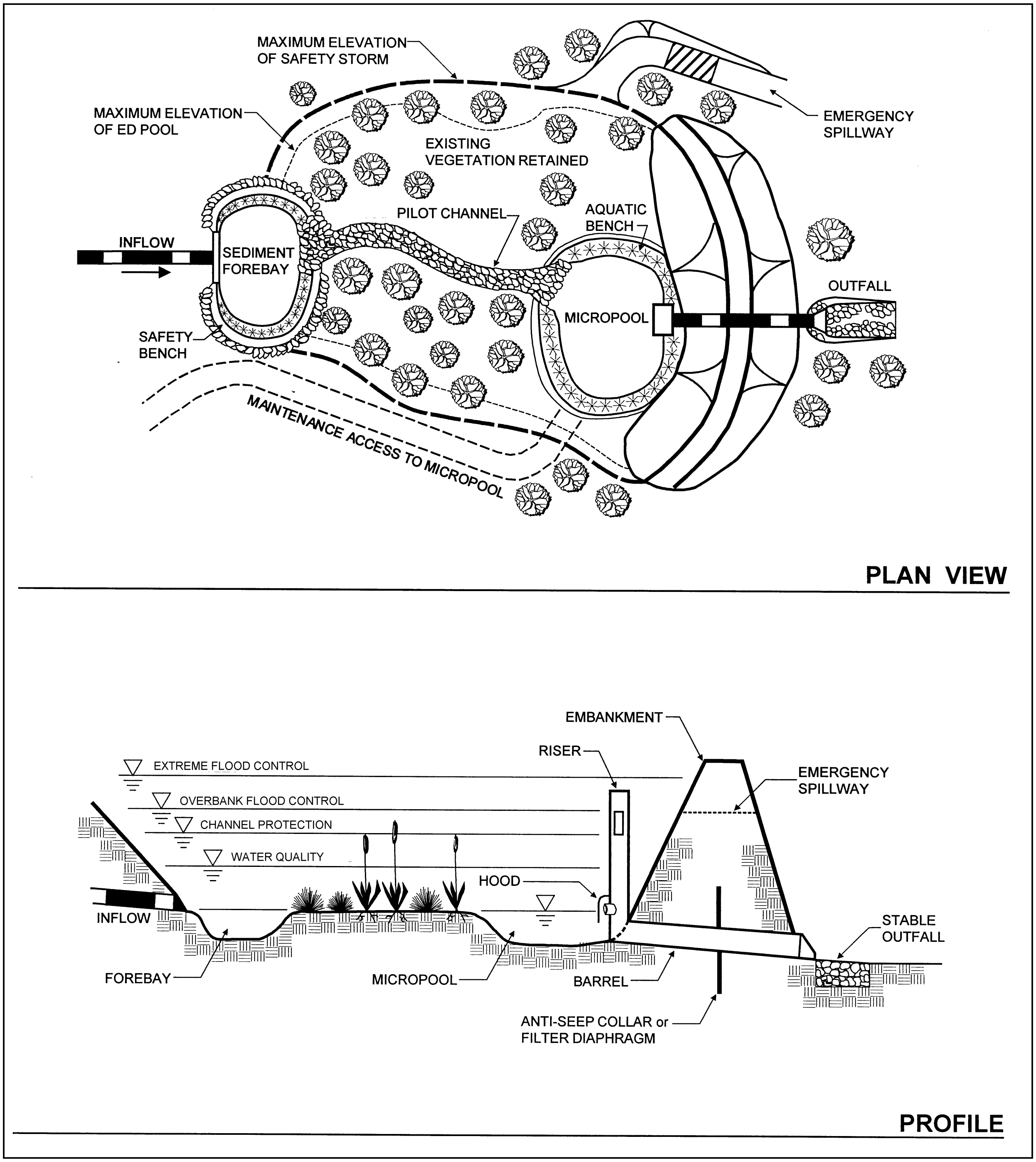
- Multiple Pond Systems: Multiple pond systems consist of a series of two or more wet ponds, wet extended detention ponds or micropool extended detention ponds. The additional cells can increase the storage capacity provided on a development or redevelopment site.



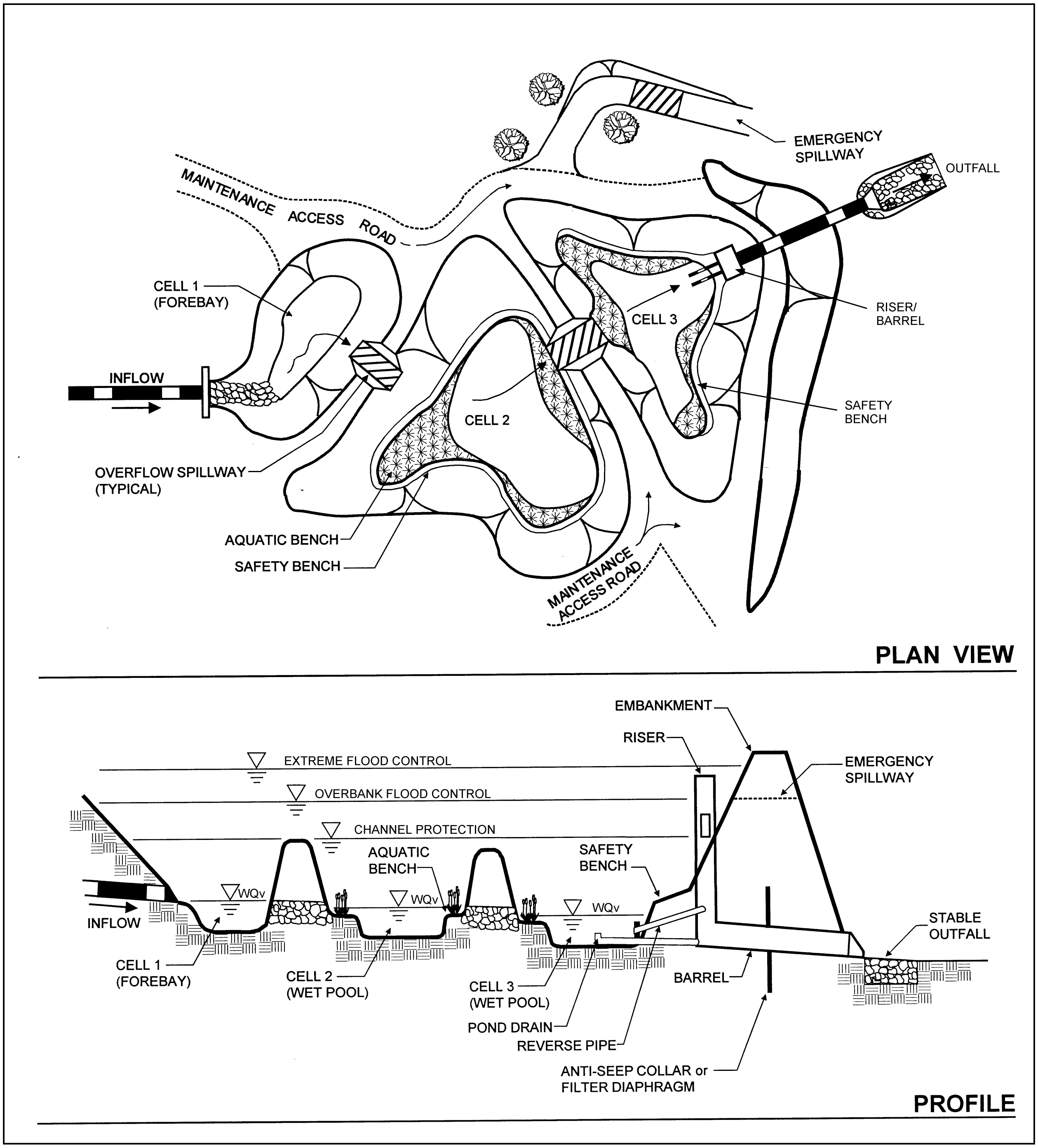
Schematic of a Typical Wet Pond
(Source: Center for Watershed Protection)



