Green Stormwater Infrastructure

MAINTENANCE AND PLANTING MANUAL

UF | IFAS Extension
UNIVERSITY of FLORIDA

Department of Agricultural and Biological Engineering

Florida-Friendly Landscaping™ PROGRAM

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Introduction to Stormwater Management

When water evaporates from the Earth's surface, forms clouds, and falls back to the ground as rain, much of it soaks into the ground to recharge the aquifer. The water cycle is changed when we build "impervious surfaces" such as roads, parking lots, and houses (roofs), which prevent rain from filtering into the ground. Uncontrolled stormwater runoff can contribute to flooding, erosion, and pollution issues, potentially causing harm to people, property, and our environment.

Stormwater refers to the runoff from rainfall that flows across surfaces such as roads, rooftops, and sidewalks, eventually making its way into streams, rivers, lakes, and other water bodies. Stormwater management aims to mitigate the impacts of urbanization and promote the sustainable use of water resources. The primary goals of stormwater management are to reduce flooding, prevent erosion, and improve water quality. With gray infrastructure (storm drains, pipes, and stormwater ponds), stormwater runoff is typically collected and conveyed quickly to a centralized system of holding ponds or storage systems that can fill quickly and then slowly release stormwater, reducing the downstream flood and erosion risk. Gray infrastructure can be enhanced to reduce trash and other pollutants through the use of curb inlet baskets, baffle boxes, exfiltration trenches, stormwater pond littoral zones, and nutrient-reducing media.

Low Impact Development (LID) is a site planning and design approach that avoids and reduces the amount of runoff and pollution generated from a site. This is done by limiting the disturbed area and impervious cover and then disconnecting impervious areas from piped collection systems by first directing runoff onto permeable surfaces. Green Stormwater Infrastructure (GSI) encompasses structural and non-structural stormwater control measures that can be incorporated into the landscape and are used to mitigate runoff that could not be avoided or minimized through LID. LID and GSI (collectively LID+GSI) are complementary approaches or tools for limiting the production of and enhancing the management of stormwater. They work to preserve a site's hydrology and manage runoff near its source rather than immediately conveying it off-site.

Green Stormwater Infrastructure are innovative techniques for stormwater management that integrate natural and engineered systems to effectively manage and treat stormwater runoff. It represents a paradigm shift from conventional "gray" infrastructure, such as pipes and storage tanks, toward more sustainable and environmentally friendly solutions. GSI mimics natural hydrological processes and utilizes vegetation, soils, and other natural elements to manage stormwater. GSI can complement traditional stormwater infrastructure when designed correctly. GSI techniques can be designed with emergency overflow structures or bypass inlets that direct water into traditional gray infrastructure during major rain events. One of the key benefits of GSI is its ability to enhance water quality. GSI components, including vegetation and engineered filtration systems, help filter and remove these contaminants, improving the quality of stormwater before it reaches lakes, rivers, and streams.

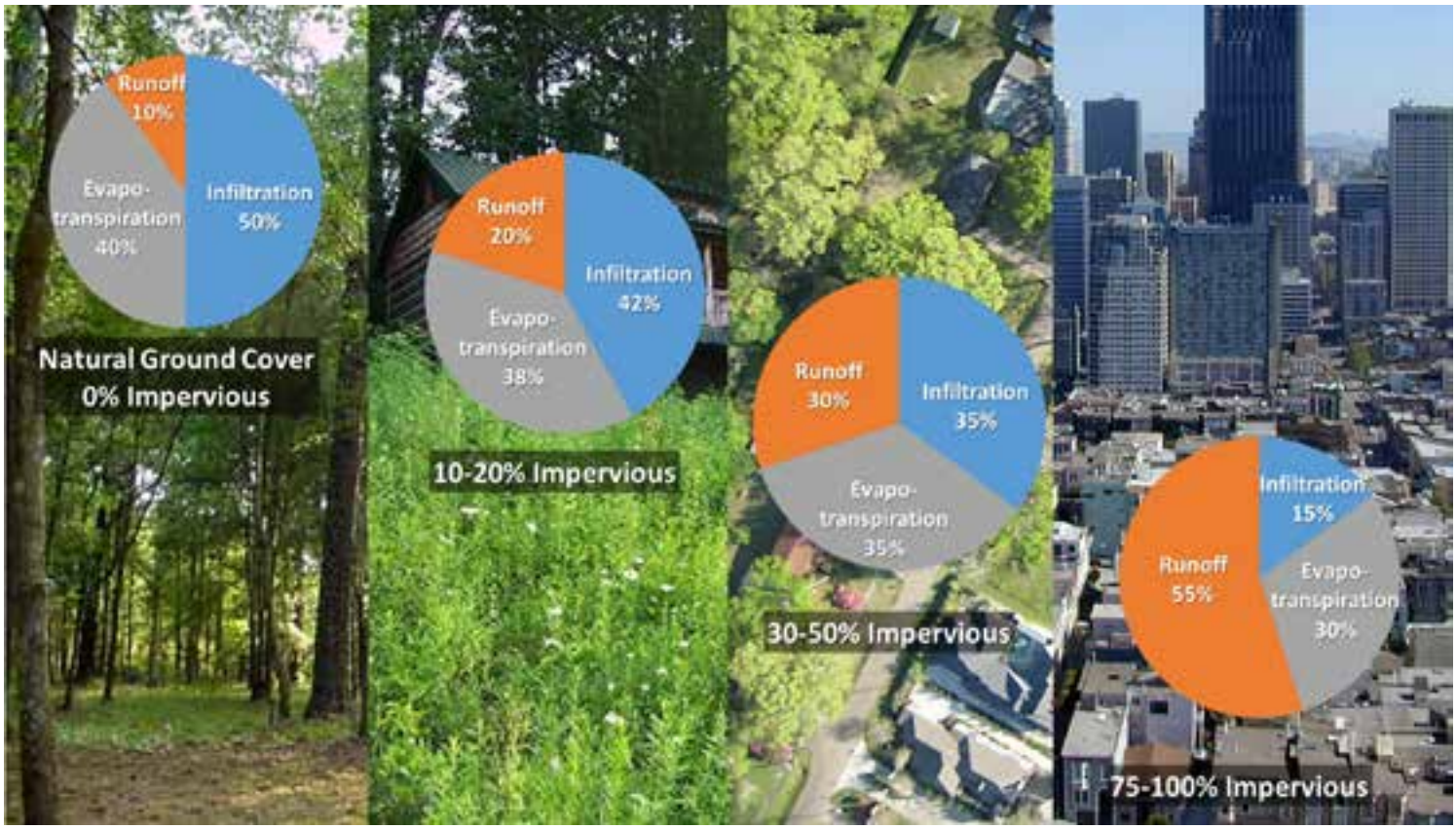
Why Green Stormwater Infrastructure Matters

Due to Florida's rapidly growing population, the state continues to see an increase in commercial, residential, and infrastructure development. Although economically advantageous, development brings environmental challenges that could negatively impact Florida residents, visitors, and businesses if not thoughtfully managed.

One such challenge involves the increase of hard, impervious surfaces like concrete, asphalt, roofs, and soils compacted by urban development that prevent rain from seeping into the ground and pollutants from being naturally filtered out by the soil. As a result, water rapidly runs off into storm drains, ponds, lakes, and streams. This stormwater runoff increases the risk of flooding and carries pollutants such as petroleum products, bacteria, fertilizer, pesticides, and heavy metals to waterbodies where it can harm ecosystems and impact water quality. Floridians rely on the state's high-quality water resources for many reasons, including fresh drinking water, recreation, fish and shellfish propagation, and tourism. GSI has the potential to positively impact the community by enhancing recreational opportunities, facilitating wildlife observation, and improving aesthetic qualities in these systems.

Due to Florida's geology, surface water and groundwater in the aquifers form one connected system. The Floridan Aquifer is a 100,000-square-mile network of subterranean pools that emerges on the surface as blue freshwater springs. The connectivity of Florida's water bodies makes them vulnerable to the transport of pollutants. If not properly managed, pollutants can accumulate in stormwater from many different sources and pass into rivers, lakes, estuaries, and the aquifer.

GSI can help supplement and enhance conventional stormwater drainage systems while protecting or helping improve water quality, limiting flooding, promoting a healthy economy, and preserving our quality of life. At its core, GSI aims to replicate the natural water cycle within urban



environments. By implementing a combination of techniques, GSI captures and treats stormwater runoff at its source. These green elements act as sponges, absorbing rainfall and allowing it to infiltrate into the ground. This reduces the volume and the velocity of runoff reaching downstream areas while also reducing pollutants.

For more information about the benefits of GSI **https://gsi.floridadep.gov/**.

Why GSI Maintenance is Important

While the implementation of GSI is a major step in managing stormwater in urban areas, its long-term performance heavily relies on maintenance. One of the primary reasons maintenance is crucial for stormwater infrastructure is to preserve its functionality. Over time, stormwater infrastructure can accumulate sediment, debris, and pollutants, diminishing its capacity to store and convey stormwater effectively. Without proper maintenance, GSI elements can degrade, leading to reduced efficiency and potential system failures.

Regular cleaning and sediment removal help maintain the designed storage volume, ensuring the infrastructure's ability to handle peak flow events and reduce the risk of localized flooding. Adequate and regular maintenance of GSI will ensure that it continues to function optimally, providing the intended benefits and mitigating potential risks. Regular maintenance of GSI encompasses various activities, including inspection, cleaning, repair, and monitoring. It involves identifying and addressing issues such as sediment buildup, debris accumulation, clogged outlets, structural damage, or vegetation overgrowth.

All pieces and elements of a stormwater system cost money. Traditional stormwater elements, such as concrete pipes, storm drain inlets, land acquisition, and excavation, are often the most expensive pieces of stormwater systems. Incorporating approaches such as LID that reduce stormwater production can reduce the size of stormwater pieces and systems, reducing costs. GSI are alternatives that can replace or complement traditional stormwater systems that can also reduce system costs. For example, swales are generally less expensive to install than pipes to convey the same water over the same length. In other instances, GSI may be more expensive than the conventional option but reduce overall costs. For example, while permeable pavements may be a more expensive pavement option, they can reduce or eliminate the need for pipes and ponds, reducing overall costs. However, both construction and maintenance costs should be considered when selecting stormwater options. Compared to GSI, conventional stormwater elements tend to have lower initial costs but higher maintenance costs over time. In general, GSI typically provides improved water quality treatment and adds greater aesthetic value to the environment. While site conditions and development goals vary, LID and GSI can reduce stormwater system construction and maintenance costs.

Figure 1. *Permeable paver walk with tree canopy.*

However, by proactively managing these maintenance needs, potential problems can be identified and resolved before they escalate into more significant and costly issues. For example, removing a small amount of sediment on filter media or a permeable pavement surface is much less expensive than replacing media or a surface that has already become clogged.

Many GSI maintenance problems start as fairly small, easily rectified issues as long as they are detected early enough through an inspection. For these issues, property owners or managers can likely take care of the issue expediently and cost-effectively. Performing routine, preventative maintenance is essential to keeping your GSI system healthy. All maintenance should be performed by trained and qualified personnel and using horticultural and safety best practices. Proper maintenance also helps preserve the aesthetic and environmental benefits associated with GSI. Well-maintained GSI elements, such as rain gardens, bioswales, and vegetated buffers, provide multiple ecosystem services, including habitat creation, urban cooling, and aesthetic enhancement. Regular maintenance activities, including pruning, weed control, and replanting, ensure the continued functionality and visual appeal of these green features.

By prioritizing GSI maintenance, communities can ensure that their stormwater management systems continue to operate effectively, providing sustainable and resilient solutions for water management in urban environments.

PART I: Plant Selection

Plant Selection

Selecting plants for GSI is more challenging than selecting plants for a typical landscape. This is because the site conditions can vary greatly and are more difficult to control.

The concept of using the right plant in the right place is important in GSI because the system may include a variety of zones, depending on the type of GSI, including a dry slope, a littoral shelf, and deeper water areas. Water depth can fluctuate widely over the year and create wet and dry conditions that the plants must be able to tolerate. Areas that are temporarily inundated may also experience long periods of drought. Selecting the right plant requires knowledge of plants, including function, aesthetics, and environmental/growing requirements and knowledge of GSI.

Consider the following when selecting plants for GSI.

Plant Function

When selecting plants, it is important to consider plant function for that particular site. Functional characteristics include foliage density to block views, root mass density and depth to prevent erosion, stalk density to buffer water movement, and the ability to take up nutrients and pollutants to improve water quality.

GSI Conditions

Conditions that affect plants in GSI systems include permanent and/or variable water depths, foraging fish, soil structure, slopes above and below the water surface, and light availability. Selecting native aquatic or wetland species that are adapted to the environmental conditions could increase survival during establishment and sustainability following planting.

Water Levels

Primary functions of GSI are to infiltrate, store, and filter stormwater. Depending on the type of GSI, this may mean that plants are only inundated during storm events, or for up to three days after an event, while others may be inundated seasonally or permanently.

However, Florida's climate can also have extended periods of drought. Be sure to consider whether your plants will need to tolerate both periods of inundation and drought.

Littoral Zones

For GSI with permanent pools, planting the littoral zone (the transitional area between land and water in aquatic ecosystems) can serve multiple functions, including limiting erosion, aesthetics, and water quality. Selecting the right plants for these functions is important. Determining the typical water level is essential because many plants will die if they are too wet or too dry for long periods.

Aquatic Plant Considerations

Light availability is the most important factor for aquatic plant growth and is primarily determined by water clarity and depth. Water clarity is determined by organics and suspended particles (silt and clay size sediments, and organic particles). Bottom-feeding fish such as carp and catfish can increase suspended sediment, which blocks light and may limit plant growth. Slowing surface runoff with plant buffers and no-mow zones, and minimizing erosion, can help decrease turbidity (cloudy water caused by suspended soil particles). Nutrient levels in ponds from both soil and human activities can affect light availability by increasing algal growth, which decreases water clarity. Large trees on the shoreline with wide canopies can create a problem with shade. Plant large trees on the north side of GSI if possible, so the shadow is cast primarily away from the GSI plants, particularly in the winter.

Soil Quality

Soil (substrate) conditions are important for plant growth and GSI function. Soil often serves as a filter and structure for chemical and biological processes to occur. It is important to maintain healthy soil in GSI practices for both plants and water quality. Filtering helps trap sediments, debris, and other particles, preventing them from moving downstream. Eroded areas or buildup of sand and/or gravel should be noted and addressed as these indicate areas where soil is unstable and not favorable for plants. Erosion typically occurs due to water moving too fast, while buildup (or deposition) occurs due to water moving too slowly (or upstream erosion).

Rocky or concrete bottoms in ponds are too hard for plant roots to penetrate, and muck soil is too soft and unstable to anchor plants. Sandy soil with some organic matter in ponded areas (between rocks and muck) is usually best. Too much organic matter in ponded areas can create high levels of acids, methane, and alcohols, which are toxic to plants.

Slope of Bank

The slope of the bank can present challenges for maintenance. Ideally, banks should be 4:1 or greater (flatter) and never less than 3:1. Steep slopes make it dangerous to maintain vegetation. In particular, using riding mowers increases the risk of erosion and creates challenges for establishing no-mow or no-maintenance plant buffer zones. Extreme caution should be used if mowing a slope steeper than 4:1.

To establish plant material on slopes, several techniques can be used to provide plants with water and prevent being washed out. Landscape timbers or bio-logs can be used as mini-baffles when installed perpendicular on the downhill side of plants. Porous landscape fabric such as burlap or jute also traps sediment and water.

Water's edge: The plant buffer along the edge of water functions as a protective barrier by filtering fertilizer and grass clippings from runoff before it enters the water. However, steep slopes along the water's edge may leave only a narrow strip available for littoral plantings before water depths are too great for planting. This makes establishing plants more difficult. Slopes may be regraded to encourage plant growth. Over time, littoral zones will typically widen (from the bank) as sediment builds up along the water's edge.

Erosion Control

Erosion typically occurs due to water moving too fast for extended periods.

For situations with concentrated flow (pipe or channel outlet), riprap made from stone, concrete rubble, or pavers can help slow water flow at outfalls, dissipating energy and protecting underlying soil from being eroded. The goal is to spread the water out laterally, to reduce the energy. If the flow is not distributed, the erosive energy will move to the edge of where the riprap ends, eroding there.

Installing plants along the water's edge and littoral zone can also reduce erosion. Turfgrass generally does not have the root structure to prevent erosion along the water's edge. Therefore, strongly rooted emergent plants are needed to help prevent erosion by buffering the water energy that undermines upland. Synthetic turf is not recommended in GSI systems.

Mulch

In GSI practices that dry out, mulch helps retain soil moisture, protects plants, and inhibits weed growth. It gives your landscape a neat, uniform appearance and is a great choice for hard-to-mow areas and shady spots. Keep a 2- to 3-inch-deep layer of mulch over soil between GSI plants. Mulch should be pulled back 1 to 2 inches from the base of plants and 12 inches from tree trunks. Use triple shredded hardwood mulch, which does not float and get washed away, or pine straw.

Visual Quality

Most people enjoy a variety of color, texture, and forms to create a composition that enhances the landscape. People generally prefer plants that grow in clumps with large, coarse-textured green foliage and colorful flowers. Aesthetically, they also prefer plants that don't block views, are neatly organized in the landscape through repetition, and have a less weedy or messy look. Considering the aesthetic factors of color, texture, form, and size, and how they vary over seasons and from planting to full grown, will help to create a successful, long-term aesthetic for GSI.

Color: It is usually the most attractive visual characteristic of plants, but it also is the most fleeting, as most plants only display prominent color during short bloom periods. The site's light qualities throughout the seasons—sunny or shady areas—affect the perception of color. Warm colors, such as white, yellow, orange, and red, show up more in aquatic and shady environments because they contrast with the darker blues, greens, and browns of water and foliage. Cool colors, such as blues and dark purples, are less noticeable because they tend to blend with greens. Including a variety of colors in the plant material creates interest year-round.

