Hillsborough County Florida

Green Infrastructure Manual

July 2023

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ACCOMMODATION STATEMENT

In accordance with the requirements of title II of the Americans with Disabilities Act of 1990 ("ADA"), Hillsborough County will not discriminate against qualified individuals with disabilities on the basis of disability in its services, programs, or activities. Persons with disabilities who need an accommodation for this document should email the Hillsborough County ADA Officer or call (813) 276-8401; TTY: 7-1-1.

Hillsborough County Florida

GREEN INFRASTRUCTURE MANUAL

0.0 PREFACE

A HOW TO USE THIS MANUAL

MANUAL PURPOSE

Green Infrastructure (GI) practices are not mandatory but rather are a voluntary option in Hillsborough County. In accordance with Objective 1.1 of the One Water Chapter of the Unincorporated Hillsborough County Comprehensive Plan (One Water), Hillsborough County encourages the use of GI practices where possible to help meet its water resources preservation and enhancement objectives.

This manual is intended to meet One Water Policy 6.2.2 as a guide for a variety of GI practices that are best suited for County capital program projects, and which can be used in the future for new development and redevelopment within the unincorporated County area. Education of GI selection and design is important for the County and can help solve existing and foreseeable problems arising from failing or undersized stormwater systems.

LIMITATIONS

This manual is intended for use with the County's capital program projects. The guidance provided in this manual is intended to be flexible to meet site conditions; performance criteria is provided where appropriate. For all projects, check with local officials to determine if additional regulatory restrictions or stormwater requirements may apply. Specific design methodologies are not addressed but are assumed to be carried out by competent stormwater design professionals.

Agencies with possible regulatory control over the development process include:

- Hillsborough County Development Services
- Southwest Florida Water Management District
- Florida Department of Environmental Protection

INTENDED AUDIENCE

County consultants, city planners, engineers, architects, and construction teams are encouraged to use this manual as a basis for GI selection and design templates. Sample specifications and design templates, in the Appendices of this manual, have been provided as standard practice but can be altered by designers to an extent.

GI IN THE DEVELOPMENT PROCESS

Hillsborough County is a region of continual growth and development, which provides the opportunity to promote the use of GI implementation within the County's existing Stormwater Management regulatory framework.

This GI manual is intended to be used in conjunction with the following County and State codes and manuals. The decision to incorporate green infrastructure as a measure to meet water quality and quantity requirements should be discussed and vetted at a pre-application meeting with County officials, prior to submitting for a permit:

1. One Water Chapter of the Unincorporated Hillsborough County Comprehensive Plan
2. Hillsborough County Stormwater Management Technical Manual
3. Hillsborough County Transportation Technical Manual for Subdivision and Site Development Projects
4. Stormwater Business Plan
5. Land Development Code - Article IV, Natural Resources and Adequate Public Facilities

High development areas, including redevelopment, are ideal locations to target GI implementation to offset the likely decreased area for infiltration and increased pollution loadings. The Hillsborough County Complete Streets Guide provides many other examples of locations within specific transportation context classifications where GI practices may be appropriate.

- Right-of-way enhancement
- Water quality
- Landscape
- Stability of stormwater outfalls
- Preservation and restoration of natural areas
- Community well-being

GI IN THE DEVELOPMENT PROCESS CONTINUED

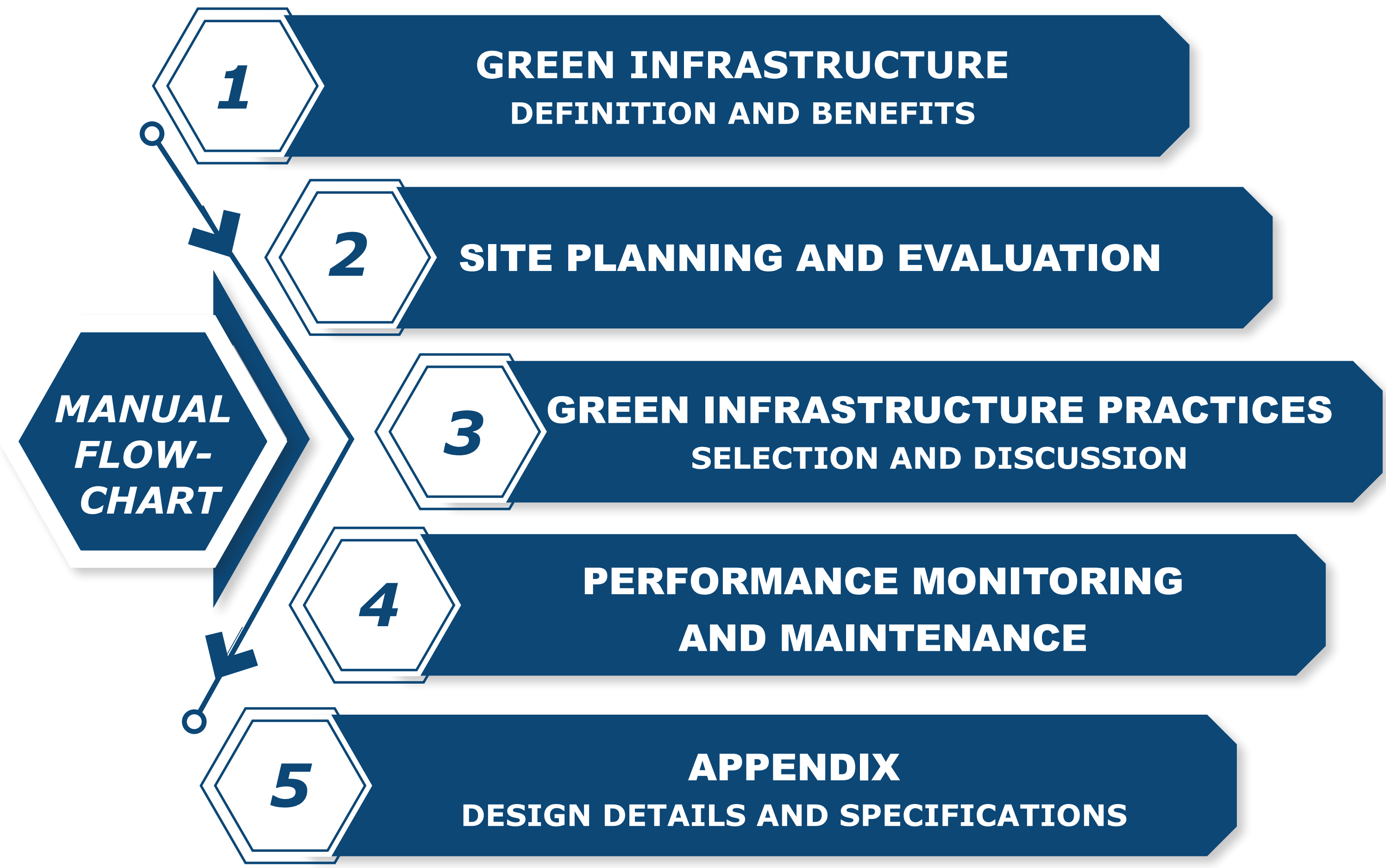
While some GI practices are highlighted in existing regulatory manuals, Hillsborough County has created this manual to provide further technical guidance to assist County capital projects managers and their consultants in implementing GI practices. The further green infrastructure guidance in this manual will assist County capital projects managers and their consultants to improve in the following areas:

- Right-of-way enhancement
- Water quality
- Landscape
- Stability of stormwater outfalls
- Preservation and restoration of natural areas
- Community well-being

B MANUAL LAYOUT

MANUAL ORGANIZATION

This manual is organized to follow the typical sequence for planning and design of GI practices during site development. Below is an outline of the chapters and their subtopics within the manual:



Chapter 3.0 contains the recommended GI Best Management Practices (BMPs) for Hillsborough County. As such, the user may benefit from using the table in Chapter 2.2 and the BMP-specific information in Chapter 3.0 as a quick reference guide for the selection of GI BMPs.

GREEN INFRASTRUCTURE MANUAL

1.0 INTRODUCTION

1.1 PURPOSE OF GREEN INFRASTRUCTURE

WHAT IS GREEN INFRASTRUCTURE?

Green Infrastructure (GI) is a range of natural and low-impact technologies that help urban environments collect and manage rainwater, in a way that provides an immediate visual, aesthetic, and environmental benefit to the community. Hillsborough County intends to use this manual to integrate green stormwater infrastructure into our community.

Green Infrastructure elements can be integrated into the community at several scales. Improvements for dense urban centers could include pervious pavement, rain gardens, or an urban tree canopy along a city street. Neighborhood green infrastructure could include park space for pedestrians adjacent to wet detention ponds or wetland areas. At the watershed scale, examples could include conserving large open natural spaces and flood-prone wetlands or landscaping steep hillsides. When GI systems are utilized as a component of the overall stormwater management system, they can provide cleaner air and water as well as add significant value for the community through flood protection, diverse habitat, and beautiful green spaces.

HOW DOES GREEN INFRASTRUCTURE HELP STORMWATER RUNOFF?

Stormwater and associated treatment areas are valuable resources and Hillsborough County recognizes that designing and implementing traditional stormwater management can be difficult in an urban setting with increased impervious surfaces and high property values. Directly connected impervious areas (DCIA) increase stormwater runoff volume and flow rate, and can lead to increased flooding, erosion, and potential infrastructure damage. Implementing GI practices promotes low impact development (LID). Both can help to reduce flooding and provide water quality benefits by slowing down runoff velocities and providing additional surface area for detention and infiltration.

Most rain events in Florida are less than 1-inch in total rainfall. Therefore, strategically placed GI practices, paired with native vegetation, can reduce erosive runoff velocities and act as a first point of infiltration, detention of the 'first flush', and reduce downstream sedimentation. GI practice promotes different methods of infiltration and storage and should be chosen based on the design requirements and site conditions. A site-specific combination of GI practices can be applied to most development scenarios in Hillsborough County but is especially useful for retrofitting existing sites with high percentages of impervious areas, such as those defined as commercial or light industrial.

MAINTENANCE AND COSTS

Maintenance costs associated with GI practices are mainly due to routine maintenance inspections and the labor needed to perform general mowing, weeding, and cleaning activities. Larger maintenance costs are usually associated with efforts such as vacuuming pervious pavement and replacement of biosorption activated media BAM at the end of its lifespan. Costs can be minimized by designing to reduce future maintenance requirements during the planning and design of GI practices. For example, maintenance costs for porous pavements can be reduced by not placing them in areas of expected high leaf litter or sediment, and BAM can be installed with additional thickness to extend the service life of the installation.

1.2 BENEFITS OF GREEN INFRASTRUCTURE

INTRODUCTION

Green infrastructure practices, such as permeable pavements, rain gardens, bioretention or bioswales, vegetative swales, infiltration trenches, plant boxes, rainwater harvesting (rain barrels or cisterns), rooftop (downspout) disconnection, urban tree canopies, and land greening and conservation, provide water quality and water quantity improvements for the community.

WATER QUALITY

Green Infrastructure practices provide water quality benefits by retaining and detaining stormwater, allowing for sediment and accumulated pollutants known as Total Suspended Solids (TSS) to settle out prior to entering downstream waters.

BIOSORPTION IS THE BINDING AND SEQUESTERING OF POLLUTANTS FROM AQUEOUS SOLUTIONS BY MICROBIAL CELLS

High levels of TSS cause turbidity and often contribute to increased concentrations of bacteria, nutrients, pesticides, and metals in the water. These pollutants attach to sediment particles and are carried into water bodies through stormwater runoff, damaging the water quality. Poor water quality can cause excess algal growth, reduced plant and animal populations and harmful anoxic zones resulting in fish kills. GI practices can also integrate biosorption activated media (BAM) to provide further nutrient reduction of dissolved constituents, like nitrogen and phosphorus. BAM and other "green medias" are usually a mixture of organic ingredients such as sand, clay, tire crumb, volcanic rock, or activated carbon. In a wet environment, phosphorus is adsorbed into the media and nitrates are converted biologically to nitrogen gas.

1.2 CONTINUED

FLOOD PROTECTION

Green infrastructure can help manage nuisance and localized flooding by preventing stormwater from overwhelming standard drainage pipes and inlets along streets. GI can decrease flooding by slowing down the flow of stormwater and reducing peak discharges. The increase of landscaped areas, rain gardens, and smaller depressions of detention provides stormwater runoff locations to store and infiltrate into the ground.

Promoting the conservation of open space, reducing impervious surfaces, and using small-scale stormwater controls can help maintain pre-development flood protection conditions and keep greater volumes of runoff from flowing to the stormwater system.

OTHER BENEFITS

Green infrastructure provides the community with increased opportunities to reap wellness benefits from the natural environment and diverse recreational opportunities. GI also provides enhancement of the natural habitat for birds and wildlife resulting in increased biodiversity, improved safety, community identity and a sense of well-being, and regional economic benefits. These GI elements are known to benefit the public health of the community through increased physical activity, reduced stress and anxiety, and access to greenspace for passive recreation. GI creates biking and walking trails as well as community spaces that positively impact social interaction. GI improves local aesthetics, increases property values, and revitalizes neighborhood, benefiting residents and business owners. This creates a stronger sense of community and the potential to reduce crime and crime related injury and stress.

GI PRACTICES HELP REDUCE AND FILTER TURBID STORM-WATER CAUSED BY HIGH FLOW RATES, SOIL EROSION, AND RUNOFF

GREEN INFRASTRUCTURE MANUAL

2.0 SITE EVALUATION AND PLANNING

2.1 GREEN INFRASTRUCTURE PRINCIPLES

INTRODUCTION

Pre-development natural drainage conditions are often disrupted by modern infrastructure. Using GI methods that mimic and preserve natural drainage in urban and suburban environments will improve water quality and restore environmental conditions.

UTILIZE EXISTING DRAINAGE

On larger commercial sites and multiple family residential sites, the strategic location of impervious surfaces and pervious areas will optimize water usage and stormwater treatment. Using multiple GI methods and practices in a treatment train approach creates a longer flow path for stormwater runoff resulting in greater infiltration to the vegetation root zone and less potable water required for irrigation. Greater infiltration within the vegetated areas of the site also results in less stormwater to convey downstream. This strategic mixing of pervious and impervious surfaces can be used on smaller projects as well, although site constraints may be more restrictive.

A TREATMENT TRAIN IS A SEQUENCE OF MULTIPLE STORMWATER TREATMENTS DESIGNED TO MAXIMIZE WATER QUALITY

DISCONNECT DIRECTLY CONNECTED IMPERVIOUS AREAS (DCIA)

Traditional stormwater mitigation methods typically use inlets and pipes to convey water to onsite treatment systems to remove pollutants. During large rain events, increases in runoff flow and velocity can clog drains with debris which results in overflow. This combination of trash, pollutants, and oils contributes to poor water quality.

GI solutions to controlling runoff relies heavily on reducing the impervious area or disconnecting impervious areas to allow rain to infiltrate where it falls, thereby reducing downstream flows.

DIRECTLY CONNECTED IMPERVIOUS AREAS (DCIA) ARE DEFINED AS SURFACES WHERE STORMWATER IS CONVEYED FROM AN IMPERVIOUS COVER TO A STORMDRAIN OR A WATERWAY

2.2 LOW IMPACT DEVELOPMENT

MINIMIZE DISTURBANCE

Low Impact Development (LID) combines systems and processes that mimic nature (bio-mimicry) and strategic land management strategies to replicate pre-development conditions on disturbed areas and reduce disturbances during construction. One form of LID is the use of green infrastructure. With emphasis on future planning and conservation, GI has numerous best practices for urban and suburban areas.

The LID concept promotes a method of treating stormwater onsite via natural infiltration and percolation and thereby mitigates water quality and water quantity impacts to surface waters and groundwater. LID design is a stormwater management approach that uses hydrologic controls (structural and non-structural) distributed throughout the site and may be integrated as a treatment train (i.e., in series) to replicate the natural hydrologic functioning of the landscape.

Green Infrastructure practices are one method of LID that should be used in urban and suburban areas. These use efforts that replace traditional stormwater collection systems with vegetated systems. All future designs in Hillsborough County should use GI as standard practices for existing and future development. GI should be considered in city planning, future land development, and landscape design projects and aim to mitigate stormwater and allow collection, storage, and pre-treatment.

PLANNING AND DESIGN CONSIDERATIONS

- Preserve or conserve existing site features and assets that facilitate natural hydrologic function.
- Reduce stormwater storage requirements for properties by decreasing impervious (paved) surfaces.
- Promote the strategic distribution of retention, detention, treatment, and infiltration of runoff.
- Harvest stormwater and rainwater onsite.
- Minimize site disturbance and compaction of soils through reduced site clearing.
- Consider utility conflicts when designing in urban environments.
- Plan for equipment access for needed maintenance.

2.3 SITE EVALUATION AND PLANNING

GREEN INFRASTRUCTURE CONSIDERATIONS

Prior to planning green infrastructure improvements, consider the following questions:

- What is the nature of the project/development?
- What natural features may provide opportunities or influence GI design and performance?
- What are the conditions within the drainage basin, for instance is there known flooding, water quality impairments or areas of poor conveyance?
- What are the existing drainage patterns onsite?
- What are the soil conditions onsite? Are they suitable for stormwater infiltration?
- Does the site contain existing drainage infrastructure that can be utilized?

DESIGNER RESPONSIBILITIES

- Preserve the natural condition of the site as much as possible.
- Accommodate the limitations of existing ROW and utilities.
- Protect (or transplant when necessary) existing healthy, well-established foliage and minimize the disturbance of land and natural drainage systems.
- In urban settings, replace and design traditional impermeable surfaces with permeable pavement as much as possible.
- Use GI to reduce property damage by anticipating heavily flooded areas and diverting water away from surrounding buildings.

SITE PLANNING

- Establish dedicated areas for the primary purpose of the site – buildings, roads, etc. – while trying to preserve desirable trees and protected wetlands.
- Identify and protect the function of legal easements on the property.
- Locate historical stormwater outfalls and form an initial plan to drain the property to that location(s).
- Look for ways to change traditionally impervious surfaces into pervious surfaces.
- Look for ways to add upstream storage to increase onsite infiltration.

2.4 SELECTING GREEN INFRASTRUCTURE BEST MANAGEMENT PRACTICES

FIGURE 2.1 GI BMP CONSIDERATIONS

The GI Guidance Chart below, lists the benefits and challenges of each GI practice in this document. This tool can be used to streamline planning and focus on GI practices which are practical for each site according to the three considerations below:

BMP Planning Considerations	Project applicability (Y or N)	Pretreatment	Bioretention	Wet detention	Bioswale	Constructed wetlands	Infiltration trench	Permeable pavement	Grass channel	Rain garden	Tree preservation	Urban forestation	Vegetated filter strips	Tree filter boxes	Rooftop runoff storage	Living shore-lines
See section		3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12	3.13	3.14	3.15
A. Project Conditons																
A.1 The project is constructed on undeveloped land		●	●	●	●	◐	●	●	●	●	●	●	●	●	●	●
A.2 The project is a retrofit		●	◐	◐	●	○	●	●	●	●	●	●	◐	●	●	●
A.3 The project is a linear project		●	●	◐	●	◐	●	●	●	●	●	●	●	●	○	●
A.4 The project is comprised of residential and commercial development		●	●	●	◐	◐	●	●	●	●	●	●	●	●	●	●
A.5 This site is predominantly commercial and impervious		●	●	◐	●	○	●	●	◐	●	●	●	◐	●	●	●
B. Site Conditions																
B.1 The seasonal high ground-water table is less than 1.5 feet below the surface		●	○	●	●	●	●	●	●	●	●	●	○	○	●	●
B.2 The soils onsite are poorly drained (i.e., SCS soils type B/D or C)		●	◐	●	●	●	●	●	●	●	●	●	●	●	●	●
B.3 The site is located within the 100-year floodplain		◐	●	●	●	●	◐	●	●	●	●	●	●	●	●	●
B.4 The site contains special environmental concerns, such as conservation, wetlands, animal habitat, etc.		●	●	●	●	●	●	●	●	●	●	●	◐	○	●	●
C. Expected Capital Costs and Level of Maintenance																
C.1 Capital investment		Medium	High	Medium	Low	Medium	High	High	Low	Medium	Low	Medium	High	Medium	Low	Medium
C.2 Maintenance Concerns		High	Medium	Low	Low	Low	High	High	Low	Medium	Low	Low	Low	Low	Low	Low

● GI Practice is feasible and recommended for consideration.
◐ The GI Practice may be feasible but may require special considerations in design.
○ The GI practice is not feasible for the conditions and should not be considered.

Low (Quarterly - Semiannual)
Medium (Monthly - Quarterly)
High (Weekly - Monthly)

Hillsborough County Florida

GREEN INFRASTRUCTURE MANUAL

3.0
GREEN INFRASTRUCTURE BEST PRACTICES

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3.0 RECOMMENDED GREEN INFRASTRUCTURE PRACTICES

GREEN INFRASTRUCTURE PRACTICES

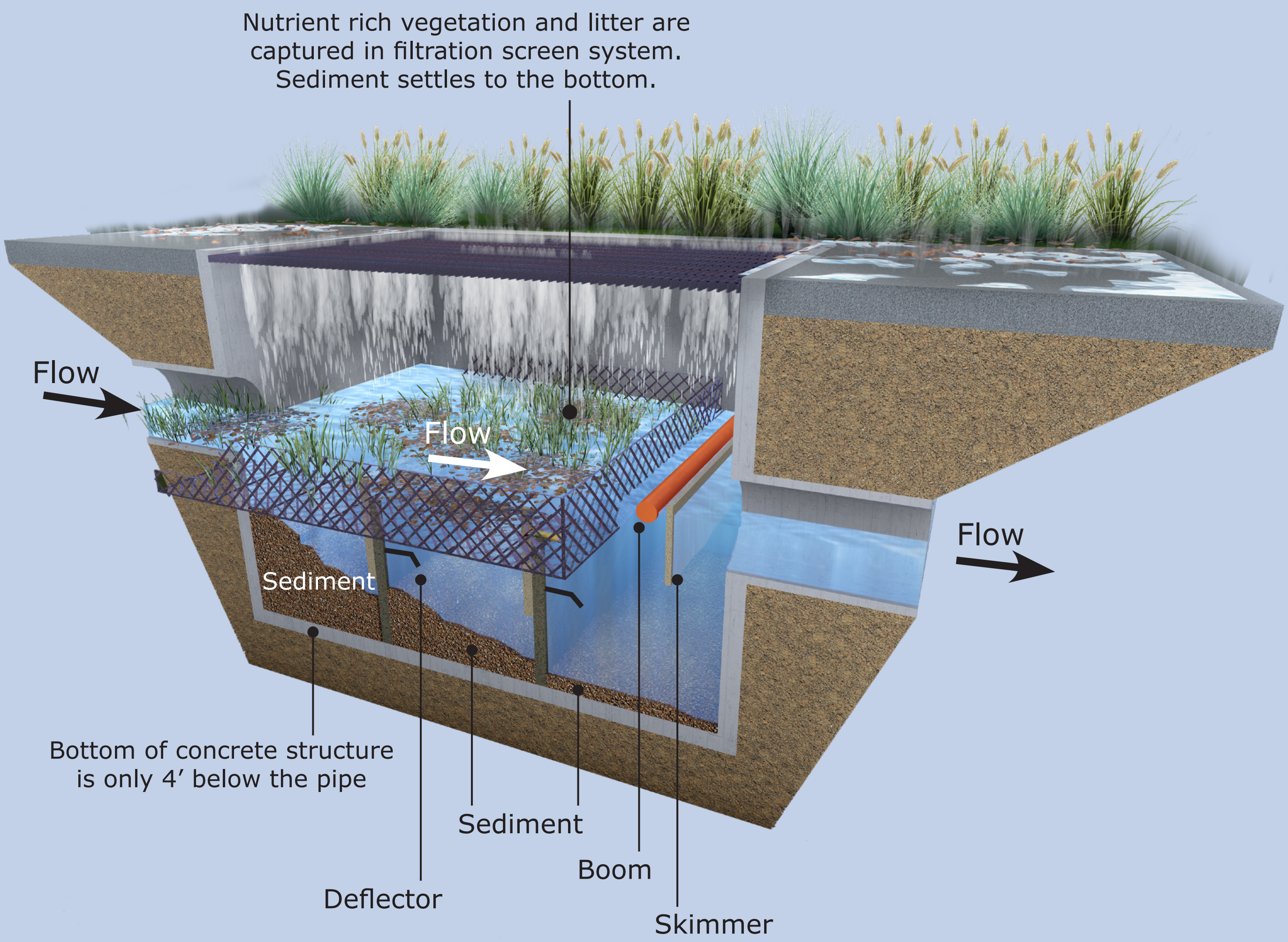
Chapter 3.0 steps through foundational information on each of the GI practices recommended for use in Hillsborough County. For each GI practice listed below:

(1) Description and Function, (2) Design Criteria, (3) Performance and Maintenance Level, and (4) Where to use, are discussed.

3.0 CONTINUED

- INFILTRATION TRENCH
- GRASS CHANNEL
- TREE PRESERVATION
- URBAN FORESTATION
- VEGETATED FILTER STRIPS
- TREE FILTER BOXES
- ROOFTOP RUNOFF STORAGE
- LIVING SHORELINES

3.1 PRETREATMENT



DESCRIPTION AND FUNCTION

Pretreatment devices are systems of preliminary runoff filtration measures for GI practices. These can include inlet baskets, baffles, trash racks, grass/aggregate buffers, and/or a forebay in retention ponds. The goal is to remove as much waste as possible before the water reaches the primary treatment area and reduces maintenance by preventing overload of the system. A pretreatment device may also aid in reducing the runoff flow rate.

DESIGN CRITERIA & PERFORMANCE

Drainage area and runoff water quality will determine the type of pretreatment to pair with the primary GI practices. The size of the pretreatment device should increase with increased drainage area and/or presence of large debris and trash in runoff. However, the presence of any pretreatment device, regardless of size, will provide some initial treatment, which can increase the longevity of any downstream GI practices. Maintenance access should be considered when designing the pretreatment areas and drainage structures.

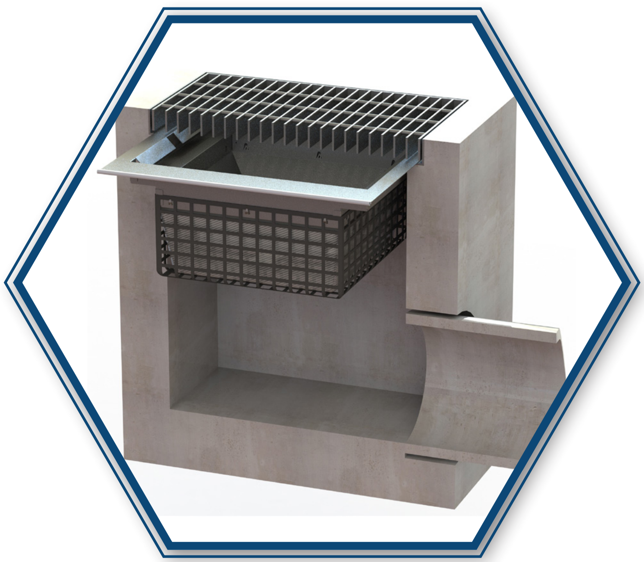
MAINTENANCE

Success of pretreatment areas relies heavily on monitoring and maintenance to ensure proper function. Use of pretreatment devices should be limited to areas maintained by the County or where regular street sweeping and maintenance will occur.