Schematic of a Typical Wet Extended Detention Pond
(Source: Center for Watershed Protection)



Schematic of a Typical Micropool Extended Detention Pond
(Source: Center for Watershed Protection)



Schematic of a Typical Multiple Pond System

(Source: Center for Watershed Protection)

Stormwater Management "Credits"
Stormwater ponds have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). Table ? in Appendix ? shows how stormwater ponds can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.1 of the CSS.

<u>Feasibility in Coastal Georgia</u>
Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using stormwater ponds to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of stormwater ponds on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Stormwater Ponds in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Stormwater Ponds**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are designed to have a permanent pool of water, the presence of poorly drained soils does not influence the use of ponds on development sites. In fact, the presence of poorly drained soils may help maintain a permanent pool of water within a stormwater pond.	
• *Well drained soils*, such as hydrologic soil group A and B soils	• May be difficult to maintain a permanent pool of water within a stormwater pond. • May allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Install a pond liner to maintain a permanent pool of water. • At stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, install a pond liner to prevent pollutants from reaching groundwater aquifers. • In areas that are not considered to be stormwater hotspots and areas that do not provide groundwater recharge to water supply aquifers, use non-underdrained bioretention areas (CSS Section 8.6.3) and infiltration practices (CSS Section 8.6.5) to significantly reduce stormwater runoff rates, volumes and pollutant loads.

Challenges Associated with Using Stormwater Ponds in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Stormwater Ponds**	**Potential Solutions**
• *Flat terrain*	• Reduces the amount of storage volume that can be provided within a stormwater pond. • Makes it difficult, if not impossible, to provide a pond drain at the bottom of a stormwater pond.	• Design stormwater ponds that have shallower permanent pools, with depths of 4 feet or less (e.g., dugouts). • Eliminate the use of pond drains, if necessary. • Consider stormwater wetlands (CSS Section 8.6.2) as an alternative stormwater management practice in areas with flat terrain and a shallow water table.
• *Shallow water table*	• Makes it easier to maintain a permanent pool within a stormwater pond, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Excavation below the water table to create a stormwater pond is acceptable, but any storage volume found below the water table should not be counted when determining the total storage volume provided by the stormwater pond. • At stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, install a pond liner to prevent pollutants from reaching underlying groundwater aquifers. • Use bioretention areas (CSS Section 8.6.3) and filtration practices (CSS Section 8.6.4) with liners and underdrains to intercept and treat stormwater runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.

Challenges Associated with Using Stormwater Ponds in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Stormwater Ponds**	**Potential Solutions**
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a stormwater pond, particularly during high tide. • May increase the amount of pollution that is transferred from stormwater ponds to adjacent estuarine resources.	• Maximize the use of low impact development practices (CSS Section 7.8) in these areas to reduce stormwater runoff rates, volumes and pollutant loads. • Provide enlarged aquatic benches (e.g., up to 30 feet wide) that have been planted with dense wetland vegetation to increase pollutant removal. • Consider the use of bubbler aeration and proper fish stocking to maintain nutrient cycling and healthy oxygen levels in stormwater ponds located in these areas. • Consider stormwater wetlands (CSS Section 8.6.2) as an alternative stormwater management practice in these areas.

Site Applicability

Although it may be difficult to use them to manage post-construction stormwater runoff in urban areas, due to space constraints, stormwater ponds can be used to manage stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other stormwater management practices, stormwater ponds have a relatively low construction cost, a relatively low maintenance burden and require a relatively large amount of surface area. (See Table 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that stormwater ponds meet all of the planning and design criteria provided in Section 3.2.1 of Volume 2 of the *Georgia Stormwater Management Manual* (ARC, 2001) to be eligible for the stormwater management "credits" described above.

Construction Considerations

To help ensure that stormwater ponds are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.1 of the CSS.

Maintenance Requirements

Maintenance is very important for stormwater ponds, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.6 in the CSS provides a list of the routine maintenance activities typically associated with stormwater ponds.

Stormwater Wetlands

Description

Stormwater wetlands are constructed wetland systems built for stormwater management purposes. They typically consist of a combination of open water, shallow marsh and semi-wet areas that are located just above the permanent water surface. As stormwater runoff flows through a wetland, it is treated, primarily through gravitational settling and biological uptake. Temporary storage (i.e., live storage) can be provided above the permanent water surface for stormwater quantity control. This allows wetlands to both *treat* stormwater runoff and *manage* the stormwater runoff rates and volumes generated by larger rainfall events.