Texture: This is typically described as coarse (large, broad leaves and big stems) medium (average leaves and stems), or fine (tiny leaves, thin stems). Texture can provide contrast and interest, particularly when color variety is lacking. Plant texture may vary through the seasons. Most GSI are typically viewed from a distance, so bold-textured plants with large, broad leaves and big flowers show better. Use a fine-textured plant, such as a grass, to contrast with the bold texture and provide more interest. Plant texture may vary through the seasons. Consider using deciduous plants that have attractive bark or branching patterns in winter.

Form: Growth habit is the most recognizable plant quality. Choose the plant form most appropriate for the desired function. It is important to remember that plants, especially larger plants and trees, change over time as they grow. Make your choice based on the full-grown size of the plant, but also consider the form at planting and intermediate stages of growth. Form also helps determine if plant material should be used in masses or as individual specimens.

Size: It is important to consider the size of the plant when it is fully mature. Tall plants can sometimes block views when they are mature, so consider height as well as spread. This is particularly important for considering areas adjacent to traffic. The slope to the water affects the visual height of the plant, depending on the plant's location on the slope. Tall plants at the top of a slope can block views below, so locate low-growing plants at the top of slope and taller plants at the bottom. Remember to consider the amount of flooding (or occasional standing water) they can tolerate if they are lower on the slope. Information on mature plant size and spacing is included in the Green Stormwater Infrastructure Plant Guide **https://ffl.ifas.ufl.edu/ffl-and-you/local-government/gsi-training/**.

Recommended Plants

The plants recommended for GSI systems in this manual include both native and non-native plants. Generally, the plants in the Green Stormwater Infrastructure Plant Guide (**https://ffl.ifas.ufl.edu/media/fflifasufledu/docs/gsi-documents/GSI-Plant-Guide.pdf**) were selected for their foliage size, variety of textures, flower color, growth habit and height, aesthetic acceptability, survivability in varying water depths, ability to withstand wet and dry conditions, and ability to grow in a wide range of zones.

Recommended plants for GSI do not include synthetic turfgrass or any other artificial vegetative material for use within GSI.

PART 2: GSI Maintenance by System Type

Bioretention

Description

At the surface, bioretention cells, or rain gardens, appear as shallow depressions with resilient plants that can handle temporary flooding and periods of drought. They allow stormwater to collect and soak directly into the soil or flow downstream if an underdrain is present. They can be planted to provide a food source for butterflies and other wildlife and can make a beautiful addition to the landscape.

These GSI can vary in size and complexity and their differences mostly lie below the surface. Rain gardens may be simple landscape depressions carved into the existing landscape and planted by a homeowner that captures and infiltrates runoff. Bioretention cells are generally designed by a professional (e.g., engineer, landscape architect) to achieve water quality goals and typically include engineered soil media. They may include an underdrain to facilitate storage recovery that ties into downstream stormwater pipe networks.

Characteristics that can distinguish a bioretention cell from a rain garden in the field are 1) presence of a clean out port (capped PVC) at the surface, typically toward the upstream end of the cell, for maintaining underdrains and 2) overflow riser structure with a grate for online bioretention. However, their maintenance essentially only varies by their complexity, configuration, and components.

Because of their visibility and aesthetic value, they are an ideal choice for a demonstration project that builds enthusiasm for GSI among the public and community partners.

Installation

- Creative shaping of bioretention cells can utilize soil excavated from the basin to accommodate sloping berms.

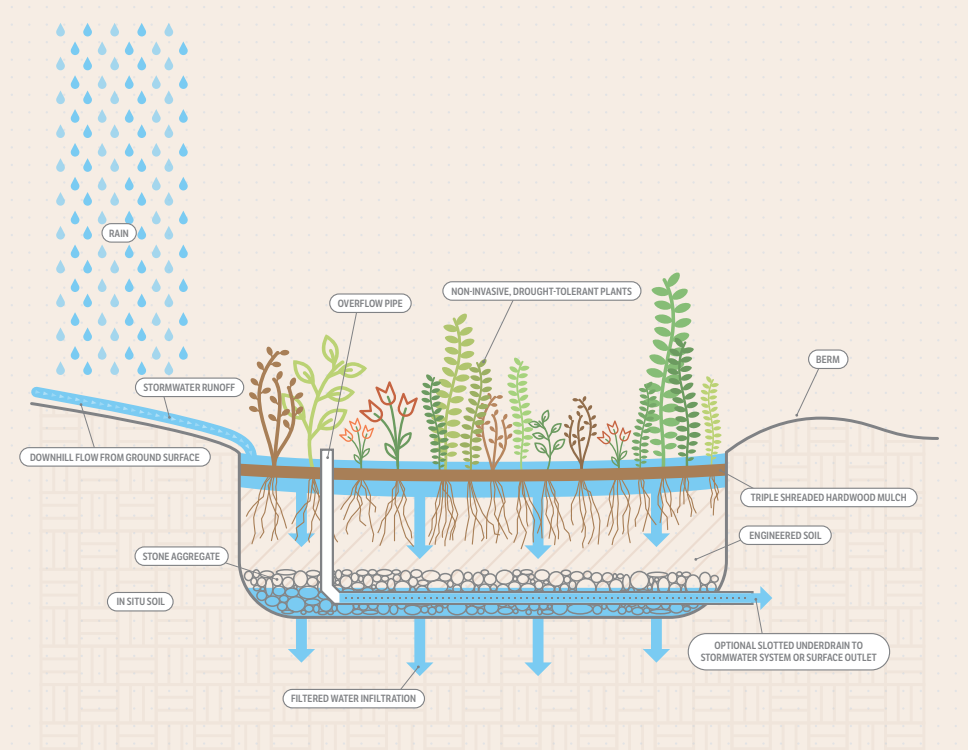


Figure 2. *Illustration of a typical bioretention cell system*

- In suburban installations an irregular or meandering shape may be most appropriate. More geometric configurations are appropriate in a more highly urbanized setting, where space is limited.
- Basin side slopes should be 4:1 or greater and never less than 3:1. Where adjacent to walkways or accessible hardscape areas they should not be less than 6:1.
- Vegetation should be selected based on local microclimate and soil conditions.
- Once the plants are installed, the area should be mulched using pine straw or triple shredded hardwood mulch (other types will float and wash away) to retain soil moisture and reduce erosion.
- For installations next to roadways, bioretention may have a curbed perimeter (i.e., next to roadways) where stormwater enters via a pipe, rather than sheetflow.

Maintenance

Proper maintenance is crucial to keeping any GSI system functional. Bioretention systems should be routinely inspected, and any needed maintenance performed as soon as possible. The frequency of maintenance will depend on the system size, location, and plants selected. In general, bioretention systems should be ideally inspected at least monthly and after heavy rain events to identify any issues early.

Use the below checklist to document system inspections and recommended maintenance practices. Keeping record of system maintenance can alert you to any potential problems before they seriously disrupt the system's function. Types of maintenance may include:

- Repair or replace broken inlet and outlet structures as soon as possible.

- Ensure splash blocks or inlet gravel/rock are adequate by checking for nearby erosion.
- Water levels should recede below the mulched surface within 24 hours (preferably, but absolutely within 48 hours) after a rain event.
- If ponding routinely remains after 48 hours, inspect subsurface water levels in observation wells and clean outs at or greater than 96 hours to determine if subsurface soils or underdrain are extending ponding durations. If accessible, check underdrain outlet into storm drain to evaluate flow.
- If surface soils are limiting infiltration and extending ponding, till, amend, or rake soil as needed to ensure ponding water drains within 48 hours.
- Identify any obstructions to flow and clear them immediately. Remove sediment, debris, and blockages from catch basins, trench drains, curb inlets, and pipes to always maintain flow capacity.
- Manually remove weeds, invasive species, and dead plant material. Replant per original planting plan, or substitute from the plant list.
- Ideally, plant selection would avoid including plants that would need irrigation and instead populate with plants that can tolerate periodic drought conditions.
- Irrigate only as needed until established and maintain 2-3 inches of mulch in landscape beds.
- Irrigate and mulch as needed.
- Fill in and lightly compact areas of erosion. Replant according to planting plan or substitute from the plant list. Whenever possible, attempt to identify cause of erosion or sedimentation to address the cause, rather than the effect alone.
- Identify and note any areas with at least 2 inches of erosion or sedimentation. Immediately remove accumulated sediment of more than 6 inches as this may affect GSI function.

Seasonal Maintenance

Season	Action
Summer	Make structural repairs, clean gutters and downspouts as necessary, remove any build-up of weeds or organic debris. Inspect and prepare for rainy season.
Fall	Replant exposed soil and replace dead plants. Remove sediment and plant debris. Inspect and repair post-rainy season.
Winter	Clear pipes and inlets of sediment and debris. Monitor ponding durations.
Spring	Remove sediment and plant debris. Replant exposed soil and replace dead plants.
All seasons	Water, seed and re-mulch as necessary, paying close attention to invasive plants.

Figure 3. *Extended ponding in bioretention on University of Florida campus.*

Site ID/Name: _____Location: _____Inspector: _____Date:

Date of last inspection:

Approximate time since last rain: < 24 h 24-48 h >48 h
Approximate size of last rain: < 0.5 inches 0.5-1 inches >1 inches

Bioretention

Note: 'Yes' indicates a maintenance need and action

General

1. Is access to the site adequately maintained? Yes/No
2. Are grass clippings present in the drainage area or within the system [inlet structure, pretreatment (filter strip and grass channel), main treatment, or outlet/overflow structure]? (*Note: grass clippings should be removed*). Yes/No

Drainage Area (pertains to the surrounding area that will contribute runoff to the practice).

3. Are exposed or actively eroding areas present? Sedimentation? Yes/No
4. Is debris obstructing flow paths at any point (overland or within pipes)? Yes/No

Inlet Structure / Pretreatment

5. Is there trash/debris/sediment in or around inlet structures? Yes/No
6. Is runoff short circuiting the inlet? Yes/No
7. Erosion (gullies, rills, or erosion) around inlet or pre- treatment? Yes/No
8. Mowing or vegetation maintenance needed around inlet? Yes/No
9. Any signs of structural damage? Yes/No

Main Treatment

10. Is there presence or evidence of prolonged ponding? Yes/No
11. Is mulch depth at least 2 inches? Yes/No
12. Are any areas showing erosion? Yes/No
13. Are any areas of sediment buildup? Yes/No
14. Is water in GSI? If yes, approx. depth: _____ Yes/No

Plants

15. Are weeds or invasive plants present? Yes/No
16. Is any dead plant material present? Yes/No
17. Do plants show signs of nutrient deficiency? Yes/No
18. Do plants show signs of disease? Yes/No
19. Do any areas need replanting? Yes/No
20. Do any plants show signs of drought stress? Yes/No
21. Are plants overgrown? Yes/No

Underdrain (if installed):

22. Are cleanouts capped? Yes/No
23. Are cleanout caps damaged? Yes/No
24. Indications of underdrain clogging or blockage? Yes/No

Emergency Overflow / Outlet Structure

25. Is there any structural damage to outlet structures? Yes/No
26. Is there accumulation of trash, debris, or sediment in or around outlet structures? Yes/No
27. Is there evidence of erosion or flooding around structures? Yes/No

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Qualitative Inspection	Good	Marginal	Poor
28. Sediment accumulation in bioretention surface area	<25%	25-50%	>50%
29. Rate the presence of debris (e.g., leaves, trash, grass clippings) in the bioretention surface area.	<25%	25-50%	>50%
30. Presence of undesirable vegetation.	<25%	25-50%	>50%
31. Rater the condition of plant health per landscaping plan and site objectives (Dying/stressed)	<25%	25-50%	>50%
32. Rate the condition of plant density per landscaping plan and site objectives. (Vegetation coverage)	<25%	25-50%	>50%

Recommended Maintenance

Examples of Potential Issues (Numbers refer to the above checklist items.)

4, 5 Inlet debris

8, 14, 20 Inlet vegetation

18, 20 Veg. maintenance

11, 12 Erosion & mulch

10 Presence of ponding

28, 31 Trash & debris

12 Mulch

28 Trash & debris

18 Replanting

14, 18, 29 Replant

25 Outlet debris

25 Extended ponding

10, 26 Outlet ponding

Bioretention Plant List

Large Tree

Acer rubrum - Red Maple	*Nyssa sylvatica* - Tupelo
Carya glabra - Pignut Hickory	*Pinus elliottii* - Slash Pine
Celtis laevigata - Sugarberry	*Platanus occidentalis* - Sycamore
Fraxinus americana - White Ash	*Quercus phellos* - Willow Oak
Ilex cassine - Dahoon Holly	*Taxodium ascendens* - Pondcypress
Liquidambar styraciflua - Sweetgum	*Taxodium distichum* - Baldcypress
Liriodendron tulipifera - Tuliptree	

Small Trees & Large Shrubs

Aesculus pavia - Red Buckeye	*Ilex cornuta* - Burford Holly
Callicarpa americana - Beautyberry	*Ilex vomitoria* - Yaupon Holly
Cephalanthus occidentalis - Buttonbush	*Myrica cerifera* - Southern Wax Myrtle
Conocarpus erectus - Buttonwood	*Sophora tomentosa* - Necklace Pod

Shrubs

Batis maritima - Saltwort; Beachwort	*Hibiscus grandiflorus* - Swamp Rosemallow
Borrichia arborescens - Silver Sea Oxeye	*Iva imbricata* - Beach Elder
Hamelia patens - Firebush	

Ornamental Grasses

Andropogon virginicus - Broomsedge Bluestem	*Spartina bakeri* - Sand Cordgrass
Distichlis spicata - Saltgrass	*Spartina patens* - Saltmeadow Cordgrass
Eleocharis interstincta - Jointed Spikerush	*Sporobolus virginicus* - Seashore DropSeed
Muhlenbergia capillaris - Muhly Grass	*Tripsacum dactyloides* - Fakahatchee Grass
Panicum amarum - Panic/ Beach Grass	*Tripsacum floridanum* - Florida Gammagrass
Paspalum vaginatum - Seashore Paspalum	*Vetiveria zizanioides* - Vetiver

Groundcoverss

Arachis glabrata - Perennial Peanut	*Paspalum notatum* - Bahia
Conoclinium coelestinum - Blue Mist Flower	*Paspalum vaginatum* - Seashore Paspalum
Dietes iridioides - African Iris	*Phyla nodiflora* - Frogfruit
Dyschoriste oblongifolia - Oblongleaf Snakeherb	*Sesuvium portulacastrum* - Sea Purslane
Licania michauxii - Gopher Apple	*Stachytarpheta jamaicensis* - Blue Porterweed
Mitchella repens - Partridgeberry	

Sedges & Rushes

Juncus effusus - Soft Rush

Annuals & Perennials

Salvia coccinea - Tropical Sage	*Hymenocallis latifolia* - Spider Lily
Asclepias tuberosa - Milkweed (Butterflyweed)	*Iris virginica* - Virginia Iris
Coreopsis lanceolata - Lanceleaf Coreopsis	*Iva frutescens* - Marsh Elder
Crinum americanum - Swamp Lily	*Lachnanthes caroliana* - Redroot
Erogrostis spectabilis - Purple Lovegrass	*Liatris spp.* - Blazing Star
Helianthus angustifolius - Swamp Sunflower	*Lobelia cardinalis* - Cardinal Flower
Heliotropium angiospermum - Scorpion Tail	*Solidago sempervirens* - Seaside Goldenrod
Hibiscus coccineus - Red Hibiscus	*Stokesia laevis* - Stoke's Aster
Hibiscus laevis - Halberdleaf Rosemallow	*Woodwardia areolata* - Chain Fern
Hibiscus moscheutos - Crimsoneyed Rosemallow	

Tree Boxes

Description

Tree boxes are typically installed underneath sidewalks adjacent to streets, with long, narrow storage volumes below the pavement within the right-of-way. Tree boxes reduce the urban heat island effect, offering shade relief from the sun. Runoff is eliminated through a combination of percolating into the ground and trees taking up water (and nutrients) via transpiration. Excess stormwater to tree boxes is typically discharged to adjacent stormwater systems via a combined overflow and underdrain, which prevents prolonged ponding that could harm trees and reduce storage volume.

Tree boxes can reduce runoff by intercepting rain as it falls onto the leaves and branches or provide direct filtration of runoff. Tree boxes with an open bottom that allows water to drain below and recharge the groundwater are referred to as tree wells. Most other tree boxes have a closed bottom with an underdrain that ties into the storm sewer system. In these configurations, water infiltrates through the engineered soil and drains via the underdrain. Pollutants are filtered as they pass through the soil media in the "box" and as trees take them up. Hence, these are frequently referred to as tree box filters.

