CH. 3—STORMWATER MANAGEMENT

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Introduction

The previous chapter presented green infrastructure-based planning and design techniques that provide better natural resource protection during the site development process. In this chapter, the GI concept is integrated into the management of *post-construction* stormwater runoff.

Stormwater has been identified as a major contributing factor to nonpoint source pollution for receiving streams and waterbodies within Georgia. With development and urbanization comes a myriad of land-altering activities which ultimately affect the way water moves through the natural hydrological cycle. The main activities affecting water quality include the addition of impervious surfaces, soil compaction and erosion, tree removal and man-made hydrological alterations (flood relief/erosion control structures).

As the natural processes of interception, evapotranspiration, and infiltration are altered and precipitation is converted to overland flow, these modifications affect not only the characteristics of the developed site but also the watershed in which the development is located. Receiving streams are significantly affected by the quantity and quality of stormwater runoff. Rainfall landing on impervious areas picks up pollutants and transports them to receiving streams and other water bodies. Runoff leaving the site at higher rates and larger amounts changes the channel profile—by scouring or filling the stream bed and eroding the banks which in turn drastically changes aquatic habitat. With an additional pollutant load, lower dissolved oxygen, and elevated water temperatures, habitat degradation is amplified. Also, since more water runs off the site sooner, there is less water percolating through the system to support base flows in the stream, creating another challenge for aquatic species.

With all of these impacts in mind, Green Infrastructure seeks to reduce runoff rates, volumes and pollutant loads through the use of a multifunctional approach—Better Site Planning, Better Site Design and Low Impact Development (LID).

In combination, this strategy takes a different approach to stormwater management as compared with conventional strategies. Conventional methods aim to convey water off-site and into the municipal storm system as quickly as possible, while GI Stormwater techniques seek to do just the opposite— either reduce the runoff or keep as much water on-site as possible for absorption and infiltration at or near the actual rainfall site. Instead of large, centralized treatment plants and water storage facilities, LID emphasizes local, distributed solutions that capitalize on the beneficial services that natural ecosystem functions provide.

Green Infrastructure stormwater practices can be both a cost-effective and an environmentally-preferable alternative to conventional hard engineering solutions. GI promotes infiltration, evapotranspiration, and re-use of stormwater rather than traditional hardscape collection, conveyance, and storage structures. It is most effective when supplemented with other decentralized storage or infiltration approaches, such as the use of permeable pavement, rain barrels, and cisterns to capture and re-use rainfall for landscape irrigation or flushing toilets. This approach reduces both the amount of stormwater entering municipal sewer systems and the amount of untreated stormwater discharging to surface waters. GI, using LID practices, facilitates or mimics natural processes that recharge groundwater, preserve baseflows, provide wildlife habitat, and protect surface water quality conditions.

The overall goal of GI is to protect the natural systems that provide us with free ecosystem goods and services. This translates into a reduction of municipal systems which means less construction and maintenance costs for the local government and its residents over time.

Stormwater Management Guidance for Coastal Georgia

High water tables, mildly-sloping to flat topography, large tidal ranges, and unique terrestrial and marine habitats present additional challenges to site development in the coastal region of Georgia. For these reasons, G3 provides stormwater management criteria and low impact development practices that have been adapted to these unique regional characteristics.

For the most part, the stormwater management criteria and practices included in this chapter are derived from the 2001 Georgia Stormwater Management Manuals (GSWMM), commonly referred to as the "Blue Books" and its Coastal Stormwater Supplement (CSS), published in 2009. With extensive public and private stakeholder input and collaboration, the technical references were developed by the Chatham County-Savannah Metropolitan Planning Commission utilizing the technical expertise of the Center for Watershed Protection and the Georgia Department of Natural Resources. Both references can be found at www.stormwater.com. Refer to the CSS directly for specific design specifications for stormwater management practices contained in this chapter.