(Source: Merrill et al., 2006)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Contributing drainage area of 25 acres or more typically needed for shallow and shallow extended detention wetlands; 10 acres or more typically needed for pocket wetlands
- A sediment forebay (or equivalent pretreatment) should be provided upstream of all wetlands
- Minimum of 35% of wetland surface area should have a depth of 6 inches or less; 10% to 20% of surface area should have a depth of between 1.5 and 6 feet
- Length to width ratio should be at least 2:1 (L:W), although a length to width ratio of 3:1 (L:W) or greater is preferred
- Side slopes should not exceed 3:1 (H:V)

BENEFITS:

- Provides moderate to high removal of many of the pollutants of concern typically contained in post-construction stormwater runoff
- Ideal for use in flat terrain and in areas with high groundwater

LIMITATIONS:

- Provides minimal reduction of post-construction stormwater runoff volumes
- Requires relatively large amount of land

SITE APPLICABILITY

☑ Rural Use	L Construction Cost
☑ Suburban Use	M Maintenance
Urban Use	H Area Required

STORMWATER MANAGEMENT "CREDITS"

Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
0% - Annual Runoff Volume
0% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
50% - Total Phosphorus
30% - Total Nitrogen
50% - Metals
70% - Pathogens

1 = expected annual pollutant load removal

Discussion

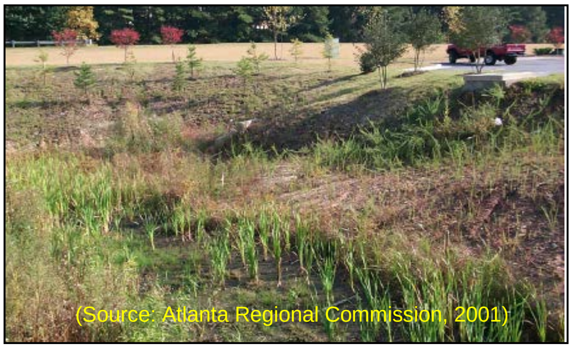
Stormwater wetlands treat post-construction stormwater runoff through a combination of physical, chemical and biological processes. The primary pollutant removal mechanisms at work in stormwater wetlands are biological uptake, physical screening and gravitational settling. Other pollutant removal mechanisms at work in stormwater wetlands include volatilization and other biological and chemical processes.

Stormwater wetlands are among the most effective stormwater management practices that can be used coastal Georgia and the rest of the United States. They are typically created by excavating a depressional area to create "dead storage" below the water surface elevation of the receiving storm drain system, stream or other aquatic resource. A well-designed stormwater wetland can be attractively integrated into a development site as a landscaping feature and, if appropriately designed, sited and landscaped, can provide valuable wildlife habitat. Stormwater wetlands differ from natural wetland systems in that they are engineered facilities designed specifically for the purpose of managing post-construction stormwater runoff. They typically have less biodiversity than natural wetlands in terms of both plant and animal life but, like natural wetlands, require continuous base flow or a high water table to maintain a permanent water surface and support the growth of aquatic vegetation.

There are several variations of stormwater wetlands that can be used to manage post-construction stormwater runoff on development sites, including shallow wetlands, shallow extended detention wetlands and pocket wetlands. In addition, stormwater wetlands can be used in combination with stormwater ponds to increase storage capacity or address specific site characteristics or constraints (e.g., flat terrain). A brief description of each of these design variants is provided below:

- Shallow Wetlands: In a shallow wetland (Figure 8.15), most of the storage volume provided by the wetland is contained in some relatively shallow high marsh and low marsh areas. The only deep water areas found within a shallow wetland are the forebay, which is located at the entrance to the wetland, and the "micropool," which is located at the outlet. One disadvantage to the shallow wetland design is that, since most of the storage volume is provided in the relatively shallow high marsh and low marsh areas, a large amount of land may be needed to provide enough storage for the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event).

- Shallow Extended Detention (ED) Wetlands: A shallow extended detention wetland (Figure 8.16) is essentially the same as a shallow wetland, except that approximately 50% of the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event) is managed in an extended detention zone provided immediately above the permanent water surface. During wet weather, stormwater runoff is detained in the extended detention zone and released over a 24-hour period. Although this design variant requires less land than the shallow wetland design variant, it can be difficult to establish vegetation within the extended detention zone due to the