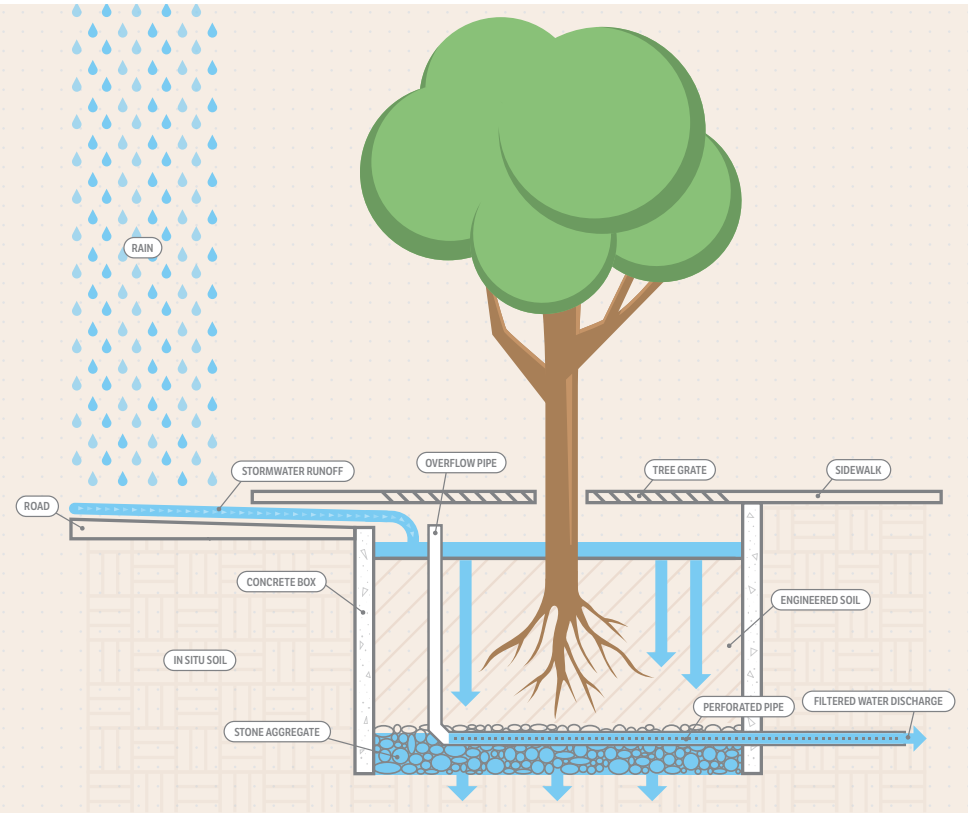

Figure 4. *Illustration of a typical tree box system*

Installation

- Tree box filters should be installed on a flat subgrade and surface grade to maximize storage.
- Planting mix soil should be carefully selected and tested to provide proper physical composition, adequate drainage, and organic matter to support designated plantings. Planting soil should be at least 18 inches deep and contain no more than 20% compost.
- Sufficient soil volume should be provided to accommodate the mature size of specified trees. A subgrade gravel layer can be used to add storage capacity.

Maintenance

Proper maintenance is crucial to keeping any GSI system functional. Tree box/tree well systems should be routinely inspected, and any needed maintenance performed as soon as possible. The frequency of maintenance will depend on the system size, location, and plants selected. In general, tree boxes/tree wells should be ideally inspected at least monthly and after heavy rain events to identify any issues early.

Use the below checklist to document system inspections and recommended maintenance practices. Keeping record of system maintenance can alert you to any potential problems before they seriously disrupt the system's function. Types of maintenance may include:

- Tree box filters should be checked seasonally and after major storm events to maintain optimum storage and drainage functions.
- Following storm events, tree box filters should be inspected to ensure that standing water is not present in the planter for more than 36 hours to avoid mosquito breeding and adverse effects on trees.
- Monitor and maintain the health of trees using best landscape maintenance practices. Prune and replace as necessary.
- Herbicides should not be used in or around tree boxes. Weeds and invasive plants should be removed manually.
- Remove sediment and debris from catch basins, trench drains, curb inlets, pipes, and around tree(s); maintain at least 50% conveyance at all times.
- Extend and secure liner to tree box walls above the high-water mark. The facility must be watertight if adjacent to foundations to

prevent moisture from affecting a foundation.

- Repair or seal cracks in tree box structure.
- Replant per original planting plan or substitute from plant list. Irrigate, mulch, trim, and prune as needed.
- Check regularly for diseases.

Seasonal Maintenance

Season	Action
Summer	Make structural repairs, remove any build-up of weeds or organic debris.
Fall	Remove sediment and plant debris.
Spring	Prune in early spring. Remove sediment and plant debris.
All seasons	Weed as necessary, paying close attention to invasive plants.

Figure 5. *Tree box located at Julian B. Lane Riverside Park in Tampa Florida.*

Tree Box Plant List

Small Boxes: 8' x 8'

- *Aesculus pavia* - Red Buckeye
- *Callicarpa americana* - Beautyberry
- *Cephalanthus occidentalis* - Buttonbush
- *Conocarpus erectus* - Buttonwood
- *Ilex cassine* - Dahoon Holly
- *Ilex cornuta* - Burford Holly
- *Ilex opaca* - American Holly
- *Ilex vomitoria* - Yaupon Holly
- *Myrica cerifera* - Southern Wax Myrtle

Medium Boxes: 10' x 10'

- *Acer rubrum* - Red Maple
- *Fraxinus americana* - White Ash
- *Gordonia lasianthus* - Loblolly Bay
- *Ilex cassine* - Dahoon Holly
- *Liquidambar styraciflua* - Sweetgum
- *Liriodendron tulipifera* - Tuliptree
- *Platanus occidentalis* - Sycamore
- *Quercus phellos* - Willow Oak
- *Taxodium ascendens – Pondcypress*
- *Taxodium distichum* - Baldcypress

Large Boxes: 12' x 12'

- *Acer rubrum* - Red Maple
- *Betula nigra* - River Birch
- *Carya glabra* - Pignut Hickory
- *Celtis laevigata* - Sugarberry
- *Diospyros virginiana* - Persimmon
- *Gordonia lasianthus* - Sweet-bay
- *Ilex vomitoria* - Yaupon Holly
- *Magnolia virginiana* - Sweetbay Magnolia
- *Nyssa sylvatica* - Blackgum
- *Pinus elliottii* - Slash Pine
- *Ulmus crassifolia* - Cedar Elm
- *Ulmus alata* - Winged Elm

*This list is not exhaustive for the state of Florida. See the Green Stormwater Infrastructure Detailed Plant Guide for additional plant recommendations. **https://ffl.ifas.ufl.edu/ffl-and-you/local-government/gsi-training/**.

Site ID/Name: _____Location: _____Inspector: _____Date:

Date of last inspection:

Approximate time since last rain:	< 24 h	24-48 h	>48 h
Approximate size of last rain:	< 0.5 inches	0.5-1 inches	>1 inches

Tree Boxes or Tree Wells

Note: 'Yes' indicates a maintenance need and action

General

1. Is access to the site adequately maintained? Yes/No
2. Are tree boxes ONLINE or OFFLINE? On/Off
3. Are grass clippings present in the drainage area or within the system [inlet structure, or outlet/overflow structure]? (*Note: grass clippings should be removed if possible*). Yes/No

Drainage Area (pertains to the surrounding area that will contribute runoff to the practice).

4. Are exposed or actively eroding areas present? Yes/No
5. Is debris obstructing flow paths in drainage area? Yes/No

Inlet Structure / Pretreatment

6. Is there trash/debris/sediment in or around inlet structures? Yes/No
7. Is runoff short circuiting the inlet? Yes/No
8. Erosion (gullies, rills, or erosion) around inlet or pre-treatment? Yes/No
9. Any signs of structural damage? Yes/No

Main Treatment

10. Is there presence or evidence of prolonged ponding? Yes/No
11. Are any areas of sediment buildup? Yes/No
12. Is water in GSI? If yes, approx. depth: _____in./ft. Yes/No

Trees

13. Do any trees show signs of drought stress? Yes/No
14. Do any trees show signs of nutrient deficiency? Yes/No
15. Do any trees show signs of disease? Yes/No
16. Do any trees need replacing? Yes/No
17. Do any trees need pruning? Yes/No
18. Are any weeds or invasive plants present? Yes/No

Underdrain (if installed)

19. Are cleanouts capped? Yes/No
20. Are cleanout caps damaged? Yes/No
21. Any indications of underdrain clogging or blockage? Yes/No

Emergency Overflow / Outlet Structure (If appropriate)

22. Is there any structural damage to outlet structures? Yes/No
23. Is there accumulation of trash, debris, or sediment in or around outlet structures? Yes/No
24. Is there evidence of erosion or flooding around structures? Yes/No

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Qualitative Inspection	Good	Marginal	Poor
25. The presence of debris (e.g., leaves, trash, grass clippings) in the drainage area.	<25%	25-50%	>50%
26. Rate tree health per landscaping plan and site objectives (Stress)	>50%	25-50%	<25%

Recommended Maintenance

Bioswale

Description

Bioswales are a combination of bioretention and swales, practices that incorporate the conveyance of swales and the filtration and retention of bioretention cells. At the surface, a bioswale is planted similarly to a traditional swale or bioretention cell. Bioswales are an alternative to concrete gutters and storm sewers for conveying stormwater from roadways or structures and can also provide habitat for birds, butterflies, and local wildlife.

They are designed to capture and filter small volumes of stormwater through engineered media. Water then either exfiltrates into the surrounding soil or collects in a stone layer and is conveyed via an underdrain into a stormwater system. Excess flow at the surface bypasses the filter media through an overflow.

Because they are typically linear, bioswales are effective when placed along streets and within parking lots. Essentially a shallow trench or ditch, bioswales can be cost-effective to implement and can also help slow foot traffic.

Installation

- Preventing erosion of in-situ soils is very important during the design. Rock, vegetation, and/or organic mulches can be used to stabilize the surface.
- Side slopes of bioswales should not be steeper than 3:1 for safety, erosion, and maintenance purposes. If meandering of a swale is desired, the bottom width should be less than 8 feet wide.
- May require rock covering, more robust soil cover, or soil amendments to counter the erosion potential for areas with steeper slopes.
- When landscaped, the design objective is typically to improve the aesthetics of the swale and/or to match the existing landscape character of the surrounding area. The landscaping treatment can range from a native, drought-tolerant palette to a more ornamental landscaping approach in line with the surrounding character. The use of native plants is encouraged in these GSI systems.
- Soil building materials such as organic mulch, biota, and fertilizers may be incorporated into the planting area to improve vegetative success; the need for these can be identified through soil fertility testing and by specifically defining the landscaping performance expectations.
- Plant selections need to consider the location of the plants within the bioswale and their potential frequency for inundation, exposure to high flow rates, or flow blockage.
- In general, installed plantings require supplemental irrigation until established. This is typically accomplished through a watering truck or a temporary irrigation. As the plants are established watering requirements will be reduced. Mature plants should not need supplemental irrigation. For installations next to roadways, bioswales may have a curbed perimeter with stormwater entering via a pipe, rather than sheetflow.

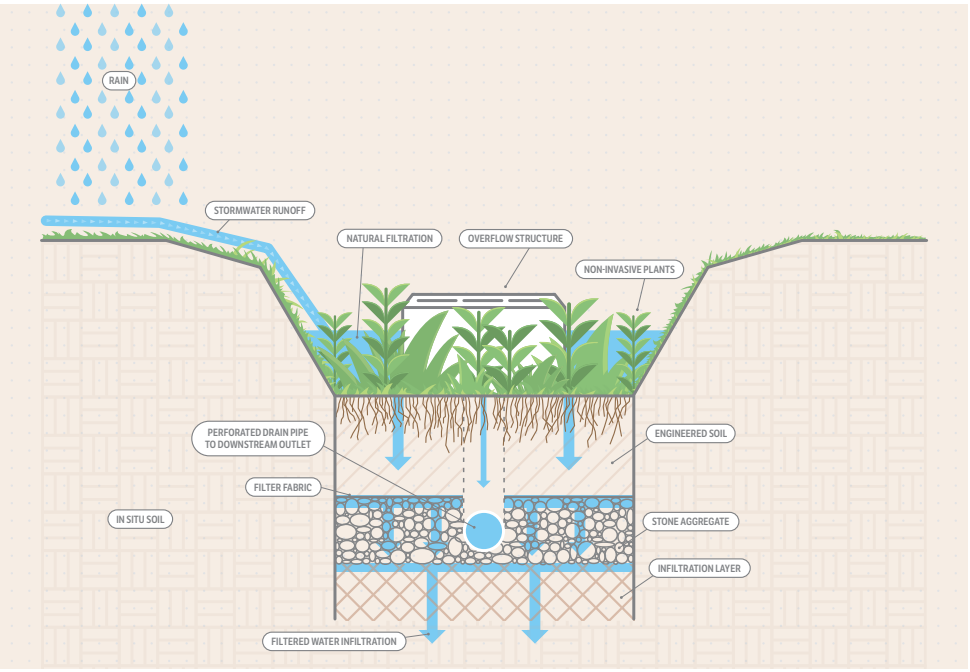

Figure 6. *Illustration of a typical bioswale system*

Maintenance

Proper maintenance is crucial to keeping any GSI system functional. Bioswales should be routinely inspected, and any needed maintenance performed as soon as possible. The frequency of maintenance will depend on the system size, location, and plants selected. In general, bioswales should be ideally inspected at least monthly and after heavy rain events to identify any issues early.

Use the below checklist to document system inspections and recommended maintenance practices. Keeping record of system maintenance can alert you to any potential problems before they seriously disrupt the system's function. Types of maintenance may include:

- Remove sediment and debris from catch basins, curb inlets, and pipes.
- Maintain at least 50% conveyance at all times.
- Repair or replace damaged inlet and outlet structures as needed.
- Repair or seal cracks and replace when repair is insufficient.

- Maintain or replace check dams per design specifications.
- Replant per planting plan or substitute from the approved plant list.
- Irrigate only as needed until established and maintain 2-3 inches of mulch in landscape beds.
- Irrigate and mulch as necessary.
- Maintain grass to a height of 6 to 9 inches.
- In areas where appropriate, prune to allow for sight lines and foot traffic.
- Prune to ensure inlets and outlets freely convey stormwater into and/or out of facility
- Manually remove weeds and monitor for invasives.
- Fill in and lightly compact areas of erosion. Replant according to planting plan or substitute from the plant list. Any erosion deeper than 2 inches must be addressed. Sediment more than 4 inches deep must be removed.
- Whenever possible, attempt to identify cause of erosion or sedimentation to address the cause rather than the effect alone.
- Ensure splash blocks or inlet gravel/rock are adequate to distribute flow and prevent erosion.
- Rake, till, or amend soil surface to restore infiltration rate as needed.

Seasonal Maintenance

Season	Action
Summer	Make structural repairs; clean gutters and downspouts as necessary; remove any buildup of weeds or organic debris.
Fall	Replant exposed soil and replace dead plants. Remove sediment and plant debris.
Winter	Clean gutters and downspouts. Ensure infiltration levels are sufficient.
Spring	Replant exposed soil and replace dead plants. Remove sediment and plant debris.
All seasons	Weed as necessary.

Figure 7. *Bioswale in Gainesville, FL*

Bioswale Plant List

Large Tree

Acer rubrum - Red Maple	*Nyssa sylvatica* - Blackgum
Carya glabra - Pignut Hickory	*Pinus elliottii* - Slash Pine
Celtis laevigata - Sugarberry	*Taxodium distichum* – *Baldcypress*

Medium Trees

Ilex cassine - Dahoon Holly	*Ilex vomitoria* - Yaupon Holly
Ilex opaca - American Holly	

Small Trees & Large Shrubs

Callicarpa americana - Beautyberry	*Conocarpus erectus* - Buttonwood
Cephalanthus occidentalis - Buttonbush	*Myrica cerifera* - Southern Wax Myrtle

Shrub

Batis maritima - Saltwort	*Hibiscus grandifloras* – *Swamp Rosemallow*
Borrichia arborescens - Silver Sea Oxeye	*Iva imbricata* - Beach Elder
Hamelia patens – *Firebush*	*Myrcianthes fragrans* - Simpson's Stopper
Hibiscus coccineus – *Red Hibiscus*	*Viburnum obovatum* - Walters Viburnum

Ornamental Grass

Andropogon virginicus - Broomsedge Bluestem	*Spartina patens* - Saltmeadow Cordgrass
Distichlis spicata - Saltgrass	*Sporobolus virginicus* - Seashore DropSeed
Eleocharis interstincta - Jointed Spikerush	*Tripsacum dactyloides* - Fakahatchee Grass
Muhlenbergia capillaris - Muhly Grass	*Tripsacum floridanum* - Florida Gammagrass
Panicum amarum - Panic/ Beach Grass	*Vetiveria zizanioides* - Vetiver
Spartina bakeri - Sand Cordgrass	

Groundcovers

Arachis glabrata - Perennial Peanut	*Paspalum notatum* - Bahia
Conoclinium coelestinum - Blue Mistflower	*Paspalum vaginatum* - Seashore Paspalum
Croton punctatus - Gulf Croton; Beach Tea	*Phyla nodiflora* - Frogfruit
Dietes iridioides - African Iris	*Sesuvium portulacastrum* - Sea Purslane
Dyschoriste oblongifolia - Oblongleaf Snakeherb	*Stachytarpheta jamaicensis* - Blue Porterweed
Licania michauxii - Gopher Apple	

Sedges & Rushes

Juncus effusus - Soft Rush

Annuals & Perennials

Asclepias tuberosa - Milkweed (Butterflyweed)	*Hibiscus laevis* - Halberdleaf Rosemallow
Coreopsis lanceolata - Lanceleaf Coreopsis	*Hibiscus moscheutos* - Crimsoneyed Rosemallow
Crinum Americanum - Swamp Lily	*Hymenocallis latifolia* - Spider Lily
Erogrostis spectabilis - Purple Lovegrass	*Hymenocallis palmeri* - Alligator Lily
Lachnanthes caroliana - Redroot	*Iris hexagona* - Louisiana Iris
Liatris spp. - Blazing Star	*Iris virginica* - Virginia Iris or Blue Flag
Lobelia cardinalis - Cardinal Flower Solidago	*Iva frutescens* - Marsh elder
Helianthus angustifolius - Swamp Sunflower	*Salvia Coccinea* - Tropical Sage
Heliotropium angiospermum - Scorpion Tail	*Sempervirens* - Seaside Godenrod
Hibiscus coccineus - Red Hibiscus	*Stokesia laevis* - Stoke's Aster

Site ID/Name: _____Location: _____Inspector: _____Date:

Date of last inspection:

Approximate time since last rain: < 24 h 24-48 h >48 h
Approximate size of last rain: < 0.5 inches 0.5-1 inches >1 inches

Bioswales

Note: 'Yes' indicates a maintenance need and action

General

1. Is access to the site adequately maintained? Yes/No
2. Are grass clippings present in the drainage area or within the system [inlet structure, pretreatment (filter strip and grass channel), main treatment, or outlet/overflow structure]? (*Note: grass clippings should be removed).* Yes/No

Drainage Area (pertains to the surrounding area that will contribute runoff to the practice).