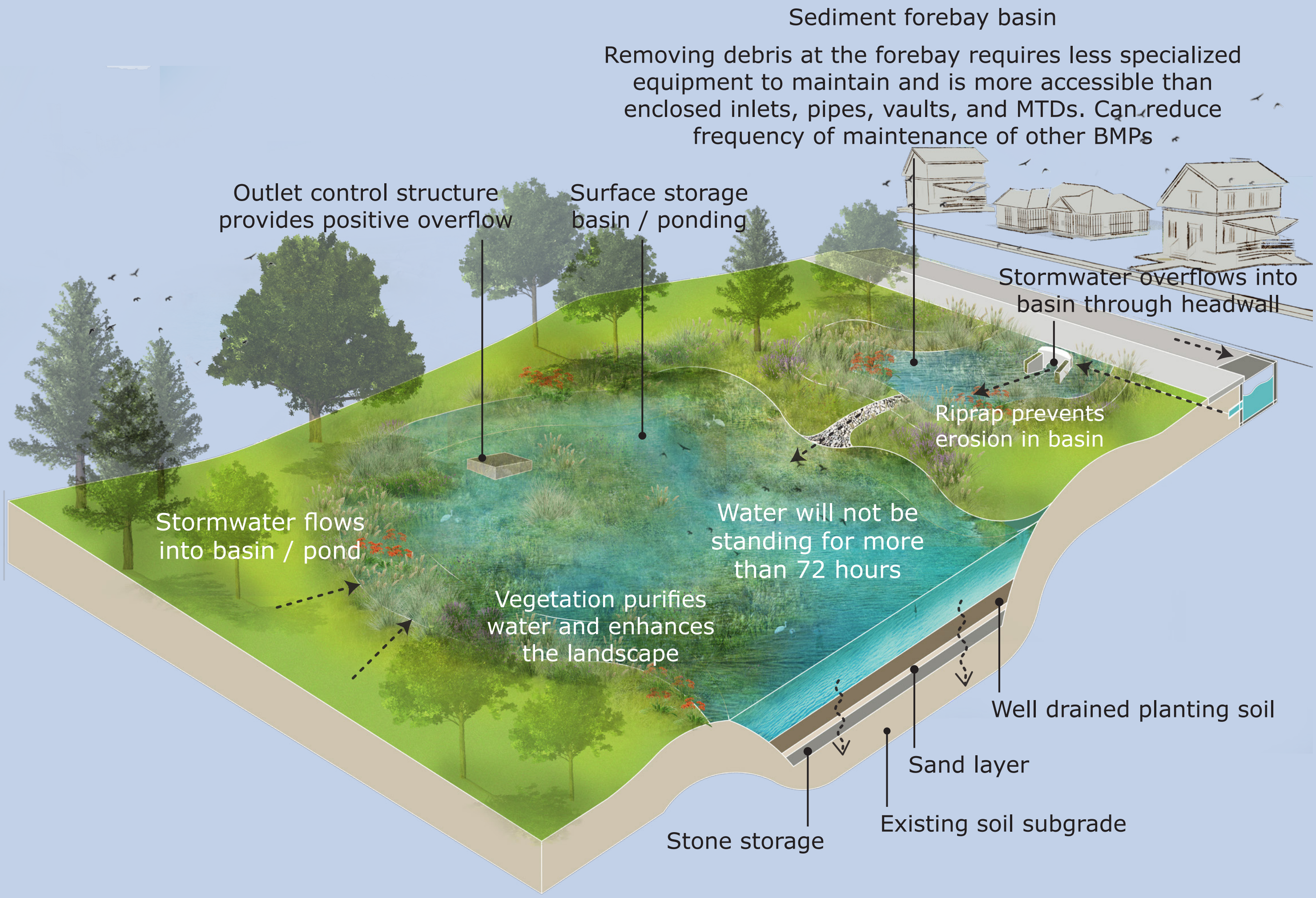
Level of Maintenance: Moderate. Inspections every two months or as recommended by the manufacturer to inspect and remove sediment, debris, and trash, especially in a high-debris area. Semi-annual inspections to repair erosion and look for cracks and joint failure.

WHERE TO USE

Pretreatment should be considered on all sites that include GI practices. The size, type and extent of pretreatment will vary depending on the drainage basin and available land for the pretreatment feature. Energy dissipation, grass buffer strips and inlet baffles may be adequate for smaller scale sites, while larger sites might require centralized sediment separators or trash racks for more robust pretreatment.



3.2 BIORETENTION

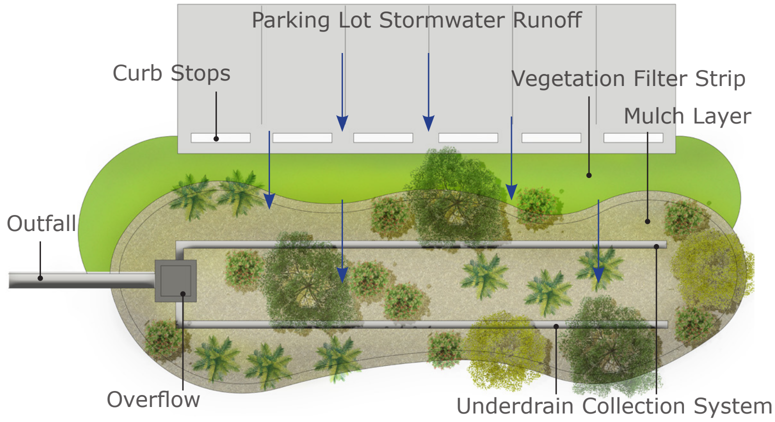


DESCRIPTION AND FUNCTION

Bioretention is the use of shallow depressed areas that employ engineered soil media and carefully selected plant materials from the Hillsborough County Approved Plant List (link provided in Appendix Reference List) that include trees, shrubs, and other herbaceous vegetation. Growth rate and maintenance should be taken into consideration when selecting plants. There are many design options for this practice that make it suitable for a variety of applications including green streets, parking lots, parks, and residential areas. A bioretention basin could be used as a community educational feature that can promote sustainable business commitments.

DESIGN CRITERIA & PERFORMANCE

Basin size will be based on the design storm and drainage area. An advantage of this practice is that media depth can be increased, to an extent, if surface area is limited. Basins can either promote exfiltration to the in-situ soils or the media can be lined, and the discharge routed through an underdrain to the storm drain network.



Capturing large debris at the forebay requires less technical and less expensive maintenance than cleaning out inlets, pipes, vaults, and manufactured treatment devices and can reduce frequency of maintenance of other BMPs. A capped cleanout pipe should be installed for each underdrain for observation and maintenance. Bioretention is not suitable if there are less than 2 feet of separation between the seasonal high water table (SHWT) and the bottom of the bioretention area. BAM should be used in areas where nutrient reduction is desired. Native vegetation species should be prioritized and should be selected to tolerate a wide range of moisture conditions, as described in the Hillsborough County Approved Plant List (link provided in Appendix Reference List).

MAINTENANCE

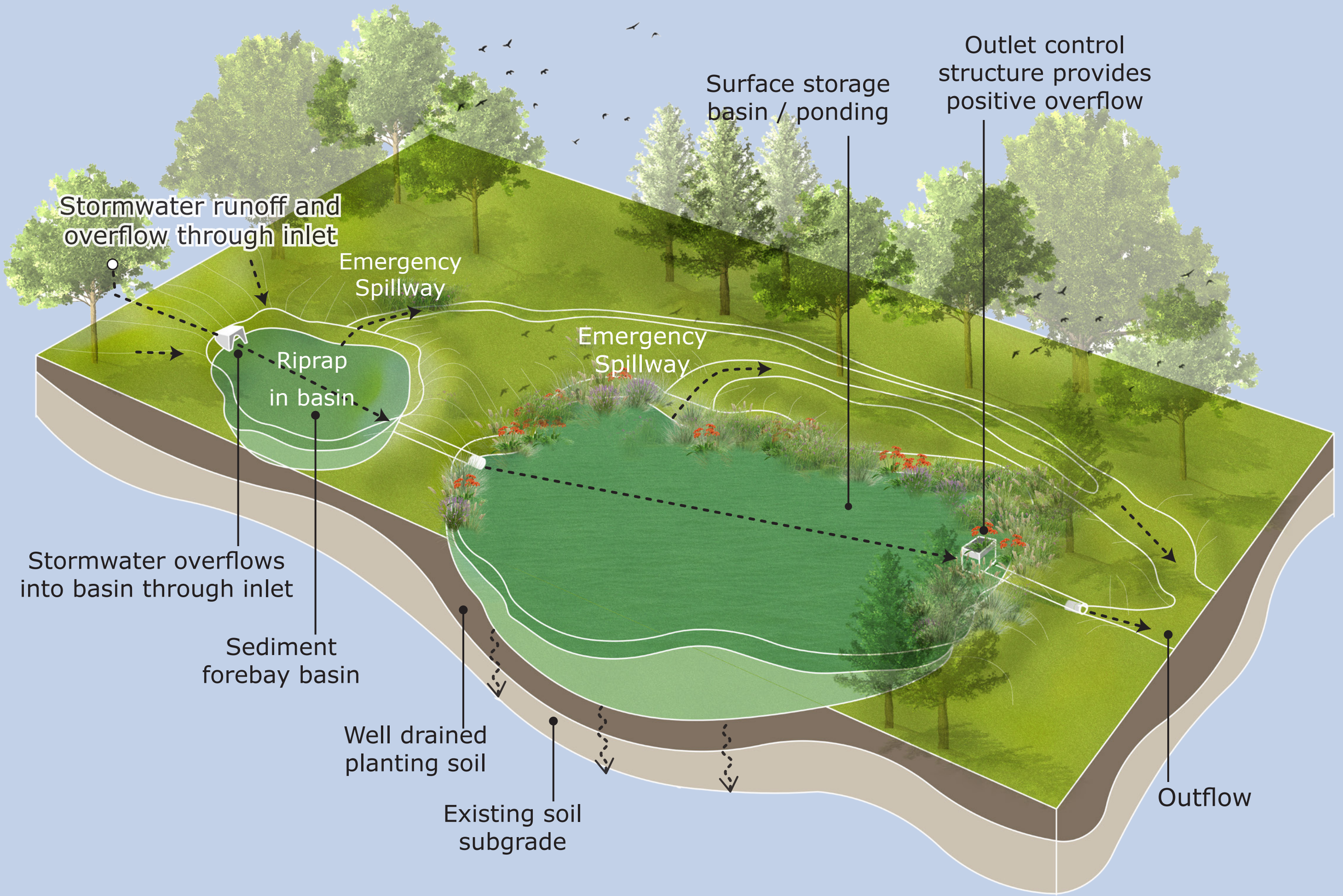
Bioretention media are designed to specifically detain stormwater runoff in the soil media and treat stormwater primarily through infiltration and plant uptake of nutrients, metals, hydrocarbons, and bacterial pollutants. Studies have shown that bioretention media has a good lifespan (20 – 40 years), but proper maintenance is needed. Native vegetation species should be prioritized from the Hillsborough County Approved Plant List (link provided in Appendix Reference List); do not use any invasive species.

Level of Maintenance: Moderate. Inspect sites after heavy rain events to observe standing water and erosion. Monthly inspections to remove sediment, debris, and trash. Quarterly inspections should be performed to repair erosion and replace

WHERE TO USE

Bioretention basins are best suited for small drainage areas, or within urbanized areas or parking lots, where the landscaped islands can become aesthetic features. These basins can be used where there is a need to provide additional rainfall storage and infiltration and where it might be necessary to disconnect impervious areas.

3.3 WET DETENTION



DESCRIPTION AND FUNCTION

Detention basins are ponds designed to hold stormwater for extended periods of time and to have a permanent pool of water. Permanent pools allow for mixing with incoming runoff and subsequent treatment by nutrient uptake, nutrient absorption, and sedimentation. Stormwater is treated by the settling down of suspended sediment, biological uptake for dissolved pollutants, and sometimes, chemical processes such as alum injection to accelerate pollutant removal. Detention basins provide the additional benefit of mitigating flooding and erosion by reducing the peak discharge velocity of stormwater runoff routed through the pond.

DESIGN CRITERIA & PERFORMANCE

Maximum design storm capacity should be considered when choosing the pond location. Detention basins typically require a larger footprint than other GI practices, due to the requirement for flatter side slopes. Areas prone to pooling water with no outlet can be desirable conditions in which to place detention basins. The design storm runoff volume will determine the outlet structure size. This structure is installed to release runoff over a period of days until the basin returns to the normal permanent pool elevation. The outlet structure is recommended to have a trash rack to prevent trash and large debris from entering the downstream waterway. A minimum 1 foot freeboard above the peak design stage should be used to protect against damage from overtopping during large storm events. Gentle slopes allow for littoral-zone vegetation growth and provide safety for foot traffic. Growth rate and maintenance should be taken into consideration when selecting plants from the Hillsborough County Approved Plant List (link provided in Appendix Reference List). Gentle slopes allow for littoral-zone vegetation growth and provide safety for foot traffic. An emergency spillway may be included if the consequences of overtopping are severe. Additionally, the depth of the permanent pool should be at least 6 feet deep to discourage aquatic weed growth and be designed with an additional 6 to 12 inches to account for sedimentation over time. For harvesting stormwater from the detention pond, see the Pinellas County Stormwater Manual for design guidance.

MAINTENANCE

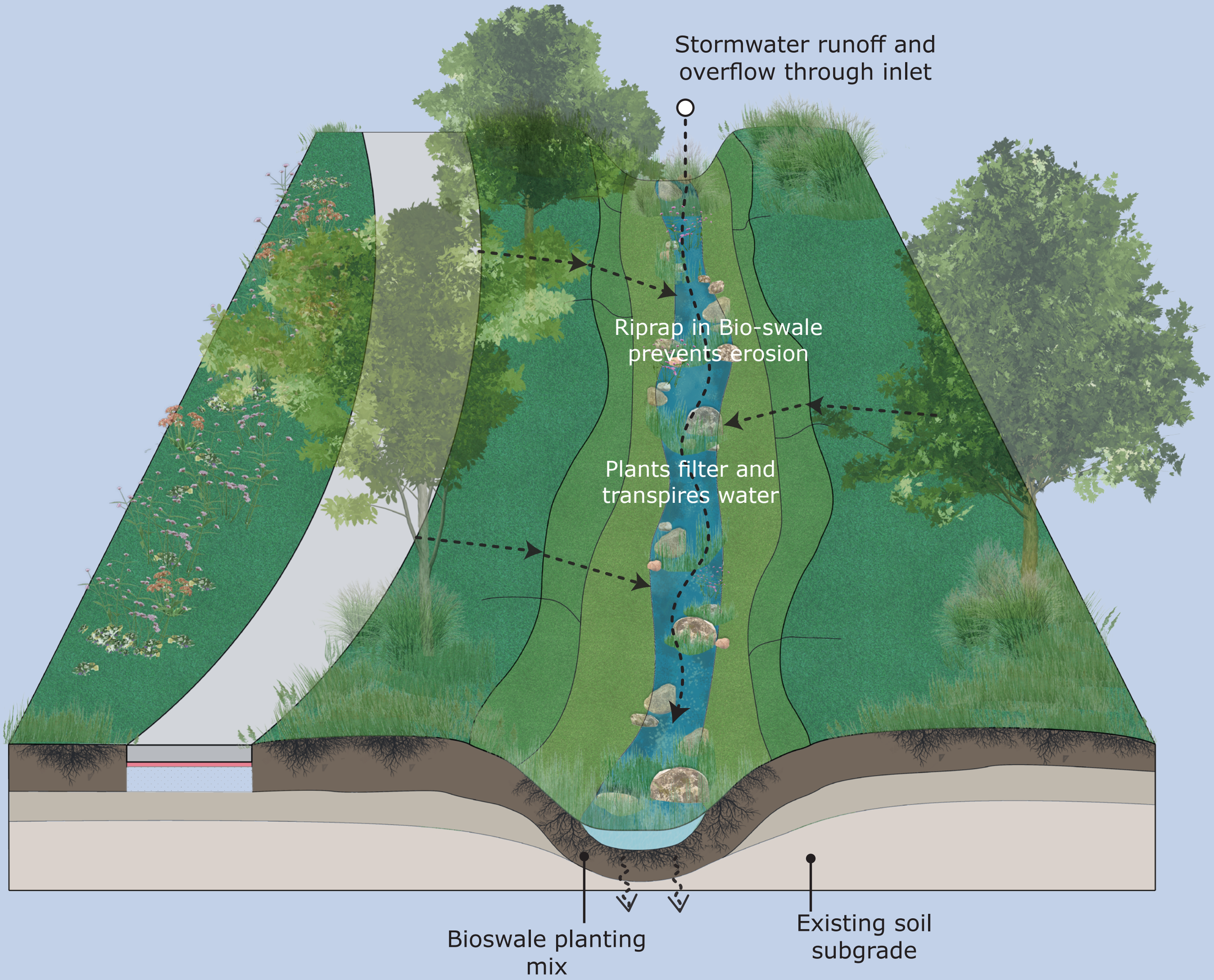
Ongoing maintenance of the outlet structure and emergency spillway helps prevent the necessity of maintenance repairs from overtopping. Debris should be cleared from the control structure, bleed down orifice, and overflow features to ensure their proper function. If debris problems persist, a skimmer or cage may be installed around the perimeter of the outlet structure to intercept debris before they reach the outlet structure.

Level of Maintenance: Moderate. Monthly inspections to mow slopes and keep ponds clear of trash and debris. Quarterly inspections of outfall structure and pipes for excess sediment, cracks, clogging, and pipe joint failures. Remove excess sediment from pond basin annually. Over-digging of the permanent pool depth can extend the cleanout cycle.

WHERE TO USE

Wet detention systems are most applicable in areas with high water tables and where sufficient land is available. Wet detention systems mimic natural lake functions and therefore are great candidates for large-scale regional stormwater ponds capturing runoff from a larger upstream basin. For regional watershed management involving the Florida Department of Transportation, please see the WATERSS Process Guidebook.

3.4 BIOSWALES

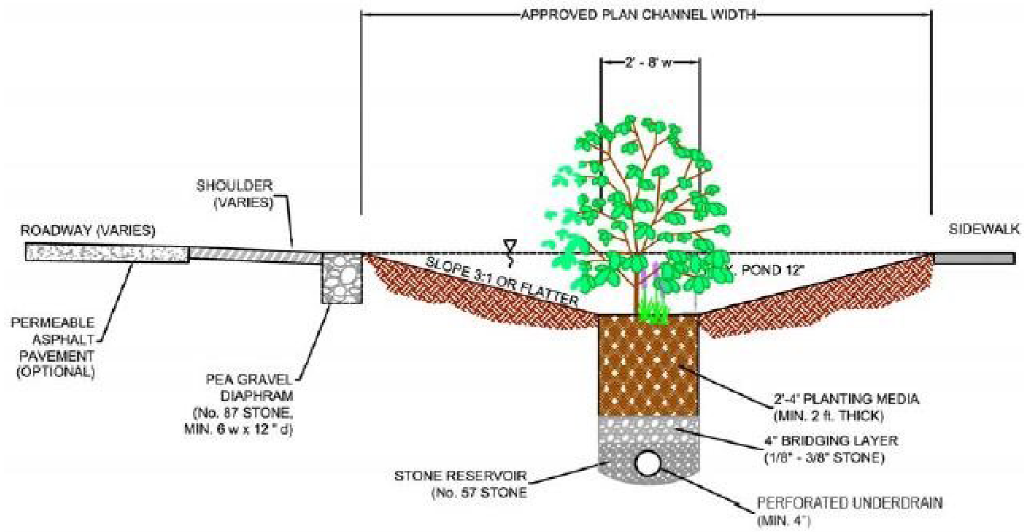


DESCRIPTION AND FUNCTION

Bioswales are engineered channels designed for stormwater conveyance and treatment. Bioswales aim to restore pre-development hydrology by reducing flowrate as water is slowed by vegetation and/or infiltrates within the system. This practice utilizes plantings and bioretention media below the vegetated surface to promote increased infiltration and pollutant removal and will therefore have more water quality treatment compared to a standard swale. A perforated underdrain can be used based on the groundwater level at the site; internal storage may be added for increased retention and pollutant removal. This practice can be used on a site regardless of underlying soil type. However, if the in-situ soil is clay or has a poor infiltration rate, then an underdrain should be used to route stored runoff away from the bioswale rather than rely on exfiltration.

DESIGN CRITERIA & PERFORMANCE

Bioswales have specific slope requirements with depth ratios between 1% and 2% to allow for proper drainage. Stormwater is routed to the upstream portion of the bioswale and moves along the ditch surface, while also infiltrating into the underlying media. Typically, the ditch surface is lined with native grass, but can also include native flowers and shrubs. Vegetation selection should ensure potential root depth does not extend past the depth and width of bioretention media if the practice is lined.



Generally, a bioswale trench will be installed above the seasonal high groundwater table. In cases where groundwater interference occurs, the base of this bioswale trench could be lined with an impermeable liner if all water is to be routed to an existing drain network. A perforated underdrain may be installed towards the base of the media trench if soil infiltration is inadequate to drain the swale. The underdrain should include a capped cleanout pipe to allow for flushing as necessary.

MAINTENANCE

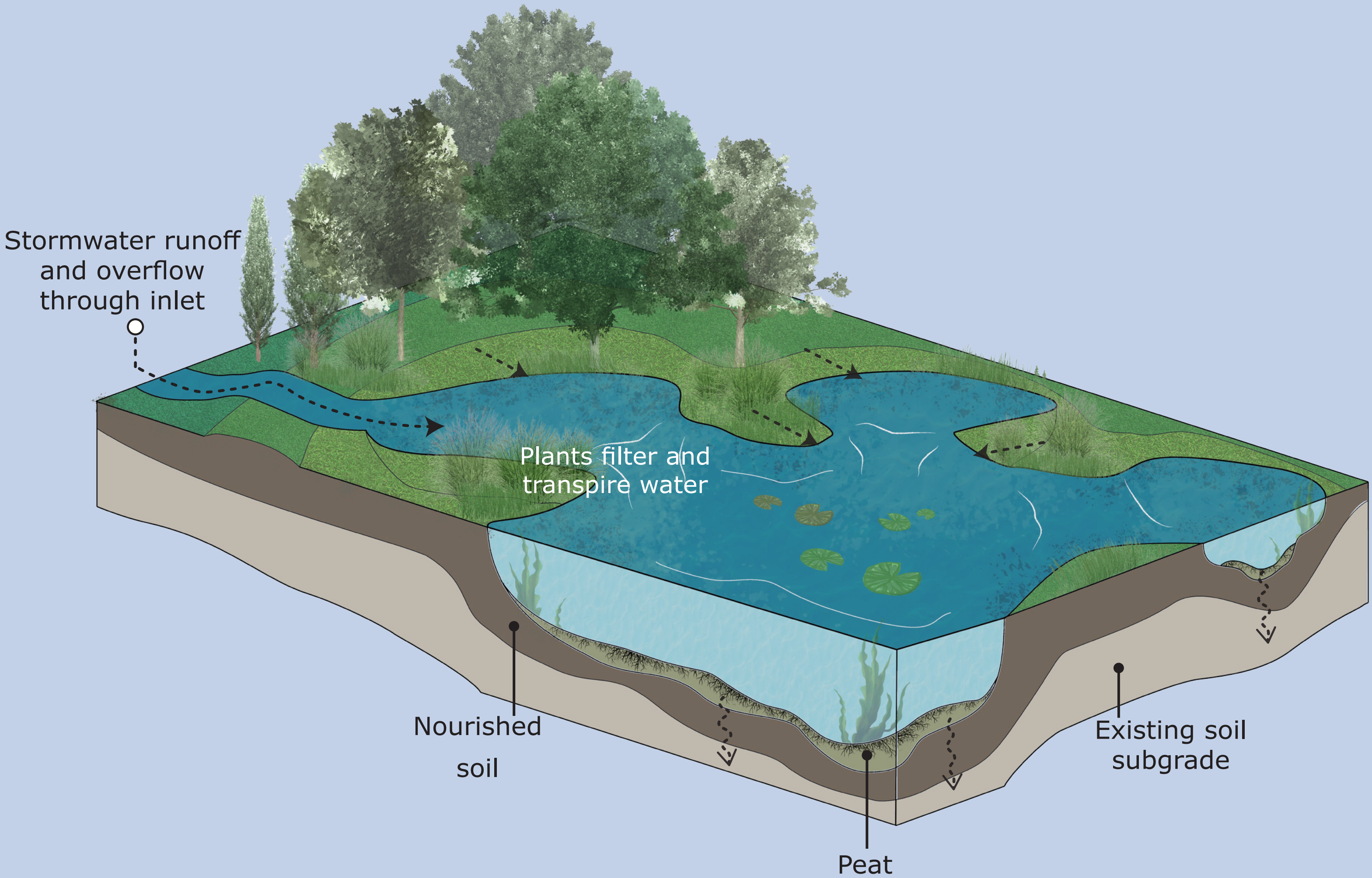
The removal of accumulated sediment is essential to protect the infiltration capacity of the bioswale.

Level of Maintenance: Moderate. Monthly inspections to remove trash and debris and remove invasive vegetation. Semi-annual inspections to remove sediment accumulation, dead/dying vegetation, and address any areas of erosion.

WHERE TO USE

Bioswales are best suited for small drainage areas or along roads and sidewalks in urbanized areas where linear landscaped areas can become aesthetic features. These swales can be used where there is a need to provide additional stormwater conveyance, storage, and infiltration, and where it might be necessary to disconnect impervious area.

3.5 CONSTRUCTED WETLANDS



DESCRIPTION AND FUNCTION

Constructed Wetlands are designed for stormwater treatment, storage, and infiltration. Storage pools may be excavated from uplands to hold considerable amounts of stormwater. Treatment occurs through sedimentation and filtration, mimicking the beneficial performance of natural wetlands. GI wetlands can easily be implemented in a park, neighborhood green spaces, or along the outside of large developments (e.g., mall parking lots). Constructed wetlands will become wetlands regulated by the state and the Environmental Protection Commission (EPC) of Hillsborough County. Additionally, the EPC requires a 30-foot setback from wetlands and prohibits construction activities within the wetlands and the wetland setback.