Shallow Wetland

Shallow Extended Detention Wetland

Shallow Wetland

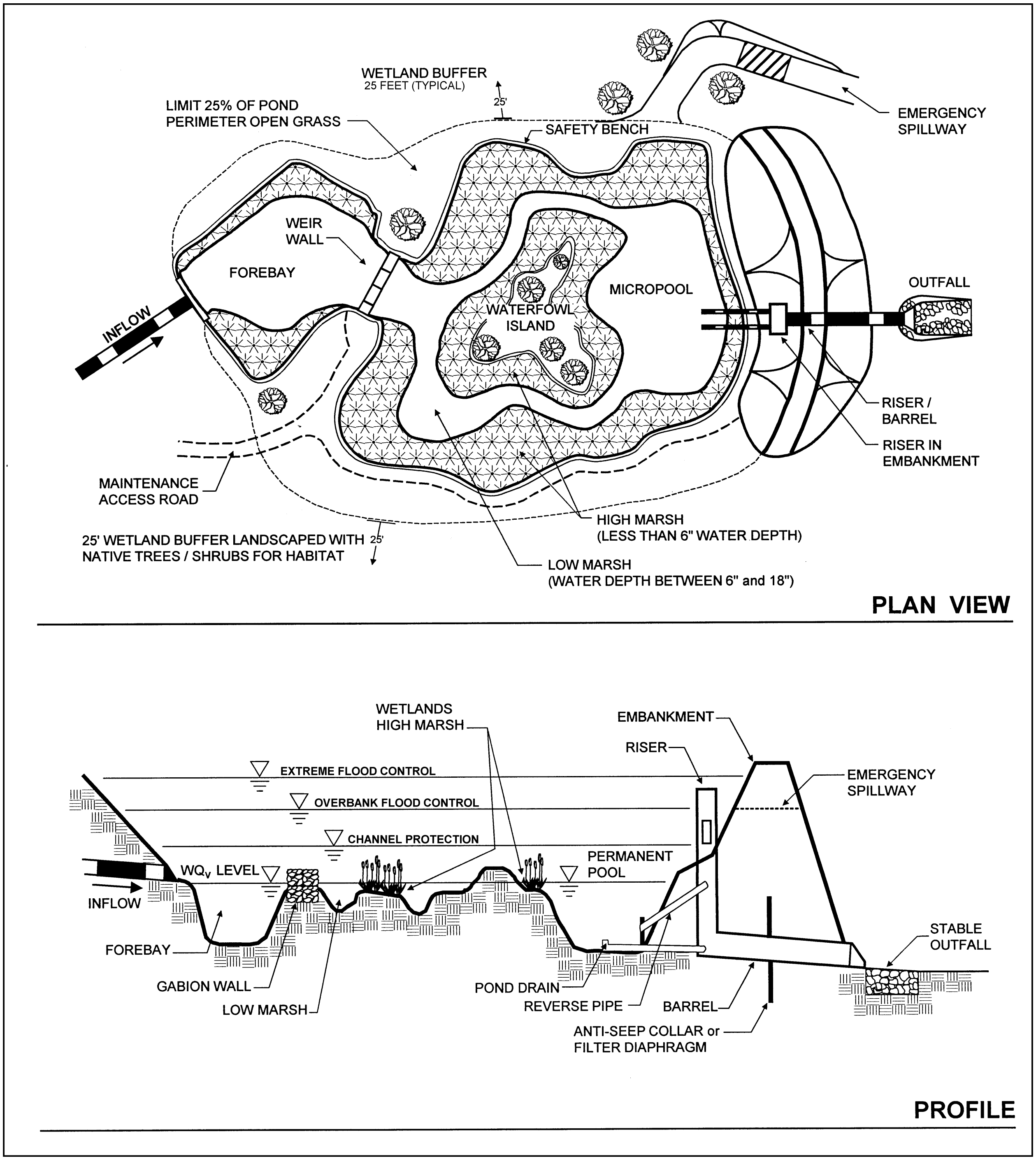
Pocket Wetland

Various Stormwater Wetlands

fluctuating water surface elevations found within.

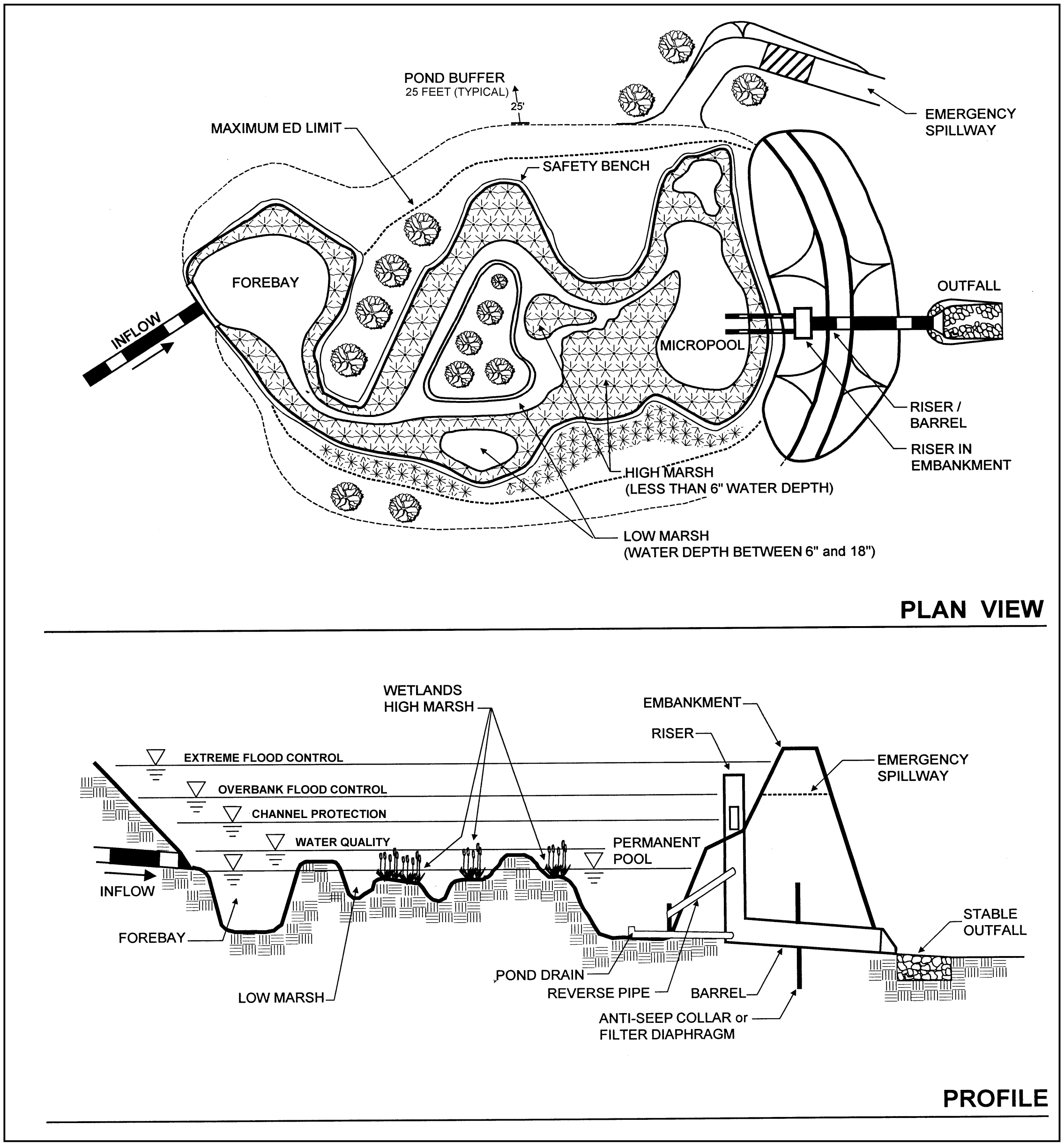
- <u>Pond/Wetland Systems</u>: A pond/wetland system has two separate cells, one of which is a wet pond and the other of which is a shallow wetland. The wet pond cell is used to trap sediment and reduce stormwater runoff velocities upstream of the shallow wetland cell. Less land is typically required for pond/wetland systems than for shallow wetlands or shallow extended detention wetlands.

- <u>Pocket Wetlands</u>: Pocket wetlands can be used to intercept and manage stormwater runoff from relatively small drainage areas of up to about 10 acres in size. In order to ensure that they have a permanent water surface throughout the year, they are typically designed to interact with the groundwater table.