The CSS adds to the multitude of information found in the GSMM by providing specific guidance for Georgia's coastal communities. The CSS was designed as the next generation of stormwater management, shifting the focus of coastal Georgia's post-construction stormwater management efforts to prevention, rather than mitigation of the negative impacts of the land development process. Runoff reduction strategies are detailed as an approach to manage stormwater. Coastal High Priority Plant and Animal Species and Habitat Areas are provided and integrated from the State's Comprehensive Wildlife Action Strategy. See Appendix C and D for a complete listing. Additional information includes a Rainfall Analysis, a Coastal Stormwater BMP Monitoring Protocol, a model local government ordinance for Coastal Georgia, and guidance for coastal local governments on establishing a stormwater financing mechanism. A user-friendly excel worksheet to calculate BMP credits is also provided as a tool to ensure a project's consistency with the Coastal Stormwater Supplement. The CSS provides Georgia's coastal communities with comprehensive guidance on an integrated, green infrastructure-based approach to natural resource protection, stormwater management and site design that can be used to advance protection of coastal Georgia's unique and vital natural resources as the region grows and develops.

The following stormwater management guidance, consistent with the Coastal Stormwater Supplement, has been designed to help developers comply with the requirements of various state and federal environmental policies, programs, and regulations including the National Pollution Discharge Elimination System (NPDES) Municipal Stormwater Program and Georgia's Coastal Nonpoint Source Pollution Control Program, created through the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990.

Using the GI Approach, better site planning and design techniques are implemented early on in the development process which reduces post-construction stormwater runoff rates, volumes, and pollutant loads to the greatest extent possible. Then, low impact development practices are distributed across the development site. If the stormwater management criteria cannot be met solely through the use of green infrastructure practices, general stormwater management practices are applied to further manage post-construction stormwater runoff rates, volumes and pollutant loads.

Adapted from Stormwater Management Concept Plan Decision Tree. Source: Center for Watershed Protection

Stormwater Management Criteria

The Coastal Stormwater Supplement (CSS) contains stormwater management practices that have been assigned quantifiable value or "credit" that can be used to address the stormwater management criteria. The Table in Appendix E shows how each practice can meet the requirements for the following criteria:

1. **Stormwater Runoff Reduction**

   Reducing stormwater runoff volumes helps maintain pre-development site hydrology and helps to protect coastal Georgia's aquatic resources from several indirect impacts of the land development process (i.e., decreased groundwater recharge, decreased surface water baseflow and degraded water quality).

   This stormwater management (SWM) criteria can be met by reducing stormwater runoff volume generated by the 85th percentile storm event (and the "first flush" of the stormwater runoff volume generated by all larger storm events) on a development site through the use of appropriate Green Infrastructure practices. This equates to reducing the stormwater runoff volume generated by the 1.2 inch rainfall event (and the stormwater runoff generated by the first 1.2 inches of all larger rainfall events).

2. **Stormwater Quality Protection**

   Adequately treating stormwater runoff before it's discharged from a development site helps to protect coastal Georgia's aquatic resources from water quality pollution. To the greatest extent possible, apply SWM criteria #1. If any of the stormwater generated by the 1.2 inch storm event (and the first 1.2 inches of all larger rainfall events) cannot be r*educed* on a development site due to site characteristics or constraints, it should be *intercepted and treated* in one or more stormwater management practices that: (1) provides for at least an 80 percent reduction in TSS loads; and (2) reduces nitrogen and bacteria loads to the *maximum extent practical*.

3. Aquatic Resource Protection

Valuable aquatic resources can be protected from negative impacts of land development processes (e.g., complete loss or destruction, stream channel enlargement, increased salinity fluctuations) by:

- implementing better site planning techniques,
- establishing effective aquatic buffers (minimum 25-foot wide aquatic buffer, 100-foot wide aquatic buffer is preferred),
- providing 24 hours of extended detention for the stormwater runoff volume generated by the 1-year, 24-hour storm event before it is discharged from a development site, and
- providing velocity control and energy dissipation measures at all new and existing stormwater outfalls.