DESIGN CRITERIA & PERFORMANCE

Constructed wetlands are typically used for polishing stormwater treated by other BMPs. Designs should provide small pools throughout the system to provide adequate storage for the expected site runoff. Invasive species are not permitted. Growth rate, maintenance and aquatic wildlife habitat viability should be taken into consideration when selecting plants from the Hillsborough County Approved Plant List (link provided in Appendix Reference List). Pools need to be designed to adequately maintain the targeted permanent pool depth, along with the necessary flood storage. Additionally, outflow structures should be designed such that the flood storage is removed within a period of days to be available for subsequent storms.

MAINTENANCE

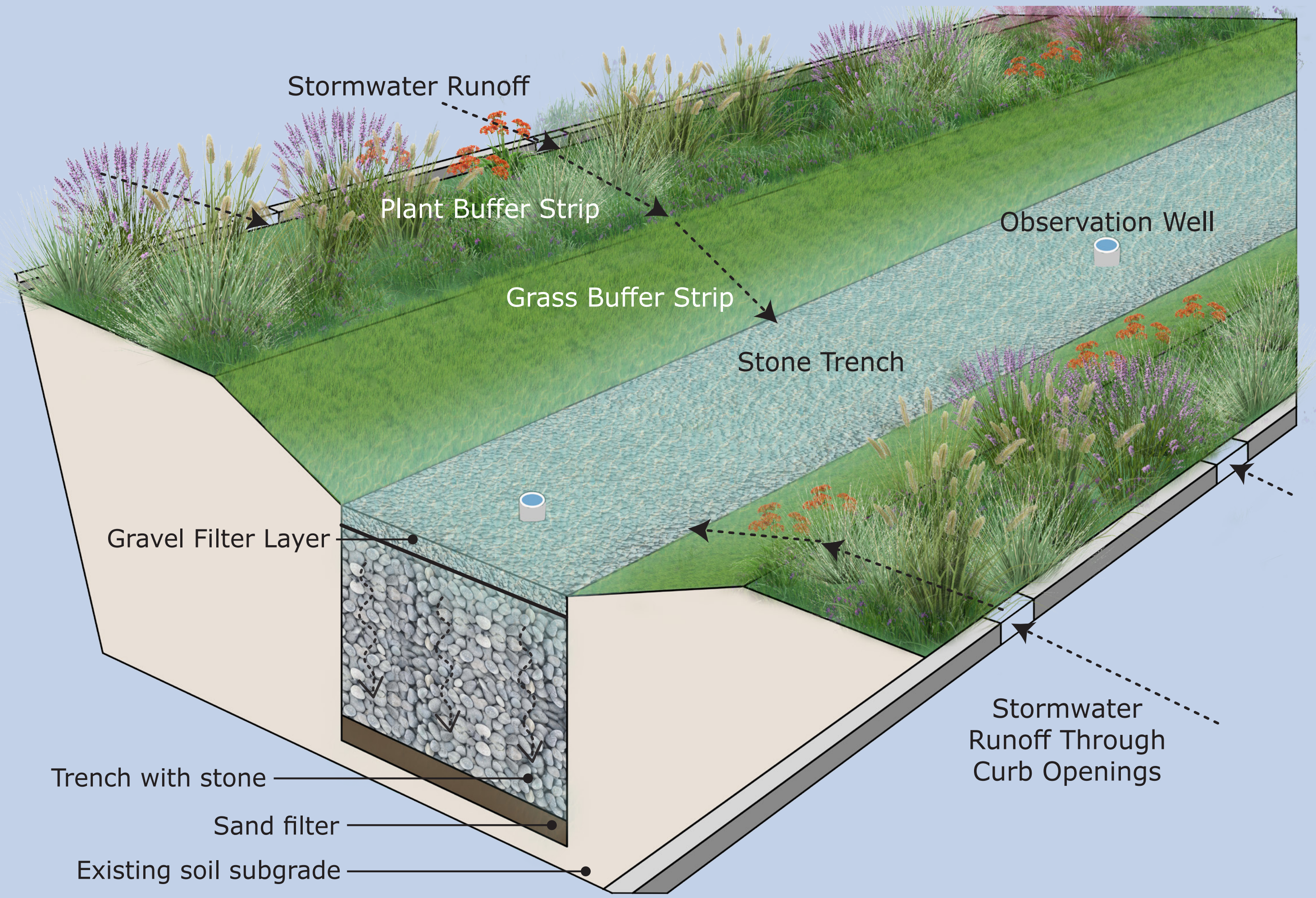
Constructed wetlands are not intended to flow into existing wetlands. They are shallow pools which treat stormwater primarily using biological and sedimentation methods. Plant selection is key for functionality as aquatic plants improve water quality through the uptake of pollutants. Pool depth should be designed to provide sufficient time for necessary sedimentation to allow outflow to meet necessary standards or guidelines.

Level of Maintenance: Low. Quarterly inspections of embankments, functioning water level and any valves or inlet/ outlet structures. Remove sediment accumulation and overgrown vegetation.

WHERE TO USE

Constructed wetlands are best used when there is a need to mimic the functions of natural wetlands. Wetlands capture stormwater, provide water quality, and create wildlife habitat. Constructed wetlands are typically used for polishing stormwater treated by other BMPs in locations with a high groundwater table, but where it might not be feasible to create the required depth of a permanent pool.

3.6 INFILTRATION TRENCH



DESCRIPTION AND FUNCTION

Infiltration trenches are filled with aggregate to accept stormwater runoff and create an onsite reservoir. The trench retains and infiltrates runoff, allowing it to return to the aquifer. When installed as drainage features underneath parking lots and other locations where the availability of land is limited, these are typically called exfiltration trenches, since the focus is on drainage rather than groundwater recharge.

Infiltration (and exfiltration trenches) are lined with filter fabric to prevent the migration of surrounding soil into the voids of the rock-filled trench.

DESIGN CRITERIA & PERFORMANCE

Infiltration trenches are shallow and consist of aggregate surrounded by filter fabric. Sizes can vary from 4 to 8 feet in depth and are typically used on sites with porous soil (not clay) and little space for BMPs that require a larger undeveloped footprint. Thus, parking lots in largely impervious developments often use infiltration trenches (a.k.a. exfiltration trenches) to manage stormwater. Where good infiltration exists, weirs can be installed in the downstream drainage structure to hold runoff within the rock trench to allow sufficient time for the runoff to infiltrate into the parent soil. Where infiltration trenches are open to the ground surface, vegetated strips should be placed between the runoff from an impervious surface and the trench to intercept and filter out suspended sediment in the runoff. A safety factor of 2 is used in modeling the expected infiltration rates. Keep the trench above the groundwater table to improve discharge and filter pollutants before discharge to the groundwater. Be careful to guard the trench against siltation during construction.

MAINTENANCE

Infiltration trenches are not designed to filter trash or other insoluble pollutants and functionality relies on regular maintenance. Infiltration into surrounding in-situ soils should take no longer than 2 - 3 days. The trench needs rehabilitation or replacement when the void spaces become filled with sediment; therefore, to extend trench service life, a vegetated buffer should be maintained between the source of runoff and the trench.

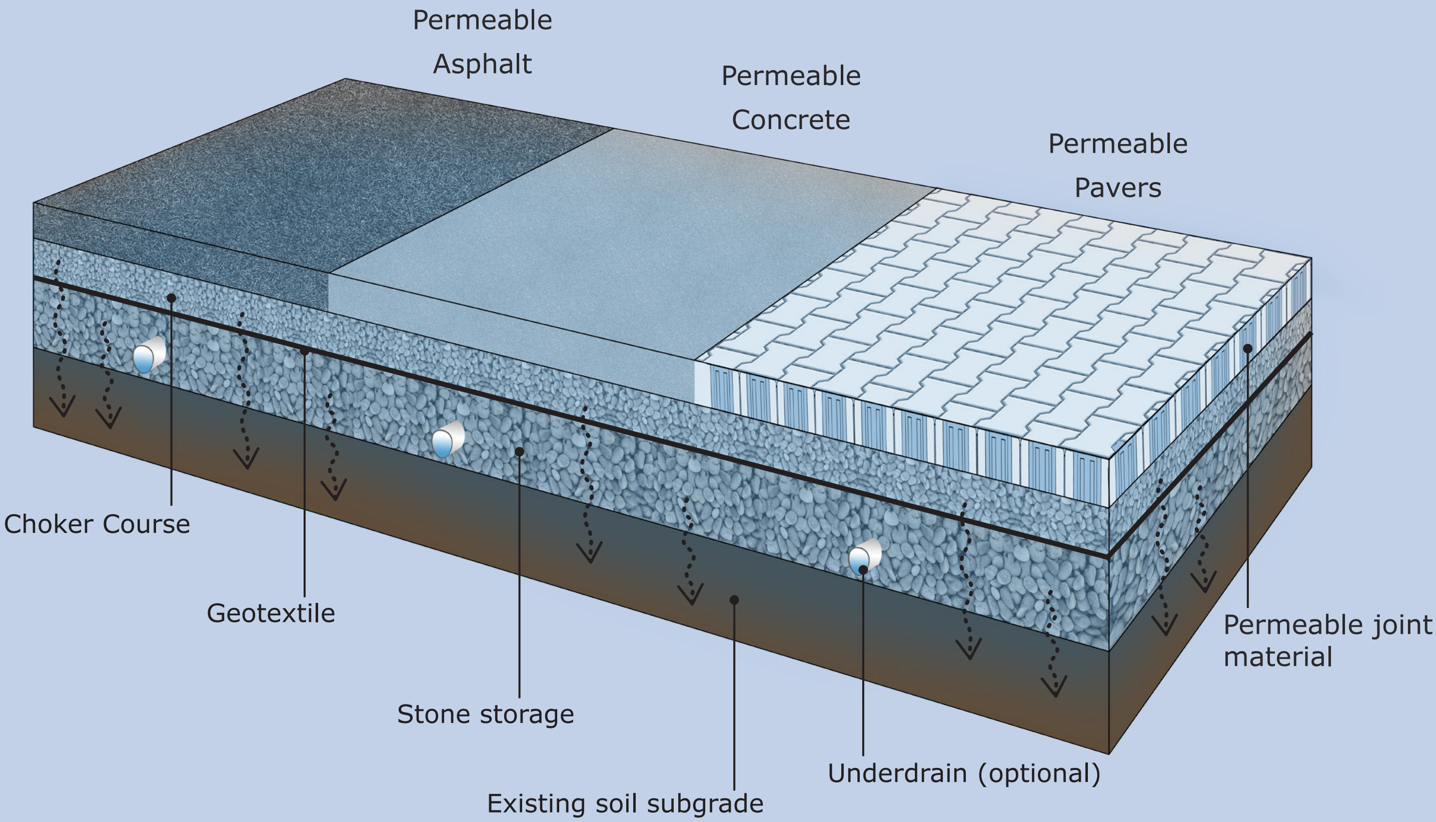
Level of Maintenance: Low. Monthly inspections to remove trash and debris, sediment accumulation and dead/dying vegetation that could cause clogging. Semi-annual inspection for signs of damage to structural components.

WHERE TO USE

An infiltration trench should be used in locations where the natural soil has moderate but limited infiltration capabilities, groundwater is low and underground storage is needed to allow the stormwater runoff time to seep into the ground. Infiltration trenches are linear by nature, and therefore are well suited for perimeter installation or along linear site features. Infiltration trenches can clog with sediment, and therefore should not be used to accept runoff from drainage areas with largely clay soils.

KEEP INFILTRATION TRENCHES ABOVE THE GROUNDWATER TABLE TO IMPROVE DISCHARGE AND FILTER POLLUTANTS

3.7 PERMEABLE PAVEMENT



DESCRIPTION AND FUNCTION

Permeable pavement is a porous surface practice which promotes infiltration while still providing a paved surface for pedestrian and vehicular traffic. Permeable pavements are designed to have pores throughout to allow the passage of water, which reduce the compressive strength of the pavement but are still suitable for many applications. There are several different types including interlocking pavers, porous concrete, and porous asphalt. These methods replace traditional impervious surfaces, which do not allow infiltration into underlying soil. Consider the effects of exfiltration to nearby site features and design for appropriate storage volume of the stormwater runoff and waste collection.

DESIGN CRITERIA & PERFORMANCE

Permeable pavement systems consist of three layers: pavers on the surface (interlocking blocks, permeable concrete, or asphalt, etc.), a filter, and an aggregate storage layer. The seasonal highwater table must be at least 2 feet below the bottom of the pervious pavement system to protect the groundwater.

MAINTENANCE

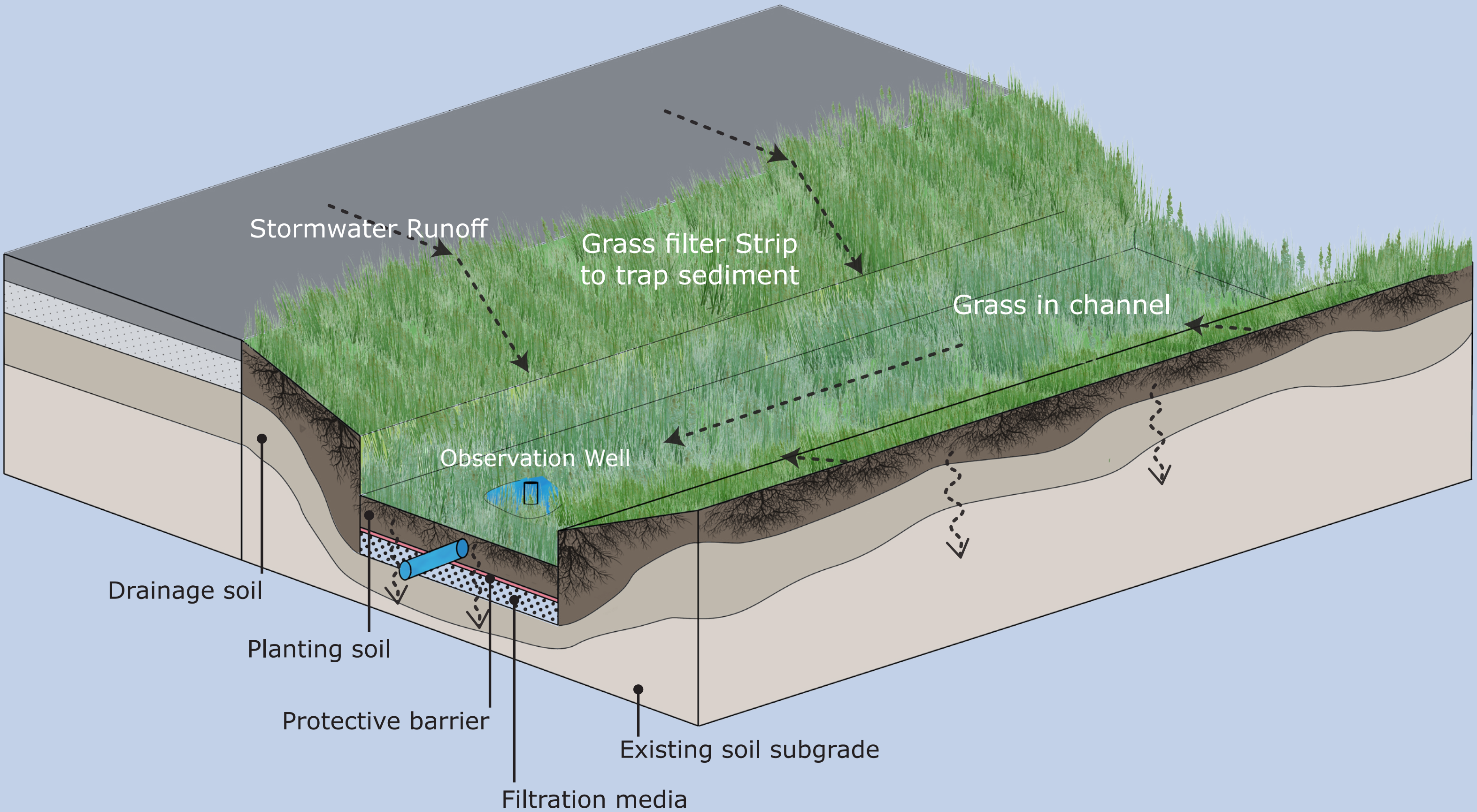
Permeable pavements may be rehabilitated by pressure washing and vacuuming to remove fine particles that have settled into the pore spaces, which increases infiltration. Permeable pavement should not, therefore, be used in areas with significant sand migration, such as beaches. If used in such locations, permeable pavements will require more frequent rehabilitation.

Level of Maintenance: Moderate. Quarterly inspections of pavement condition for clogging, cracks, and spalling. Repair pavers, concrete, joints and remove debris, trash, invasive vegetation, and stains. Periodic vacuum sweeping is recommended to restore pavement infiltration.

WHERE TO USE

Permeable pavement can be used in lieu of traditional pavement in most applications with light compressive and shear loadings. It is primarily used in settings such as trails, sidewalks, alleyways, parking lots, and parking stalls, due to load bearing limitations. Permeable pavement should not be used in high traffic areas, nor in drive lanes where the surface will be exposed to excessive shear stress. Be sure to check local zoning regulations for sidewalk and trail pavement requirements. Designers should consult the manufacturer for appropriate design loads for the material. Permeable pavement should not be used within the right-of-way without an operation and maintenance agreement in place and the approval of the County Engineer. Permeable asphalt should not be used under gasoline or diesel vehicles since the oils from cars and trucks will eventually dissolve the asphalt.

3.8 GRASS CHANNEL



DESCRIPTION AND FUNCTION

Grassed channels are long, man-made ditches designed to convey stormwater runoff with sufficient residence time to allow time for sedimentation and nutrient uptake. This practice is designed to capture runoff from adjacent paved surfaces. Sod is the recommended vegetation approach to achieve fast cover and prevent erosion. However, sod that is grown in soil that has an impermeable layer should be avoided, as this soil can be transferred during installation, limiting future infiltration. Grass seeding is an option, but requires significant time, water, and maintenance to achieve adequate cover.

DESIGN CRITERIA & PERFORMANCE

Gentle side slopes (flatter than or equal to 4 feet horizontal to 1 foot vertical) should be used, vegetated with sod or grass for soil stabilization. Side slopes may be increased due to limited room for the channel. If the site requires a steeper longitudinal slope, then reinforcement matting, or staked sod can be included to handle the higher velocities. The channel should have standing or flowing water only following a rainfall event. The area contributing to each channel should be limited to result in a low velocity in the channel. These channels are designed to infiltrate into underlying soils and are therefore best suited for well-drained soils. Channels located on more poorly drained soils can be improved using soil amendments, such as bioactivated absorption media. A minimum depth from the channel bottom to the seasonal highwater table of 2 feet should be maintained to encourage infiltration and allow for mowing without damage to the channel.

MAINTENANCE

Level of Maintenance: Low.

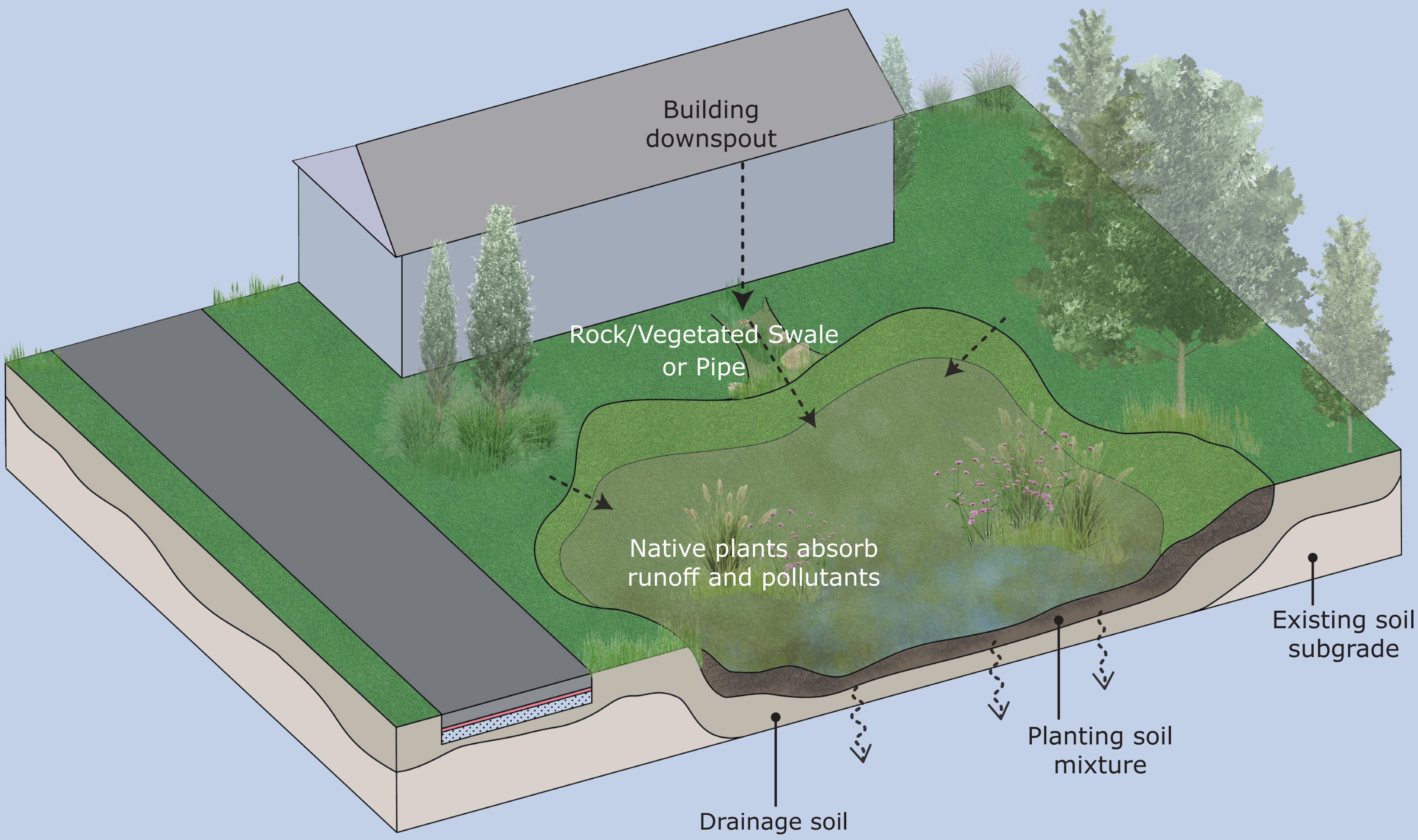
Mow grassed swales monthly and water as needed.

WHERE TO USE

Grassed swales are typically used when there is a need to convey and infiltrate stormwater runoff. Recommended use is along roadways but can be beneficial in other locations including lawns, roadway medians, parking lot islands, and drainage easements. Swales should not impound water nor be constructed in areas with a high water table causing standing water at the bottom.

GRASS CHANNELS SHOULD HAVE STANDING OR FLOWING WATER ONLY FOLLOWING A RAINFALL EVENT

3.9 RAIN GARDEN



DESCRIPTION AND FUNCTION

Rain gardens are small-scaled retention basins located near sidewalks, buildings, and roof downspouts. Stormwater runs off impervious surfaces and is diverted away from structures into these shallow basins. This practice promotes infiltration, reducing flood risk and filtering trash, chemicals, oils, and pollutants, resulting in water quality improvements to downstream waters. Rain gardens can be designed with native soils or with specialized bioretention media based on the specific site requirements, and should utilize native flora and fauna; thus, this practice restores habitat to insects, birds, and small animals. Choose plants that can perform in all seasons and tolerate wet root zones, so that rain gardens have year-round activity.

DESIGN CRITERIA & PERFORMANCE

The area draining to the rain garden should be relatively small. The seasonal high ground water table should be at least 2 feet below the bottom of the rain garden and relatively flat slopes (< 5%) are required to accommodate runoff filtering through the system. Soils should have at least moderate infiltration rates; if the soil is not permeable enough for retention, design the rain garden as a bio-filtration system with an under-drain. An overflow conveyance system should be included to pass larger storms.

Plants indigenous to Florida are required for rain garden implementation, for both functionality and maintenance. Effective native plants are based on climate, rainfall, and wildlife present. It is important to select plants that will tolerate a wide range of moisture conditions. Dense plantings are necessary for establishing root systems and mimicking natural growth patterns. Select plant varieties that will avoid monocultures, encourage wildlife habitation, and promote healthy root systems. Growth rate, irrigation needs, and maintenance should be taken into consideration when selecting plants from the Hillsborough County Approved Plant List (link provided in Appendix Reference List). Bioretention media can be utilized to promote further infiltration and water quality treatment. Use lush, colorful landscaping to promote aesthetic appeal and increase property values.

MAINTENANCE

Level of Maintenance: Moderate. Monthly inspections to remove trash and debris, prune and weed garden and replace needed mulch. Semi-annual inspections to remove sediment accumulation and dead/dying vegetation, and to address any areas of erosion.

WHERE TO USE

Rain gardens are typically used in a low section of the site, where runoff would naturally flow, but does not habitually have standing water. This area should also be a location suitable for landscaping. Rain gardens can help reduce stormwater runoff but should not be the primary rainfall storage area for this site. They are most beneficial when used to collect water from downspouts or smaller paved surfaces, especially in conjunction with upstream rain barrels and cisterns.

3.10 TREE PRESERVATION

Image credit: https://www.scenic.org/visual-pollution-issues/tree-conservation/

DESCRIPTION AND FUNCTION

Healthy trees add value to sites and Hillsborough County is committed to growing trees within the urban forest to reduce greenhouse gases and improve air quality, biodiversity and overall health and wellbeing. Existing trees provide soil and air quality benefits that take newly planted trees decades to accomplish. Preservation can occur on a regional scale with the establishment of wildlife corridors, restoration or riparian zones, creation of upland buffers, etc. Designers often have the capability to avoid impact on trees during the design and construction phases and should work with local authorities and owners to protect trees on a site. Reference the Hillsborough County Complete Streets Guide for further information on urban street trees.

DESIGN CRITERIA & PERFORMANCE

When designing a new site, a tree survey is required by Hillsborough County. If feasible, overall tree size and health should be documented with intended protect-in-place measures or relocation during construction. Designers should design around the trees, as much as possible, including the use of benching and short retaining walls (< 4 feet), and use existing trees to benefit the site. This includes evaluating the impacts to trees from excavation in their root zones under or nearly under their canopy. Root directors can be utilized when existing trees are adjacent to foundations or utilities. Root pruning should be utilized when appropriate. An arborist or landscape architect should be consulted to evaluate these root zone impacts.

MAINTENANCE

Protected trees preserve soil systems that prevent erosion and enhance aesthetics. Excavation costs extra money and, if avoidable, trees should be left alone. Protection measures will be in full effect during the construction phase.

Level of Maintenance: Low. Remove trash and invasive vegetation on a weekly basis. Annual inspections should be performed to trim trees to prevent visual and physical obstruction.