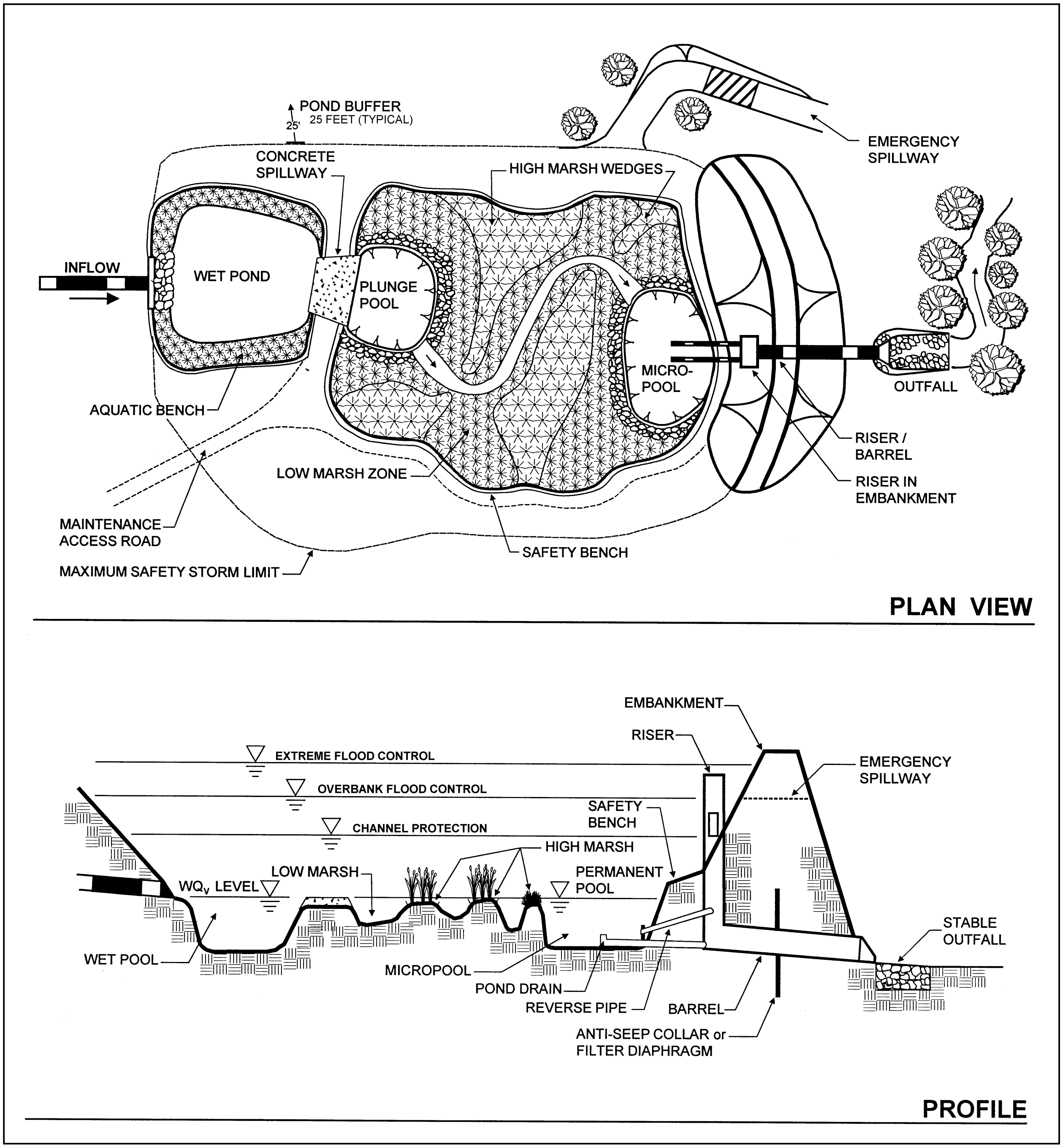
Schematic of a Typical Shallow Wetland

(Source: Center for Watershed Protection)



Schematic of a Typical Shallow Extended Detention Wetland

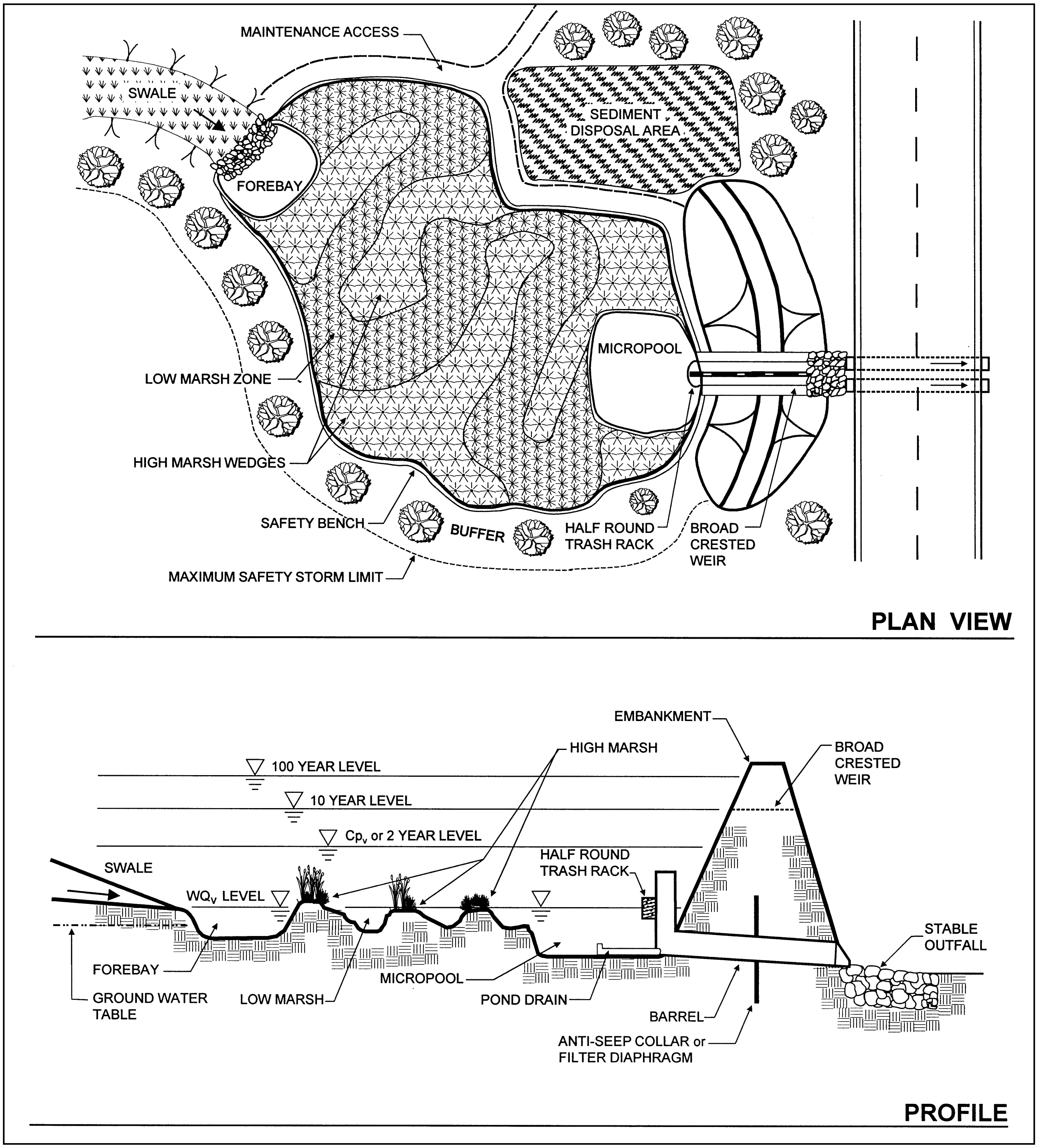
(Source: Center for Watershed Protection)