4. Overbank Flood Protection

This stormwater management criteria can be satisfied by controlling (attenuating) the post-development peak discharge generated by the 25-year, 24-hour storm event helps prevent an increase in the duration, frequency and magnitude of damaging overbank flooding.

5. Extreme Flood Protection

Control (attenuate) the peak discharge generated by the 100-year, 24-hour storm event to help prevent an increase in the duration, frequency and magnitude of dangerous extreme flooding. Stormwater credit can be obtained by controlling (attenuating) the peak discharge generated by the 100-year, 24-hour storm event under post-development conditions.

6. Increased Stormwater Reduction

Stormwater runoff should be reduced on development sites within ½ mile of shellfish harvesting areas to better protect these sensitive natural resources from contamination and closure.

7. Enhanced Aquatic Resource Protection

Wider aquatic buffers around all aquatic resources located within a ½ mile of shellfish harvesting areas helps better protect these sensitive natural resources from contamination and closure.

Evaluating Overall Feasibility

Site planning and design teams can evaluate the overall feasibility of applying each of the stormwater practices on a development site. The following table shows the factors to consider when selecting an appropriate stormwater practice for an individual site:

Drainage Area: Describes how large of a contributing drainage area each practice can realistically handle. It indicates the maximum size of the contributing drainage area that each practice should be designed to receive stormwater runoff.

Area Required: Indicates how much space each practice typically consumes on a development site.

Slope: Describes the influence that site slope can have on the performance of each practice. It indicates the minimum or maximum slope recommended for installation.

Minimum Head: An estimate of the minimum amount of elevation difference needed within the stormwater practice, from the inflow to the outflow, to allow for gravity operation.

Minimum Depth to Water Table: Indicates the minimum distance that should be provided between the bottom of the each practice and the top of the water table.

Soils: Describes the influence that the underlying soils (i.e., hydrologic soil groups) can have on the performance of the each practice.

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)

Green Infrastructure Practice	Drainage Area	Area Required	Slope	Minimum Head	Minimum Depth to Water Table	Soils
Low Impact Development Practices						
Alternatives to Disturbed Pervious Surfaces						
Soil Restoration	N/A	No restrictions	10% maximum	N/A	1.5 FT	Restore hydrologic soil group C/D or disturbed soils

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)						
Green Infrastructure Practice	**Drainage Area**	**Area Required**	**Slope**	**Minimum Head**	**Minimum Depth to Water Table**	**Soils**
Site Reforestation/ Revegetation	N/A	10,000 SF minimum to receive stormwater management "credits"	25% maximum	N/A	No restrictions	No restrictions
Alternatives to Impervious Surfaces						
Green Roofs	N/A	No restrictions	25% maximum, although 10% or less is recommended	6 to 12 inches	N/A	Use appropriate engineered growing media
Permeable Pavement	N/A	No restrictions	6%	2 to 4 feet	2 feet	Should drain within 48 hours of end of rainfall event
"Receiving" Low Impact Development Practices						
Undisturbed Pervious Areas	Length of flow path in contributing drainage area maximum 75 to 150 feet long	Length of flow path in undisturbed pervious area minimum 50 feet long	Maximum 3% in contributing drainage area; 0.5% to 6% in undisturbed pervious area	N/A	No restrictions	No restrictions