WHERE TO USE

Tree protection measures should be used around trees that are desired to remain in place after construction. The County may approve removal of the existing trees during the design process if there are conflicts between existing trees and sidewalk replacement, utility installation or repair, new construction, or infrastructure installation. The designer should work with a licensed arborist or landscape architect to prepare a Tree Protection Plan that identifies all existing trees to remain and the necessary tree protection measures required during the construction process.

3.11 URBAN FORESTATION

Image credit: Tampa Bay Sunset by Matthew Paulson
https://www.flickr.com/photos/matthewpaulson/12057027956/

DESCRIPTION AND FUNCTION

Urban environments generally consist of impervious surfaces (buildings, streets, structures, etc.) resulting in virtually no stormwater infiltration and increased surrounding temperatures in summer. Under such conditions, rain events can overwhelm urban storm drain systems. Efforts should be made to mitigate stormwater by adding vegetated areas adjacent to these impervious surfaces. Adequate plantings providing shade can result in reducing urban heat island effects. For additional information on local urban forestry efforts, see the City of Tampa's Urban Ecological Analysis and Management Plan.

DESIGN CRITERIA & PERFORMANCE

Urban forestation can be established within limited conditions. Designs should take advantage of the space provided adjacent to sidewalks and streets and in between buildings and driveways. Mature trees approximately 25-30 feet in height should be spaced 25-40 feet apart (depending on species) to avoid creating hazards by planting too close to highways. Root directors can be utilized when existing or proposed trees are adjacent to building foundations or utilities. Reference the Hillsborough County Complete Streets Guide for further information on urban street trees.
Healthy trees can grow large enough to provide shade to otherwise unshaded spaces and should be considered as part of the development of urban shared use paths. Tree selection and placement should consider impacts of the mature canopy to overhead utilities and to sidewalks, to prevent future damage.

MAINTENANCE

Urban forestation can be established by adding vegetated strips next to impervious surfaces. This allows stormwater infiltration and thereby reduces runoff to existing storm drain systems. Once trees and other vegetation are established, they provide shade, absorb carbon dioxide emissions, reduce runoff, and treat stormwater.

Level of Maintenance: Moderate.
Remove trash and invasive vegetation on a weekly basis. Semi-annual inspections to prune vegetation and trim larger shrubs and trees to prevent visual and physical obstruction. Mow grassed areas and water as needed.

WHERE TO USE

Urban forestation or "reforestation" should be used in highly urbanized locations where there is a need to create shade for pedestrians, points for stormwater infiltration, noise reduction and animal habitat. Urban forest can be exceptionally impactful in depressed locations to provide economic value and community revitalization.

3.12 VEGETATED FILTER STRIPS

DESCRIPTION AND FUNCTION

The EPA defines a Vegetated Filter Strip (VFS) as a “permanent, maintained strip of planted or indigenous vegetation located between nonpoint sources of pollution and receiving water bodies for the purpose of removing or mitigating the effects of nonpoint source pollutants such as nutrients, pesticides, sediments, and suspended solids.” Filter Strips are primarily designed to reduce total suspended solids, although pollutant levels of hydrocarbons, heavy metals, and nutrients may also be reduced. Pollutant removal mechanisms include sedimentation, filtration, absorption, infiltration, biological uptake, and microbial activity.

DESIGN CRITERIA & PERFORMANCE

Uniform sheet flow across a vegetated filter strip is desirable to avoid concentrated flows across the VFS that could cause erosion. This may require additional grading to level portions of the site. VFS slope should be < 5% and a minimum length of 25 feet, though shorter lengths also provide an environmental benefit. The VFS width should be equal to the width of the contributing drainage area and contain medium to dense vegetation. Creating VFSs through preservation is preferred. VFS construction should minimize disturbance to existing vegetation, to the extent possible. Native vegetation is encouraged and provides better erosion control than installed turf. Growth rate and maintenance should be taken into consideration when selecting plants from the Hillsborough County Approved Plant List (link provided in Appendix Reference List). Vehicular traffic on filter strips should be restricted and pedestrian traffic discouraged.

CREATING VEGETATED FILTER STRIPS THROUGH LAND PRESERVATION IS PREFERRED

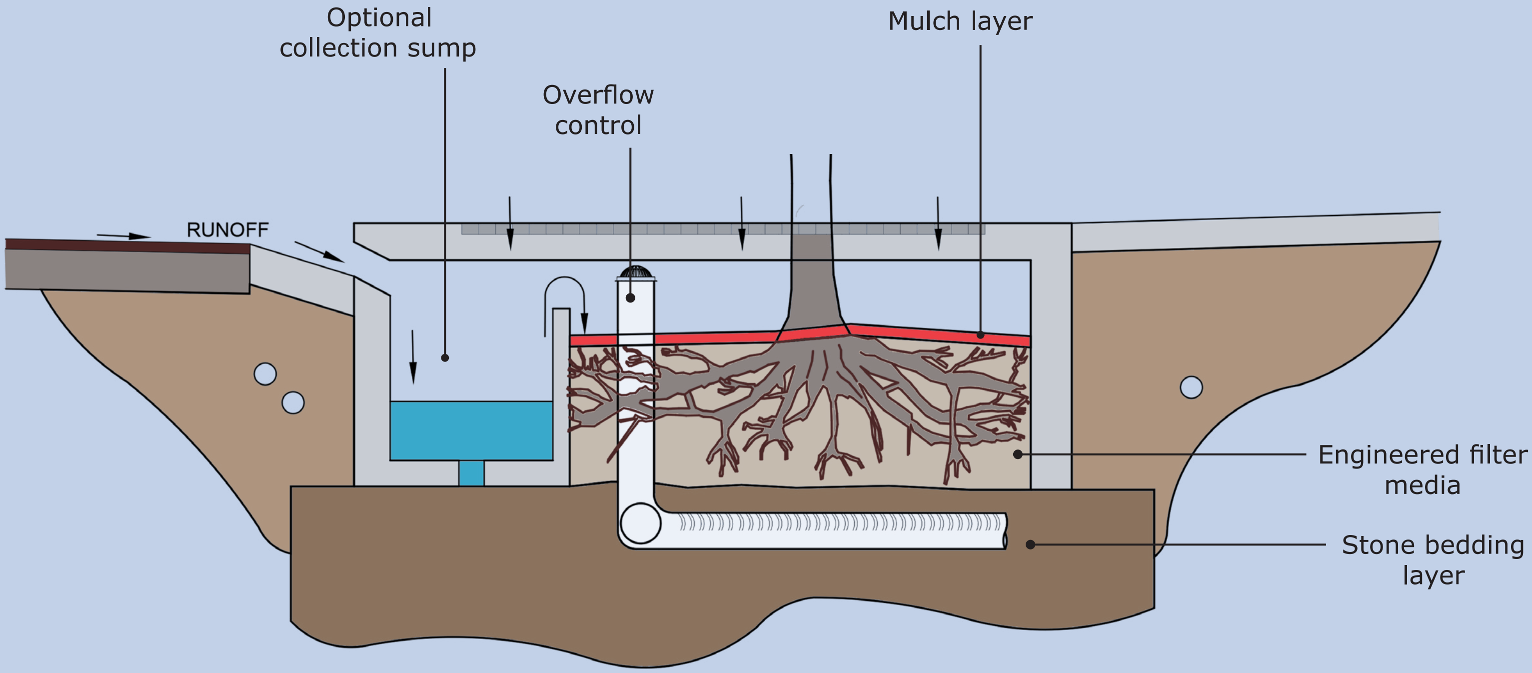
MAINTENANCE

Level of Maintenance: Low. Select mowing, if turf is used, and periodic maintenance of trees and shrubs. Quarterly inspections to repair erosion.

WHERE TO USE

VFS are often used as buffers around downstream BMPs, ponds, or receiving waterways when land is available and sediment removal is desirable. They can be aesthetically pleasing as natural areas with a mixture of trees and undergrowth. If a VFS is used adjacent to wetlands within the wetland setback, it must be done through preservation. Construction activities are not permitted within the regulated 30-foot wetland setback.

3.13 TREE FILTER BOXES



DESCRIPTION AND FUNCTION

A tree box filter usually consists of a tree planted in a soil media, contained in a small, square, concrete box. Tree box filters are popular bioretention and infiltration practices, as they collect, retain, and filter the first flush of runoff as it passes through vegetation and microorganisms in the soil. The water is then either consumed by the tree or transferred into the storm drain system. They are used to control the volume and amount of urban runoff pollutants by providing areas where water can collect and naturally infiltrate or seep into the ground.

DESIGN CRITERIA & PERFORMANCE

Select the tree box location and choice of tree to be compatible with adjacent pedestrian or vehicular usage. If heavy pedestrian traffic is foreseen, consider using a swing top grate for pedestrian safety. If bicycles have access to tree grates, the grates should be bicycle-safe. The tree box should be located adjacent to and have the capability to overflow to the storm drain system without damage or nuisance ponding. Choose trees that have minimal leaf drop and avoid using mulch that may float out of the tree box during heavier rainfall events.

Tree box soil media should have infiltration greater than or equal to the native soil. Tree boxes may use a layer of BAM if nutrients are being treated before infiltration.

MAINTENANCE

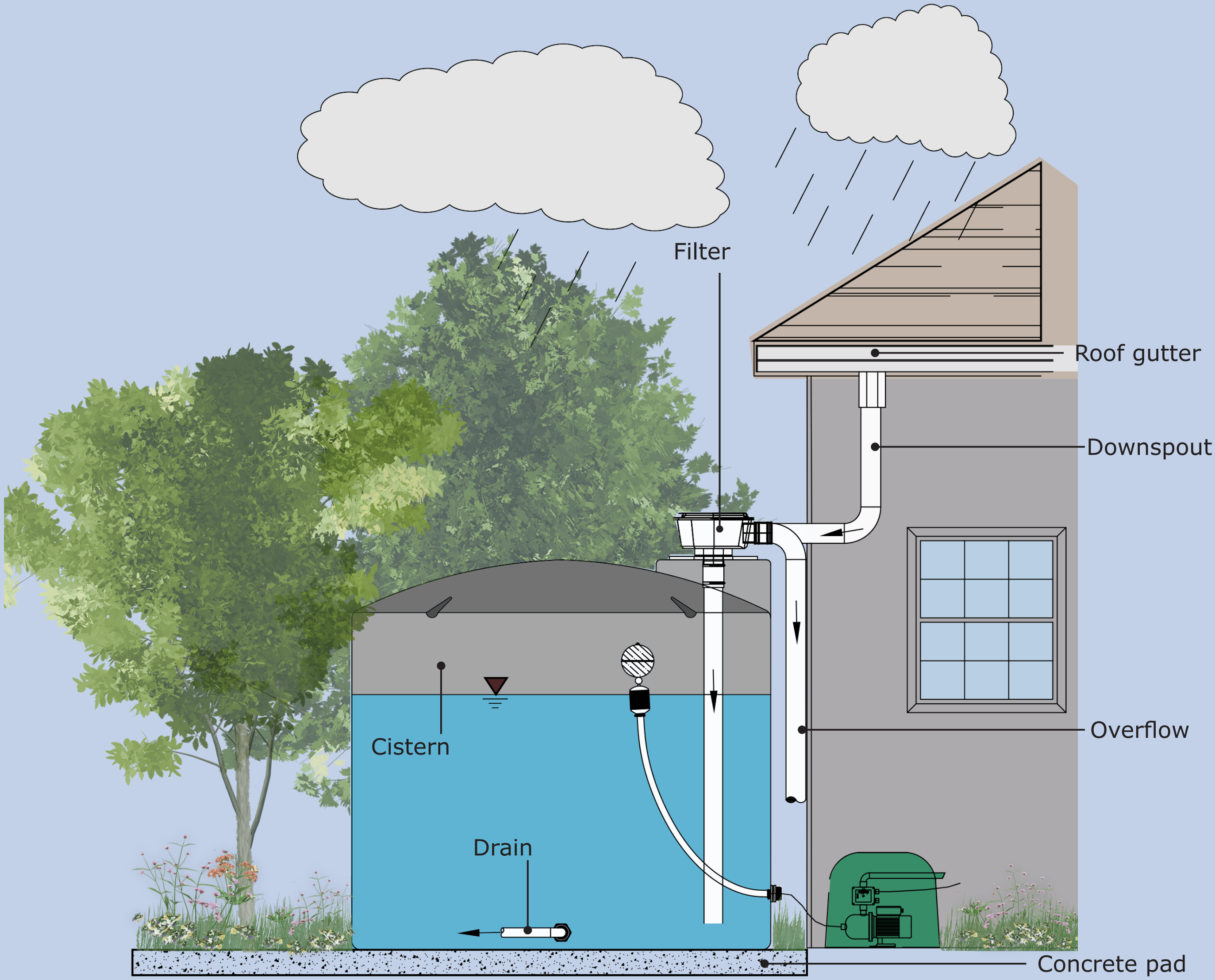
Level of Maintenance: Low. Maintenance consists of annual removal/replacement of mulch and litter, and pruning of trees. Tree grates should expand to accommodate growth.

WHERE TO USE

Tree boxes are widely implemented along sidewalks, street curbs, and parking lots. They are often chosen for their aesthetic appeal and can contribute to a community’s urban forestation goals.

TREE FILTER BOXES ALLEVIATE WATER QUALITY CONCERNS IN URBAN ENVIRONMENTS BY REDUCING EXCESS NITROGEN AND PHOSPHORUS

3.14 ROOFTOP RUNOFF STORAGE



DESCRIPTION AND FUNCTION

Cisterns and rain barrels are simple techniques to store rooftop runoff for reuse for landscaping and other non-potable uses. They are based on the low impact design approach that treats rooftop runoff as a resource that should be reused or infiltrated. In contrast, conventional stormwater management strategies take rooftop runoff, which is often relatively free of pollutants, and send it into the stormwater treatment system along with runoff from paved areas. The most common approach to roof runoff storage involves directing each downspout to a 55-gallon rain barrel. A hose is attached to a faucet at the bottom of the barrel and water is distributed by gravity pressure.

DESIGN CRITERIA & PERFORMANCE

Rain barrels should be childproof and secured against disturbance by people or animals. Any openings should be sealed with mosquito netting. Minimize leaves and debris in the storage tank by placing a screen at the top of the downspout inflow. Direct overflow from rain barrels and cisterns to a dry well, infiltration trench, rain garden, bioretention area, or grassed swale sized to infiltrate the overflow volume and avoid nuisance ponding. If desired, visually screen rain barrels and exposed cisterns with shrubs or other landscaped features or paint with designs to add aesthetic appeal. Refer to the Hillsborough County Extension Service, Rain Barrell Program for additional information.

MAINTENANCE

Level of Maintenance: Low. Semi-annual inspection for clogging, erosion from storage mechanism, and for siltation and cracking of the storage structure.

WHERE TO USE

Cisterns and rain barrels are applicable to most commercial and residential properties where there is a gutter and downspout system to direct roof runoff to the storage tank. They take up very little room and so can be used in very dense urban areas. Rain barrels and cisterns are excellent retrofit techniques for almost any circumstance.

ONE INCH OF RAIN ON A 1,000-SQUARE-FOOT ROOF YIELDS 623 GALLONS OF WATER AND THE AVERAGE ANNUAL RAINFALL FOR HILLSBOROUGH COUNTY IS 52 INCHES

3.15 LIVING SHORELINES

DESCRIPTION AND FUNCTION

Living shorelines are a GI approach for addressing shoreline erosion and protecting marsh areas. Unlike traditional hardened coastal structures such as bulkheads or seawalls, living shorelines incorporate as many natural elements as possible to serve as buffers in absorbing wave energy and protecting against shoreline erosion. The softer materials used in the construction of living shorelines create and maintain valuable habitat. Living shorelines are generally located within existing wetland systems. There may be conditions that will require heightened review from local, state, and federal entities. Conducting a pre-application meeting with the appropriate entities is strongly suggested. Living shorelines can be broadly summarized by three categories, including vegetative planting solutions, oyster solutions, and incorporation of green elements into hardened coastal structures.

DESIGN CRITERIA & PERFORMANCE

Use the softest approaches to shoreline stabilization feasible, based on the wave environment and other site conditions. The figure below (obtained from floridalivingshorelines.com) provides a guide to appropriate living shoreline environments compared to harder coastal structure environments.

Vegetative plantings are appropriate for lower wave energy environments but can incorporate a protective toe to stabilize the vegetation for added protection (still not suitable for high wave energy environments). Most marsh grasses and mangroves thrive when planted in the intertidal zone (between Mean Low Water and Mean High -Water); however, there are also some mid-high marsh grass species that can thrive above Mean High Water. Depending on the elevations of the nearshore environment, fill material may be required to raise the elevations into the desired range for vegetative plantings. If toe stabilization is incorporated, common toe materials include rock or oysters, and gaps in the toe protection should be positioned to allow circulation and prevent marine species from getting trapped in changing tide conditions.

Oyster habitat solutions can also be appropriate for lower wave energy environments and can exist in many different forms. Oyster products can be used for (1) toe stabilization of vegetative plantings, (2) seawall toe protection to increase the shoreline roughness and dissipate wave energy, and (3) nearshore breakwaters to reduce the wave environment closer to shore and encourage natural vegetation recruitment. There are also many different types of oyster habitat products, including various proprietary solutions. Oyster habitat is more likely to establish below the Mean Higher-High Water line, which should be considered where oyster products are incorporated. Evidence of oysters should also be present in the project vicinity to indicate a suitable environment for added oyster products.

MAINTENANCE

Level of Maintenance: Low.
Inspection after high wave energy events or overtopping of upland areas. During the establishment period, verify the success of vegetation/mangrove and oyster installations.

WHERE TO USE

Living shorelines may be used wherever tidal shorelines need to be defended against erosion from currents and waves; however, how green or gray of a solution that can be implemented varies based on the anticipated wave environment and other site conditions. Some solutions may also be applicable to non-tidal waterbodies.

GREEN INFRASTRUCTURE MANUAL

4.0 PERFORMANCE MONITORING AND MAINTENANCE

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4.1 ESTABLISHMENT

WARRANTY PERIOD

For the period of one year after construction, vegetation within GI installations should be held under a performance warranty by the construction contractor. During that warranty period, GI installations should be inspected and tended to regularly to ensure proper establishment. GI installations with a vegetation component should receive regular watering and weeding to prevent the growth of invasive species. Avoid applying too much mulch, which may negatively affect plant growth. Mulch can be discontinued at plant maturity provided that the soil surface is fully covered with dense vegetation.

SPECIAL CONSIDERATIONS

Avoid excessive foot traffic on planting beds during construction. If compaction is known to have occurred during construction, apply compost to the soil surface and rototill it into the soil as deep as possible to improve infiltration before planting. If compaction is deeper than a rototiller can reach, deep tilling equipment may also be used to lift and fracture the subsoils without turning over the topsoil.

GI BMPs with structural components such as inlets, pipes, baffles, etc., should be inspected at the end of construction to ensure proper installation during construction. Pipes should be desilted at the end of construction.

4.2 PERFORMANCE AND MAINTENANCE

FIGURE 4.1 SCHEDULED TASKS

Regular maintenance inspections and tasks should be performed to maintain the functionality and performance of GI installations.

Maintenance guidance is provided, below, for routine tasks required for each GI practice. The maintenance frequency is also provided for each GI practice; these are intended to be used as a general reference and may need to be adjusted based onsite-specific conditions.

Within the table shown below are general performance standards that should be met during routine maintenance inspections.

<table>
<tr><th>Appearance</th><th>Invasives, Pests, Diseases</th><th>Mulch, Erosion</th><th>Drainage</th></tr>
<tr><td>Heavy vegetation, tidy appearance.</td><td rowspan="2">Invasive vegetation is not acceptable; every effort should be made to control and eliminate all invasive vegetation - except in vegetative filter strips.</td><td rowspan="2">Mulch evenly distributed two (2) inches to four (4) inches deep.</td><td rowspan="2">Zero ponding depth observed 48 hours following a rain event.</td></tr>
<tr><td>Vegetation watered during dry periods over two (2) weeks in length.</td></tr>
<tr><td>Vegetation confined to planted areas.</td><td rowspan="4">Pests or diseases that threaten vegetation should be removed with pest management techniques supported by the Hillsborough County Extension Service. If problem is limited to less than 5% of plants, remove infected plants and replace with different species.</td><td rowspan="3">No evidence of erosion.</td><td rowspan="6">Clear, open flow paths for water (inlet, outlet, overflow).</td></tr>
<tr><td>Clean, distinct planting bed edges.</td></tr>
<tr><td>Litter/trash removed.</td></tr>
<tr><td>Fallen/blown foliage removed (leaves, nuts, sticks, lawn clippings, fallen branches).</td><td rowspan="3">Little to no sediment or silt on mulch surface.</td></tr>
<tr><td>Little to no sediment or silt on surface.</td><td rowspan="2">Mosquito larvae removed; Contact the Hillsborough County Mosquito Control Department for further guidance.</td></tr>
<tr><td>No cracking, settling, or damage to GI components.</td></tr>
</table>

GREEN INFRASTRUCTURE MANUAL

5.0
APPENDIX

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5.1 SAMPLE SPECIFICATIONS

HOW TO USE THESE SPECIFICATIONS

This section includes sample specifications, written to the contractor, and are intended to serve as general guidelines for the construction of GI practices. These specifications, in their current form, are not contractual documents but a starting place for the development of more detailed specifications. Each specification should be customized to the project and reviewed by the County Engineer. The general framework for these specifications is Description, Materials, Construction, but additional details may always be added on a project basis.

THESE SPECIFICATIONS INCLUDE REFERENCES TO THE FOLLOWING DOCUMENTS:

- FDOT Standard Specification for Road and Bridge Construction, January 2022
- University of Florida IFAS Extension, Best Management Practices for Protection of Water Resources in Florida, by Florida Green Industries.
- EPA, Constructed Wetlands
- ASTM D 7176, Standard Specification for Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes
- GRI - GM13 Standard Specification
- GRI Test Method GM21
- ASTM C1701 Standard Test Method for Infiltration Rate of In Place Pervious Concrete
- Florida Erosion and Sediment Control Manual

5.1 CONTINUED

TABLE OF CONTENTS

5.1.1 PRETREATMENT

DESCRIPTION

Pretreatment devices are systems that provide preliminary runoff filtration. These can include inlet baskets, baffles, trash racks, grass/aggregate buffers, or a forebay in retention ponds. Proprietary precast filtration structures are available to remove trash, sediment, oils, and greases, or "baffle-box" structures may be designed to include weirs and skimmers to accomplish the same purpose.

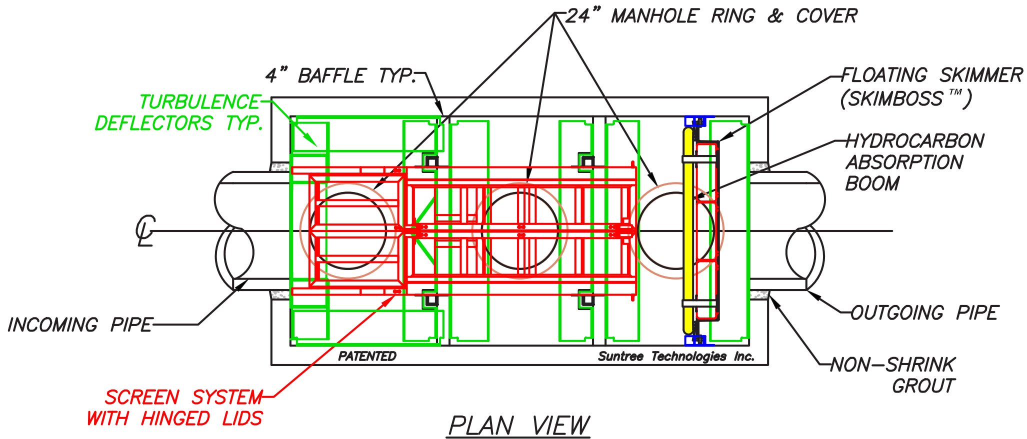
MATERIALS

- *Drainage Structures*: FDOT Specification Section 449, Precast Concrete Drainage Products
- *Pipe*: Section 430, Pipe Culverts
- *Sod/Grass*: Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements.
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.

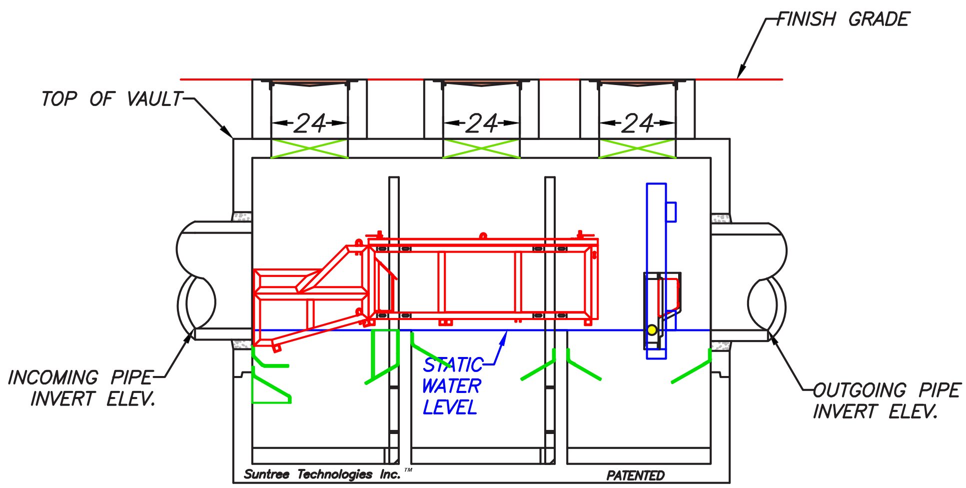
CONSTRUCTION

- Precast Pretreatment Structures: install per the manufacturer's guidelines.
- Forebays: Excavate the forebay according to the dimensions shown in the plans.
- Baffle-box Structures: Construct to the lines and grades shown on the plans

Sample baffle-box structure layout:



PLAN VIEW
NTS



FRONT SIDE VIEW
NTS

NOTES

1. CONCRETE 28 DAY COMPRESSIVE STRENGTH FC=5000 PSI
2. REINFORCING: ASTM A–615 GRADE 60
3. SUPPORTS AN H20 LOADING AS INDICATED BY AASHTO.
4. JOINT SEALANT: BUTYL RUBBER SS–S–00210
5. ALL WALLS TO BE 6" THICK, BOTTOM TO BE 6" THICK, AND TOP TO BE 6" THICK.
6. TREATMENT DESIGN FLOW FOR 80% REMOVAL EFFICIENCY OF TSS IS 24 CFS.
7. INFLOW AND OUTFLOW PIPES ARE TO BE FLUSH WITH THE INSIDE SURFACE OF THE CONCRETE STRUCTURE. (CAN NOT INTRUDE BEYOND FLUSH)
8. BAFFLES ARE TO BE SEALED WITH GROUT TO FORM 3 WATER TIGHT CHAMBERS.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida (EST. 1834)	NUTRIENT SEPARATING BAFFLE BOX (NSBB) (SUNTREE EXAMPLE)	SHT. NO. 1234

5.1.2 BIORETENTION

DESCRIPTION

Bioretention is a shallow depressed area that employs engineered media and carefully selected plant materials that include trees, shrubs, and other herbaceous vegetation. They are designed to detain stormwater runoff in the soil media and treat stormwater primarily through infiltration. If desired, an underdrain may be used for the discharge of infiltrated water.