Schematic of a Typical Pond/Wetland System
(Source: Center for Watershed Protection)

Stormwater Management “Credits”

Stormwater wetlands have been assigned quantifiable stormwater management “credits” that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how stormwater ponds can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.2 of the CSS.



Schematic of a Typical Pocket Wetland
(Source: Center for Watershed Protection)

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not stormwater wetlands are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for stormwater wetlands including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.2 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using stormwater wetlands to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of stormwater wetlands on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Stormwater Wetlands in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Stormwater Wetlands**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are designed to have a permanent water surface, the presence of poorly drained soils does not influence the use of stormwater wetlands on development sites. In fact, the presence of poorly drained soils may help maintain a permanent water surface within a stormwater wetland.	
• *Well drained soils*, such as hydrologic soil group A and B soils	• May be difficult to maintain a permanent water surface within a stormwater wetland. • May allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Install a liner to maintain a permanent water surface. • At stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, install a liner to prevent pollutants from reaching underlying groundwater aquifers. • In areas that are not considered to be stormwater hotspots and areas that do not provide groundwater recharge to water supply aquifers, use non-underdrained bioretention areas (CSS Section 8.6.3) and infiltration practices (CSS Section 8.6.5) to significantly reduce stormwater runoff volumes.

Challenges Associated with Using Stormwater Wetlands in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Stormwater Wetlands**	**Potential Solutions**
• *Flat terrain*	• Makes it difficult, if not impossible, to provide a drain at the bottom of a stormwater wetland.	• Eliminate the use of drains, if necessary.
• *Shallow water table*	• Makes it easier to maintain a permanent water surface within a stormwater wetland, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Excavation below the water table to create a stormwater wetland is acceptable, but any storage volume found below the water table should not be counted when determining the total storage volume provided by the stormwater wetland. • At stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, install a liner to prevent pollutants from reaching underlying groundwater aquifers. • Use bioretention areas (CSS Section 8.6.3) and filtration practices (CSS Section 8.6.4) with liners and underdrains to intercept and treat stormwater runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a stormwater wetland, particularly during high tide.	• Maximize the use of low impact development practices (CSS Section 7.8) in these areas to reduce stormwater runoff rates, volumes and pollutant loads. • Consider the use of bubbler aeration and proper fish stocking to maintain nutrient cycling and healthy oxygen levels in stormwater wetlands located in these areas.

Site Applicability

Although it may be difficult to use them to manage post-construction stormwater runoff in urban areas, due to space constraints, stormwater wetlands can be used to manage stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other stormwater management practices, stormwater wetlands have a relatively low construction cost, a moderate maintenance burden and require a relatively large amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that stormwater wetlands meet all of the planning and design criteria provided in Section 3.2.2 of Volume 2 of the *Georgia Stormwater Management Manual* (ARC, 2001) to be eligible for the stormwater management “credits” described above.

Construction Considerations

To help ensure that stormwater wetlands are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.2 of the CSS.

Maintenance Requirements

Maintenance is very important for stormwater wetlands, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.9 in the CSS provides a list of the routine maintenance activities typically associated with stormwater wetlands.

Filtration Practices

Description

Filtration practices are multi-chamber structures designed to treat stormwater runoff using the physical processes of screening and filtration. After passing through the filter media (e.g., sand), stormwater runoff is typically returned to the conveyance system through an underdrain. Because they have very few site constraints beyond head requirements (i.e., vertical distance between inlet and outlet), filtration practices can often be used on development sites where other stormwater management practices, such as stormwater ponds (CSSSection 8.6.1) and infiltration practices (CSS Section 8.6.5), cannot.

(Source: Atlanta Regional Commission, 2001)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Maximum contributing drainage area of 10 acres for surface filters; maximum contributing drainage area of 2 acres for perimeter filters
- Filtration practices should be designed to completely drain within 36 hours of the end of a rainfall event
- A maximum ponding depth of 12 inches is recommended to help prevent the formation of nuisance ponding conditions
- Typically require 3 to 6 feet of head, although perimeter filters may be designed to function on development sites with as little as 2 feet of head

BENEFITS:

- Provides moderate to high removal of many of the pollutants of concern typically contained in post-construction stormwater runoff
- Ideal for intercepting and treating stormwater runoff from small, highly impervious areas, including stormwater hotspots

LIMITATIONS:

- Relatively high construction and maintenance costs
- Should not be used to “receive” stormwater runoff that contains high sediment loads

SITE APPLICABILITY

✱	Rural Use	H	Construction Cost
☑	Suburban Use	H	Maintenance
☑	Urban Use	L	Area Required

STORMWATER MANAGEMENT “CREDITS”

Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management “credits” that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
0% - Annual Runoff Volume
0% - Runoff Reduction Volume

Pollutant Removal[1]
80%- Total Suspended Solids
60% - Total Phosphorus
40% - Total Nitrogen
50% - Metals
40% - Pathogens

1 = expected annual pollutant load removal

Description

Filtration practices treat stormwater runoff primarily through a combination of the physical processes of gravitational settling, physical screening, filtration, absorption and adsorption. The filtration process effectively removes suspended solids, particulate matter, heavy metals and fecal coliform bacteria and other pathogens from stormwater runoff. Surface filters that are designed with vegetative cover provide additional opportunities for biological uptake of nutrients by the vegetation and for biological decomposition of other stormwater pollutants, such as hydrocarbons.