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)						
Green Infrastructure Practice	**Drainage Area**	**Area Required**	**Slope**	**Minimum Head**	**Minimum Depth to Water Table**	**Soils**
Vegetated Filter Strips	Length of flow path in contributing drainage area maximum 75 to 150 feet long	Length of flow path in vegetated filter strip minimum 15 to 25 feet long	Maximum 3% in contributing drainage area; 0.5% to 6% in vegetated filter strip	N/A	No restrictions	No restrictions
Grass Channels	5 acres	Bottom of grass channel 2 to 8 feet wide; side slopes of 3:1 or flatter	0.5% to 3%, although 1% to 2% is recommended	N/A	2 feet	No restrictions
Simple Downspout Disconnection	2,500 square feet; length of flow path in contributing drainage area maximum 75 feet long	Length of flow path at least 15 feet long and equal to or greater than that of contributing drainage area	0.5% to 6%, although 1% to 5% is recommended	N/A	No restrictions	No restrictions
Rain Gardens	2,500 square feet; length of flow path in contributing drainage area maximum 75 to 150 feet long	10-20% of contributing drainage area	6%	30 to 36 inches[1]	2 feet	Should drain within 24 hours of end of rainfall event

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)						
Green Infrastructure Practice	**Drainage Area**	**Area Required**	**Slope**	**Minimum Head**	**Minimum Depth to Water Table**	**Soils**
Stormwater Planters	2,500 square feet; length of flow path in contributing drainage area maximum 75 to 150 feet long	5% of contributing drainage area	6%	30 to 36 inches[1]	2 feet[1]	Should drain within 24 hours of end of rainfall event
Dry Wells	2,500 square feet; length of flow path in contributing drainage area maximum 75 to 150 feet long	5-10% of contributing drainage area	6%	2 feet[1]	2 feet	Should drain within 24 hours of end of rainfall event
Rainwater Harvesting	No restrictions	Varies according to the dimensions of the rain tank or cistern used to store the harvested rainwater	No restrictions	N/A	N/A	N/A
Bioretention Areas	5 acres	5-10% of contributing drainage area	6%	42 to 48 inches[1]	2 feet	Should drain within 48 hours of end of rainfall event

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)						
Green Infrastructure Practice	Drainage Area	Area Required	Slope	Minimum Head	Minimum Depth to Water Table	Soils
Infiltration Practices	2 to 5 acres	5% of contributing drainage area	6%	42 to 48 inches[1]	2 feet	Should drain within 48 hours of end of rainfall event
Dry Swales	5 acres	5-10% of contributing drainage area	0.5% to 4%, although 1% to 2% is recommended	36 to 48 inches[1]	2 feet	Should drain within 48 hours of end of rainfall event

Site Applicability

Site planning and design teams should evaluate the applicability of each of the practices on a particular development site. The following table shows important factors to consider when evaluating the applicability of each practice:

Rural Use: Indicates whether or not the practice is suitable for use in rural areas and on low-density development sites.

Suburban Use: Indicates whether or not the practice is suitable for use in suburban areas and on medium-density development sites.

Urban Use: Identifies the practices that are suitable for use in urban and ultra-urban areas where space is at a premium.

Construction Cost: Assesses the relative construction cost of each of the practices.

Maintenance: Assesses the relative maintenance burden associated with each practice. It is important to note that nearly *all* stormwater practices require some kind of routine inspection and maintenance.

Factors to Consider When Evaluating the Applicability of Stormwater Management Practices on a Development Site (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement, CWP/MPC, 2009.)

SW Practice	Rural Use	Suburban Use	Urban Use	Construction Cost	Maintenance
Stormwater Ponds	✓	✓		Low	Low
Stormwater Wetlands	✓	✓		Low	Medium
Bioretention Areas	✓	✓	✓	Medium	Medium
Filtration Practices	❋	✓	✓	High	High
Infiltration Practices	✓	✓	✓	Medium	High
Dry Swales	✓	✓	❋	Medium	Medium
Wet Swales	✓	✓	❋	Medium	Medium

Notes: ✓ = Suitable for use on development sites located in these areas. ❋ = Under certain situations, can be used on development sites located in these areas.