3. Are exposed or actively eroding areas present? Sedimentation? Yes/No
4. Is debris obstructing flow paths at any point (overland or within pipes)? Yes/No

Inlet Structure / Pretreatment

5. Is there trash/debris/sediment in or around inlet structures? Yes/No
6. Is runoff short circuiting the inlet? Yes/No
7. Erosion (gullies, rills, or erosion) around inlet or pre-treatment? Yes/No
8. Mowing or vegetation maintenance needed around inlet? Yes/No
9. Any signs of structural damage? Yes/No

Main Treatment

10. Is there presence or evidence of prolonged ponding? Yes/No
11. Are any areas showing erosion? Yes/No
12. Are any areas of sediment buildup? Yes/No
13. Is water in GSI? If yes, approx. depth: _____ Yes/No

Plants

14. Are weeds or invasive plants present? Yes/No
15. Is any dead plant material present? Yes/No
16. Are there signs of nutrient deficiency? Yes/No
17. Are there signs of disease? Yes/No
18. Do any areas need replanting/resodding? Yes/No
19. Are there signs of drought stress? Yes/No
20. Are plants overgrown? Yes/No

Emergency Overflow / Outlet Structure

21. Is there any structural damage to outlet structures? Yes/No
22. Is there accumulation of trash, debris, or sediment in or around outlet structures? Yes/No
23. Is there evidence of erosion or flooding around structures? Yes/No

Qualitative Inspection

24. Sediment accumulation in swale surface area

Qualitative Inspection	Good	Marginal	Poor
25. Rate the presence of debris (e.g., leaves, trash, grass clippings) in the swale surface area.	<25%	25-50%	>50%
26. Presence of undesirable vegetation:	<25%	25-50%	>50%
27. Rate the condition of plant health per landscaping plan and site objectives (Dying/stressed)	<25%	25-50%	>50%
28. Rate the condition of plant density per landscaping plan and site objectives. (Vegetation coverage)	<25%	25-50%	>50%

Recommended Maintenance

Examples of Potential Issues (Numbers refer to the above checklist items.)

4, 5 Inlet debris

8, 14, 20 Inlet vegetation

18, 20 Veg. maintenance

11, 12 Erosion

10 Extended ponding

28, 31 Trash & debris

12 Sedimentation

28 Trash & debris

18 Replanting

14 Long term, Erosion/Incision

25 Outlet debris

25 Extended ponding

10, 26 Outlet ponding

Good	Marginal	Poor
‹25%	25-50%	›50%

Green Roof

Description

A green roof is a vegetated roof system where nutrients are taken up by plants and rainwater is transpired into the air to reduce runoff from the roof. Green roofs also provide an extra layer of insulation that reduces heating and cooling costs and are likely to extend the life of the roof by up to 10-20 years. Keep in mind the building needs to be engineered to support the additional weight of the green roof, thus the addition of a green roof is almost never a retrofit. Green roof vegetation enhances the building's appearance, improves outdoor air quality and reduces the urban heat island effect.

Well-designed green roofs include subsystems for drainage, plant nourishment and support, and protect underlying waterproofing systems. Green roofs maintain growing conditions and manage heavy rainfall without sustaining damage from high winds, erosion or pooling water. Green roof engineered soil meets specific requirements, including grain-size, air spaces and moisture retention to store rainfall and support plants that meet site-specific "right plant-right place" requirements. Green roofs are classified as extensive as shown in **Figure 8** or intensive, which typically have deeper profiles and can support larger vegetation such as trees.

Installation

- The intended function of a green roof will have a significant effect on its design.
- The height of the roof above grade, its exposure to wind, orientation to the sun and shading by surrounding buildings will all impact types of materials used and maintenance requirements. Views to and from the roof will also determine where elements are located for maximum effect.
- Professionals must be consulted for the design and construction of the green roof. Having a qualified architect, structural engineer, landscape architect and facility maintenance personnel are critical to the success of a green roof project.
- Access to the green roof site is crucial - not only for installation and maintenance, but also for delivery of materials, soil and plants.

Maintenance

Proper maintenance is crucial to keeping any GSI system functional. Green roofs should be routinely inspected, and any needed maintenance performed as soon as possible. The frequency of maintenance will depend on the system size, location, and plants selected. In general, green roofs should be ideally inspected at least monthly and after heavy rain events to identify any issues early.

Use the below checklist to document system inspections and recommended maintenance practices. Keeping record of system maintenance can alert you to any potential problems before they seriously disrupt the system's function. Types of maintenance may include:

- Vegetation will require supplemental irrigation, at least initially, and only very hardy plants should be selected for green roof systems. Depending on the green

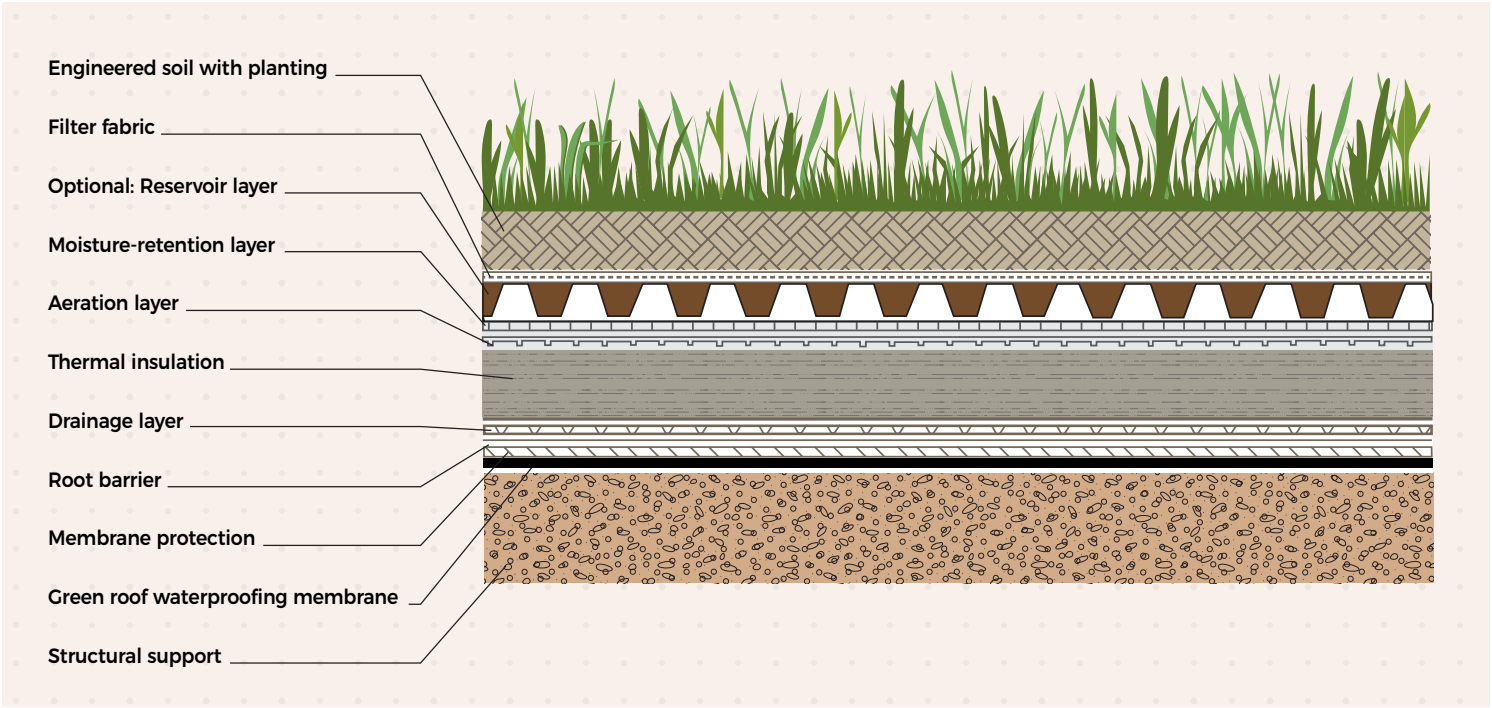

Figure 8. *Illustration of a typical extensive Green Roof system*

roof, required plant maintenance will range from two to three yearly inspections to check for weeds or damage (intensive), to weekly visits for irrigation, pruning, and replanting (extensive).

- To ensure continuity in the warranty and the maintenance requirements, the building architect, structural engineer and/or owner should specify and maintain everything up to and including the waterproof membrane. The green roof designer and installer should only be responsible for those items above the waterproof membrane, including soils, drainage and plantings.
- Immediately after construction, property owners need to regularly monitor green roofs to ensure that vegetation is healthy. During the first season, owners may need to water green roofs periodically if precipitation is insufficient. After the first season, property owners may only need to inspect and lightly fertilize extensive green roofs approximately once per year.
- Property owners need to maintain intensive green roofs like any other landscaped area. Maintenance may involve gardening and irrigation in addition to general roof maintenance.
- Green roofs are less prone to leaking than conventional roofs. In most cases, detecting and fixing a leak under a green roof is no more difficult than doing the same for a conventional roof. Still, a qualified professional should use proper construction techniques and conduct leak testing before planting occurs. Many green roof guidance documents provide helpful descriptions of leak detection methods, including flood tests and low-voltage leak detection.
- Remove sediment and debris if necessary.
- Repair any leaks or structural deficiencies, and contact manufacturer for repair or replacement.
- Replant per original planting plan or substitute from plant list.
- Trim dry grasses and remove clippings. Irrigate or prune as needed.
- Manually remove weeds before they go to seed.
- Cover with plants and mulch as needed.
- Fill, hand tamp, or lightly compact and plant to disperse flow.
- Rake or amend to restore infiltration or flow
- Clear drains. Check irrigation system for leaks.

Seasonal Maintenance

Season	Action
Summer	Make necessary repairs. Improve growing medium as needed. Irrigate as needed.
Fall	Replant areas of exposed soil, replace dead plants. Provide erosion control for bare soil.
Winter	Monitor infiltration/flow-through rates.
Spring	Replant areas of exposed soil and replace dead plants.
All seasons	Weed as necessary. Clean drains as necessary.

Green Roof Plant List

Trees - Large Note: Extensive roofs only.

Acer rubrum - Red Maple	*Pinus elliottii* - Slach Pine
Carya glabra - Pignut Hickory	*Nyssa sylvatica* - Blackgum
Celtis laevigata - Sugarberry	*Taxodium distichum* - Baldcypress
Ilex cassine - Dahoon Holly	

Large Shrub Small Tree Note: Extensive roofs only.

Aesculus pavia - Red buckeye	*Fraxinus americana* - White Ash
Callicarpa americana - Beautyberry	*Ilex cornuta* - Burford Holly
Cephalanthus occidentalis - Buttonbush	*Ilex vomitoria* - Yaupon Holly
Conocarpus erectus - Buttonwood	*Myrica cerifera* - Southern Wax Myrtle
Coccoloba uvifera - Sea Grape	

Shrub

Batis maritima - Saltwort; Beachwort	*Hibiscus grandiflorus* - Swamp Rosemallow
Borrichia arborescens - Silver Sea Oxeye	*Iva imbricata* - Beach Elder
Clethra alnifolia - Sweet Pepperbush	*Sophora tomentosa* - Necklace Pod
Lantanadepressa - Pineland *Lantana*	*Zamia floridana* - Coontie
Hamelia patens - Firebush	

Ornamental grass

Amphicarpum muhlenbergianum - Blue Maidencane	*Spartina bakeri* - Sand Cordgrass
Andropogon glomeratus - Bushy Bluestem	*Spartina patens* - Saltmeadow Cordgrass
Andropogon virginicus - Broomsedge Bluestem	*Spartina spartinae* - Gulf Cordgrass
Distichlis spicata - Saltgrass	*Sporobolus virginicus* - Seashore DropSeed
Eleocharis interstincta - Jointed Spikerush	*Tripsacum dactyloides* - Fakahatchee Grass
Muhlenbergia capillaris - Muhly Grass	*Tripsacum floridanum* - Florida Gammagrass
Panicum amarum - Panic/Beach Grass	*Vetiveria zizanioides* - Vetiver

Ornamental grass

Eragrostis spectabilis - Elliott's Lovegrass	*Schizachyrium scoparium* - Little Bluestem
Schizachyrium maritimum - Gulf Bluestem	*Uniola paniculata* - Sea Oats

Groundcovers

Arachis glabrata - Perennial Peanut	*Helianthus debilis* - Beach Sunflower
Blechnum serrulatum - Swamp Fern	*Juniperus chinensis 'parsonii'* - Parson's Juniper
Conoclinium coelestinum - Blue Mist Flower	*Mimosa strigillosa* - Sunshine Mimosa
Croton punctatus - Gulf Croton; Beach Tea	*Mitchella repens* - Partridgeberry
Dietes iridioides - African Iris	*Paspalum notatum* - Bahia
Dyschoriste oblongifolia - Oblongleaf Snakeherb	*Paspalum vaginatum* - Seashore Paspalum
Licania michauxii - Gopher Apple	*Phyla nodiflora* - Frogfruit
Dianella tasmanica - Flax Lily	*Sesuvium portulacastrum* - Sea Purslane
Gaillardia pulchella - Indian Blanket	*Sisyrinchium angustifolium* - Blue-Eyed Grass
Glandularia tampensis - Tampa Vervain	*Stachytarpheta jamaicensis* - Blue Porterweed

Sedges & Rushes

Cladium jamaicense - Native Sawgrass	*Juncus roemerianus* - Black Rush; Needle Rush
Eleocharis cellulosa - Coastal Spikerush	*Schoenoplectus americanus* - Three-Square Rush
Juncus effusus - Soft Rush	*Schoenoplectus tabernaemontani* - Softstem Bulrush

Annuals & Perennials

Coreopsis leavenworthii - Common Tickseed	*Hymenocallis latifolia* - Spider Lily
Eustoma exaltatum - Seaside Gentian	*Hymenocallis palmeri* - Alligator Lily
Salvia coccinea - Tropical Sage	*Iris hexagona* - Louisiana Iris
Asclepias perennis - Swamp Milkweed	*Iris virginica* - Virginia Iris
Asclepias tuberosa - Milkweed (Butterflyweed)	*Iva frutescens* - Marsh elder
Bacopa caroliniana - Lemon Bacopa	*Lachnanthes caroliana* - Redroot
Canna flaccida - Golden Canna	*Liatris spp.* - Blazing Star
Coreopsis lanceolata - Lanceleaf Coreopsis	*Lilium catesbaei* - Pine Lily
Crinum americanum - Swamp Lily	*Lobelia cardinalis* - Cardinal Flower
Erogrostis spectabilis - Purple Lovegrass	*Lythrum alatum* - Loosestrife
Helianthus angustifolius - Swamp Sunflower	*Rhynchospora latifolia* - Sandswamp Whitetop
Heliotropium angiospermum - Scorpion Tail	*Solidago sempervirens* - Seaside Goldenrod
Hibiscus coccineus - Red Hibiscus	*Stokesia laevis* - Stoke's Aster
Hibiscus laevis - Halberdleaf Rosemallow	*Woodwardia areolata* - Chain Fern
Hibiscus moscheutos - Crimsoneyed Rosemallow	

Vine

Canavalia rosea - Beach Bean	*Ipomoea pes*-caprae - Railroad Vine
Imperati - Beach Morning Glory	*Passiflora incarnata* - Passion Vine

Site ID/Name: _____Location: _____Inspector: _____Date:

Date of last inspection: _____Time:

Approximate time since last rain:	< 24 h	24-48 h	>48 h
Approximate size of last rain:	< 0.5 inches	0.5-1 inches	>1 inches

Greenroof

Note: 'Yes' indicates a maintenance need and action

General

1. Is access to the site adequately maintained for inspection? Yes/No
2. Are there any signs of structural damage? Yes/No
3. Any evidence of roof leaks? Yes/No

Greenroof Area (if appropriate; pertains to the area that contributes runoff to the greenroof):

4. Are exposed or actively eroding areas present? Yes/No
5. Any standing water on surface? _____ in. Yes/No
6. Any signs of prolonged storage or wetness (storage not draining between storms; plant responses)? Yes/No

Vegetation

7. Are weeds or invasive plants present? Yes/No
8. Do plants show signs of nutrient deficiency/disease? Yes/No
9. Do any areas need replanting? Yes/No
10. Do plants show signs of drought/moisture stress? Yes/No
11. Are any plants overgrown? Yes/No

Outlet and Overflow Structures

(if applicable)

12. Is there evidence of erosion or flooding around outlets? Yes/No
13. Is there any structural damage to outlets? Yes/No
14. Is there evidence of bypass of the outlets or drains, such as disconnected gutters or downspouts? Yes/No
15. Is trash/debris/sediment obstructing overflow structures or gutters? Yes/No

Qualitative Inspection	Good	Marginal	Poor
16. Rate the presence of debris (e.g., leaves, trash, grass clippings) in the greenroof surface area.	<25%	25-50%	>50%
17. Presence of undesirable vegetation.	<25%	25-50%	>50%
18. Rate the plant health per landscaping plan and site objectives. (Dying/stressed)	>50%	25-50%	<25%
19. Rate the plant density per landscaping plan and site objectives. (Vegetation coverage)	>50%	25-50%	<25%

Recommended Maintenance

Examples of Potential Issues (Numbers refer to the above checklist items.)