There are several variations of filtration practices that can be used to manage post-construction stormwater runoff on development sites, the most common of which include surface sand filters and perimeter sand filters. A brief description of each of these design variants is provided below:

- Surface Sand Filters: Surface sand filters are ground-level, open air practices that consist of a pretreatment forebay and a filter bed chamber. Surface sand filters can treat stormwater runoff from contributing drainage areas as large as 10 acres in size and are typically designed as off-line stormwater management practices. Surface sand filters can be designed as excavations, with earthen side slopes, or as structural concrete or block structures.

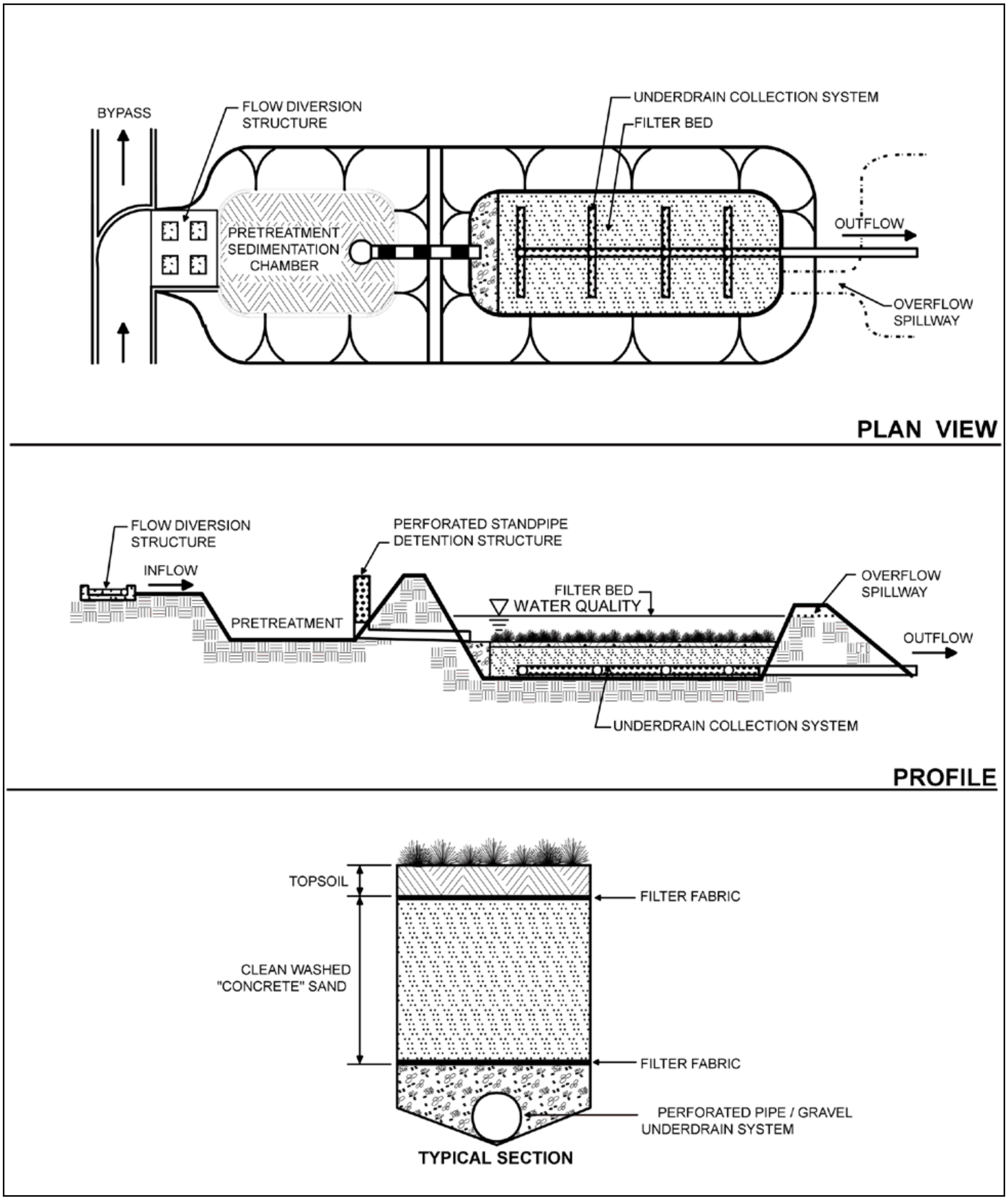
- Perimeter Sand Filters: Perimeter sand filters are enclosed stormwater management practices that are typically located just below grade in a trench along the perimeter of parking lot, driveway or other impervious surface. Perimeter sand filters consist of a pretreatment forebay and a filter bed chamber. Stormwater runoff is conveyed into a perimeter sand filter through grate inlets located directly above the system.

Other design variants, including the underground sand filter and the organic filter, are intended primarily for use on ultra-urban development sites, where space is limited, or for use at stormwater hotspots, where enhanced removal of particular stormwater pollutants (e.g., heavy metals) is desired. Additional information about these *limited application stormwater management practices* is provided in Section 8.7 of this CSS.