Stormwater Management Practices

Green Infrastructure (GI) and Low Impact Development (LID) comprises a set of small-scale, non-structural stormwater management practices that promote the use of natural or engineered systems for infiltration, evapotranspiration, and reuse of rainwater. These practices are designed to replicate pre-development site hydrology by integrating green space, native landscaping and natural hydrologic functions that function to reduce runoff volumes and rates, and capture and treat runoff from developed land. When installed and maintained correctly, these practices are quite adept at removing nutrients, pathogens, and metals from stormwater, as well as reducing the volume and intensity of stormwater flows.

This section contains stormwater practice profiles for GI and LID-based practices as well as general application structural controls. First, GI practices should be applied to reduce runoff volumes and rates to the greatest extent possible. Then, the remaining runoff should be captured and treated using LID practices. Finally, general application structural controls can be applied if needed. Design Profiles showing how to properly apply and design these practices on coastal development sites are provided for the following practices:

Green Infrastructure Practices

- Soil Restoration
- Site Reforestation/Revegetation
- Green Roofs
- Permeable Pavement

Low Impact Development Practices

- Undisturbed Pervious Areas
- Vegetated Filter Strips
- Grass Channels
- Simple Downspout Disconnection
- Rain Gardens
- Stormwater Planters
- Dry Wells
- Rainwater Harvesting
- Bioretention Areas
- Infiltration Practices
- Dry Swales

General Application Structural Stormwater Controls

- Stormwater Ponds
- Stomwater Wetlands
- Filtration Practices

Stormwater Management System Design Checklist

Green Growth Guidelines	√	Comments/Notes
Stormwater Management System Design		
Review the stormwater management requirements that apply to the development site		
Distribute the following runoff-reducing low impact development practices across the development site:		
• Soil Restoration		
• Site Reforestation/ Revegetation		
• Green Roofs		
• Permeable Pavement		
• Undisturbed Pervious Areas		
• Vegetated Filter Strips		
• Grass Channels		
• Simple Downspout Disconnection		
• Rain Gardens		
• Stormwater Planters		
• Dry Wells		
• Rainwater Harvesting		
• Bioretention Areas		
• Infiltration Practices		

Green Growth Guidelines	√	Comments/Notes
• Dry Swales		
Where feasible, use permeable pavement to construct alleys, parking stalls, walking paths and trails, driveways, sidewalks and light-duty service roads		
Provide vegetated filter strips and depressed landscaped islands in and around parking lots		
Use dry swales and grass channels along roadways and in roadway medians to reduce stormwater runoff rates, volumes and pollutant loads near their source		
Use primary and secondary conservation areas and aquatic buffers to “receive” stormwater runoff and buffer environmentally sensitive areas		
Check to see if the stormwater management requirements that apply to the development site have been satisfied		
If the stormwater management requirements that apply to the development site cannot be satisfied exclusively through the use of better site planning and design techniques and low impact development practices, use the following general application stormwater management practices to further manage stormwater runoff rates, volumes and pollutant loads on the development site:		
• Stormwater Ponds		
• Stormwater Wetlands		
• Bioretention Areas		
• Filtration Practices		

Green Growth Guidelines	√	Comments/Notes
• Infiltration Practices		
• Swales		
Use the following limited application stormwater management practices only when better site planning and design techniques, low impact development and general application stormwater management practices cannot be used to satisfy the the stormwater management requirements that apply to the development site:		
• Dry Detention Basins		
• Dry Extended Detention Basins		
• Multi-Purpose Detention Areas		
• Underground Detention Systems		
• Organic Filters		
• Underground Filters		
• Submerged Gravel Wetlands		
• Gravity (Oil-Grit) Separators		
• Alum Treatment Systems		
• Proprietary Systems		
Check to see if the stormwater management requirements that apply to the development site have been satisfied		

Green Growth Guidelines	√	Comments/Notes
If the stormwater management requirements have not been completely satisfied, go back to the site layout to apply additional low impact development and stormwater management practices to further reduce and manage stormwater runoff rates, volumes and pollutant loads on the development site		