4 Exposed

18, 19 Planting quality

9, 11 Replant, stressed

18 Plant health

11 Overgrown

4, 9 Exposed, Replant

7 Weeds

11 Overgrown

11 Overgrown

4, 9 Exposed, replant

Permeable Pavement

Description

Permeable pavement, which can be composed of pervious concrete, porous asphalt or interlocking pavers, quickly percolate rainwater where it falls as well as runoff from adjacent areas, allowing it to slowly soak into the ground. For more information https://doi.org/10.32473/edis-ae530-2019.

Parking lots, which make up a substantial portion of developed land areas, can be retrofitted or built with pervious surfaces from the start to significantly reduce runoff volumes.

Permeable pavement can be constructed to be similar in appearance to conventional asphalt or concrete surfacing, while pavers can be used to create intricate pavement designs. The implementation of permeable pavement of all types is often particularly cost-effective in places with high land values and recurrent nuisance flooding.

Permeable pavers

- Permeable pavers are composed of precast concrete unit pavers designed to be set on a compacted stone base and highly permeable setting bed with joints filled with sand or fine gravel.
- Water enters the joints between the pavers and flows through an open-graded base to infiltrate into the subgrade or be carried out into the storm system via underdrain piping.
- The void spaces in the subbase store water and infiltrate it back into the subgrade or allow it to evaporate providing local air cooling.

Installation

Installation should only be performed by certified and experienced installer. A stable compacted subbase is essential for any flexible pavement. The depth of rock and gravel must be capable of holding rainwater long enough for the soil underneath to absorb it while also providing structural support to the traffic it receives.

- Excavate to required subgrade depth, compact subsoil using a roller or vibratory compactor, and install geotextile fabric.
- Prepare base material and compact using a roller or compactor. Install the crushed rock in separate layers and recompact. The surface layer is then installed over the bedding layer. Paver gaps are then filled with sand or pea gravel.

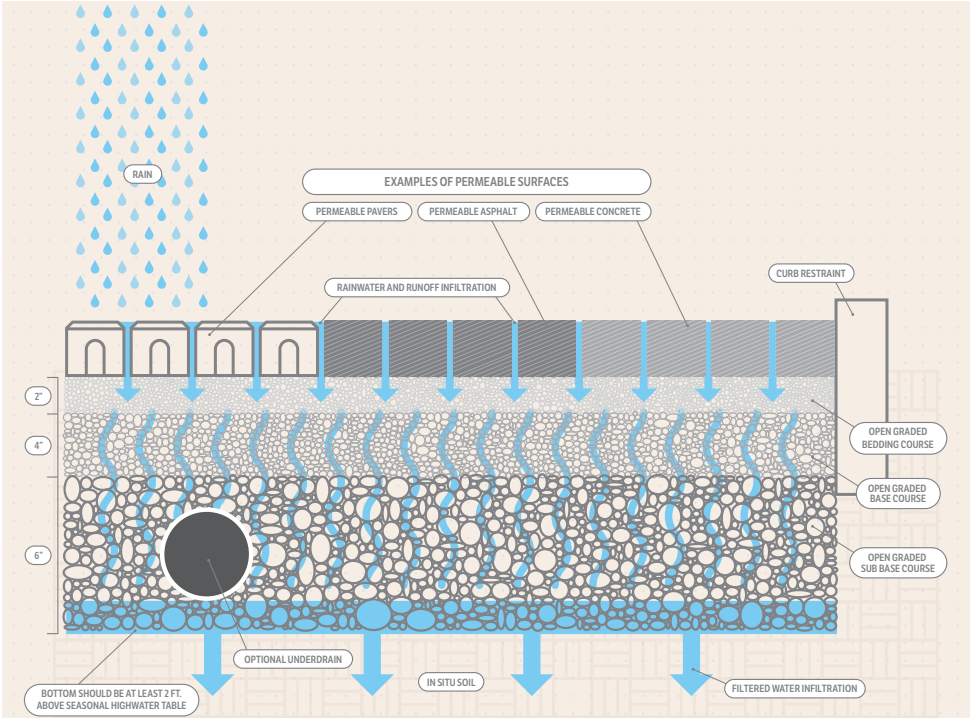

Figure 9. *Illustration of a typical permeable pavement system*

Maintenance

Inspect pavement regularly for settlement and structural defects. Replace broken pavers immediately to prevent structural instability. Pavers can be removed individually and replaced during utility work. Pavement sections can be cut out and replaced with permeable or conventional pavement materials.

Proper maintenance is crucial to keeping any GSI system functional. Permeable pavement should be routinely inspected, and any needed maintenance performed as soon as possible. The frequency of maintenance will depend on the system size and location. In general, permeable pavement should be inspected at least monthly and after heavy rain events to identify any issues early.

Use the below checklist to document system inspections and recommended maintenance practices. Keeping record of system maintenance can alert you to any potential problems before they seriously disrupt the system's function. Types of maintenance may include:

- At least annual vacuum sweeping is recommended to remove clogging material from the pavement surface. Pressure washing is discouraged, except as a last option.
- Check drainage area for bare soil or erosion, and replant or stabilize adjacent areas as necessary.
- Check to see whether underdrains are clogged by inspecting cleanouts or observation wells and looking for extended water storage.

- For smaller areas, remove the damaged pavers, check and fill the underlying gravel.
- Repair as per manufacturer specification. Do not apply sealants to permeable pavement.
- Sweep leaf litter and sediment regularly to prevent surface clogging and ponding.
- Prevent large root systems from damaging subsurface structural components.
- Manually remove, mow, or torch weeds.
- Use a herbicide only if it is approved for use in or near water (check with your local Extension Office for suggestions).
- Replace paver pore space with aggregate per original design.

Seasonal Maintenance

Season	Action
Summer	Make structural repairs.
Fall	Vacuum sweep
Winter	Monitor infiltration rates
Spring	Vacuum sweep
All seasons	Weed as necessary

Permeable Pavement Plant List

Groundcovers (for pavers with large, sand filled openings or reinforcing mats)

Arachis glabrata - Perennial Peanut

Paspalum notatum - Bahia

Paspalum vaginatum - Seashore Paspalum

Figure 10. *Permeable interlocking concrete pavers with oak leaves in gaps.*

Site ID/Name: _____Location: _____Inspector: _____Date:

Date of last inspection: _____Time:

Approximate time since last rain:	< 24 h	24-48 h	>48 h
Approximate size of last rain:	< 0.5 inches	0.5-1 inches	>1 inches

Permeable Pavement

Note: 'Yes' typically indicates maintenance is needed

General

1. Is access to the site adequately maintained? Yes/No
2. Is there evidence of runoff short-circuiting (going around) the practice? Yes/No
3. Is there evidence of gullies, rills, or erosion around the site? Yes/No

Drainage Area (pertains to the surrounding area that will contribute runoff to the practice).

4. Is there any exposed or unstable soil around the site that could cause sediment accumulation and clogging on the pavement? Yes/No
5. Is vegetation around the site unhealthy? (e.g., signs of stressed/dead grass) Yes/No
6. Does vegetation around the pavement need to be pruned/mowed? Yes/No

Note: grass clippings should be removed.

Permeable Pavement Surface

7. Is there evidence of clogging, long-term ponding, or standing water on the surface? Yes/No
8. Are there signs of the pavers or pavement settling? Yes/No
9. Do the pavers or pavement show signs of cracks, splitting or structural damage? Yes/No
10. Is there aggregate missing between the pavers? Yes/No

Inlets/Outlets

11. Do drainage ways (overland flow or pipes) to the practice have trash, debris, etc., present? Yes/No
12. If cleanouts are included, are caps missing? Yes/No
13. If an underdrain system is included, are there signs of it clogging or a blockage? Yes/No
14. Does the emergency overflow have trash, debris, sediment, or structural damage present? Yes/No

***If signs of clogging, puddling, or standing water are found, have an infiltration test (ASTM C1781 or ERIK Device) performed by a trained professional.**

Special Scenario (Grid Pavers with Vegetation)

15. Is the grass in the grids unhealthy? (e.g., dead grass or bare spots) Yes/No
16. Is the grass in the grids overgrown or are grass clippings present? Yes/No

---

Qualitative Inspection	Good	Marginal	Poor
17. Rate the presence of undesirable vegetation.	<25%	25-50%	>50%
18. Rate the presence of sediment accumulation in pore spaces.	<25%	25-50%	>50%
19. Rate the presence of debris (e.g., leaves, trash, grass clippings) on the permeable pavement surface.	<25%	25-50%	>50%
20. Rate the presence of pervious concrete raveling (e.g., porous concrete aggregate becoming loose).	<5%	5-15%	>15%
21. Is there visible smearing of pervious concrete (e.g., no visible pore space)?	<5%	5-15%	>15%

Recommended Maintenance

Examples of Potential Issues (Numbers refer to the above checklist items.)

Well Maintained (Other than Leaves Between Pavers)

6 Unstable drainage area

8, 18 Settling, Sediment

8 Settling

9 Structural

9, 18 Structural, Sediment

9 Aggregate

10 Aggregate

17 Vegetation (poor)

17 Vegetation (poor)

17 Vegetation (marginal)

18 Sediment (poor)

18 Sediment (poor)

19 Debris (poor)

21 Smearing (poor)

Infiltration (Dry Retention) Basin

Description

An infiltration basin is a shallow impoundment that infiltrates stormwater into the soil. This control is effective at increasing groundwater recharge (thus increasing baseflow to nearby streams) and can also help remove pollutants from stormwater. Infiltration basins have specific underlying soil requirements, which can preclude them from being feasible on all sites. Pretreatment design and regular inspection and maintenance procedures are crucial to ensure they do not fail.

Infiltration basins are vegetated depressions designed to store runoff on the surface and infiltrate it gradually into the ground. They are generally dry other than following rainfall events, in which case they should be dry within 72 hours of the event.

Installation

In an infiltration basin, the most important purpose of vegetation is to reduce the basin's tendency to clog.

- Construction staff should properly stabilize upland drainage with a thick layer of vegetation, especially following construction.
- In addition, providing healthy vegetation at the basin bottom at helps encourage infiltration and prevent the formation of rills.

Maintenance

Proper maintenance is crucial to keeping any GSI system functional. Infiltration basins should be routinely inspected, and any needed maintenance performed as soon as possible. The frequency of maintenance will depend on the system size and location. In general, permeable pavement should be inspected at least monthly and after heavy rain events to identify any issues early.

Use the below checklist to document system inspections and recommended maintenance practices. Keeping record of system maintenance can alert you to any potential problems before they seriously disrupt the system's function. Types of maintenance may include:

- Remove sediment, debris, and blockages from catch basins, curb inlets, and pipes to maintain conveyance.
- Identify obstructions and clear them immediately.
- Repair or replace inlet and outlet structures needed. Monitor minor damage such as dents, rust, or minor cracks for indicators of when repair or replacement is required.
- Sedimentation in the flow path can clog inlets and outlets and reduce conveyance efficiency and infiltration. Any areas with at least 2 inches of erosion or sedimentation should be addressed. Immediately remove accumulated sediment of more than 6 inches, as this may affect GSI function. Shallower accumulations may also need to be addressed. In any case, source areas of sediment should be stabilized as soon as possible.

Figure 11. *New plant installation in infiltration basin.*

Seasonal Maintenance

As needed

- Replace pea gravel or topsoil (when clogged).

Monthly

- Ensure inlets are clear of debris, including sediment and oil/grease.
- Stabilize the surrounding area.
- Mow grass and remove grass clippings of filter strip areas, if applicable.
- Repair undercut and eroded areas at inflow/outflow structures.

Semiannually

- Inspect pretreatment devices and diversion structures for debris accumulation and structural integrity; take corrective action as needed.

Annually

- Aerate the pretreatment basin bottom or de-thatch it, if applicable.

Every 5 years

- Scrape the pretreatment bottom to remove accumulated sediment and re-seed ground cover, if applicable.

Upon failure

- Perform total rehabilitation of the basin and restore design storage capacity. Excavate the basin bottom to expose clean soil.

Infiltration (Dry Retention) Basin Plant List

Trees - Large

Acer rubrum - Red Maple	*Nyssa sylvatica* - Blackgum
Carya glabra - Pignut Hickory	*Pinus elliottii* - Slash Pine
Celtis laevigata - Sugarberry	*Taxodium distichum* - Baldcypress
Gordonia lasianthus - Loblolly Bay	

Trees - Small

Ilex cassine - Dahoon Holly	*Conocarpus erectus* - Buttonwood
Myrica cerifera - Southern Wax Myrtle	

Shrub

Batis maritima - Saltwort; Beachwort	*Cephalanthus occidentalis* - Buttonbush
Borrichia arborescens - Silver Sea Oxeye	*Hamelia patens* - Firebush
Callicarpa americana - Beautyberry	*Iva imbricata* - Beach Elder

Ornamental Grass

Andropogon virginicus - Broomsedge Bluestem	*Spartina patens* - Saltmeadow Cordgrass
Distichlis spicata - Saltgrass	*Sporobolus virginicus* - Seashore Dropseed
Eleocharis interstincta - Jointed Spikerush	*Tripsacum dactyloides* - Fakahatchee Grass
Muhlenbergia capillaris - Muhly Grass	*Tripsacum floridanum* - Florida Gammagrass
Panicum amarum - Panic/Beach Grass	*Vetiveria zizanioides* - Vetiver
Spartina bakeri - Sand Cordgrass	

Groundcovers

Arachis glabrata - Perennial Peanut	*Paspalum notatum* - Bahia
Conoclinium coelestinum - Blue Mistflower	*Paspalum vaginatum* - Seashore Paspalum
Croton punctatus - Gulf Croton; Beach Tea	*Phyla nodiflora* - Frogfruit
Dietes iridioides - African Iris	*Sesuvium portulacastrum* - Sea Purslane
Dyschoriste oblongifolia - Oblongleaf Snakeherb	*Stachytarpheta jamaicensis* - Blue Porterweed
Licania michauxii - Gopher Apple	

Annuals & Perennials

Salvia coccinea - Tropical Sage	*Hibiscus moscheutos* - Crimsoneyed Rosemallow
Asclepias tuberosa - Milkweed (Butterflyweed)	*latifolia* - Spider Lily
Coreopsis lanceolata - Lanceleaf Coreopsis	*Iris virginica* - Virginia Iris or Blue Flag
Crinum americanum - Swamp Lily	*Iva frutescens* - Marsh Elder
Eragrostis spectabilis - Purple Lovegrass	*Lachnanthes caroliana* - Redroot
Helianthus angustifolius - Swamp Sunflower	*Liatris spp.* - Blazing Star
Heliotropium angiospermum - Scorpion Tail	*Solidago sempervirens* - Seaside Goldenrod
Hibiscus coccineus - Red hibiscus	*Stokesia laevis* - Stoke's Aster
Hibiscus laevis - Halberdleaf Rosemallow	*Woodwardia areolata* - Chain Fern

Site ID/Name: _____Location: _____Inspector: _____Date:

Date of last inspection: _____Time:

Approximate time since last rain:	< 24 h	24-48 h	>48 h
Approximate size of last rain:	< 0.5 inches	0.5-1 inches	>1 inches

Infiltration (Dry Retention) Basin

Note: 'Yes' typically indicates a maintenance need and action

General

1. Is access to the site adequately maintained? Yes/No
2. Is basin ONLINE or OFFLINE ? On/Off
3. If online, are grass clippings present in the drainage area or within the system [inlet structure, pretreatment (filter strip and grass channel), main treatment, or outlet/overflow structure]? (*Note: grass clippings should be removed*). Yes/No

Drainage Area (pertains to the surrounding area that will contribute runoff to the practice)

4. Are exposed or actively eroding areas present? Sedimentation? Yes/No
5. Is debris obstructing flow paths at any point (overland or within pipes)? Yes/No

Inlet Structure / Pretreatment

6. Is there trash/debris/sediment in or around inlet structures? Yes/No
7. Is runoff short circuiting any of the inlets? Yes/No
8. Is there erosion around any of the inlets or pre-treatments? Yes/No
9. Is mowing or other vegetation maintenance needed around any of the inlets? Yes/No
10. Are there any signs of structural damage? Yes/No

Main Treatment

11. Are there any areas showing erosion? Yes/No
12. Are there any areas of sediment or debris buildup? Yes/No
13. Is there presence or evidence of prolonged ponding? Yes/No
14. Is water currently in the basin? If yes, approx. depth: _____ in./ft. Yes/No

Vegetation and Turfgrass

15. Are there weeds or invasive plants present? Yes/No
16. Is any dead plant material present that needs removing? Yes/No
17. Do plants show signs of nutrient deficiency? Yes/No
18. Do plants show signs of disease? Yes/No
19. Do any areas need replanting? Yes/No
20. Do any plants show signs of drought/moisture stress? Yes/No
21. Are any plants overgrown? Yes/No

Underdrain or Side Bank Filters (if installed)

22. Are cleanout caps missing or damaged? Yes/No
23. Indications of clogging or blockage? Yes/No
24. Any erosion or sedimentation over or adjacent to side bank filter? Yes/No

Emergency Overflow / Outlet Structure (if present)

25. Is there any damage to outlet structure(s)? Yes/No
26. Is there accumulation of trash, debris, or sediment in or around outlet structure(s)? Yes/No
27. Is there evidence of erosion or flooding around the outlet structure(s)? Yes/No

Qualitative Inspection	Good	Marginal	Poor
28. Sediment accumulation in basin surface area.	<25%	25-50%	>50%
29. Rate the presence of debris (e.g., leaves, trash, grass clippings) in the basin surface area.	<25%	25-50%	>50%
30. Presence of undesirable vegetation.	<25%	25-50%	>50%
31. Rate the plant health per landscaping plan and site objectives. (Dying/stressed)	>50%	25-50%	<25%
32. Rate the plant density per landscaping plan and site objectives. (Vegetation coverage)	>50%	25-50%	<25%

Recommended Maintenance

Examples of Potential Issues (Numbers refer to the above checklist items.)