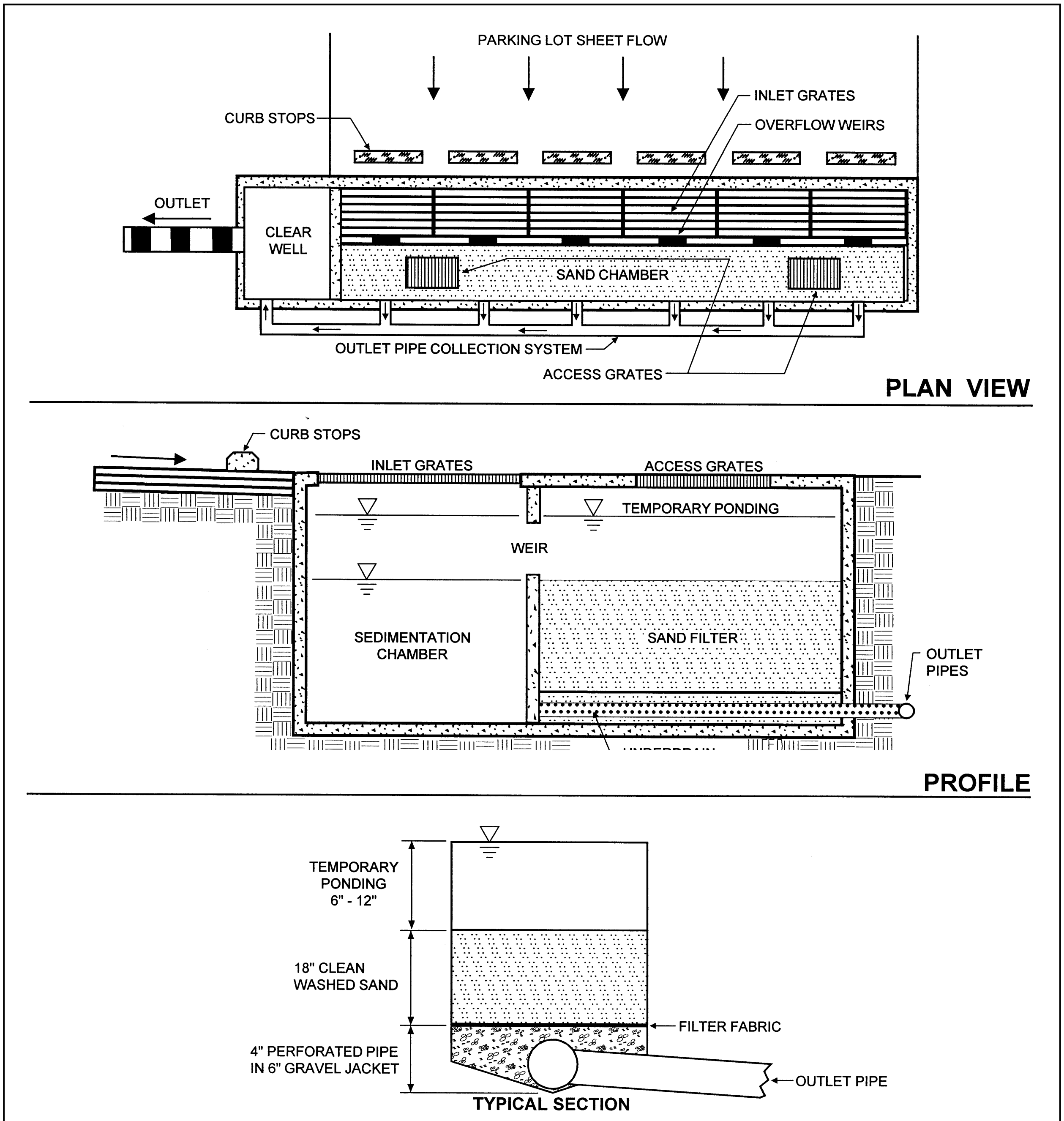
Surface Sand Filter

Perimeter Sand Filter

Various Filtration Practices



Schematic of a Typical Surface Sand Filter
(Source: Center for Watershed Protection)



Schematic of a Typical Perimeter Sand Filter
(Source: Center for Watershed Protection)

Stormwater Management "Credits"

Filtration practices have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how stormwater ponds can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.4 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not filtration practices are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for filtration practices including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.4 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using filtration practices to manage post-construction stormwater runoff on development and redevelopment sites. The following Table identifies these common site characteristics and describes how they influence the use of filtration practices. The table also provides site planning and design teams with some ideas about how they can work around these potential design constraints.

Challenges Associated with Using Filtration Practices in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Filtration Practices**	**Potential Solutions**
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are equipped with underdrains, the presence of poorly drained soils does not influence the use of filtration practices on development sites.	
• *Well drained soils*, such as hydrologic soil group A and B soils	• May allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Use filtration practices and bioretention areas (CSS Section 8.6.3) with liners and underdrains to intercept and treat stormwater runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. • In areas that are not considered to be stormwater hotspots and areas that do not provide groundwater recharge to water supply aquifers, use non-underdrained bioretention areas (CSS Section 8.6.3) and infiltration practices (CSS Section 8.6.5) to significantly reduce stormwater runoff rates, volumes and pollutant loads.

Challenges Associated with Using Filtration Practices in Coastal Georgia		
Site Characteristic	**How it Influences the Use of Filtration Practices**	**Potential Solutions**
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the filtration practice for extended periods of time.	• Ensure that the filtration practice will drain completely within 36 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the filtration practice and the top of the water table. • May occasionally cause stormwater runoff to pond in the filtration practice.	• Ensure that the distance from the bottom of the filtration practice to the top of the water table is at least 2 feet. • Use stormwater ponds (CSS Section 8.6.1), stormwater wetlands (CSS Section 8.6.2) and wet swales (CSS Section 8.6.6), instead of bioretention areas to intercept and treat stormwater runoff in these areas.

Site Applicability

Filtration practices can be used to manage stormwater runoff on a wide variety of development sites. They are particularly well suited for intercepting and treating stormwater runoff from small, highly impervious areas (e.g., parking lots) on development sites where space for other stormwater management practices is limited. Filtration practices should primarily be considered for use on parts of commercial, industrial and institutional development sites where fine sediment (e.g., clay, silt) loads will be relatively low, as high sediment loads will cause them to clog and fail. When compared with other stormwater management practices, filtration practices have a relatively high construction cost, a relatively high maintenance burden and require a relatively small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that filtration practices meet all of the planning and design criteria provided in Section 3.2.4 of Volume 2 of the *Georgia Stormwater Management Manual* (ARC, 2001) to be eligible for the stormwater management “credits” described above.

Construction Considerations

To help ensure that filtration practices are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.4 of the CSS.

Maintenance Requirements

Maintenance is very important for filtration practices, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.15 in the CSS provides a list of the routine maintenance activities typically associated with filtration practices.