Low Impact Development Local Case Study

Assessment of Stormwater Management in Coastal South Carolina: A Focus on Stormwater Ponds and Low Impact Development (LID) Practices

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This report addresses strengths and weaknesses of two stormwater management strategies: stormwater ponds and low impact development (LID) practices. It also addresses issues such as water quality, the permitting process, and the design, construction, and maintenance of stormwater-management projects, and measures to improve them. This report is based on 19 interviews of stormwater professionals and the input gathered from 51 workshop attendees. Stormwater professionals include:

- engineers,
- developers,
- contractors,
- landscape architects,
- regulatory staff, and
- land planners.

The workshop, Stormwater Management in Coastal S.C.: A Focus on Stormwater Ponds and Low Impact Development (LID) Practices, was held on January 22, 2009. The workshop identified informational, regulatory, and educational needs of stormwater professionals regarding both traditional and alternative stormwater-management technologies. Previous research and the responses provided by stormwater professionals were analyzed. The purpose of this report is to assist coastal communities and other stakeholders with making decisions regarding the selection and implementation of stormwater-management strategies.

Stormwater management is one way to protect our local waterbodies from the impacts of coastal development. Photo/NOAA-HML

South Carolina Stormwater Management

Southeastern coastal regions have adopted and implemented the use of Best Management Practices (BMPs) as a means of controlling stormwater quantity and quality. Generally, stormwater regulations in South Carolina require stormwater-management systems to retain the first ½ inch of runoff on site or 1 inch of runoff from the built upon area (whichever is greater), maintain pre-development discharge rates, and remove 80 percent of suspended solids during construction (SMSRA, 1991; SCDHEC, 2002; 2003; 2006). The selection and implementation of BMPs in the South Carolina coastal zone must take into consideration regional characteristics such as the flat coastal topography, shallow water tables, and minimal soil storage.

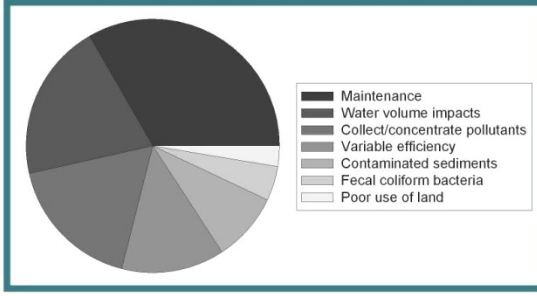
Stormwater Ponds

Stormwater ponds were initially designed and implemented to manage localized flooding. But as the impacts of urbanization on adjacent streams and water bodies became better understood, ponds have been required as a mechanism to treat stormwater and protect adjacent water quality (SCDHEC, 2004). Stormwater ponds can be categorized into two general types: 1) detention ponds with a permanent pool of water that is gradually discharged into adjacent water bodies through an overflow structure or 2) retention ponds with a permanent pool of water that is discharged through infiltration and groundwater transport. South Carolina regulations, coupled with regional geography and hydrology, result in stormwater-detention ponds serving as the most commonly used BMP in the South Carolina coastal zone. In 1999, more than 8,000 stormwater ponds were estimated to be located within the eight coastal counties of South Carolina (Siewicki et al., 2007). Interviews with engineers of this region suggest that additional stormwater ponds will be located in the region because of ease of designing, permitting, and constructing them. Ponds also serve a critical role in providing fill material for development within topographically low-lying areas. In addition, ponds can be marketed as an amenity to a development, providing both practical management of stormwater runoff, while also serving as open space and offering recreational opportunities such as fishing, boating, and sometimes even swimming.