5, 6 Inlet debris

9, 15, 21 Inlet vegetation

19, 21 Veg. maintenance

11, 19 Erosion & veg.

13 Presence of ponding

12, 29 Trash & debris

19, 20 Stress & exposed soil

29 Trash & debris

8, 9 Inlet veg. & algae

16, 20, 31 Replant

26 Outlet debris

26 Outlet Debris

13, 27 Outlet ponding

Stormwater Pond

Description

Stormwater is the biggest contributor to water pollution in Florida, and stormwater ponds are the most common method for stormwater management, with over 76,000 across Florida. In areas where the groundwater is near the surface or the ground has slow infiltration rates, wet ponds are constructed to capture and treat stormwater runoff. These structures are designed to manage very large storm events and limit flooding downstream by temporarily storing large runoff volumes and slowly releasing them downstream. Because stormwater ponds slow the velocity of runoff, they are very effective at removing sediments and particles from stormwater runoff. Plants can play a valuable role in enhancing stormwater ponds to remove nutrients more effectively.

Installation

Stormwater ponds are engineered to capture and treat certain volumes and flowrates from developed areas. The excavation associated with stormwater ponds typically occurs during grading of the watersheds as the excavated soil can be used for fill material to elevate the larger site. The pond will likely be part of the stormwater management during construction to capture runoff and trap sediments. Once construction upstream of the pond is complete, sediments trapped during construction may be removed and plant material can be installed.

Vegetation serves multiple functions in and around stormwater ponds. First, it stabilizes soils and reduces erosion, particularly on sloped banks and along the pond edge. Second, vegetation can create a buffer around the pond edge that filters runoff before it enters the pond. Buffer vegetation can also create a habitat. Trees at the water's edge or in littoral zones can also help control erosion by breaking up wind and wave action. Finally, along the water's edge or littoral zone, vegetation can take up nutrients from the water and facilitate treatment of stormwater.

- Determine the planting zones of the stormwater pond based on vegetation types, water level observations, as-built plans, and/or pond designs. This is especially important because water levels may vary dramatically, which can stress of plants if they are kept too wet or too dry for extended periods.
- Stormwater ponds typically have a normal pool elevation where the water surface is most of the time. The water level will frequently rise about a foot above this level in response to regular storm events.
- In large, open areas such as ponds, large, upright plants with well-defined leaves that grow in large clumps are often preferred. Floating plants with broad, flat leaves, such as water lilies, work well but may need to be pruned back to keep from spreading.
- Where to Plant: If possible, locate aquatic plants 2 or 3 feet away from the edge of the pond. The gap between the aquatic plants and the shore plants will prevent accidental trimming of aquatic plants with the weed trimmer when maintaining the shore plants on the bank. Otherwise select low-growing plants for immediate edge of the pond.
- When to Plant: Annuals/perennials and grasses should be planted during peak growing season (in mid-to-late summer) to allow enough time for their root systems to become established before they go dormant in the late fall. Trees and shrubs should be planted in spring and fall when there is adequate rainfall to help them develop strong roots and leafy growth.
- Plant in Groups. Planting like species in a group creates attractive concentrations of color and provides more varied habitat features. Smaller plants can be clumped together. It also creates a central nucleus with redundant plantings that can support spreading out across the ground surface.

Maintenance

Proper maintenance is crucial to keeping any GSI system functional. Stormwater ponds should be routinely inspected, and any needed maintenance performed as soon as possible. The frequency of maintenance will depend on the pond's size, location, and plants selected. In general, stormwater ponds should be inspected at least monthly and after heavy rain events to identify any issues early.

Use the below checklist to document system inspections and recommended maintenance practices. Keeping record of system maintenance can alert you to any potential problems before they seriously disrupt the system's function. Types of maintenance may include:

- Routine maintenance is needed during the initial stage after the installation of plants to allow expansion of the desirable plants and control the growth of invasive species.
- Routine maintenance requirements are generally minimal after plantings become established.
- Remove weeds and invasive plants in the shoreline area. When practical remove roots of these species to prevent regrowth.
- A lake mower can be used to control aquatic vegetation by selectively cutting some lily pads and leaving others for fish habitat. Because lilies spread their roots (rhizomes) laterally, the only other method to prevent spread is planting in submerged containers.
- Herbicides may be needed if undesirable plants become established after the first year

when wetland plants are better established. Only herbicides that are registered specifically for use in wetlands by the U.S. Environmental Protection Agency and the Florida Department of Environmental Protection may be used.

- Desirable native species do not require fertilizers or spray.
- Selectively harvest vegetation for permanent nutrient removal before they die back. Otherwise nutrients can return to the pond.
- Remove sediment, debris, and blockages from inlet and outlet structures. Sedimentation in the flow path can clog inlets and outlets and reduce conveyance efficiency and infiltration.
- Identify obstructions and clear them immediately.
- Identify any areas with at least 2 inches of erosion or sedimentation. Immediately remove accumulated sediment of more than 4 inches, as this may affect GSI function.
- Repair or replace broken inlet and outlet structures or components as needed. Monitor minor damage such as dents, rust, or minor cracks for indicators of when repair or replacement is required.

Erosion at the water line can lead to bank failure by eroding soil from underneath plants. Plantings and, in extreme cases, stone can dissipate wave energy.

Seasonal Maintenance

Season	Action
Summer	Make structural repairs, clean gutters and downspouts as necessary, remove any build-up of weeds or organic debris.
Fall	Replant exposed soil and replace dead plants. Remove sediment and plant debris.
Winter	Clear gutters and downspouts. Monitor infiltration rates.
Spring	Remove sediment and plant debris. Replant exposed soil and replace dead plants.
All seasons	Weed as necessary, paying close attention to invasive plants.

Stormwater Pond Plant List

Trees - Large

Acer rubrum - Red Maple	*Magnolia virginiana* - Sweetbay Magnolia
Betula nigra - Pignut Hickory	*Nyssa sylvatica* - Blackgum
Betula nigra - River Birch	*Pinus elliottii* - Slash Pine
Carya glabra - Pignut Hickory	*Platanus occidentalis* - Sycamore
Fraxinus americana - White Ash	*Quercus phellos* - Willow oak
Gordonia lasianthus - Loblolly Bay	*Taxodium ascendens* – *Pondcypress*
Liquidambar styraciflua - Sweetgum	*Taxodium distichum* - Baldcypress
Liriodendron tulipifera - Tuliptree	

Trees - Medium

Ilex cassine - Dahoon Holly	*Ilex opaca* - American Holly

Large Shrub Small Tree

Aesculus pavia - Red Buckeye	*Ilex cornuta* - Burford Holly
Callicarpa americana - Beautyberry	*Ilex vomitoria* - Yaupon Holly
Cephalanthus occidentalis - Buttonbush	*Myrica cerifera* - Southern Wax Myrtle
Conocarpus erectus - Buttonwood	

Shrub

Batis maritima - Saltwort; Beachwort	*Hibiscus grandiflorus* - Swamp Rosemallow
Borrichia arborescens - Silver Sea Oxeye	*Hypericum fasciculatum* - St. John's Wort
Clethra alnifolia - Sweet Pepperbush	*Iva imbricata* - Beach Elder
Hamelia patens - Firebush	

Ornamental Grass

Amphicarpum muhlenbergianum - Blue Maidencane	*Spartina bakeri* - Sand Cordgrass
Andropogon glomeratus - Bushy Bluestem	*Spartina patens* - Saltmeadow Cordgrass
Andropogon virginicus - Broomsedge Bluestem	*Spartina spartinae* - Gulf Cordgrass
Distichlis spicata - Saltgrass	*Sporobolus virginicus* - Seashore DropSeed
Eleocharis interstincta - Jointed Spikerush	*Tripsacum dactyloides* - Fakahatchee Grass
Muhlenbergia capillaris - Muhly Grass	*Tripsacum floridanum* - Florida Gammagrass
Panicum amarum - Panic-Beach Grass	*Vetiveria zizanioides* - Vetiver

Groundcovers

Arachis glabrata - Perennial Peanut	*Paspalum notatum* - Bahia
Blechnum serrulatum - Swamp Fern	*Paspalum vaginatum* - Seashore Paspalum
Conoclinium coelestinum - Blue Mistflower	*Phyla nodiflora* - Frogfruit
Croton punctatus - Gulf Croton; Beach Tea	*Rumohra adiantiformis* - Leatherleaf
Dietes iridioides - African Iris	*Sesuvium portulacastrum* - Sea Purslane
Dyschoriste oblongifolia - Oblongleaf Snakeherb	*Sisyrinchium angustifolium* - Blue-Eyed Grass
Licania michauxii - Gopher Apple	*Stachytarpheta jamaicensis* - Blue Porterweed

Groundcovers

Mitchella repens - Partridgeberry	

Sedges & Rushes

Cladium jamaicense - Native Sawgrass	*Juncus roemerianus* - Black Rush; Needle Rush
Eleocharis cellulosa - Coastal Spikerush	*Schoenoplectus americanus* - Three-Square Rush
Juncus effusus - Soft Rush	*Schoenoplectus tabernaemontani* - Softstem Bulrush

Annuals & Perennials

Coreopsis leavenworthii - Common Tickseed	*Hymenocallis latifolia* - Spider Lily
Eustoma exaltatum - Seaside Gentian	*Hymenocallis palmeri* - Alligator Lily
Salvia coccinea - Tropical Sage	*Iris hexagona* - Louisiana Iris
Asclepias perennis - Swamp Milkweed	*Iris virginica* - Virginia Iris or Blue Flag
Asclepias tuberosa - Milkweed (Butterflyweed)	*Iva frutescens* - Marsh Elder
Bacopa caroliniana - Lemon Bacopa	*Lachnanthes caroliana* - Redroot
Canna flaccida - Golden Canna	*Liatris spp.* - Blazing Star
Coreopsis lanceolata - Lanceleaf Coreopsis	*Lilium catesbaei* - Pine Lily

Annuals & Perennials

Crinum americanum - Swamp Lily	*Lobelia cardinalis* - Cardinal Flower
Erogrostis spectabilis - Purple Lovegrass	*Lythrum alatum* - Loosestrife
Helianthus angustifolius - Swamp Sunflower	*Rhynchospora latifolia* - Sandswamp Whitetop
Heliotropium angiospermum - Scorpion Tail	*Solidago sempervirens* - Seaside Goldenrod
Hibiscus coccineus - Red Hibiscus	*Stokesia laevis* - Stoke's Aster
Hibiscus laevis - Halberdleaf Rosemallow	*Woodwardia areolata* - Chain Fern
Hibiscus moscheutos - Crimsoneyed Rosemallow	

Aquatic/Perennial

Equisetum hyemale - Horsetail	*Saururus cernuus* - Lizard's Tail
Polygonum punctatum - Dotted Smartweed	*Schoenoplectus tabernaemontani* - Softstem Bulrush
Pontederia cordata - Pickerel Weed	*Scirpus californicus* - California Bulrush
Sagittaria lancifolia - Lance-leaf Arrowhead	*Thalia geniculata* - Alligator Flag
Sagittaria latifolia - Duck Potato	

Figure 12. *Stormwater pond with planted edge in Gainesville, FL.*

Site ID/Name: _____Location: _____Inspector: _____Date:

Date of last inspection:

Approximate time since last rain:	< 24 h	24-48 h	>48 h
Approximate size of last rain:	< 0.5 inches	0.5-1 inches	>1 inches

Stormwater Ponds

Note: 'Yes' indicates a maintenance need and action

General

1. Is access to the site adequately maintained? Yes/No
2. Are grass clippings present in the drainage area or within the pond? (*Note: grass clippings should be removed if possible*). Yes/No

Drainage Area

3. Are exposed or actively eroding areas present? Sedimentation? Yes/No
4. Is debris obstructing flow paths at any point (overland or within pipes)? Yes/No

Inlet Structure / Pretreatment

5. Is there any structural damage to the inlet structures? Yes/No
6. Is runoff short circuiting the inlet? Yes/No
7. Is there trash/debris/sediment in or around the inlet? Yes/No
8. Is there evidence of erosion (gullies or rills) or flooding around inlet? Yes/No
9. Is plant maintenance needed around inlet? Yes/No

Emergency Overflow / Outlet Structure

10. Is there any structural damage to outlet structures? Yes/No
11. Is there trash/debris/sediment/vegetation in or around outlet structures? Yes/No
12. Is there evidence of erosion (gullies or rills) or flooding around structures? Yes/No

Upland or top of bank

13. Are there any signs of erosion? Yes/No
14. Do any areas need replanting? Yes/No
15. Do any plants need maintenance? Yes/No
16. Are any weeds or invasive plants present? Yes/No

Bank

17. Are there any signs of prolonged ponding? Yes/No
18. Are there any signs of drought? Yes/No
19. Are there any plants showing stress or disease? Yes/No
20. Are there any signs of damage from animal activity? Yes/No
21. Is there any erosion or sedimentation? Yes/No
22. Do any areas need replanting? Yes/No
23. Does any dead plant material need to be removed?

Littoral shelf

24. Are there any signs of damage from animal activity? Yes/No
25. Are there any plants showing stress or disease? Yes/No
26. Are weeds or invasive species present (e.g., cattails)? Yes/No
27. Is there any evidence of channelization? Yes/No
28. Do any areas need replanting? Yes/No
29. Does any dead plant material need to be removed? Yes/No

Open Water

30. Are there any plants showing stress or disease? Yes/No
31. Is any dead plant material present? Yes/No
32. Do any plants need removal or replacing? Yes/No

Qualitative Inspection

33.	Color of water	Clear	Blue-green	Milky/Tan/Brown	Tea
			Good	**Marginal**	**Poor**
34.	Algae coverage on water surface		<25%	25-50%	>50%
35.	Rate the presence of debris (e.g., leaves, trash, grass clippings) in stormwater pond area.		<25%	25-50%	>50%
36.	Presence of undesirable vegetation:		<25%	25-50%	>50%
37.	Rate the condition of plant health per landscaping plan and site objectives (Dying/stressed):		<25%	25-50%	>50%
38.	Rate the condition of plant density per landscaping plan and site objectives. (Veg. coverage):		>50%	25-50%	<25%

Recommended Maintenance

Examples of Potential Issues (Numbers refer to the above checklist items.)

4, 7 Inlet debris

10 Outlet vegetation

11 Outlet debris

12 Outlet flooding

13, 14 Replant, Mulch

19, 23 Dead/stressed veg.

18, 22 Replant, mulch

18, 28 Drought, Replant

21 Erosion, plant, mulch

24, 25, 28 Replant

32 Weeds, replant

32 Overgrown open water

34 Algae

Constructed Stormwater Wetlands

Description

Constructed stormwater wetlands for water treatment can be complex, integrated systems of water, plants, animals, microorganisms, and the environment.

Wetlands provide a number of functions and values including: water quality improvements, flood storage and reducing stormwater surface runoff, cycling of nutrients and other materials, creation of wildlife habitat, recreation, education and research, aesthetics and landscape enhancement.

Installation

Constructed stormwater wetlands are generally built on uplands and outside floodplains or floodways in order to avoid damage to natural wetlands and other aquatic resources.

Wetlands are constructed by excavating, backfilling, grading, diking and installing water control structures to establish desired hydraulic flow patterns.

If the site has highly permeable soils, an impervious, compacted clay liner is usually installed and the original soil placed over the liner

Plants are zone specific for wetlands (varying water depths and duration). Refer to the Green Stormwater Infrastructure Detailed Plant Guide for additional plant recommendations. **https://ffl.ifas.ufl.edu/ffl-and-you/local-government/gsi-training/**.

Maintenance

Constructed stormwater wetlands must have a maintenance plan and be maintained by an experienced professional. Privately owned facilities often require an easement, deed restriction, or other legal measure to prevent neglect or removal.

Use the below checklist to document system inspections and recommended maintenance practices. Keeping record of system maintenance can alert you to any potential problems before they seriously disrupt the system's function. Types of maintenance may include:

- Constructed stormwater wetlands must have a maintenance plan and be maintained by an experienced professional. Privately owned facilities often require an easement, deed restriction, or other legal measure to prevent neglect or removal.
- During the first growing season, vegetation should be inspected every 2 to 3 weeks. Inspections should assess the vegetation, erosion, flow channelization, bank stability, inlet/outlet conditions, and sediment/debris accumulation.
- Once established, properly designed and installed constructed wetlands should require little maintenance. They should be inspected at least 2 times per year and after major storms.
- Remove sediment, debris, and blockages from catch basins, trench drains, curb inlets, and pipes to maintain conveyance at all times.
- Identify obstructions and clear them immediately.
- Repair or replace broken inlet and outlet structures as needed. Monitor minor damage such as dents, rust, or minor cracks for indicators of when repair or replacement is required.
- Sedimentation in the flow path can clog inlets and outlets and reduce conveyance efficiency and infiltration rates.
- Address any channelized or actively eroding areas by mitigating cause for erosion and/or stabilizing areas.
- Replant per original planting plan or substitute from the plant list.
- Remove weeds or invasive plants that will inhibit the function of the stormwater wetland.
- Inspect each spring, particularly in early years, for emerging weeds and/or invasive plants. Address early to limit establishment.

Seasonal Maintenance

Season	Action
Summer	Remove any build-up of weeds or organic debris.
Fall	Replant exposed soil and replace dead plants. Remove sediment and plant debris.
Winter	Clear gutters and downspouts. Monitor infiltration rates.
Spring	Remove sediment and plant debris. Replant exposed soil and replace dead plants.
All seasons	Weed as necessary, paying close attention to invasive plants.