MATERIALS

- *Sod/Grass*: Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements. Topsoil: FDOT Specification 987, Soil Layer Materials.
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.
- *Pipe*: If a pipe is called for, use perforated Polyvinyl Chloride (PVC), High Density Polyethylene (HDPE) or Polypropylene (PP) pipe. Refer to FDOT Specification Section 443-2 for perforated pipe requirements.
- *Backfill Rock*: FDOT Specification 901, Coarse Aggregate
- *Geotextile/Filter Fabric*: If an underdrain is called for, use Type D-3 as listed in FDOT Specification Section 985.
- *Engineered Media*: If an engineered media is used, it should achieve a long-term, in-place infiltration rate and support plant growth. Engineered soils media are typically patented products, therefore installation instructions should adhere to proprietary requirements.

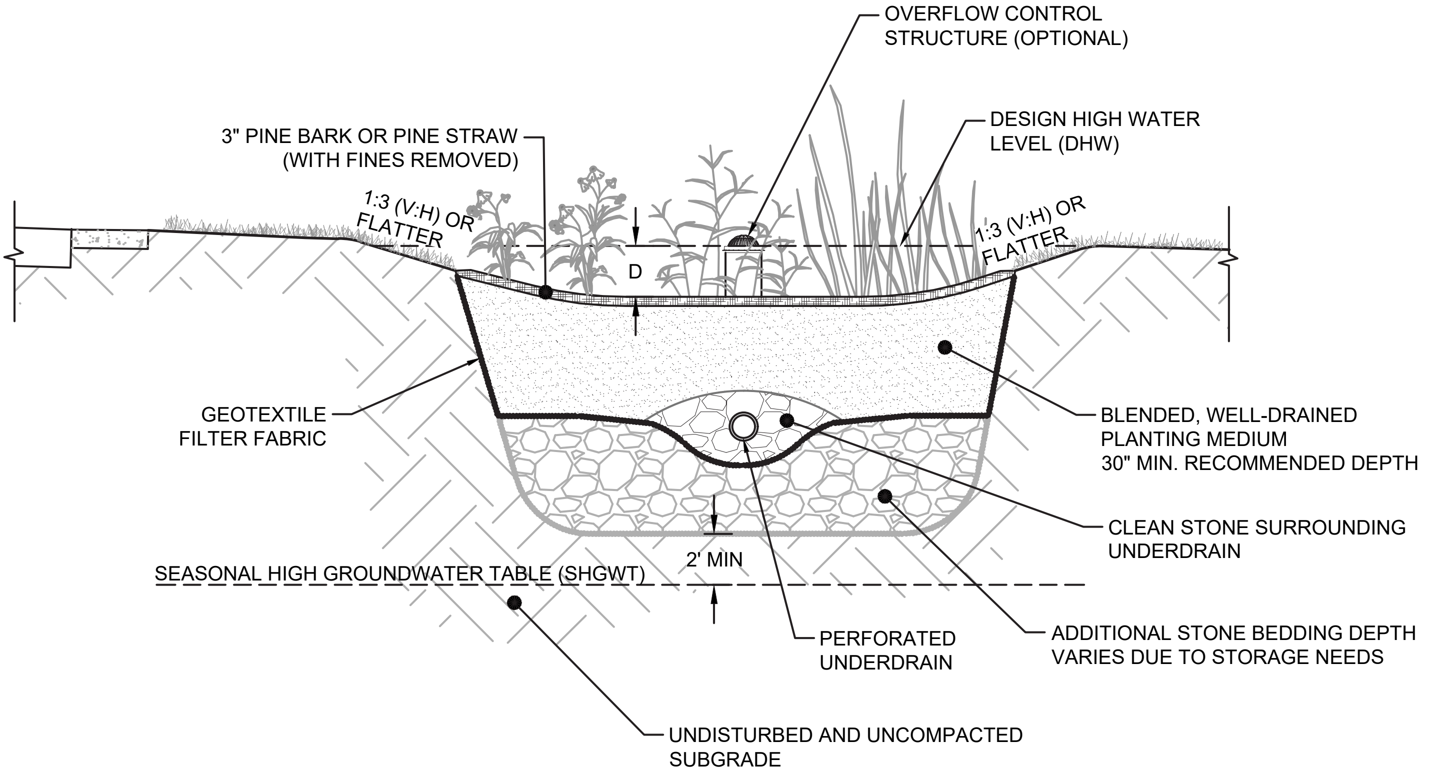
CONSTRUCTION

General: Before the site is graded, prevent heavy equipment traffic from compacting the underlying soils in the area of the bioretention area. During construction, sediment and erosion controls should be used to keep runoff and sediment away from the bioretention area, to prevent clogging and sedimentation.

Shape the bioretention area to the elevations as shown on the plans. Subsoil should be prepared with a rototiller to a depth of 8-10 inches and gently smoothed. A minimum of 12-inches of topsoil should be applied for the development of the rooted vegetation.

If an engineered media is to be used, excavate the trench carefully, to the depth required to allow the media to be laid to the grade shown in the plans. If an underdrain is called for in the plans, place the filter, rock, and pipe per the line, grades, and dimensions shown in the plans, being careful to overlap the filter fabric over the top of the rock envelope.

Landscape Plantings: Before digging a hole for landscape plants, 1) remove all soil from above the topmost root, and 2) measure the distance between the topmost root and the bottom of the root ball. Dig the hole about 10 percent shallower than this depth and as wide as possible (at least one and a half times the width of the ball and even wider in compacted soils). The root ball should be positioned in the hole shallowly enough so that the finished grade of the backfill soil and landscape soil is lower than the top of the root ball, so no more than 10% of the upper portion of the sides of the root ball is exposed to the air. Then apply mulch so that it covers the sides of the root ball. Be sure that when you are finished planting, there is NO SOIL, and little or no mulch, over the top of the root ball. For more information refer to Section 10 of the Hillsborough County Transportation Technical Manual and the University of Florida IFAS Extension, Best Management Practices for Protection of Water Resources in Florida, by Florida Green Industries.



DESIGN NOTES:

1. VEGETATED FILTER STRIP CAN BE USED BETWEEN IMPERVIOUS AREA AND TOP OF BANK.
2. AVOID COMPACTION OF ALL IN-SITU SOILS AND IMPORTED SOILS UNLESS OTHERWISE SPECIFIED.
3. PLANTING SCHEME WITHIN BIORETENTION AREA SHOULD BE PROJECT SPECIFIC AND DEPEND ON SITE CONDITIONS. NATIVE PLANTS ARE RECOMMENDED.
4. DESIGN DEPTH (D) SHOULD BE A MAXIMUM OF 18" AND SHOULD BE AT LEAST 6" BELOW LOW EDGE OF SHOULDER, OR TOP OF BANK (WHICHEVER IS LOWER).
5. BIOSORPTION ACTIVATED MEDIA (BAM) CAN BE USED INSTEAD OF PLANTING MEDIUM, WHEN NUTRIENT REDUCTION IS NEEDED.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	BIORETENTION	SHT. NO. 1234

5.1.3 WET DETENTION

DESCRIPTION

Wet detention is a stormwater management facility with a wet permanent pool, designed to slowly release collected stormwater runoff through an outfall structure.

MATERIALS

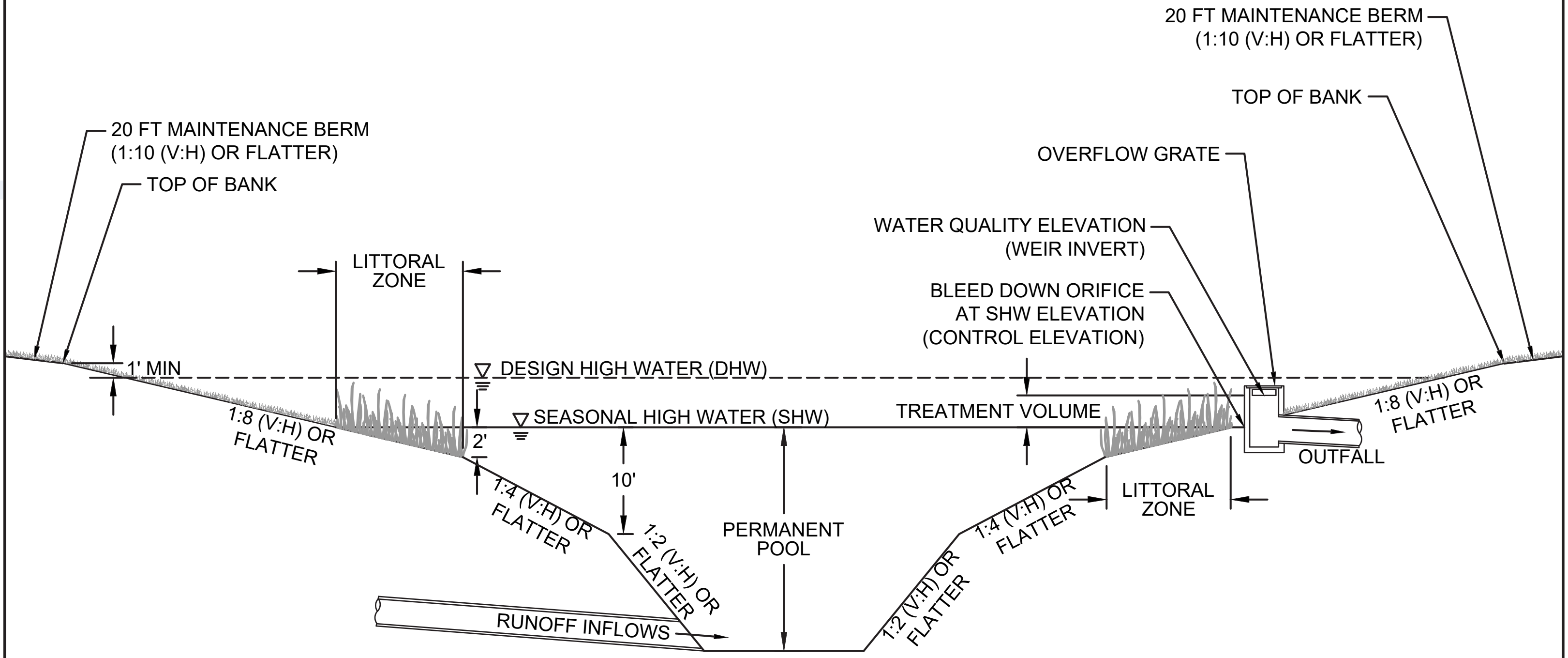
- *Drainage Structures*: FDOT Specification Section 449, Precast Concrete Drainage Products
- *Pipe*: Section 430, Pipe Culverts
- *Sod/Grass*: *Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements. Topsoil: FDOT Specification 987, Soil Layer Materials.*
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.

CONSTRUCTION

Excavate the wet detention pond to the bottom elevation and shape the pond side slopes as shown on the plans. Subsoil should be prepared with a rototiller to a depth of 8-10 inches and gently smoothed with a roller. A minimum of 12-inches of topsoil should be applied for the development of the rooted vegetation.

During the plant establishment period, replace aquatic vegetation that has failed. After the 2-years post construction period or as specified by permit condition, 80 percent coverage of the littoral zone by suitable, rooted aquatic plants is required.

Construct the inflow pipes, outflow pipes, and structures per the plans.



DESIGN NOTES:

1. LITTORAL PLANTING SCHEME SHOULD BE PROJECT SPECIFIC AND DEPEND ON SITE CONDITIONS. NATIVE PLANTS ARE RECOMMENDED.
2. PERMANENT POOL DEPTH IS RECOMMENDED TO BE A MINIMUM 6' TO AVOID PLANT OVERGROWTH.
3. FOR SPECIFIC PERMIT CRITERIA, SEE THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT, APPLICANT'S HANDBOOK II.
4. FOR POND DESIGN CRITERIA, SEE THE HILLSBOROUGH COUNTY STORMWATER MANAGEMENT TECHNICAL MANUAL FOR CATEGORIES OF PONDS AND OPTIONS WITHIN THOSE CATEGORIES (COUNTY-MAINTAINED WET POND WITHOUT FENCING IS SHOWN ABOVE).

5.1.4 BIOSWALE

DESCRIPTION

A bioswale is an engineered channel, designed for stormwater conveyance and water quality treatment. A bioswale typically includes plantings and can include engineered soil media and underdrain for the discharge of infiltrated water.

MATERIALS

- *Sod/Grass*: Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements. Topsoil: FDOT Specification 987, Soil Layer Materials.
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.
- *Pipe*: If a pipe is called for, use a perforated Polyvinyl Chloride (PVC), High Density Polyethylene (HDPE) or Polypropylene (PP) pipe, per FDOT Specification 443 French Drains.
- *Backfill Rock*: FDOT Specification 901, Coarse Aggregate
- Geotextile/Filter Fabric: use Type D-3 as listed in FDOT Specification Section 985.
- *Engineered Media*: If an engineered media is used, it should achieve a long-term, in-place infiltration rate and support plant growth. Engineered soils media are typically patented products, therefore installation instructions should adhere to proprietary requirements.

CONSTRUCTION

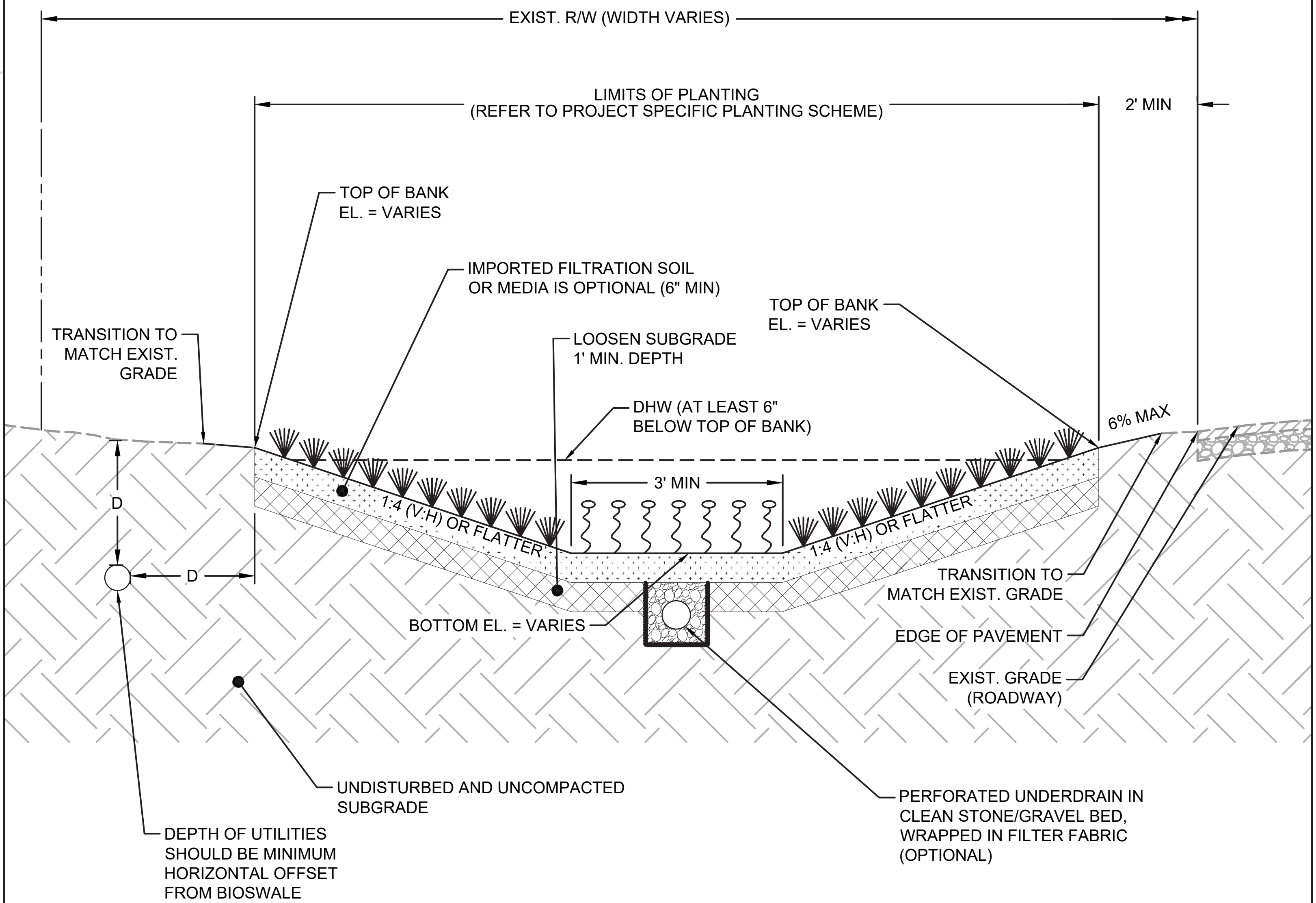
General: Before the site is graded, prevent heavy equipment traffic from compacting the underlying soils in the area of the bioswale. During construction, sediment and erosion controls should be used to keep runoff and sediment away from the bioswale, to prevent clogging and sedimentation.

Shape the bioswale to the elevations as shown on the plans. Subsoil should be prepared with a rototiller to a depth of 8-10 inches and gently smoothed. A minimum of 12-inches of topsoil should be applied for the development of the rooted vegetation.

If an engineered media is to be used, excavate the trench carefully, to the depth required to allow the media to be laid to the grade shown in the plans. If an underdrain is called for in the plans, place the filter, rock, and pipe per the line, grades, and dimensions shown in the plans, being careful to overlap the filter fabric over the top of the rock envelope.

5.1.4 CONTINUED

Landscape Plantings: Before digging a hole for landscape plants, 1) remove all soil from above the topmost root, and 2) measure the distance between the topmost root and the bottom of the root ball. Dig the hole about 10 percent shallower than this depth and as wide as possible (at least one and a half times the width of the ball and even wider in compacted soils). The root ball should be positioned in the hole shallowly enough so that the finished grade of the backfill soil and landscape soil is lower than the top of the root ball, so no more than 10% of the upper portion of the sides of the root ball is exposed to the air. Then apply mulch so that it covers the sides of the root ball. Be sure that when you are finished planting, there is NO SOIL, and little or no mulch, over the top of the root ball. For more information refer to Section 10 of the Hillsborough County Transportation Technical Manual and the University of Florida IFAS Extension, Best Management Practices for Protection of Water Resources in Florida, by Florida Green Industries.



DESIGN NOTES:

1. VEGETATED FILTER STRIP CAN BE USED BETWEEN IMPERVIOUS AREA AND TOP OF BANK.
2. AVOID COMPACTION OF ALL IN-SITU SOILS AND IMPORTED SOILS UNLESS OTHERWISE SPECIFIED.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida EST. 1834	BIOSWALE	SHT. NO. 1234

5.1.5 CONSTRUCTED WETLANDS

DESCRIPTION

Constructed wetlands are low lying storage areas designed for stormwater treatment, storage, and infiltration by mimicking the performance of natural wetlands.

MATERIALS

- *Drainage Structures*: FDOT Specification Section 449, Precast Concrete Drainage Products
- *Pipe*: FDOT Specification Section 430, Pipe Culverts
- *Manufactured Liners*:

  PVC Liner: ASTM D 7176, Standard Specification for Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes Used in Buried Applications and ASTM D7408, Standard Specification for Non-Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams

  HDPE Liners: GRI - GM13 Standard Specification

  EPDM Liners: GRI Test Method GM21

CONSTRUCTION

General: Shape the wetland bottom to the elevations as shown on the plans. Install wetland control structures after the site is graded and before planting of aquatic plants. This will help maintain the needed water elevation during plant establishment.

If a clay liner is called for in the plans, place and compact the clay to the thickness called for in the plans. If a manufactured liner is called for in the plans, install the liners according to the manufacturers recommendations and to the limits shown in the plans, being careful to guard against flotation if the groundwater table is above the bottom of the liner.

Place the soil, specified in the plans, in the wetland to the grades shown in the plans, prior to the planting of aquatic plants called for in the plans.

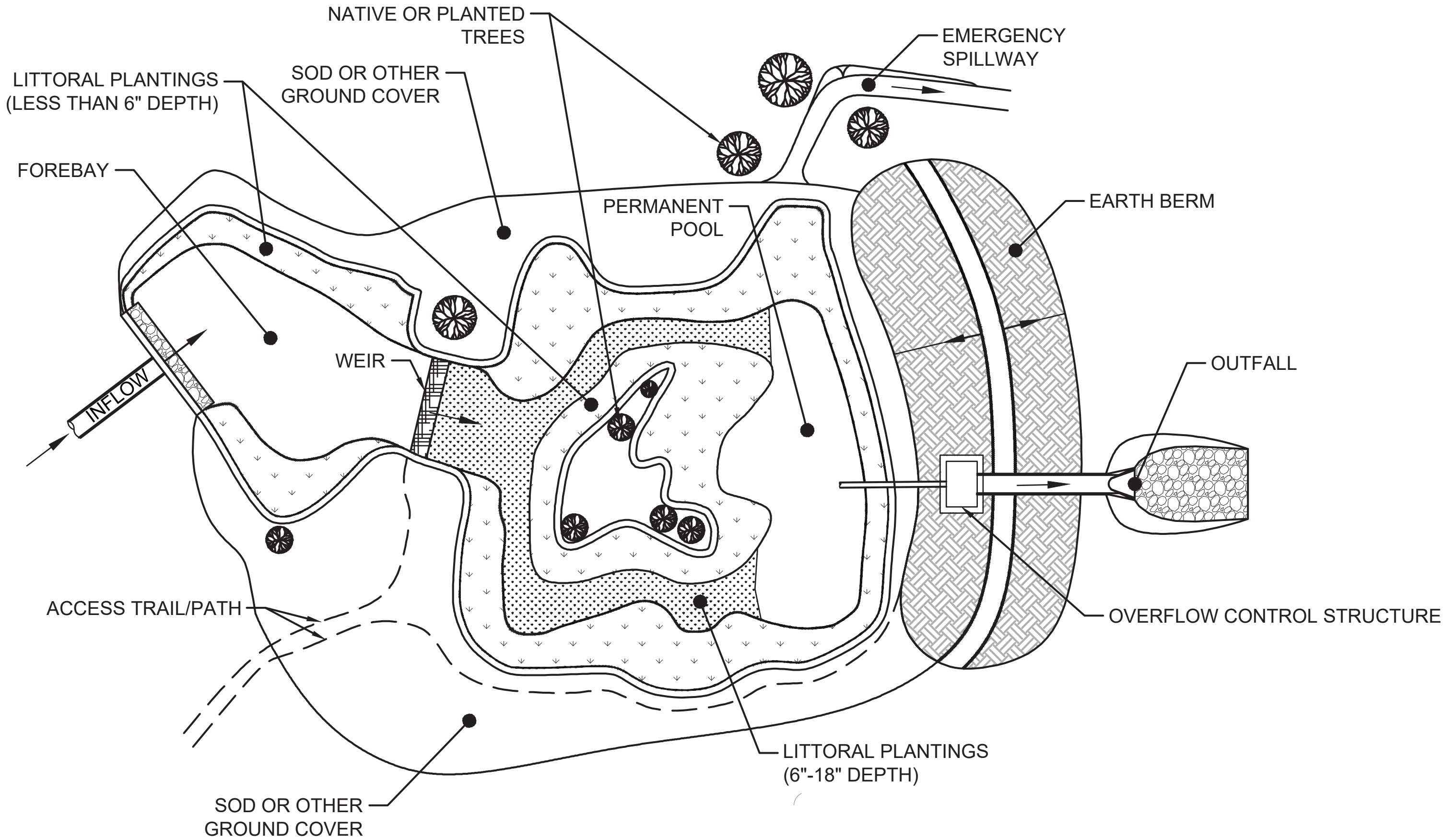
5.1.5 CONTINUED

Wetland Plantings: Plant aquatic vegetation at the spacings shown in the plans. Whole plants or dormant rhizomes and tubers should be planted rather than seeds. Once the wetland area has been shaped and graded, the site should also be disked, harrowed, and otherwise prepared for plantings. Release water onto the site so that the soil is saturated and to facilitate soil settlement prior to planting. Plant materials should be planted deep enough to prevent propagules from floating out of the planted hole.

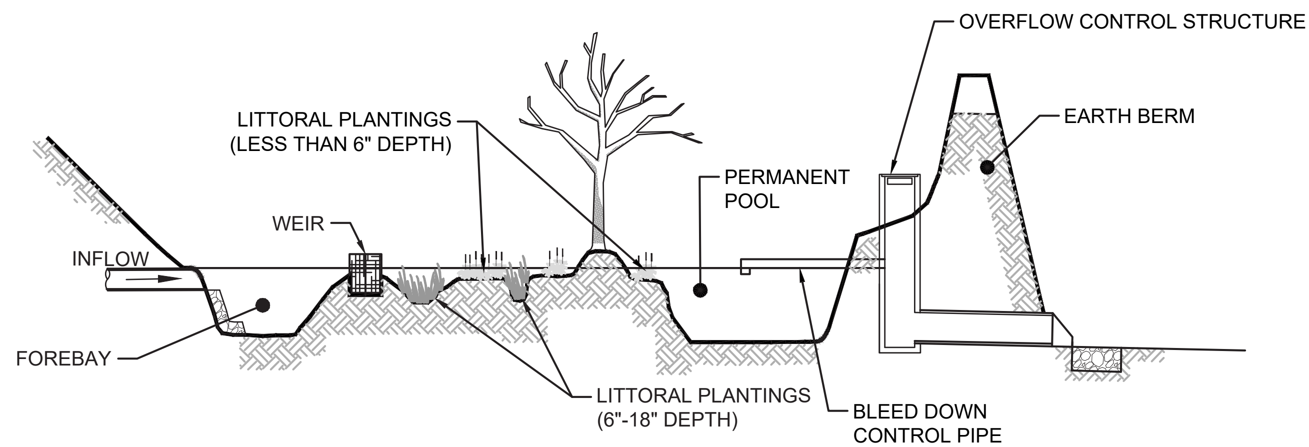
Post-planting Water Level Management: Proper regulation of water depth is the most critical factor for plant survival during the first year after planting. After the constructed wetlands are planted, the substrate should be saturated with water to about 1 inch for four to five weeks. After the sixth week or when new plantings show new and vigorous growth, water levels should be gradually increased to support erect, upright growth forms. Water levels should be above the roots and below the stems and leaves.