Although national research suggests that these ponds are effective in reducing stormwater peak flows and retaining pollutants (Table 1), recent regional research suggests that the efficiency of these ponds may be less than nationally reported (Messersmith, 2007). It is important to note that BMP efficiency is dependent upon several factors, including storm characteristics (rain volume, intensity, and frequency), pond age, pond size, and pond design (length, width, and placement of inlet and outlet) (SCDHEC-OCRM, 2007). In addition to the broad question of regional efficiency of stormwater ponds, other more specific concerns suggest a need to re-evaluate the impact of stormwater ponds on water quality. Since ponds are designed to retain stormwater, they receive high loadings of nutrients, pesticides, chemicals, and fecal coliform (SCDHEC-OCRM, 2007). As a result, the surface waters and sediments of these ponds become compromised and can lead to problems such as harmful algal blooms (HABs) or fish kills within the ponds. These conditions can be expected (given the purpose of the pond) and might not be problematic. But these ponds attract humans and wildlife, and there is often exchange between the pond and adjacent tidal creeks. These conditions can create a health hazard for those exposed to the pollutants (e.g., toxins and pathogens). In addition, these ponds are often neglected and not regularly maintained, which leads to sedimentation, reduction of the storage capacity of the ponds over time, and increased discharge of polluted water to adjacent water bodies (Messersmith, 2007).

Stormwater ponds are designed to collect and concentrate pollutants and can promote algal blooms, such as these found in a pond in Berkeley County, S.C. Photo/SCDHEC-OCRM

Limitations of Stormwater Ponds



Attendees of the workshop said that maintenance is the biggest disadvantage to relying on stormwater ponds (33%). It was noted that pond failure is often not apparent and that many ponds are maintained only for aesthetics. As a result, pond maintenance can be easily overlooked. In many cases, maintenance costs serve as a disincentive to Homeowners Associations (HOAs) to address problems. Therefore, homeowners need to be informed and educated about the importance of maintaining their ponds. Monitoring and enforcement of pond maintenance must be addressed through education and the development of guidelines for local municipalities. Additional disadvantages to relying on stormwater ponds include water-volume impacts of ponds (20%) (e.g., conveying stormwater to one location rather than promoting natural infiltration and groundwater recharge throughout a site), the collection and concentration of pollutants (18%), and variable efficiency of ponds (13%). The attendees were also concerned about sediment contamination (9%), fecal coliform bacteria (4%), and the fact that ponds are a poor solution to small sites and can be seen as a waste of developable land (3%).

The attendees indicated a need to address the concerns associated with ponds and offered solutions, such as retrofitting ponds through the use of other BMPs, tightening pond-design guidelines, or addressing maintenance educational needs. The majority of

Researchers from NOAA's Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) enlisted the assistance of volunteers to plant a vegetated buffer along a stormwater pond on James Island, S.C. Photo/NOAA-CCEHBR

responses suggested that ponds should be used in concert with other BMPs (38%) to minimize the quantity and improve the quality of stormwater leaving a site. One engineer noted that a typical pond in the lowcountry is not capable of achieving the regulatory standards of discharging stormwater over 24 hours due to the low relief and shallow water tables of this area. Therefore, by incorporating ponds as a component of a stormwater management plan, one can benefit from the advantages of ponds while also improving the performance of a stormwater-treatment system of a site. Respondents said that problems related to ponds are primarily due to a lack of maintenance, which if addressed could improve the performance of ponds (27%). Specifically there is a need for better enforcement of maintenance plans and education of the homeowners. Additional options for improving the performance of ponds were suggested, including forebays (15%), better pond design (9%), flow control devices (7%), littoral shelves (3%), and improved design criteria (e.g., design storm event) of ponds (1%).