Constructed Wetlands Plant List

Large Trees

Acer rubrum - Red Maple	*Magnolia virginiana* - Sweetbay Magnolia
Betula nigra - River Birch	*Nyssa sylvatica* - Tupelo
Carya glabra - Pignut Hickory	*Pinus elliottii* - Slash Pine
Celtis laevigata - Sugarberry	*Taxodium distichum* - Baldcypress
Gordonia lasianthus - Loblolly Bay	

Figure 13. *Stormwater pond with planted buffer at Depot Park in Gainesville, Florida.*

Medium Trees

Ilex cassine - Dahoon Holly

Large Shrub & Small Tree

Callicarpa americana - Beautyberry	*Conocarpus erectus* - Buttonwood
Cephalanthus occidentalis - Buttonbush	*Myrica cerifera* - Southern Wax Myrtle

Shrubs

Batis maritima - Saltwort; Beachwort	*Hibiscus grandiflorus* - Swamp Rosemallow
Borrichia arborescens - Silver Sea Oxeye	*Hypericum fasciculatum* - St. John's Wort
Clethra alnifolia - Sweet Pepperbush	*Iva imbricata* - Beach Elder
Hamelia patens - Firebush	

Ornamental grass

Amphicarpum muhlenbergianum - Blue Maidencane	*Spartina alterniflora* - Smooth Cordgrass
Andropogon glomeratus - Bushy Bluestem	*Spartina bakeri* - Sand Cordgrass

Ornamental grass

Andropogon virginicus - Broomsedge Bluestem	*Spartina spartinae* - Gulf Cordgrass
Distichlis spicata - Saltgrass	*Sporobolus virginicus* - Seashore DropSeed
Eleocharis interstincta - Jointed Spikerush	*Tripsacum dactyloides* - Fakahatchee Grass
Muhlenbergia capillaris - Muhly Grass	*Tripsacum floridanum* - Florida Gammagrass
Panicum amarum - Panic-Beach Grass	*Vetiveria zizanioides* - Vetiver
Spartina patens - Saltmeadow Cordgrass	

Groundcovers

Arachis glabrata - Perennial Peanut	*Mitchella repens* - Partridgeberry
Blechnum serrulatum - Swamp Fern	*Paspalum notatum* - Bahia
Conoclinium coelestinum - Blue Mistflower	*Paspalum vaginatum* - Seashore Paspalum
Croton punctatus - Gulf Croton; Beach Tea	*Phyla nodiflora* - Frogfruit

Groundcovers

Dietes iridioides - African Iris	*Sesuvium portulacastrum* - Sea Purslane
Dyschoriste oblongifolia - Oblongleaf Snakeherb	*Sisyrinchium angustifolium* - Blue-Eyed Grass
Licania michauxii - Gopher Apple	*Stachytarpheta jamaicensis* - Blue Porterweed

Sedges & Rushs

Cladium jamaicense - Native Sawgrass	*Juncus roemerianus* - Black Rush; Needle Rush
Cyperus articulatus - Jointed Flat Sedge	*Schoenoplectus americanus* - Three-Square Rush
Eleocharis cellulosa - Coastal Spikerush	*Schoenoplectus californicus* - Giant Bulrush
Juncus effusus - Soft Rush	*Schoenoplectus tabernaemontani* - Softstem Bulrush

Annuals & Perennials

Coreopsis leavenworthii - Common Tickseed	*Hymenocallis latifolia* - Spider Lily
Eustoma exaltatum - Seaside Gentian	*Hymenocallis palmeri* - Alligator Lily
Salvia coccinea - Tropical Sage	*Iris hexagona* - Louisiana Iris
Asclepias perennis - Swamp Milkweed	*Iris virginica* - Virginia Iris or Blue Flag
Asclepias tuberosa - Milkweed (Butterflyweed)	*Iva frutescens* - Marsh Elder
Bacopa caroliniana - Lemon Bacopa	*Lachnanthes caroliana* - Redroot
Canna flaccida - Golden Canna	*Liatris spp.* - Blazing Star
Coreopsis lanceolata - Lanceleaf Coreopsis	*Lilium catesbaei* - Pine Lily

Annuals & Perennials

Crinum americanum - Swamp Lily	*Lobelia cardinalis* - Cardinal Flower
Erogrostis spectabilis - Purple Lovegrass	*Lythrum alatum* - Loosestrife
Helianthus angustifolius - Swamp Sunflower	*Rhynchospora latifolia* - Sandswamp Whitetop
Heliotropium angiospermum - Scorpion Tail	*Solidago sempervirens* - Seaside Goldenrod
Hibiscus coccineus - Red Hibiscus	*Stokesia laevis* - Stoke's Aster
Hibiscus laevis - Halberdleaf Rosemallow	*Woodwardia areolata* - Chain Fern
Hibiscus moscheutos - Crimsoneyed Rosemallow	

Aquatics

Equisetum hyemale - Horsetail	*Sagittaria latifolia* - Duck Potato
Nymphaea mexicana - Yellow Water Lily	*Saururus cernuus* - Lizard's Tail
Nymphaea odorata - Fragrant Water Lily	*Schoenoplectus tabernaemontani* - Softstem Bulrush
Polygonum punctatum - Dotted Smartweed	*Scirpus californicus* - California Bulrush
Pontederia cordata - Pickerel Weed	*Thalia geniculata* - Alligator Flag
Sagittaria lancifolia - Lance-leaf Arrowhead	*Vallisneria americana* - Tape-Grass/Eel-Grass

Site ID/Name: _____Location: _____Inspector: _____Date:

Date of last inspection:

Approximate time since last rain:	< 24 h	24-48 h	>48 h
Approximate size of last rain:	< 0.5 inches	0.5-1 inches	>1 inches

Constructed Stormwater Wetlands

Note: 'Yes' indicates a maintenance need and action

General

1. Is access to the site adequately maintained? Yes/No
2. Are grass clippings present in the drainage area or within the system [inlet structure, pretreatment (filter strip and grass channel), main treatment, or outlet/overflow structure]? (Note: grass clippings should be removed if possible). Yes/No

Drainage Area

3. Are exposed or actively eroding areas present? Sedimentation? Yes/No
4. Is debris obstructing flow paths at any point (overland or within pipes)? Yes/No

Inlet Structure / Pretreatment

5. Is there any structural damage to the inlet structures? Yes/No
6. Is runoff short circuiting the inlet? Yes/No
7. Is there trash/debris/sediment in or around the inlet? Yes/No
8. Is there evidence of erosion (gullies or rills) or flooding around inlet? Yes/No
9. Is plant maintenance needed around inlet? Yes/No

Emergency Overflow / Outlet Structure

10. Is there any structural damage to outlet structures? Yes/No
11. Is there trash/debris/sediment/vegetation in or around outlet structures? Yes/No
12. Is there evidence of erosion (gullies or rills) or flooding around structures? Yes/No

Upland

13. Are there any signs of erosion? Yes/No
14. Do any areas need replanting? Yes/No
15. Do any plants need maintenance? Yes/No
16. Are any weeds or invasive plants present? Yes/No

Shallow Land

17. Are there any signs of prolonged ponding? Yes/No
18. Are there any signs of drought? Yes/No
19. Are there any plants showing stress or disease? Yes/No
20. Are there any signs of damage from animal activity? Yes/No
21. Is there any erosion or sedimentation? Yes/No
22. Do any areas need replanting? Yes/No
23. Does any dead plant material need to be removed?

Shallow Water

24. Are there any signs of damage from animal activity? Yes/No
25. Are there any plants showing stress or disease? Yes/No
26. Are weeds or invasive species present (e.g., cattails)? Yes/No
27. Is there any evidence of channelization? Yes/No
28. Do any areas need replanting? Yes/No
29. Does any dead plant material need to be removed? Yes/No

Open Water

30. Are there any plants showing stress or disease? Yes/No
31. Is any dead plant material present? Yes/No
32. Do any plants need removal or replacing? Yes/No

Qualitative Inspection

33. Color of water — Clear — Blue-green — Milky/Tan/Brown — Tea — Other:_____

	Good	Marginal	Poor
34. Algae coverage on water surface	<25%	25-50%	>50%
35. Rate the presence of debris (e.g., leaves, trash, grass clippings) in wetland area.	<25%	25-50%	>50%
36. Presence of undesirable vegetation:	<25%	25-50%	>50%
37. Rater the condition of plant health per landscaping plan and site objectives (Dying/stressed):	<25%	25-50%	>50%
38. Rate the condition of plant density per landscaping plan and site objectives. (Veg. coverage):	>50%	25-50%	<25%

Recommended Maintenance

Examples of Potential Issues (Numbers refer to the above checklist items.)

4, 7 Inlet debris

10 Outlet vegetation

11 Outlet debris

12 Outlet flooding

13, 14 Replant, Mulch

19, 23 Dead/stressed veg.

18, 22 Replant, mulch

18, 28 Drought, Replant

21 Erosion, plant, mulch

24, 25, 28 Replant

32 Weeds, replant

32 Overgrown open water

34 Algae

PART 3: Guide to Installation and Maintenance of Plants

Green Stormwater Infrastructure
MAINTENANCE GUIDE

UF | IFAS Extension
UNIVERSITY of FLORIDA

Department of Agricultural
and Biological Engineering

Florida-Friendly Landscaping™ PROGRAM

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

The nine Florida-Friendly Landscaping™ principles are the cornerstone of the Florida-Friendly Landscaping™ (FFL) Program. Based on UF/IFAS science, the principles teach homeowners, builders and developers, landscape maintenance professionals, and other Florida citizens how to implement environmentally sound design and maintenance techniques in their landscapes. Green stormwater infrastructure (GSI) systems that use plants should be designed and maintained according to the nine FFL principles. The principles are outlined briefly here. For more detailed information, please refer to the FFL state office Website (**FloridaFriendlyLandscaping.com**).

Principle # 1 Right Plant, Right Place

Plants well-suited to their site need less irrigation and fertilizer and are more resistant to pest infestation. Florida-Friendly Landscaping™ principles encourage the selection of the right plant for the right place, helping you create a healthy, attractive landscape that works with the natural ecosystem rather than against it. Match plants with site conditions based on USDA zone, water and light requirements, soil conditions, salt and wind tolerance, and other factors. The Green Stormwater Plant Guide **https://ffl.ifas.ufl.edu/ffl-and-you/local-government/gsi-training/** can help you make the right plant selections for your GSI system.

Principle # 2 Water Efficiently

Overwatering not only depletes water supplies, it also raises costs and makes landscapes more prone to pest infestation. The nature of GSI systems requires that the plants be able to withstand periods of drought and inundation. Except under extreme drought conditions, properly designed GSI systems should not need supplemental irrigation once plants are established.

If needed, irrigate plants according to UF/IFAS-recommended rates and application schedules, taking into account local restrictions issued by your water management district. Water only when plants show signs of wilt, preferably in the early morning.

Principle # 3 Fertilize Appropriately

GSI systems are designed to capture stormwater runoff and filter nutrients from the water; therefore nutrients (fertilizer) should not be added to the system. Prior to plant selection a soil test should be performed to aid in plant selection. If plants show continuous signs of nutrient deficiency, replace them with more suitable plants.

Principle # 4 Mulch

Florida-Friendly Landscaping™ methods recommend using mulch to protect against soil erosion, maintain soil moisture, inhibit weed growth, improve soil structure and aeration, and reduce pesticide use. GSI systems should be mulched with triple shredded hardwood or pine straw mulch, which are less likely to float. Rocks may be used in GSI systems to slow waterflow but should never be used around the base of plants or as mulch.

Principle # 5 Attract Wildlife

Florida-Friendly Landscaping™ encourages landscapes that attract birds, bees, butterflies, bats, and other creatures displaced by rapid urban development. GSI systems can be planted to provide food, water, and habitat to an urban area. Be mindful of the system's location and avoid attracting wildlife close to busy roads.

Principle # 6 Manage Yard Pests Responsibly

The Florida-Friendly Landscaping™ Program advocates a more holistic approach to pest control than merely spraying chemicals. Integrated Pest Management (IPM) creates an effective defense against yard pests while minimizing environment impact. IPM emphasizes smart planning, proper maintenance, and natural or low-toxicity controls to ensure that plants stay healthy and resist disease and insect infestation. Chemical treatments may still be necessary in some cases, but use of toxic materials will be minimized by this approach. IPM should always be practiced in GSI systems to avoid pollution from flowing to natural waters.

Principle # 7 Recycle

A Florida-Friendly landscape recycles yard waste generated by activities like mowing, pruning, and raking. Use these leftovers as mulch or compost, returning valuable nutrients to your landscape. Save money and use utility mulch when possible.

Principle # 8 Manage Stormwater Runoff

GSI is intended to mitigate the impacts of stormwater runoff in an urban environment. Great care must be given not to increase inputs into a GSI system. Anything added to the system (nutrients, pesticides, water, etc.) will impact how the system functions and could end up in natural waterbodies. Properly managed GSI systems will not add fertilizers, herbicides or other pesticides, or unnecessary irrigation to the ecosystem.

Principle # 9 Protect The Waterfront

Implementing Florida-Friendly Landscaping™ design and maintenance methods helps protect water bodies from pollution. This is particularly true for GSI systems, which are designed to protect and manage water. GSI systems such as constructed wetlands and ponds should allow for a 10-foot low-maintenance zone between the water and the landscape. Do not mow, fertilize, or apply pesticides in that area.

Perennials

Selection and Installation

The most important step in establishing perennials is proper plant selection for the soil and GSI conditions.

Spacing of plants should be based on the mature size of the plant. Plant selection should consider the type of soils within the GSI and choose plants appropriate for the soil conditions. If the soils would need to be amended to support the plants by increasing water holding capacity and/or providing nutrients, consider selecting plants more appropriate for the GSI conditions.

Plant perennials so that the top of the root ball is slightly above the soil surface. Mulch heavily, at least 2 to 3 inches, with an organic mulch, such as pine straw or triple shredded wood chips. A thick layer of mulch conserves moisture, insulates roots from heat and cold, facilitates pollutant removal, and discourages weeds. Do not allow the mulch to touch the base of the plants and reapply it as needed.

Most perennials in GSI require little maintenance other than occasional pruning.

Pruning

Ideally, plants should be selected based on their mature size and should not require pruning and should be allowed to grow to their natural shape. Occasional pruning may be needed to remove dead flower spikes or unsightly leaves, or to reduce the size of the plant due to line-of-sight. Some perennials become top-heavy when in bloom and need to be staked.

Pest Control

Although many perennials are relatively pest-free, perennials should be inspected frequently for insects and diseases. If pests are detected early enough, they can be managed before much damage occurs. Many pest problems can be eliminated by simply hand-picking the insects or infected leaves. For severe infestations, chemical control may be needed.

Perennials can also be damaged by microscopic, worm-like parasites called nematodes which live in soil and feed on plant roots. Severely infested areas should be treated and replanted with new plants. For information on nematodes, insects, and diseases, contact your local UF/IFAS Extension office: **https://sfyl.ifas.ufl.edu/find-your-local-office/**.

Watering

Irrigation should only be for establishment, with no permanent in-ground irrigation. After establishment, plants should be able to survive on the runoff into the system. Reduce watering frequency gradually until the plants are established enough to survive with rainfall and runoff. The watering frequency will depend on the site (soil and sunlight), plants, and the time of year. Thereafter, keep a close eye on the plants and water only as needed.

Ornamental Grasses

Selection and Installation

The first principle of Florida-Friendly Landscaping™ is to put the right plant in the right place to optimize the health of the plant and the success of your GSI system. Each plant species has naturally adapted to thrive in certain environmental conditions.

Make sure that the grasses you choose are adapted and recommended for the GSI environment you have.

At the outset, before you make your grass selections, consider the environmental conditions in the GSI system.

Determine your soil type, how long your soil retains moisture, how much sunlight there is in different areas, whether water will be ponded for any amount of time, and whether you are affected by salinity.

If you are within one-eighth of a mile of saltwater, you will want to choose plants that are at least somewhat salt tolerant; see the UF/IFAS Gardening Solutions page (**https://gardeningsolutions.ifas.ufl.edu/design/landscaping-for-specific-sites/coastal-landscape.html**) for further discussion and links to resources on coastal landscaping.

To determine your soil type and for a discussion of other factors relating to soil, see SL322, *Preplant Soil Assessment for New Residential Landscapes in Florida* (**https://edis.ifas.ufl.edu/publication/ss534**).

Growth Form and Mature Size

The growth form and mature size will influence how ornamental grasses should be used. Ornamental grasses can be characterized as either clump-forming or creeping. Clump-forming grasses, also called bunch grasses, grow in compact tufts, the width at the base slowly increasing over time. Creeping grasses, also called running or spreading grasses, spread by aboveground stems, called stolons, or underground stems, called rhizomes. Grasses that spread by stolons or rhizomes form roots along these stems, making many of them difficult to maintain within a confined area. Be sure to select the growth form best suited to your site.

The mature size of grass should be used as a guide to determine where it should be used. In particular, water and nutrient availability will influence plant size. An important consideration to remember is that although the mature size of the grass is important in selection and placement, a majority of grasses are dynamic and do not remain the same height throughout the growing season, because of pruning of deciduous foliage or flowering characteristics.

Seasonality

The first characteristic to consider is whether the plant is annual or perennial. A perennial grass will live for many years, while an annual grass will only last one season and die after flowering or be killed when exposed to freezing temperatures.

Determine if the foliage is winter hardy (evergreen) or not (deciduous). This may not be an easy process, because many grasses behave differently in different climates. Grasses are classified as warm season or cool season. Warm-season grasses are active in the warmer months and tend to go dormant in the winter. Dormant warm-season grasses may remain green, or the foliage may freeze, die and remain intact until pruned. Cool-season grasses are active in the cooler months and are more likely to remain evergreen during the winter. A hard freeze may affect even "evergreen" grasses by damaging the foliage, but when warmer conditions return, new foliage will usually regrow quickly. Grasses with foliage that dies in the winter and remains dormant until the weather warms in the spring are considered deciduous.

Watering

Water only for establishment. Grasses should not need supplemental irrigation after establishment. If plants are not able to survive on rainfall and runoff, consider replacing with more drought-tolerant grasses or plants.