Plant Establishment Period: During the plant establishment period, replace any plantings that fail and remove any undesirable invasive plants.

For more information refer to EPA, Constructed Wetlands.



NOT TO SCALE



NOT TO SCALE

DESIGN NOTES:

1. PLANTING SCHEME WITHIN WETLAND IS TO BE DETERMINED BY LANDSCAPE ARCHITECT. NATIVE PLANTS ARE RECOMMENDED.
2. CONSTRUCT RUBBLE RIP RAP AT OUTLET PIPE ONLY IF DESIGN VELOCITIES ARE EXPECTED TO BE GREATER THAN 3 FPS.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	CONSTRUCTED WETLAND	SHT. NO. 1234

5.1.6 INFILTRATION TRENCH

DESCRIPTION

Infiltration trenches are filled with aggregate to accept stormwater runoff and create an onsite reservoir. The trench retains and infiltrates runoff, allowing it to return to the aquifer. When installed as drainage features underneath parking lots and other locations where the availability of land is limited, these are typically called exfiltration trenches or French Drains, since the focus is on drainage rather than groundwater recharge. Infiltration (and exfiltration trenches) are lined with filter fabric to prevent the migration of surrounding soil into the voids of the rock-filled trench.

MATERIALS

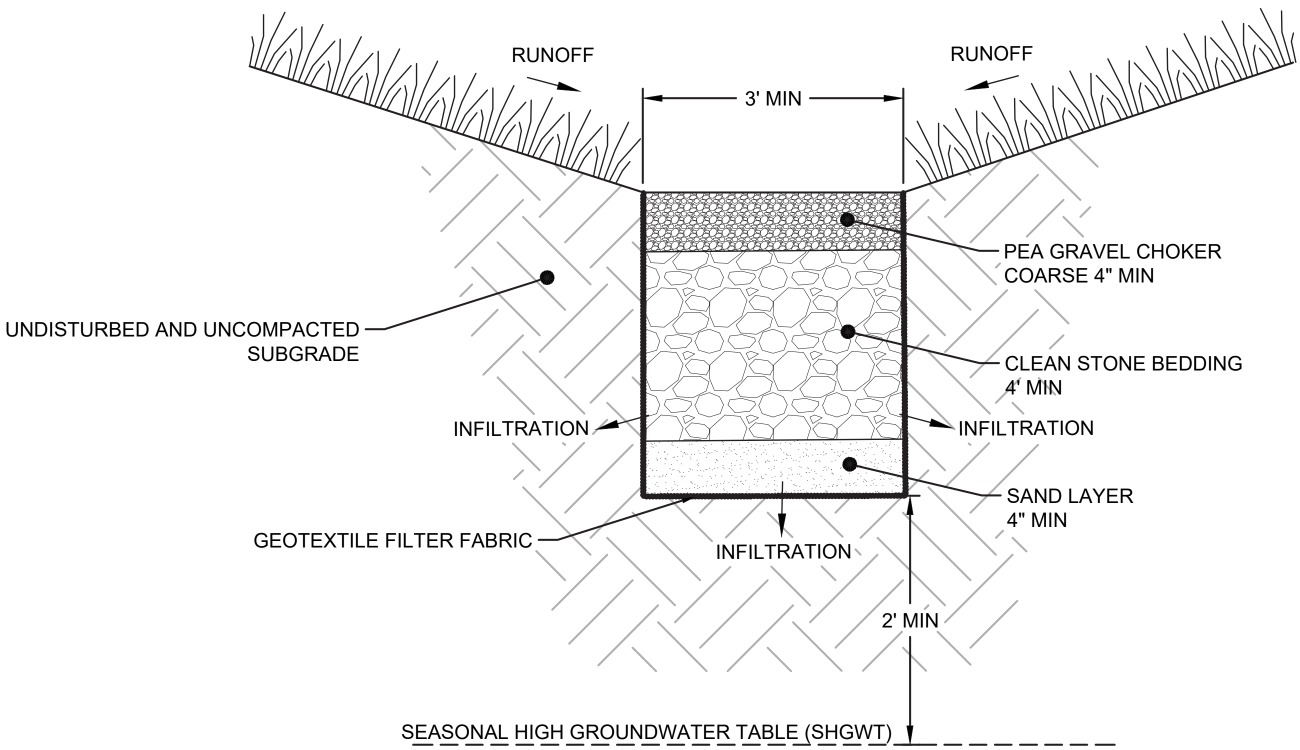
- *Backfill Rock*: FDOT Specification 901, Coarse Aggregate
- *Filter Sand*: FDOT Specification 902, Fine Aggregate
- *Pipe*: FDOT Specification Section 948, Optional Drainage Products
- *Filter Fabric Sock*: FDOT Specification Section 948-8, Filter Fabric Sock for Use with Underdrain
- *Geotextile Fabrics*: FDOT Specification Section 985

CONSTRUCTION

Excavate the trench to the depth and dimensions shown in the plans. Place FDOT Type D-3 filter fabric in the bottom of the trench in a width sufficient to allow a single piece of filter fabric to cover the trench cross section to the limits of the filter fabric envelope. Place filter sand to the depth shown in the plans.

If an underdrain pipe is used, lay all pipe conforming with the lines and grades specified in the plans, with joints securely made. After laying the pipe, backfill the trench with coarse aggregate to the lines shown in the plans.

If the infiltration trench does not extend to the surface, carefully fold and overlap the filter fabric over the top of the trench. If the infiltration trench is open at the top and an underdrain pipe is used, place the filter fabric sock securely around the length of the perforated undrain pipe.



DESIGN NOTES:

1. AVOID COMPACTION OF ALL IN-SITU SOILS AND IMPORTED SOILS UNLESS OTHERWISE SPECIFIED.
2. PERFORATED UNDERDRAIN PIPE CAN BE USED WITHIN CLEAN STONE BEDDING LAYER IF NEEDED.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	INFILTRATION TRENCH	SHT. NO. 1234

5.1.7 PERMEABLE PAVEMENT

DESCRIPTION

Permeable pavement is a porous surface practice which promotes infiltration while still providing a paved surface for pedestrian and vehicular traffic.

MATERIALS

- *Pipe*: If a pipe is called for, use a perforated Polyvinyl Chloride (PVC), High Density Polyethylene (HDPE) or Polypropylene (PP) pipe, per FDOT Specification 443 French Drains.
- *Geotextile/Filter Fabric*: use Type D-3 as listed in FDOT Specification Section 985.
- *Backfill Rock*: FDOT Specification 901, Coarse Aggregate Sod/Grass: FDOT Specification 981
- Sod/Grass: Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements. Topsoil: FDOT Specification 987, Soil Layer Materials.

CONSTRUCTION

All permeable pavement areas should be fully protected from sediment intrusion by silt fence or construction fencing. To prevent soil compaction, heavy vehicular traffic should be kept out of permeable pavement areas during and immediately after construction.

During construction, care should be taken to avoid tracking sediments onto any permeable pavement to avoid surface clogging. Any area of the site intended ultimately to be a permeable pavement area should generally not be used as the site of a temporary sediment basin.

Permeable pavement systems can be patented products; if so, installation instructions should adhere to proprietary requirements of the manufacturer.

PERMEABLE PAVEMENT CONSTRUCTION SEQUENCE

The following is a typical construction sequence to properly install permeable pavement, which may be modified depending on the pavement type:

Step 1. Construction of the permeable pavement begins after the entire contributing drainage area has been stabilized.

Step 2. Temporary erosion and sediment controls should be used during installation to divert stormwater away from the permeable pavement area until it is constructed. The proposed permeable pavement area must be kept free from sediment during the entire construction process.

Step 3. Where possible, excavation should work from the sides and outside the footprint of the permeable pavement area (to avoid soil compaction). Areas of permeable pavement should be shielded from use by heavy equipment during construction.

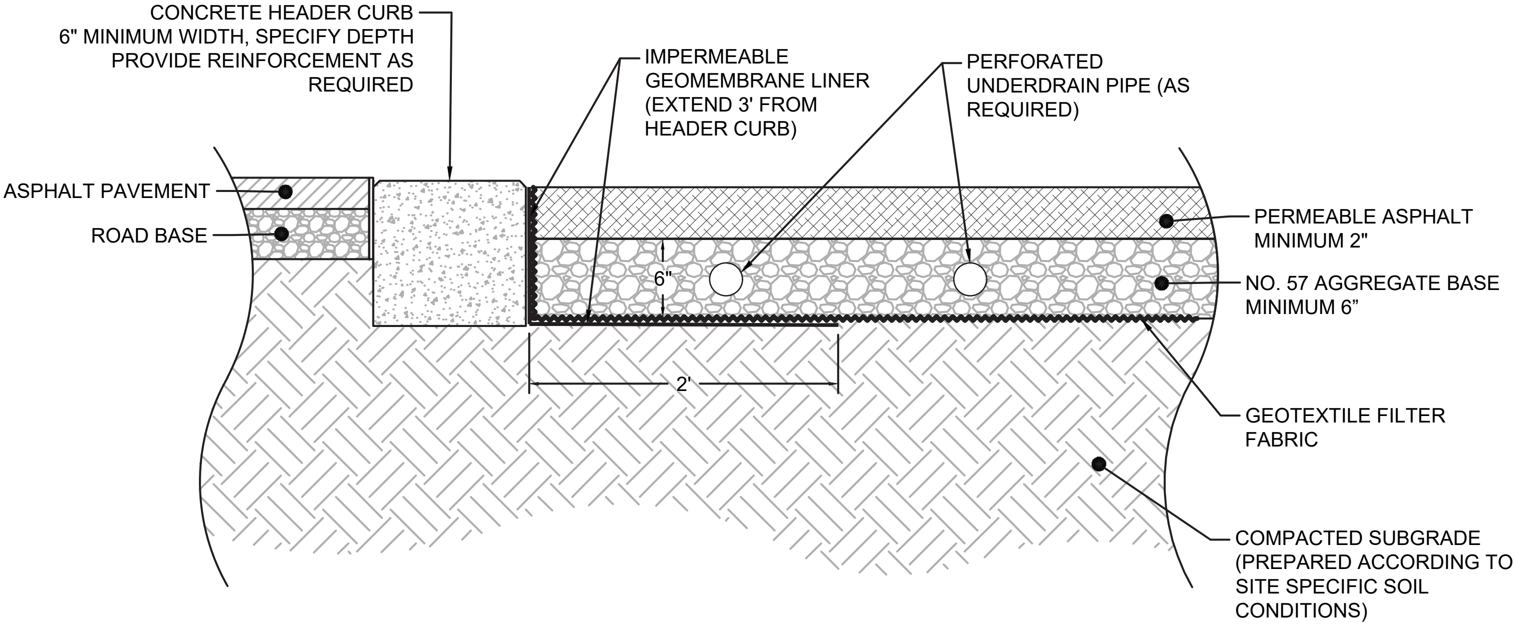
Step 4. The native soils along the bottom of the permeable pavement system should be scarified or tilled to a depth of 8 to 10 inches and graded prior to the placement of the filter fabric and aggregate.

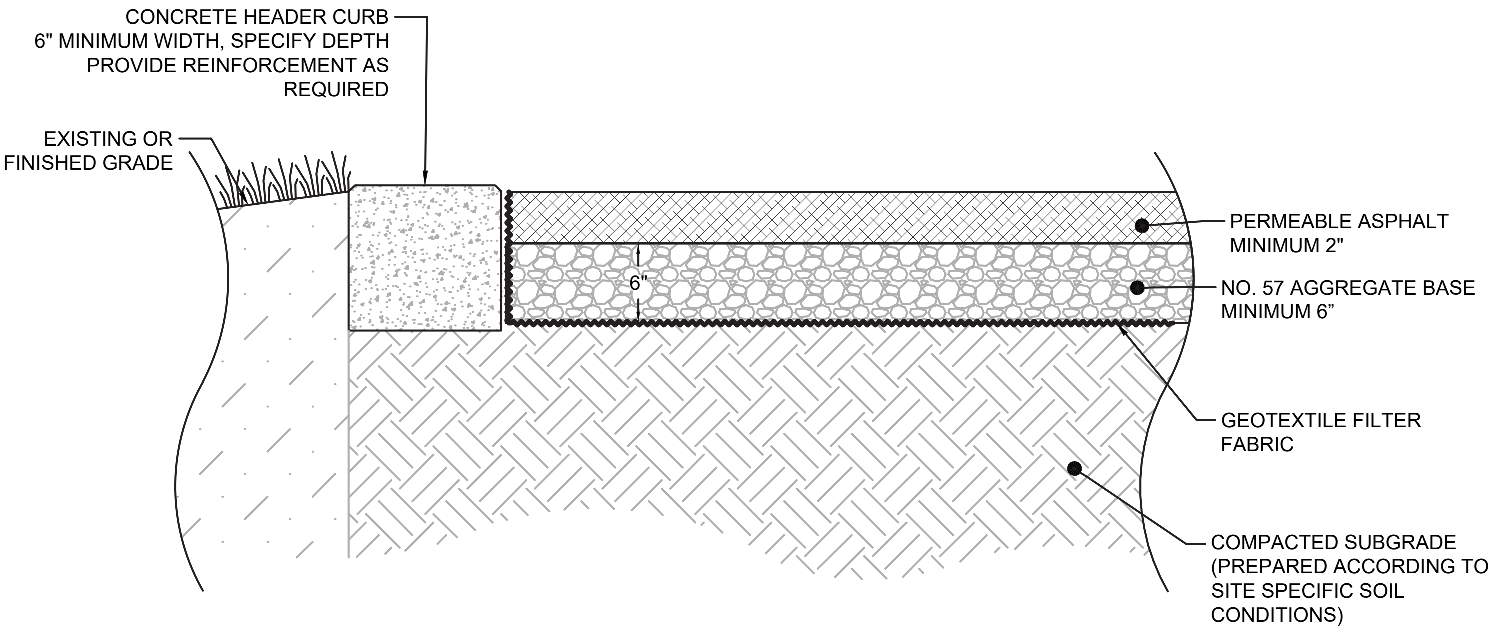
Step 5. Geotextile should be installed per plan details.

Step 6. Install the underdrain per plan line and grade. The underdrains should slope down towards the outlet at a grade of 0.5 percent or steeper. The up-gradient end of underdrains in the reservoir layer should be capped. Where an underdrain pipe is connected to a structure, there should be no perforations within at least one foot of the structure. Ensure that there are no perforations in clean-outs within at least one foot from the surface.

Step 7. Spread maximum 6 inches of the reservoir base/subbase or base stone per plan grades and dimensions. Moistening the aggregate during spreading will facilitate better compaction. Compact reservoir layers. Do not crush the aggregate with the roller. Corners and other areas where rollers cannot reach are compacted with a vibratory plate compactor capable of least 13,500 pound-force (lbf) and equipped with a compaction indicator.

Step 8. Paving materials should be installed according to manufacturer or industry specifications for the type of pavement called for in the plans. After the installation is complete, the permeable pavement surface should be tested for acceptance using a minimum infiltration rate of 100 inch/hr using ASTM C1701 Standard Test Method for Infiltration Rate of In Place Pervious Concrete. This test method can also be used on porous asphalt and permeable interconnected concrete pavers.

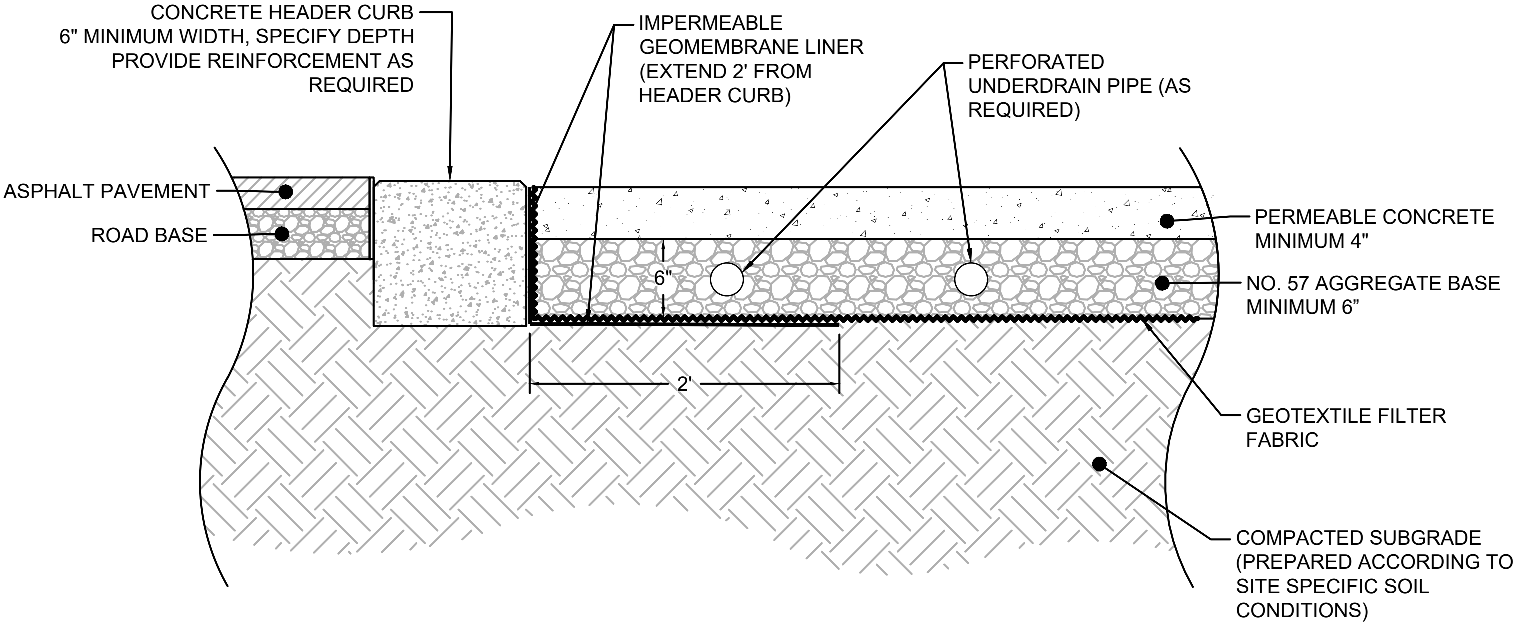


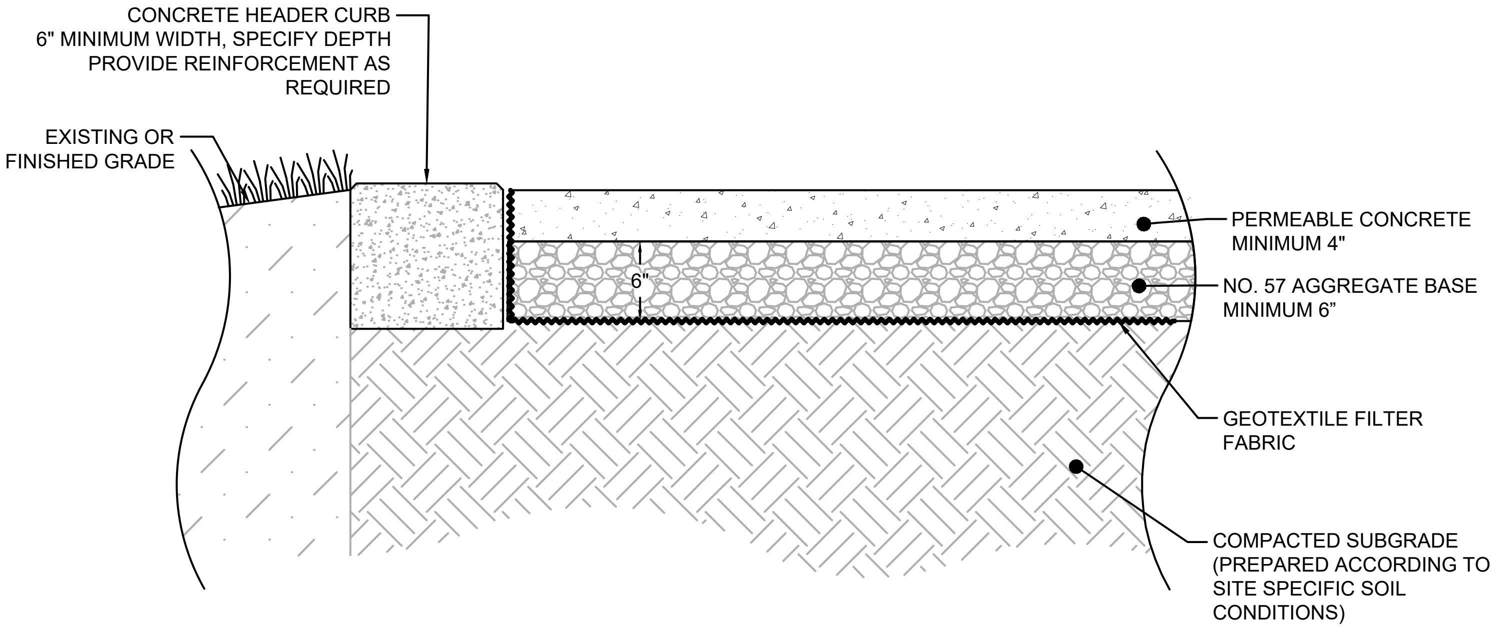


DESIGN NOTES:

1. DESIGNER TO SPECIFY DEPTH OF PERMEABLE PAVEMENT. DEPTH SHALL BE DESIGNED TO WITHSTAND ANTICIPATED STRUCTURAL LOADING.
2. GEOTECHNICAL ENGINEER NEEDS TO BALANCE STRUCTURAL STABILITY AND SOIL INFILTRATION WHEN RECOMMENDING SUBGRADE CONDITIONS.
3. WHERE THE FILTRATION GEOTEXTILE IS NEEDED, USE TYPE D-3 AS LISTED IN FDOT SPECIFICATION SECTION 985.
4. ADDITIONAL AGGREGATE STORAGE LAYER CAN BE INSTALLED BENEATH NO. 57 BASE, BUT ABOVE GEOTEXTILE FABRIC AND IMPERMEABLE LINER, FOR INCREASED STORAGE CAPACITY.
5. UNDERDRAIN IS OPTIONAL, AND SHOULD CONSIST OF PERFORATED PVC, HDPE, OR PP PER FDOT SPECIFICATION 443 FRENCH DRAINS.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	PERMEABLE ASPHALT	SHT. NO. 1234

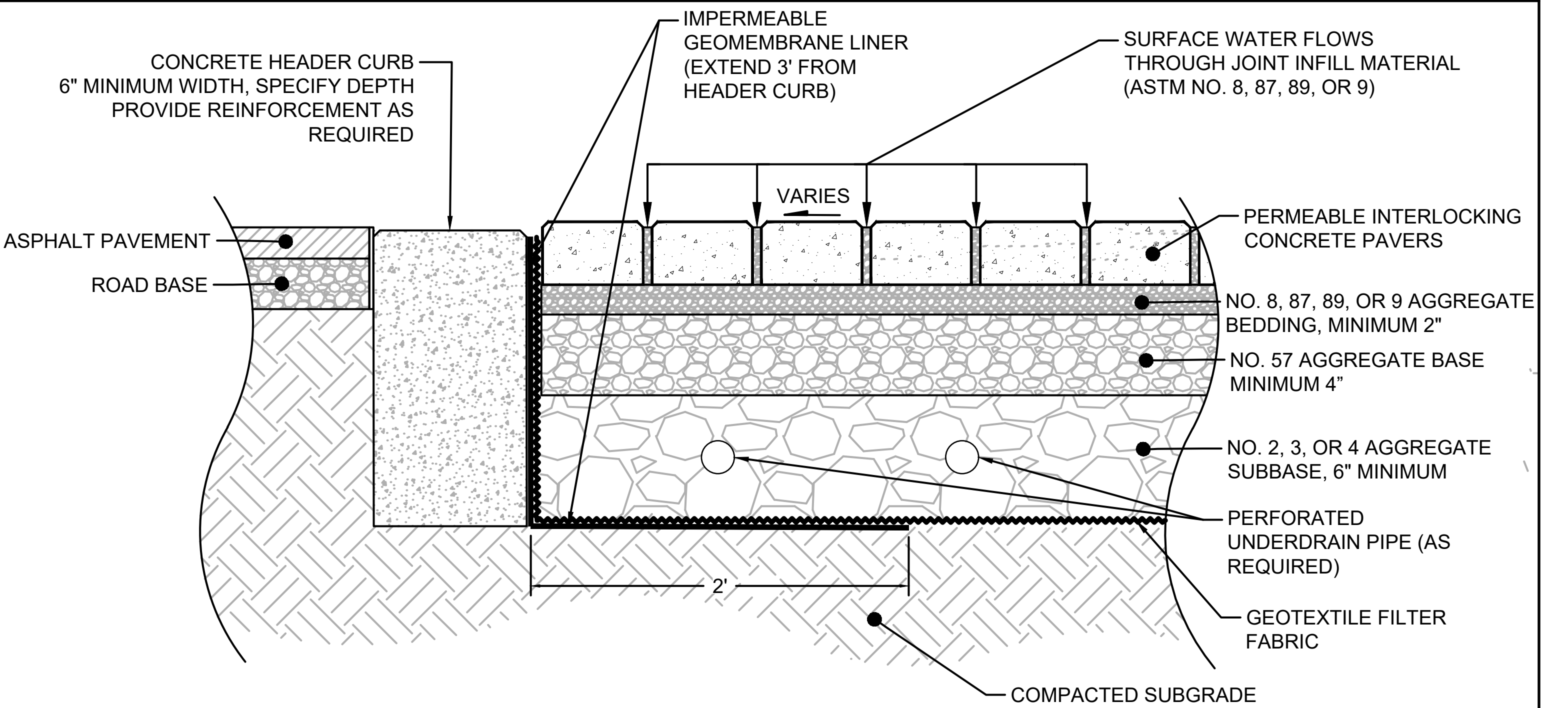


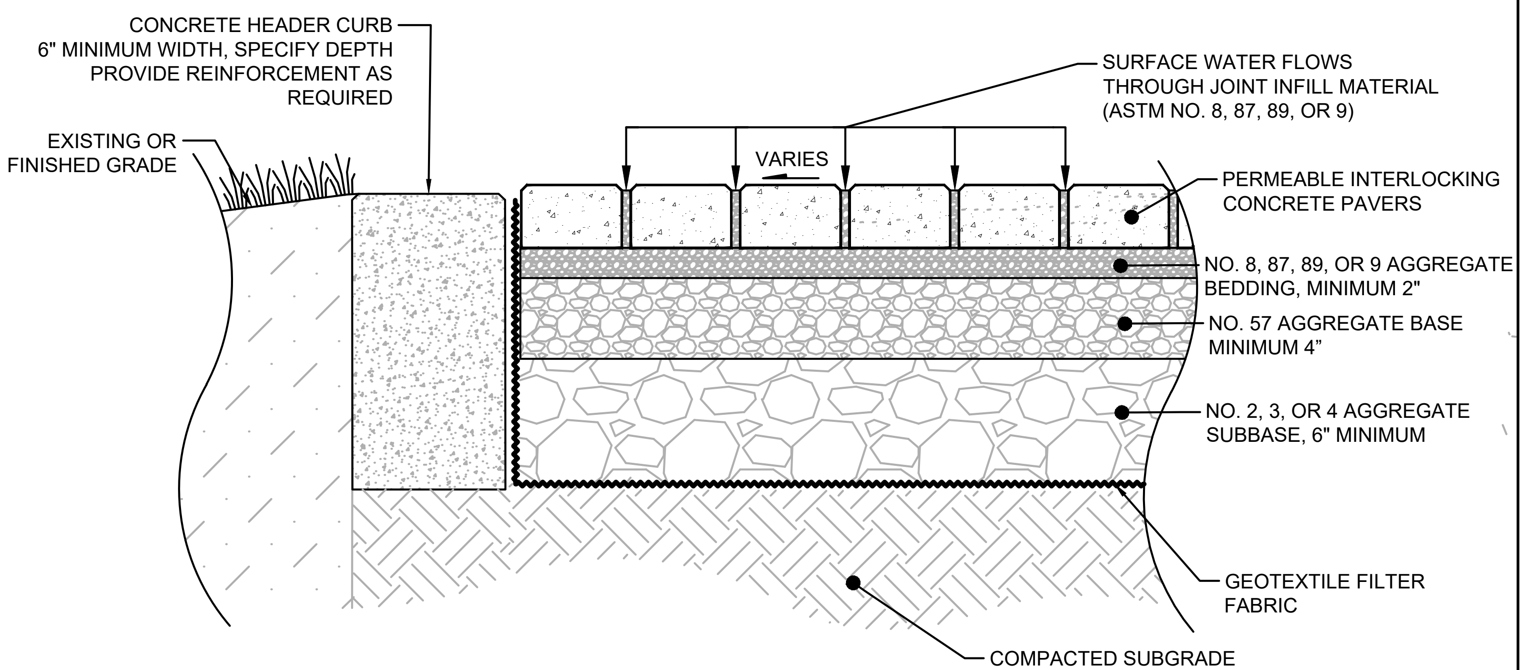


DESIGN NOTES:

1. DESIGNER TO SPECIFY DEPTH OF PERMEABLE PAVEMENT. DEPTH SHALL BE DESIGNED TO WITHSTAND ANTICIPATED STRUCTURAL LOADING.
2. GEOTECHNICAL ENGINEER NEEDS TO BALANCE STRUCTURAL STABILITY AND SOIL INFILTRATION WHEN RECOMMENDING SUBGRADE CONDITIONS.
3. WHERE THE FILTRATION GEOTEXTILE IS NEEDED, USE TYPE D-3 PER FDOT SPECIFICATION SECTION 985.
4. ADDITIONAL AGGREGATE STORAGE LAYER CAN BE INSTALLED BENEATH NO. 57 BASE, BUT ABOVE GEOTEXTILE FABRIC AND IMPERMEABLE LINER, FOR INCREASED STORAGE CAPACITY.
5. UNDERDRAIN IS OPTIONAL, AND SHOULD CONSIST OF PERFORATED PVC, HDPE, OR PP PER FDOT SPECIFICATION 443 FRENCH DRAINS.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	PERMEABLE CONCRETE	SHT. NO. 1234





DESIGN NOTES:

1. GEOTECHNICAL ENGINEER NEEDS TO BALANCE STRUCTURAL STABILITY AND SOIL INFILTRATION WHEN RECOMMENDING SUBGRADE CONDITIONS.
2. WHERE THE FILTRATION GEOTEXTILE IS NEEDED, USE TYPE D-3 AS LISTED IN FDOT SPECIFICATION SECTION 985.
3. UNDERDRAIN IS OPTIONAL, AND SHOULD CONSIST OF PERFORATED PVC, HDPE, OR PP PER FDOT SPECIFICATION 443 FRENCH DRAINS.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	PERMEABLE INTERCONNECTING CONCRETE PAVERS (PICP)	SHT. NO. 1234

5.1.8 GRASS CHANNEL

DESCRIPTION

Grassed channels are long, man-made ditches designed to convey stormwater runoff with sufficient residence time to allow time for sedimentation and nutrient uptake.

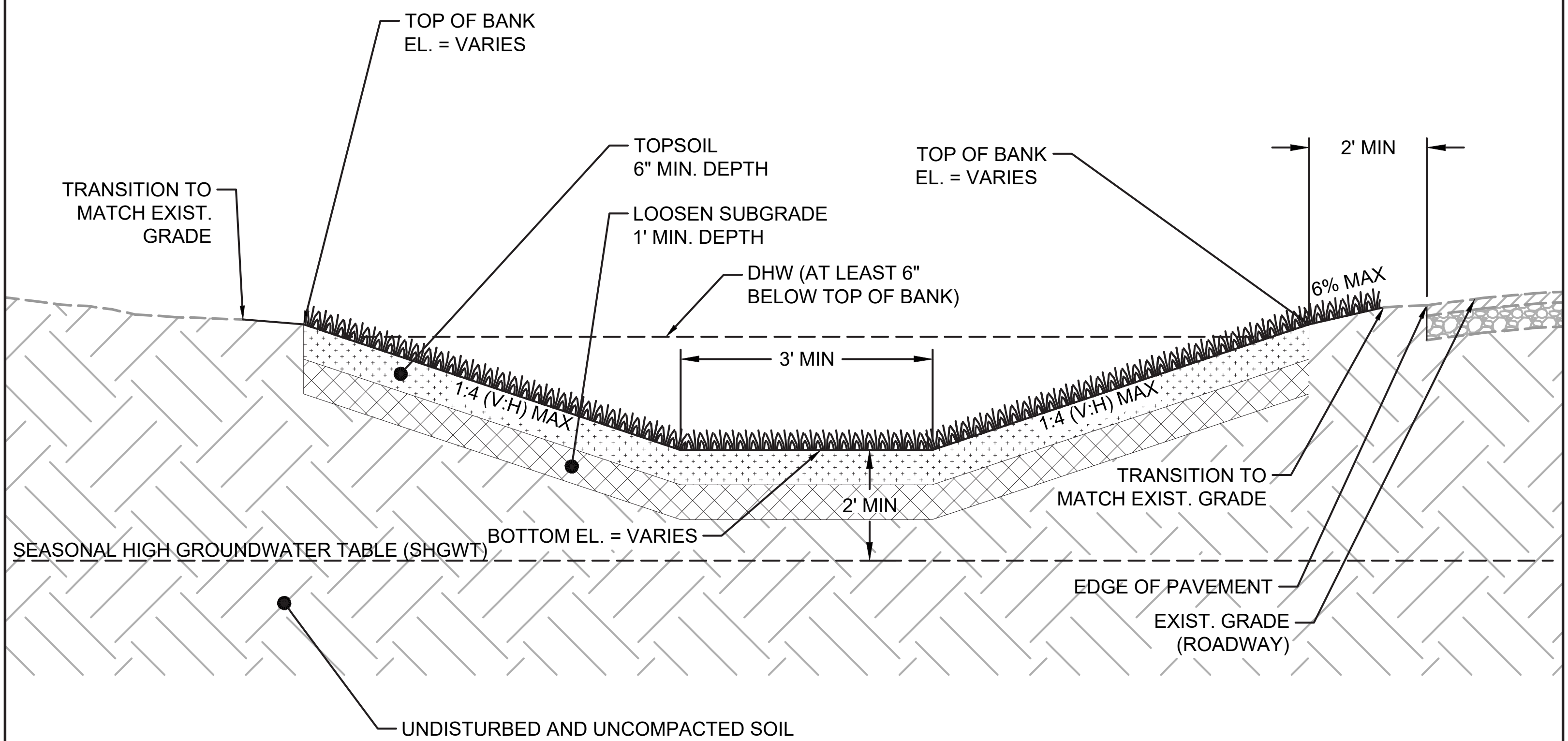
MATERIALS

- *Seed*: FDOT Specification 570, Performance Turf
- *Sod/Grass*: Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements. Topsoil: FDOT Specification 987, Soil Layer Materials.
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.
- For areas with specific turf needs, consult Table 1 in the University of Florida IFAS Extension, Best Management Practices for Protection of Water Resources by Green Industries, for a comparison of lawn grasses available for use in Florida.

CONSTRUCTION

Construct the grassed channel to the shape and elevations shown in the plans. Remove all construction debris in areas to be grassed. Place topsoil and install performance turf at the earliest practical time for erosion control and establishment.

Monitor placed seed/sod for growth of invasive pest plants and noxious weeds. If exotic or invasive pest plants and/or noxious weeds move in, treat affected areas by means acceptable to the County.



DESIGN NOTES:

1. AVOID COMPACTION OF ALL IN-SITU SOILS AND IMPORTED SOILS UNLESS OTHERWISE SPECIFIED.
2. SOD TYPE SHOULD BE SELECTED BASED ON SITE CONDITIONS INCLUDING SOIL TYPE, MOISTURE CONDITIONS, DESIGN FLOWS, SUN EXPOSURE, AESTHETICS AND MAINTENANCE REQUIREMENTS.
3. FOR PERMISSIBLE CHANNEL LININGS AND VELOCITIES, SEE FDOT DRAINAGE MANUAL CHAPTER 2.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida EST. 1834	GRASS CHANNEL	SHT. NO. 1234

5.1.9 RAIN GARDEN

DESCRIPTION

Rain Gardens are small-scaled retention basins, typically designed in low areas on the site, with native soils or specialized engineered media. Rain Gardens utilize native flora and promote habitat for insects, birds, and small animals.

MATERIALS

- *Sod/Grass*: Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements. Topsoil: FDOT Specification 987, Soil Layer Materials.
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.
- *Pipe*: If a pipe is called for, use a perforated Polyvinyl Chloride (PVC), High Density Polyethylene (HDPE) or Polypropylene (PP) pipe, per Section 443 of FDOT Specification for French Drains.
- *Backfill Rock*: FDOT Specification 901, Coarse Aggregate
- *Geotextile/Filter Fabric*: If an underdrain is called for, use Type D-3 as listed in FDOT Specification Section 985.
- *Engineered Media*: If an engineered media is used, it should achieve a long-term, in-place infiltration rate and support plant growth. Engineered soils medias are typically patented products, therefore installation instructions should adhere to proprietary requirements.

CONSTRUCTION

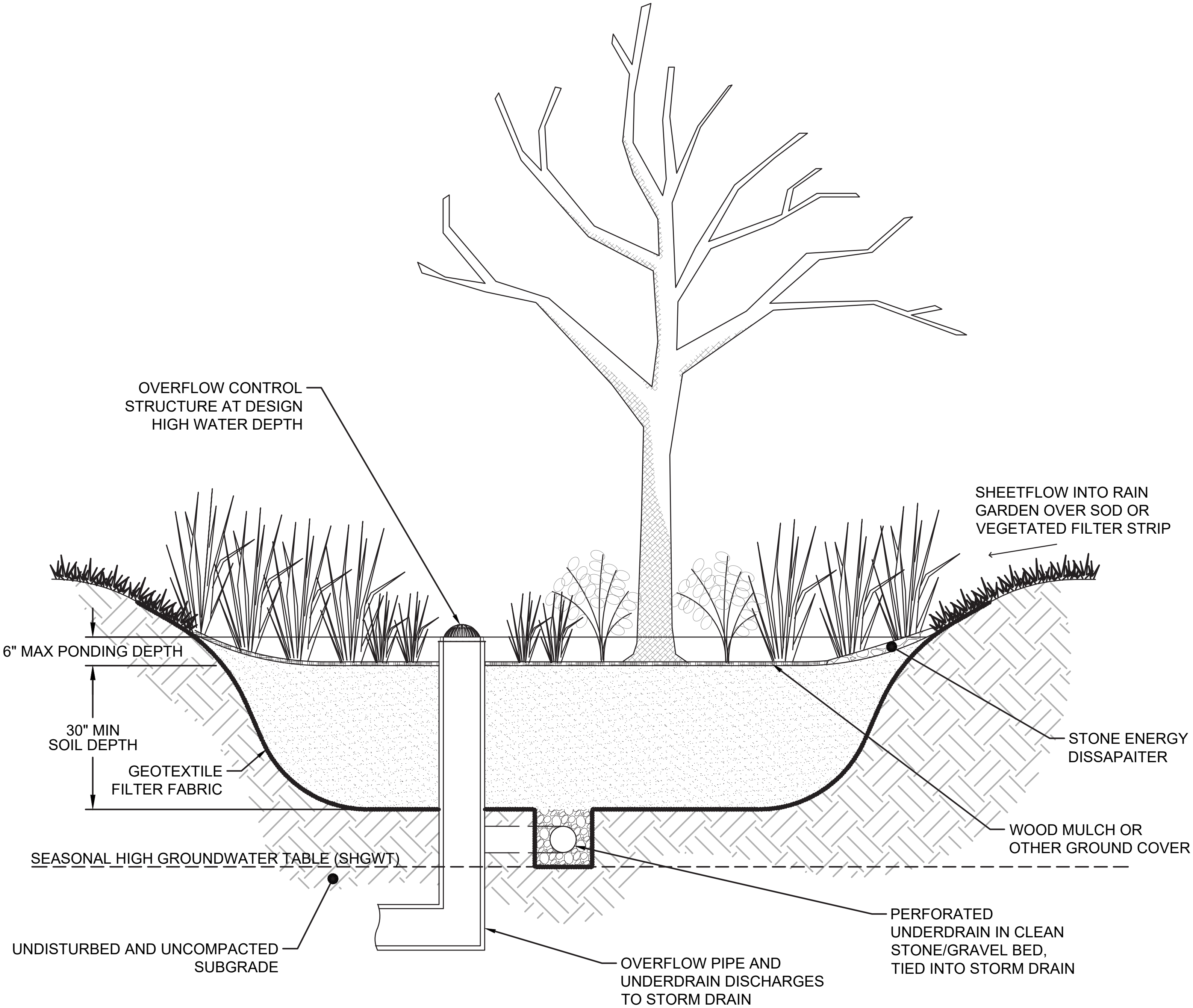
General: Before the site is graded, prevent heavy equipment from compacting the underlying soils in the area of the rain garden. During construction, sediment and erosion controls should be used to keep runoff and sediment away from the rain garden to prevent sedimentation.

Shape the rain garden as shown on the plans. Subsoil should be prepared with a rototiller to a depth of 8-10 inches and gently smoothed. Add a two-inch layer of compost along the entire bottom of the garden. A minimum of 12-inches of topsoil should be applied for the development of the rooted vegetation. Mulch as needed to prevent weed growth.

5.1.9 CONTINUED

If an engineered media is to be used, excavate the garden to the depth shown in the plans to allow the media to be placed. If an underdrain is called for in the plans, place the filter, rock, and pipe per the line, grades, and dimensions shown in the plans, being careful to overlap the filter fabric over the top of the rock envelope.

Landscape Plantings: Before digging a hole for landscape plants, 1) remove all soil from above the topmost root, and 2) measure the distance between the topmost root and the bottom of the root ball. Dig the hole about 10 percent shallower than this depth and as wide as possible (at least one and a half times the width of the ball and even wider in compacted soils). The root ball should be positioned in the hole shallowly enough so that the finished grade of the backfill soil and landscape soil is lower than the top of the root ball. In other words, leave no more than 10% of the upper portion of the sides of the root ball exposed to the air. Then apply mulch so that it covers the sides of the root ball. Be sure that when you are finished planting, there is NO SOIL, and little or no mulch, over the top of the root ball. For more information refer to Section 10 of the Hillsborough County Transportation Technical Manual and the University of Florida IFAS Extension, Best Management Practices for Protection of Water Resources in Florida, by Florida Green Industries.



DESIGN NOTES:

1. AVOID COMPACTION OF ALL IN-SITU SOILS AND IMPORTED SOILS UNLESS OTHERWISE SPECIFIED.
2. PLANTING SCHEME WITHIN RAIN GARDEN IS TO BE DETERMINED BY A LANDSCAPE ARCHITECT. NATIVE PLANTS ARE RECOMMENDED.
3. RAIN GARDEN SHALL BE SIZED APPROPRIATELY FOR SITE CONDITIONS.
4. UNDERDRAIN ROCK ENVELOPE SHOULD BE KEPT ABOVE THE SHGWT.

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5.1.10 TREE PRESERVATION

DESCRIPTION

Designers often have the capability to avoid impact on trees during the design and construction phases and should work with local authorities and owners to protect trees on a site.

MATERIALS

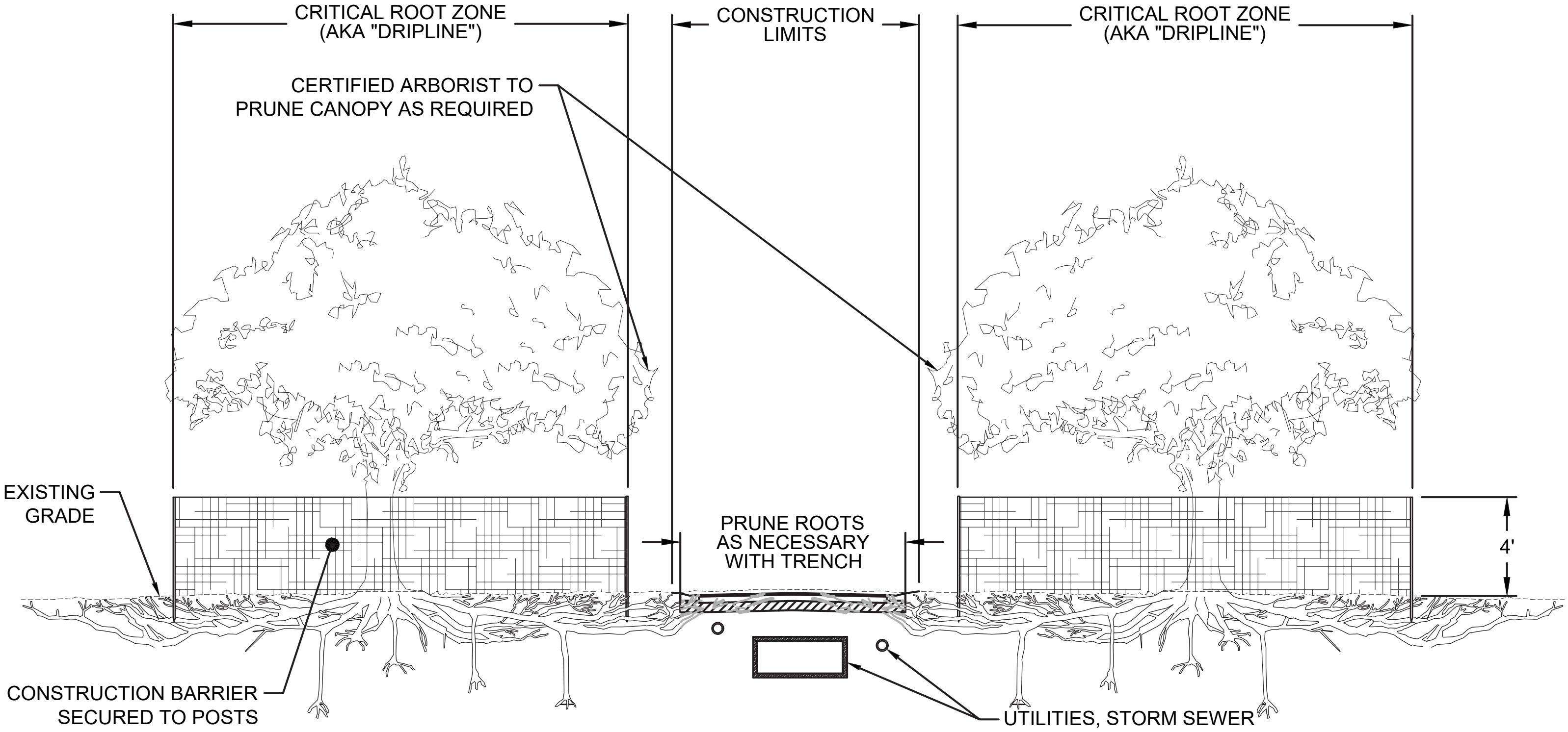
Temporary barrier or fencing and posts as required in Hillsborough County Transportation Technical Manual, Tree Protection TD-16(01)

CONSTRUCTION

Refer to Hillsborough County Transportation Technical Manual, Tree Protection TD-16(01). Tree barricades should be placed prior to site clearing and grubbing begins for construction.

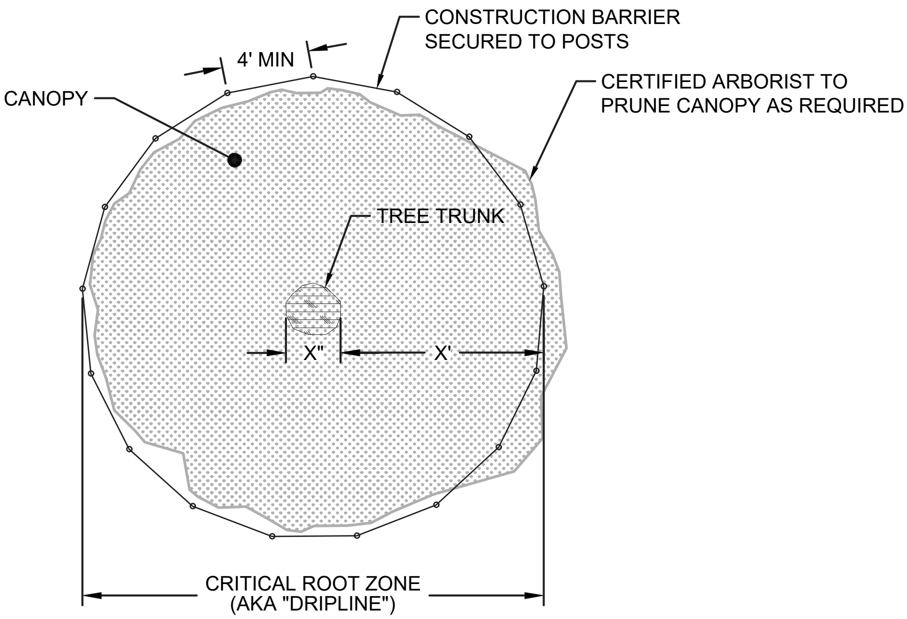
Tree barricade dimensions are based on Diameter at Breast Height (DBH) of the existing tree to be preserved. Barricades shall be built in the dimensions of a box. Use the DBH of the existing tree to be preserved to determine the dimensions of the tree barricade and adjust as needed for sidewalks, curbs, buildings, and proposed building footprints.

Barricades shall remain erected and maintained throughout the construction process. Only hand tools may be used within the barricade. Trenching, digging, or grading is not allowed.



SECTION VIEW

NOT TO SCALE



PLAN VIEW

NOT TO SCALE

DESIGN NOTES:

1. CRITICAL ROOT ZONE: EXTENDS IN ALL DIRECTIONS FROM TRUNK OF TREE TO A DISTANCE EQUAL TO ONE FOOT PER INCH OF TRUNK DIAMETER AT BREAST HEIGHT.
2. FOR TREE GROUPINGS, FENCE OFF GROUP OF INDIVIDUAL BARRIERS AND PROVIDE ACCESS FOR MAINTENANCE.

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5.1.11 URBAN FORESTATION

DESCRIPTION

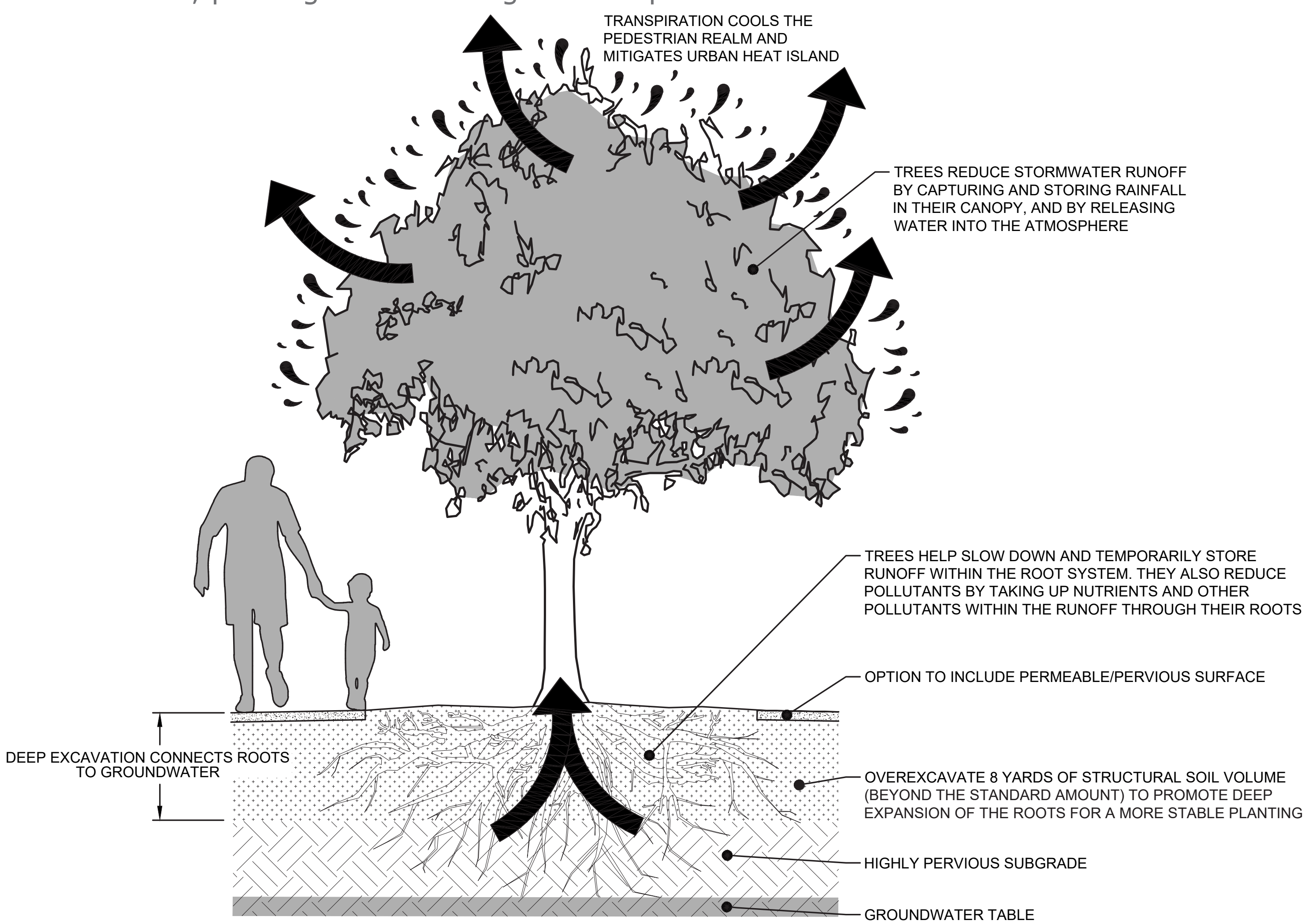
Urban forestation is the incorporation of trees and other vegetation into the urban environment.