Fertilizing

Grasses should obtain sufficient nutrients from the soil and in-coming runoff. No additional application of fertilizer nutrients should be necessary to promote growth of healthy foliage or flowering. In fact, excessive application of fertilizer nutrients will result in weak, floppy growth of foliage and weak flowering stems that will not stand up even to mild winds, and potentially introduce additional nutrients into the environment.

Pruning

Pruning of ornamental grasses should be done in late winter or early spring, just prior to new shoot growth. Many of the ornamental grasses have spectacular winter characteristic that should be preserved through the winter months. In north and central Florida, the months of February and March are appropriate times to prune ornamental grasses. In South Florida you may wish to cut back or trim ornamental grasses in January or February prior to new growth.

Use visual cues to determine the frequency of pruning the plant material. Only remove dead plant material when necessary. For deciduous grasses, such as Japanese silver grass (*Miscanthus sinensis*), the old foliage may be completely removed within inches of the soil. For evergreen grasses, such as muhly grass (*Muhlenbergia capillaris*), the ragged, dead tips of leaves can be removed to neaten the appearance of the plant. Many evergreen grasses recover quickly from heavier pruning. Old flower stalks and seed heads may be removed any time they no longer have a neat appearance.

Winter Characteristics

The winter appearance of an ornamental grass will differ with the winter hardiness of the foliage. For many landscapes, the winter character of deciduous ornamental grasses is much more important than the spring and summer foliage or flowers. The mature flowers of grasses may remain intact through the winter, or they may shatter. Regardless, these dead, dry features add tremendous interest to the winter garden when contrasted with evergreen plants or structures such as walls or fences. The dried foliage of deciduous grasses interacts with wind to create movement in the garden. For these reasons, pruning of the dead foliage and inflorescences is not recommended until growth resumes in the early spring.

Ground Covers

Selection and Installation

The most important step in establishing groundcovers is proper plant selection for the soil and GSI conditions.

Spacing of plants should be based on the mature size of the plant. Plant selection should consider the type of soils within the GSI and choose plants appropriate for the soil conditions. If the soils would need to be amended to support the plants, by increasing water holding capacity and/or providing nutrients, consider selecting plants more appropriate for the GSI conditions.

Pruning

Ground covers may need their runners directed across the soil. If needed, creeping ground covers can have their ends pinched back to cause branching and new growth. They may also need coaxing to stay in-bounds, so bend the runners back into the ground cover area. Edge ground covers creeping over walkways. You may need to check these plantings monthly for errant growth during warm weather.

Watering

After planting ground covers, you should give each plant enough water to establish a root system and begin growth out into the surrounding soil. Water daily for the first week or two. Then reduce the waterings to every other day for a few more weeks. When the plants begin growth and roots can be found in the surrounding soil, reduce to an as-needed schedule. Ground covers usually become established very quickly. Too much water can cause many ground covers to develop root rot problems. After establishment, they can mostly exist with seasonal rains and runoff.

Nutrient Management

Add mulch in the planted area. Most ground cover plantings are never fertilized after establishment. They obtain nutrients from decomposing mulches.

Pest Control

Most ground covers can tolerate the few leaf spots and holes made by occasional pests.

Mites are a common pest during drier months. Other problems include aphids, caterpillars, grasshoppers, mites, powdery mildew, and scales. Hand-pick or rinse away with water.

Aphid presence can be ignored unless populations are high.

Once your new plants are in the ground, weed control is up to you. Add a layer of mulch and remember that hoeing and pulling are still good ways to control weeds.

Shrubs

Selection and Installation

The most important step in establishing shrubs is proper plant selection for the soil and GSI conditions.

Spacing of plants should be based on the mature size of the plant. Plant selection should consider the type of soils within the GSI and choose plants appropriate for the soil conditions. If the soils would need to be amended to support the plants, by increasing water holding capacity and/or providing nutrients, consider selecting plants more appropriate for the GSI conditions.

Watering

To keep shrubs healthy during establishment, irrigation is usually required. Irrigating newly planted shrubs for only one or two months could result in stressed plants and plant death unless regular rainfall follows. Once shrubs are established, however, they should survive on rainfall alone.

Shrubs planted from 3-gallon containers can be established in the northern half of Florida–north of Orlando–with as little as one gallon of irrigation water applied every eight days. In the southern half of the state–south of Orlando - apply a gallon of water every four days. Light, frequent applications are much more efficient and effective than applying large volumes less frequently. Applying large volumes of water cannot compensate for infrequent irrigation.

Shrubs are considered established when they can survive and grow without irrigation. Most shrubs can make it on rainfall alone once roots have grown to the edge of the foliage canopy. This root growth normally occurs within 20 to 28 weeks after planting in landscapes if the guidelines provided here are followed and normal rainfall occurs. Runoff contributes water in addition to rainfall for plants. Therefore, shrubs are likely to establish more quickly within GSI than typical landscapes.

In prolonged hot, dry weather, occasional irrigation may be needed after the establishment period. Such weather can occur at any time in Florida but is most likely to occur in the spring and fall—April, May, October and/or November. During the first year after planting, 1 to 2 gallons of water may be needed during periods of more than approximately two weeks without a ¼ inch of rain.

Nutrient Management

Most shrubs in GSI are never fertilized after establishment; they obtain nutrients from decomposing mulches and incoming runoff. Supplemental nutrients may only be necessary to encourage growth during the establishment period. After establishment, fertilizer is not needed. If nutrient deficiency is observed, application of a top dressing of compost around the base of plants may be helpful.

Pest Control

If care is taken in selecting the right plant for the right place, pests should not be a major problem.

Should you find pests on your shrubs, management should involve Integrated Pest Management (IPM) strategies. IPM is the best strategy for dealing with pest management, and it relies on the use of chemicals only as a last resort. Check out these IPM techniques.

- Start with getting any pest that you find properly identified.
- Remove affected leaves or plant parts. When pests are heavily concentrated on a plant, you can often reduce or eliminate the problem by simply removing the affected leaves or stems.
- Pick insects off by hand. This easy step can often defeat infestations of large, slow-moving pests. Dispose of any captured insects so they do not return to feed again. Try one of these methods:
  - » Drop pests into soapy water or isopropyl alcohol.
  - » Place them in the freezer overnight (in a baggy or plastic container).
  - » Crush them and put them in your household trash.
- Look for beneficial insects. If you see a pest outbreak, determine if it's being managed by natural enemies already present. Many beneficial insects prey on pests, and harming the beneficials will just help the pests.

Don't treat by default. Plants with aesthetic damage don't necessarily need to be treated. Consider the amount of damage you're willing to accept. Remember that there will always be insects in any healthy landscape, and don't worry about minor damage. Start with low-impact techniques. Always try the safest alternatives first, such as handpicking insects or pruning affected parts of a plant. If pesticide use does become necessary, choose products that are the least harmful to people, pets, and wildlife. These products include insecticidal soap, horticultural oil, botanicals (e.g., pyrethrum, neem, and rotenone), microbials (e.g., spinosad, abamectin, and *Bacillus thuringiensis*), and entomopathogenic nematodes (small worms that kill insects).

- Spot-treat only. Use pesticides to treat only the affected areas of a plant or lawn. Never use blanket applications to treat problems.
- Avoid using broad-spectrum insecticides. They're not selective, meaning they also kill beneficials. Instead, choose targeted products, which are designed to harm only specific pests. For example, products that contain an extract of the bacterium *Bacillus thuringiensis* 'Kurstaki' are used to manage caterpillars without affecting other organisms.

- Read and follow all label instructions. Be careful and remember that the label is the law!
- Apply pesticides during the cooler part of the day. Heat combined with soaps, horticultural oils, and other pesticides can injure plants.
- Use products only on recommended plants. Always read the label to find out which plants a product can be applied on and which plants are sensitive to the product. If you're unsure about applying a product to a plant, test it on a small area of the plant first. Check for leaf burn in the tested area after one to two days. Phytotoxicity, or chemical injury, often looks like a burn on the edge of leaves.

Trees

Selection and Installation

The most important step in establishing trees is proper plant selection for the GSI conditions and proper installation. Spacing of trees should be based on the mature size of the plant and local conditions. Plant selection should consider the type of soils within the GSI and choose plants appropriate for the existing conditions. If the soils would need to be amended to support the trees, by increasing water holding capacity and/or providing nutrients, consider selecting trees more appropriate for the GSI conditions.

Planting your tree properly is imperative. See the tips below for the best success.

- Look up. Find a new planting site if there is an overhead wire, security light, or building nearby that could interfere with the tree as it grows.
- Dig a wide, shallow hole. Dig a hole that is one and one-half to three times the width of the root ball (the roots and soil attached to the plant when you remove it from its pot). You can also dig a hole that is only slightly larger than the root ball and simply loosen the soil around it with a shovel.
- Find the point where the uppermost root emerges from the trunk. This point is called the trunk flare, root flare, or root crown and should be even with or slightly above the soil surface. Remove any roots that circle close to the trunk.
- Slide the tree into the planting hole and position it carefully. Place the trunk flare slightly above the surface of the landscape soil and begin to fill the hole with the excavated soil, making sure the tree is straight as you go. As you add the soil, slice a shovel down into it twenty to thirty times, all around the tree. Compress the soil with your foot to stabilize the tree.
- Shave off the outer inch or so of the root ball with a sharp shovel. This removes roots that could strangle the trunk later as it grows in diameter. It also encourages roots to quickly grow into the landscape soil and makes the tree sturdier in winds.
- Add plenty of water to the root ball and planting hole. Make sure the root ball and surrounding soil or media are thoroughly moistened. Add more soil or media around the root ball if needed.
- Cover the backfill soil or media with mulch. Apply mulch to a minimum 8-foot diameter circle 3 inches deep around the tree, with a gap of 12 inches between the trunk and the mulch.
- Stake the tree, if necessary. Staking holds the root ball firmly in the soil. Top-heavy trees might require staking, especially if they're located in a windy location. Stakes should be removed within one year of planting.

Watering for Establishment

Newly planted trees need regular irrigation to rapidly grow the roots necessary for proper establishment. For trees planted in spring or summer, water two to three times per week.

After the first few months, provide weekly irrigation until plants are fully established. Most trees are established after a year. Irrigation applications should be 2 to 3 gallons of water per inch trunk diameter.

For example, a 2-inch tree should be watered with 4 to 6 gallons each irrigation. In some situations, hand watering may be the only way to follow this schedule and still comply with water restrictions.

Nutrient Management

Many trees in managed landscapes can obtain enough nutrients through their extensive root systems. Stormwater runoff typically contains sufficient nutrients such that plants do not need supplemental fertilization. Fertilization can add excess nutrients to the stormwater management system, counteracting one of the main goals of GSI, which is to remove nutrients from the environment. When foliage shows deficiency symptoms, determine what element is missing and apply treatments accordingly. When you suspect a deficiency, have the soil or foliage tissue tested for important elements before prescribing a fertilizer treatment.

Pest Control

If care is taken in selecting the right plant for the right place, pests may not be a major problem. Your scouting should be more concentrated on younger trees in the landscape. Because of their size, mature trees are rarely sprayed. Should you find pests on your trees, management should involve Integrated Pest Management (IPM) strategies. IPM is the best strategy for dealing with pest management, and it relies on the use of chemicals only as a last resort. Check out these IPM techniques.

- Start with getting any pest that you find properly identified.
- Remove affected leaves or plant parts. When pests are heavily concentrated on a plant, you can often reduce or eliminate the problem by simply removing the affected leaves or stems.
- Pick insects off by hand. This easy step can often defeat infestations of large, slow-moving pests.

Dispose of any captured insects so they do not return to feed again. Try one of these methods:

  - » Drop pests into soapy water or isopropyl alcohol.
  - » Place them in the freezer overnight (in a baggy or plastic container).
  - » Crush them and put them in your household trash.

- Look for beneficials. If you see a pest outbreak, determine if it's being managed by natural enemies already present. Many beneficial insects prey on pests, and harming them will just help the pests.
- Don't treat by default. Plants with aesthetic damage don't necessarily need to be treated. Consider the amount of damage you're willing to accept. Remember that there will always be insects in any healthy landscape, and don't worry about minor damage.
- Start with low-impact techniques. Always try the safest alternatives first, such as handpicking insects or pruning affected parts of a plant. If pesticide use does become necessary, choose products that are the least harmful to people, pets, and wildlife. These products include insecticidal soap, horticultural oil, botanicals (e.g., pyrethrum, neem, and rotenone), microbials (e.g., spinosad, abamectin, and *Bacillus thuringiensis*), and entomopathogenic nematodes (small worms that kill insects).
- Avoid using broad-spectrum insecticides. They're not selective, meaning they also kill beneficials. Instead, choose targeted products, which are designed to harm only specific pests. For example, products that contain an extract of the bacterium *Bacillus thuringiensis* 'Kurstaki' are used to manage caterpillars without affecting other organisms.
- Spot-treat only. Use pesticides to treat only the affected areas of a GSI. Never use blanket applications to treat problems. This is particularly true within GSI and stormwater systems, as pesticides introduced into them can be carried to downstream water bodies.
- Read and follow all label instructions. Be careful and remember that the label is the law!
- Apply pesticides during the cooler part of the day. Heat combined with soaps, horticultural oils, and other pesticides can injure plants.
- Use products only on recommended plants. Always read the label to find out which plants a product can be applied on and which plants are sensitive to the product. If you're unsure about applying a product to a plant, test it on a small area of the plant first. Check for leaf burn in the tested area after one to two days. Phytotoxicity, or chemical injury, often looks like a burn on the edge of leaves.

Palms

Planting

Field-grown palms should always be transplanted to the same depth at which they were previously growing. Palms transplanted deeper have been shown to have an increased incidence of chronic nutritional deficiencies, such as iron or manganese deficiencies. Such palms often are also stunted and grow poorly, compared to properly planted palms. In addition to nutrient deficiencies, deeply planted palms may also suffer from water stress. As a result of these palms' weakened condition, they may attract secondary pests, such as palm weevils (*Rhychophorus* sp.). Palms that are planted too deeply may also develop secondary root rots due to the suffocation of deeply buried roots. Deeply planted palms may linger in a state of poor health for many years, or they may die at any time. For this reason, it is important to not plant palms in areas that will be frequently inundated for long durations.

Support

Tall palms should be provided with supports to prevent toppling over in high winds and to provide a stable rootball-soil interface. Deep planting is not an acceptable alternative to mechanical support. Support timbers must not be nailed directly into the trunk since any wounds to a palm trunk are permanent and can allow for entry of pathogens such as *Thielaviopsis*. For more information see Thielaviopsis Trunk Rot of Palm, **https://edis.ifas.ufl.edu/pp143**.

An excellent method for providing support to a tall palm during establishment is to strap short lengths of 2 x 4-inch lumber to the trunk and nail the support timbers into these pieces. Supports should be left in place for about a year.

Watering

Although container-grown palms can be planted any time of the year, the best time to plant field-grown palms is during the early summer, when the soil is warm and rainfall is frequent.

Be patient; your newly planted palm won't look like it's growing much the first year because most of its energy will be channeled into growing roots. Water daily for the first few weeks and continue watering frequently thereafter until the palms are well established.

Nutrient Management

It is best to avoid fertilization in GSI systems unless deficiencies are observed. For more information, more information see Fertilization of Field-Grown and Landscape Palms in Florida **https://edis.ifas.ufl.edu/publication/EP261**.

Pruning

If you have palm trees, you may be wondering about the proper way to prune them. Some palm trees don't need to be pruned, like our native cabbage palm—it automatically sheds its dead leaves. If you have palms that aren't self-cleaning, you may choose to prune them periodically. Just use a pole saw to remove any brown fronds. Leave the green fronds alone, since they're the energy factory for the tree. Be sure not to damage the trunk. If you hire a tree service, don't let them climb with tree spikes, since these cause permanent damage to the trunk.

When pruning palms, only remove fronds that are completely brown and that hang below the 9 o'clock or 3 o'clock position. If you hire a professional, make your wishes clear by putting them in writing. Explain that you want your palms to have a rounded canopy, not a mohawk. Always remember that the point of pruning is to remove only dead growth.

Pest Control

If care is taken in selecting the right plant for the right place, pests may not be a major problem. Your scouting should be more concentrated on younger trees in the landscape. Should you find pests on your palms, management should involve Integrated Pest Management (IPM) strategies. IPM is the best strategy for dealing with pest management, and it relies on the use of chemicals only as a last resort. Check out these IPM techniques.

- Start with getting any pest that you find properly identified.
- Remove affected leaves or plant parts. When pests are heavily concentrated on a plant, you can often reduce or eliminate the problem by simply removing the affected leaves or stems.
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- Apply pesticides during the cooler part of the day. Heat combined with soaps, horticultural oils, and other pesticides can injure plants.
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Aquatic Plants

(from **https://edis.ifas.ufl.edu/publication/FA163**)

When trying to address an aquatic plant issue, first determine what state agency or agencies are responsible for aquatic plant management in the area and then contact the agencies to determine what assistance is available and what courses of action are legal. Decisions concerning perceived stormwater ponds should be addressed through the consensus of a homeowner's association.

Simply weeding by hand may be all that is necessary to remove small amounts of vegetation that interfere with proper functioning of the structure(s).

Specialized machines are available in many sizes and with several different accessories for removing aquatic vegetation in a variety of situations. Small machines are practical for limited areas, and large machines in combination with transports and shore conveyors are suitable for large, whole-lake operations. These machines are commonly called mechanical harvesters or weed harvesters, and the process is called mechanical harvesting or removal.

In extreme cases of overgrown aquatic vegetation, conventional or specially adapted dredging machines may be used to remove vegetation and associated sediments. Dredging is expensive, especially if a nearby disposal site is not available. The secondary environmental effects of dredging can be quite drastic, and therefore permits from regulatory agencies may be required before a dredging operation can begin.

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