CONSTRUCTION

Plant trees per the locations shown in the plans. When planting trees, refer to the University of Florida guide on proper techniques for planting and establishing trees:

http://gardeningsolutions.ifas.ufl.edu/care/planting/planting-and-establishing-trees.html

Monitor and maintain trees during the tree establishment period, replacing any trees that fail, pruning and restoring trees to plumb as needed.



5.1.12 VEGETATED FILTER STRIPS

DESCRIPTION

Vegetated Filter Strips are permanent, maintained strips of planted or indigenous vegetation located between nonpoint sources of pollution and receiving water bodies for the purpose of removing or mitigating the effects of nonpoint source pollutants such as nutrients, pesticides, sediments, and suspended solids.

MATERIALS

- *Seed*: FDOT Specification 570, Performance Turf
- *Sod/Grass*: Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements. Topsoil: FDOT Specification 987, Soil Layer Materials.
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.
- For areas with specific turf needs, consult Table 1 in the University of Florida IFAS Extension, Best Management Practices for Protection of Water Resources by Green Industries, for a comparison of lawn grasses available for use in Florida.

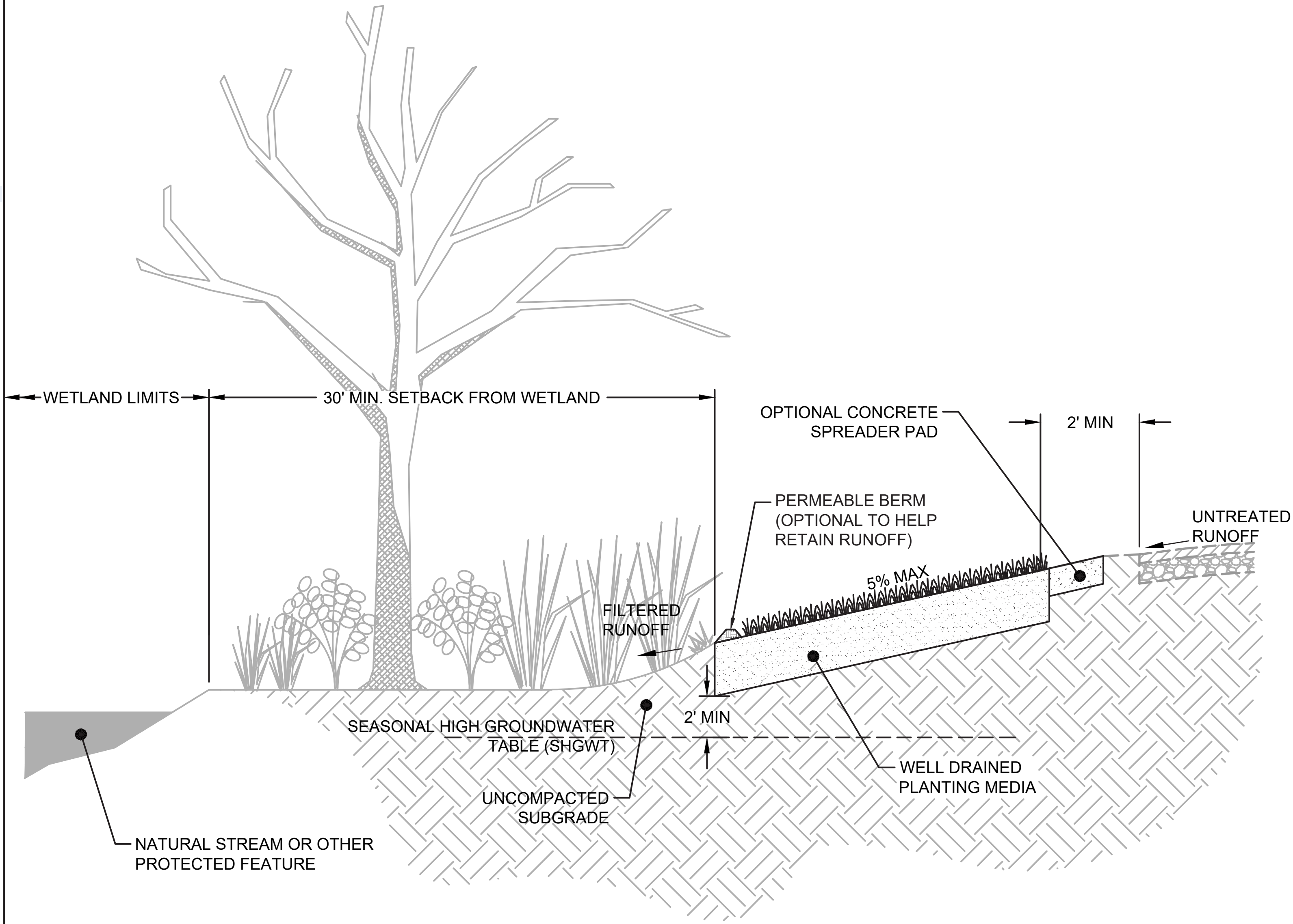
CONSTRUCTION

General: Vegetated filter strips can be created by the preservation of onsite existing landscape. If this is the case, erosion control measures (silt fencing, hay bales, etc.) should be installed at the beginning of site development to prevent damage to existing vegetation and preserve its natural state.

If a vegetated filter strip is to be constructed, prepare the subsoil with a rototiller to a depth of 8-10 inches and gently smoothed. A minimum of 12-inches of topsoil should be applied before plantings are installed.

Stabilize the vegetated strip using seed, sod or plantings as shown in the plans. Mulch as needed to prevent weed growth.

Landscape Plantings: Before digging a hole for landscape plants, 1) remove all soil from above the topmost root, and 2) measure the distance between the topmost root and the bottom of the root ball. Dig the hole about 10 percent shallower than this depth and as wide as possible (at least one and a half times the width of the ball and even wider in compacted soils). The root ball should be positioned in the hole shallowly enough so that the finished grade of the backfill soil and landscape soil is lower than the top of the root ball, so no more than 10% of the upper portion of the sides of the root ball is exposed to the air. Then apply mulch so that it covers the sides of the root ball. Be sure that when you are finished planting, there is NO SOIL, and little or no mulch, over the top of the root ball. For more information refer to Section 10 of the Hillsborough County Transportation Technical Manual and the University of Florida IFAS Extension, Best Management Practices for Protection of Water Resources in Florida, by Florida Green Industries.



DESIGN NOTES:

1. AVOID COMPACTION OF ALL IN-SITU SOILS AND IMPORTED SOILS UNLESS OTHERWISE SPECIFIED.
2. VEGETATION TYPE SHOULD BE SELECTED BASED ON SITE CONDITIONS INCLUDING SOIL TYPE, MOISTURE CONDITIONS, DESIGN FLOWS, SUN EXPOSURE, AESTHETICS AND MAINTENANCE REQUIREMENTS. VEGETATED FILTER STRIP MAY ALSO BE NATURAL VEGETATION LEFT UNDISTURBED.

5.1.13 TREE FILTER BOXES

DESCRIPTION

Tree box filters are popular bioretention and infiltration practices, as they collect, retain, and filter the first flush of runoff as it passes through vegetation and microorganisms in the soil. Tree box filters are installed at curb level and consist of an open bottom concrete structure filled with a soil media, an underdrain of crushed gravel, and a tree.

MATERIALS

- *Drainage Structures*: FDOT Specification Section 449, Precast Concrete Drainage Products.
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.
- *Pipe*: If an underdrain is called for, use perforated Polyvinyl Chloride (PVC), High Density Polyethylene (HDPE) or Polypropylene (PP) pipe. Refer to FDOT Specification Section 443-2 for perforated pipe requirements.
- *Backfill Rock*: FDOT Specification 901, Coarse Aggregate.
- *Geotextile/Filter Fabric*: If an underdrain is called for, use Type D-3 as listed in FDOT Specification Section 985.
- *Engineered Media*: If an engineered media is used, it should achieve a long-term, in-place infiltration rate and support plant growth. Engineered soils medias are typically patented products, therefore installation instructions should adhere to proprietary requirements.

CONSTRUCTION

Tree boxes are typically patented products; therefore, installation of manufactured tree boxes instructions should adhere to the recommendations of the manufacturer.

PROPRIETARY INSTALLATION SEQUENCE

In lieu of proprietary installation instructions, the following sequence can be followed:

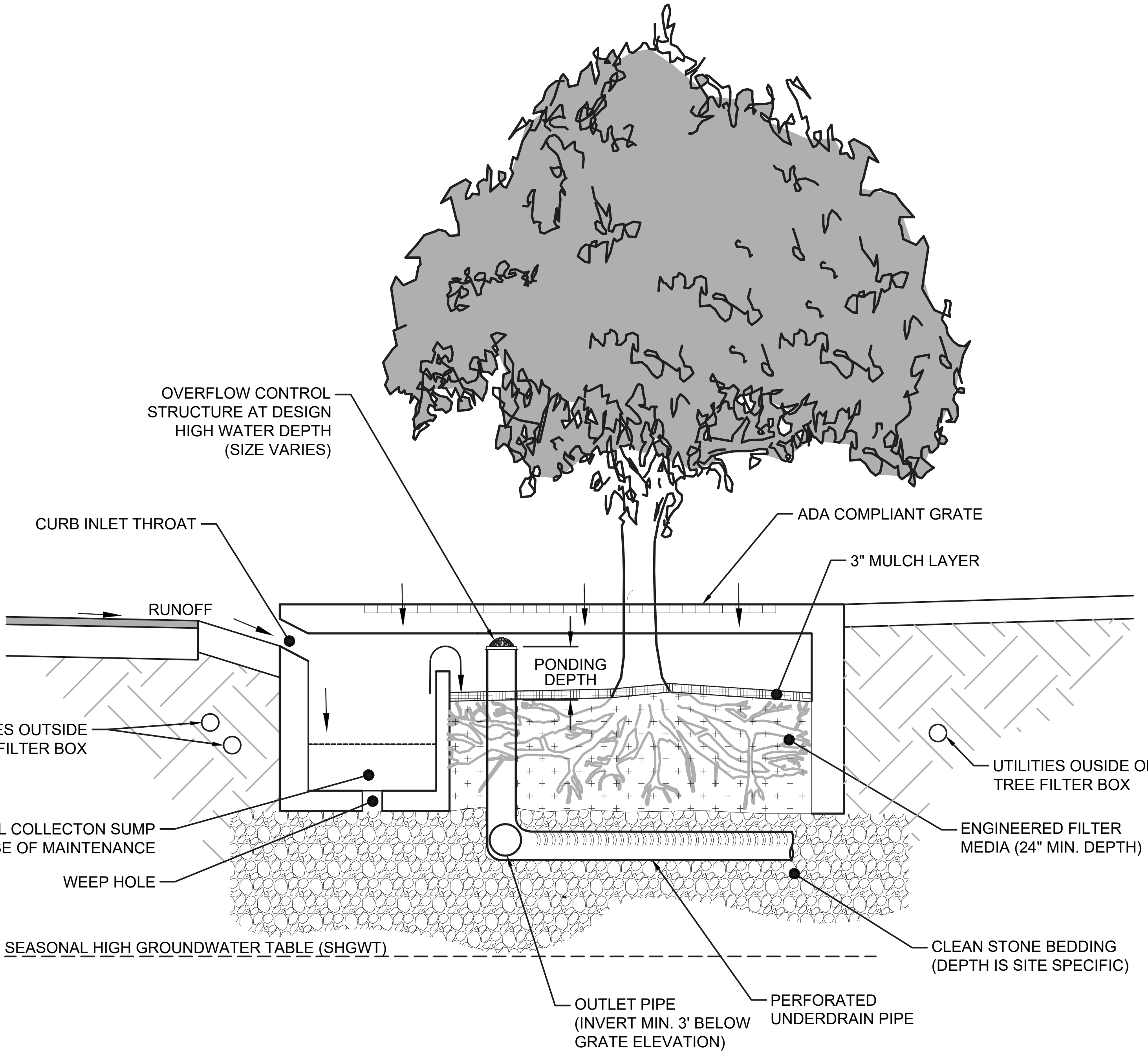
Step 1. Excavate the area where the box will be placed.

Step 2. Place aggregate base into the hole and set the concrete box on a leveled base.

Step 3. Connect underdrain pipes and fill any gaps around the tree box.

Step 4. If a confining concrete structure is not used, install root barriers to provide protection for infrastructure from tree roots when planting a street tree 8 feet or less from hardscape in any parkway or median strip.

Step 5. Plant the tree and install the metal grate(s) flush with the surrounding concrete.



DESIGN NOTES:

1. FILTER MEDIA AND STONE BEDDING CAN EXTEND BEYOND TREE FILTER FRAME FOR ADDITIONAL INFILTRATION AND STORAGE CAPACITY.
2. TREE TO BE APPROVED BY NATURAL RESOURCES.
3. STONE BEDDING LAYER SHOULD BE WRAPPED IN FILTER FABRIC.

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5.1.14 ROOFTOP RUNOFF STORAGE

DESCRIPTION

Cisterns and rain barrels are the most common, simple devices used to store rooftop runoff for reuse for landscaping and other non-potable uses.

MATERIALS

- *Sod/Grass*: Hillsborough County Land Development Code, Section 6.06 Landscaping, Irrigation and Buffering Requirements.
- *Topsoil*: FDOT Specification 987, Soil Layer Materials.

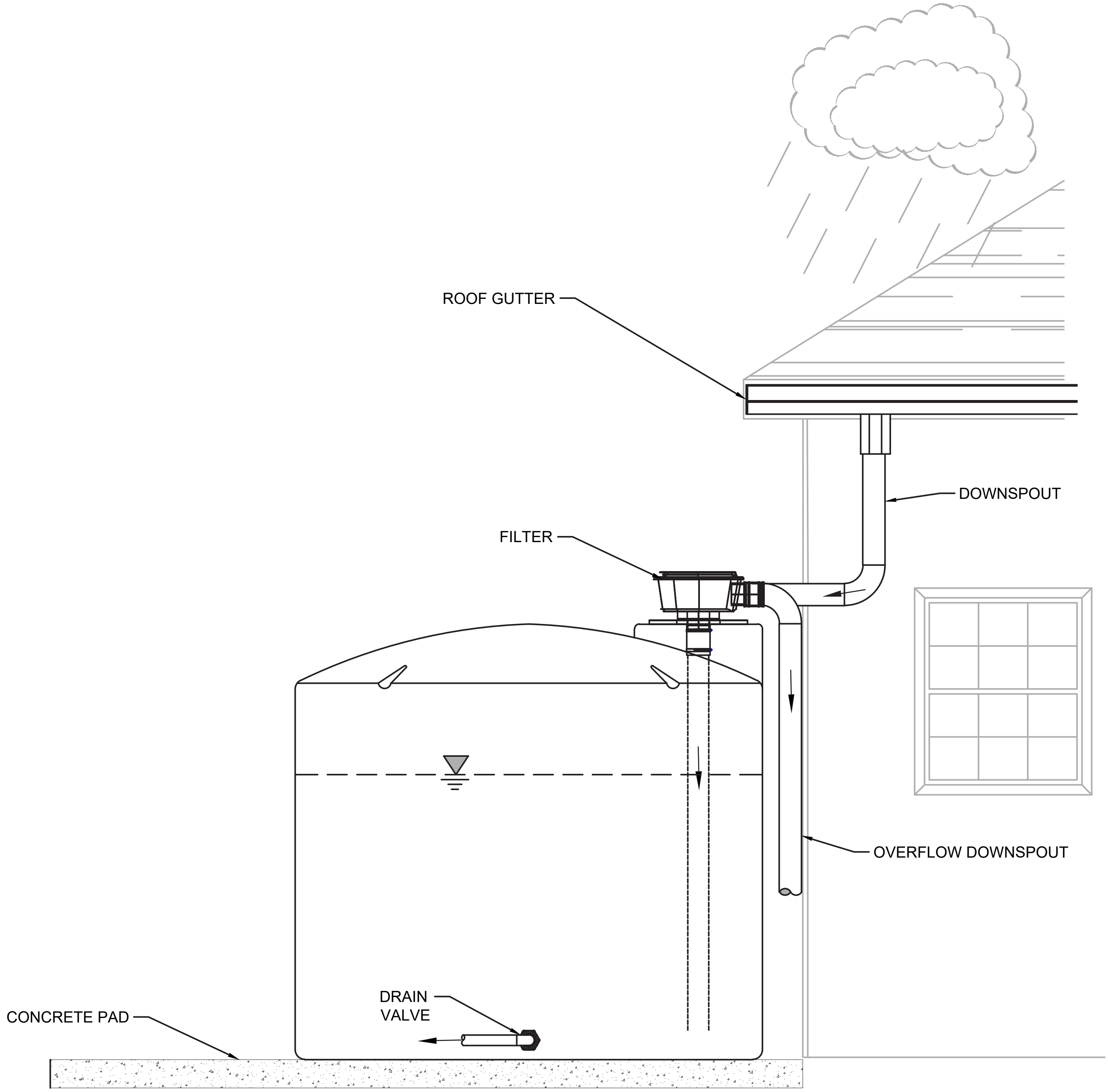
Generally, all rainwater barrel/cistern devices should include the following components:

- A solid secure cover
- A leaf / mosquito screen at cistern entrance
- A coarse inlet filter with clean-out valve
- An overflow pipe
- A manhole, sump, and drain to facilitate cleaning
- An extraction system that does not contaminate the water (e.g., a tap or pump)
- Grading of adjacent land to prevent spilled water from forming puddles near the tank

CONSTRUCTION

Place or construct rain barrels or cisterns in the locations and dimensions shown in the plans. Prefabricated rain barrels and cisterns should be installed according to the manufacturer's recommendations. Place permanent erosion control or turf, as shown in the plans, to prevent erosion during overflow from the device.

If pumps are called for as a part of larger cisterns, follow the manufacturer's recommended installation procedures.



DESIGN NOTES:

1. STORAGE RESERVOIR CAN BE CONSTRUCTED BELOW GROUND.

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	ROOFTOP RUNOFF STORAGE	SHT. NO. 1234

5.1.15 LIVING SHORELINES

DESCRIPTION

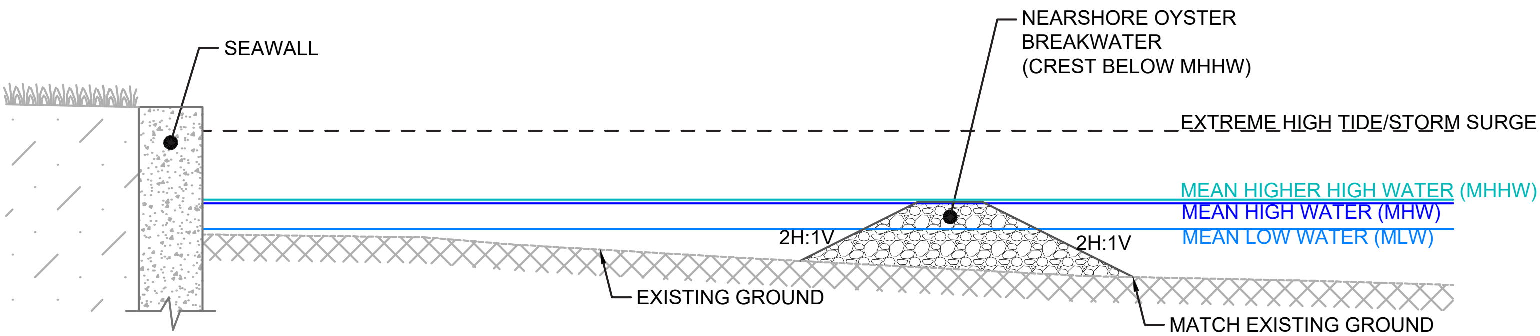
A living shoreline has a footprint that is made up mostly of native material. It incorporates natural vegetation or other living, natural soft elements alone, like oyster reefs, or in combination with some type of harder shoreline structure, rock sills, rubble, seawalls, or anchored large wood for added stability.

MATERIALS

- *Riprap*: FDOT Specification Section 530, Revetment Systems

CONSTRUCTION

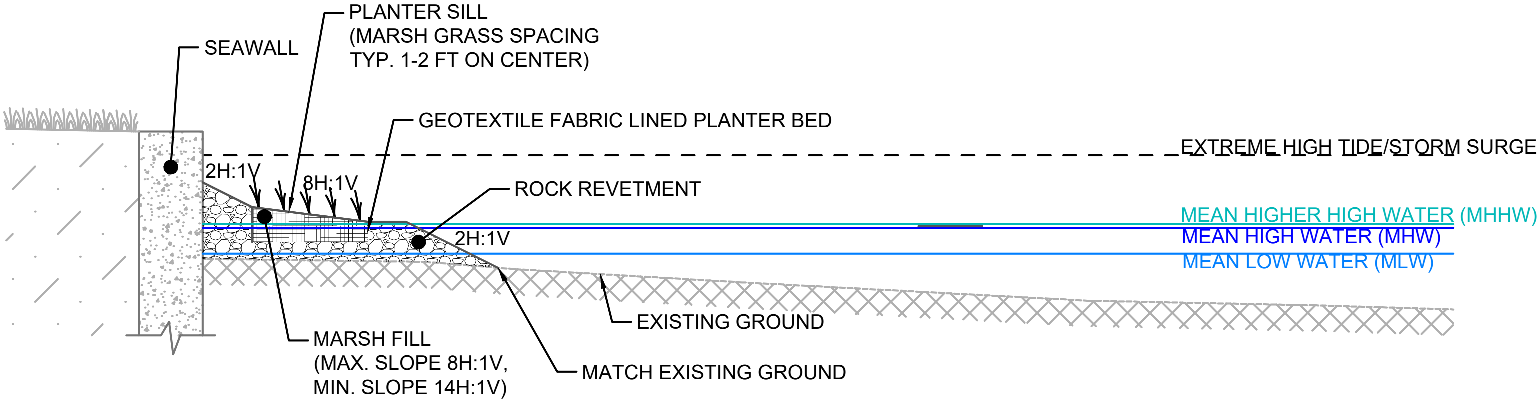
Place floating silt barrier, in accordance with the Florida Erosion and Sediment Control Manual, around the area of living shoreline construction to prevent siltation of the adjacent waterbody. Place revetment, plantings, oyster beds, and other shoreline components at the locations and spacings shown in the plans. Plantings shall be vigorous and planted according to the supplier's guidelines. Monitor the stability and health of plantings and oyster beds during the specified establishment period, replacing components of the shoreline system if they fail.



DESIGN NOTES:

1. OYSTER BREAKWATER COULD BE CONSTRUCTED WITH OYSTER BAG, SHELL HASH, OR OTHER PROPRIETARY OYSTER PRODUCTS.
2. OYSTER BREAKWATERS ARE ONE POTENTIAL APPLICATION OF OYSTER HABITAT CREATION AND PROTECTION. OYSTER HABITAT PRODUCTS MAY ALSO BE PLACED ALONG THE SEAWALL TOE OR AS STABILIZATION/PROTECTION FOR VEGETATION.

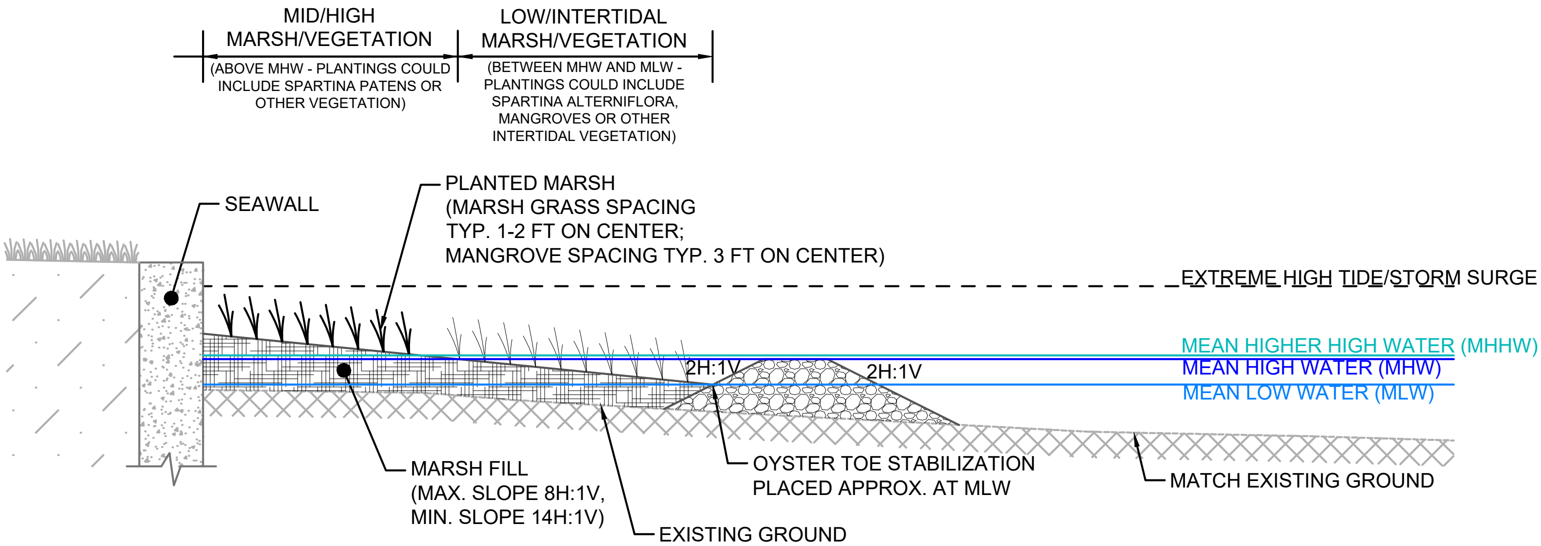
REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	LIVING SHORELINE - OYSTER BREAKWATER	SHT. NO. 1234



DESIGN NOTES:

1. IF PLANTER SILL IS LOCATED ABOVE MHW THEN MID/HIGH MARSH VEGETATION IS APPLICABLE (COULD INCLUDE SPARTINA PATENS). IF PLANTER SILL IS LOCATED BETWEEN MLW AND MHW THEN LOW/INTERTIDAL MARSH VEGETATION IS APPLICABLE (COULD INCLUDE SPARTINA ALTERNIFLORA).

REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	LIVING SHORELINE - REVETMENT WITH PLANTER SILL	SHT. NO. 1234



REV.	GREEN INFRASTRUCTURE MANUAL	Hillsborough County Florida	LIVING SHORELINE - VEGETATIVE PLANTINGS WITH TOE	SHT. NO. 1234