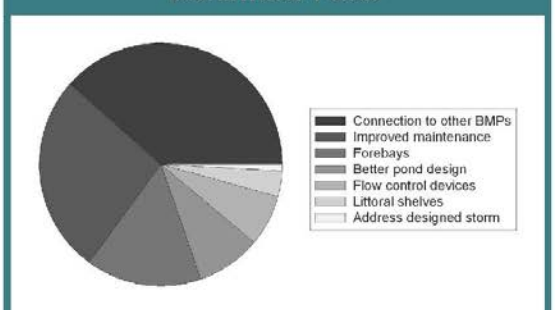
LID Practices

LID strategies integrate the use of site planning (e.g., clustering, reducing impervious cover, and preservation of open space) and alternative stormwater management strategies (e.g., bioretention swales, pervious pavement, and rainwater harvesting) to promote the infiltration and retention of stormwater runoff at the source to foster maintenance of a site's pre-development hydrologic condition (Prince George's County DER, 1999). For the purposes of this report, subsequent use of the term LID practices will refer to the stormwater-management technologies utilized to minimize the impact of development on a site.

LID practices were first implemented in Prince George's County, Maryland, in the 1990s. Since then, there have been a handful of research projects to evaluate the efficiency of these LID practices in reducing stormwater runoff and maintaining pre-development discharge rates. These projects have found that bioretention swales, pervious pavement, surface sand filters, vegetated roof tops, and gravel wetlands are effective at reducing runoff rates and removing selected pollutants (e.g., total suspended sediments [TSS], nutrients, metals, polyaromatic hydrocarbons) from stormwater runoff (EPA, 2000; Hsieh and Davis, 2005; Hunt and Lord, 2006; Roseen et al., 2006; UNH Stormwater Center, 2007; Dietz and Clausen, 2008). LID practices can generally reduce stormwater peak flows and pollutant loads to levels similar to traditional stormwater-management techniques (e.g., detention ponds), suggesting they may be a reasonable alternative to ponds (see Table 1; EPA, 2000, UNH Stormwater Center, 2007; Dietz and Clausen, 2008).

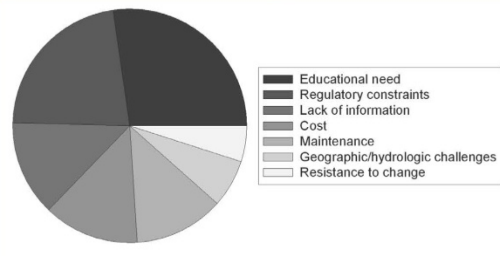
Although there have been several studies that suggest LID practices may be a useful alternative to traditional stormwater management, these studies were conducted in areas outside of

Options to Address Limitations of Stormwater Ponds



The Clemson Extension Carolina Yard constructed at the Charleston Exchange Park incorporates the use of pervious pavers, pervious walkways, a rain barrel, and a rain garden to educate the general public on the site-scale use of LID practices. Photo/USC

Obstacles to Utilizing LID Practices



Researchers from Clemson University have recently designed, installed, and are currently studying water retention capacity and performance of bioretention cells at their new Baruch Institute facility in Georgetown, S.C. Photo/Clemson University

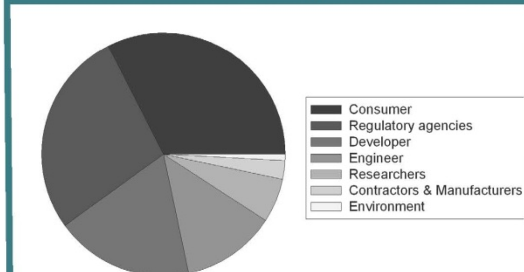
the Southeast coastal region and may not apply to regional soils and shallow water tables. Scientists, developers, managers, and engineers are uncertain whether LID systems will be efficient at retaining stormwater volume and pollutants along the southeastern coast where soil storage is generally minimal and rain events are flashy and often intense. The regional geographic and hydrologic limitations of the Southeast coast have also resulted in a suite of perceived and real concerns among the professional stormwater community regarding the use of LIDs. Consequently the prevalence of LID practices is limited along the Southeast coast.

When questioned about the obstacles that may inhibit the regional implementation of LID practices, workshop attendees indicated that the educational needs of stakeholders (27%) and the regulatory process (22%) were the primary obstacles. Attendees suggested that there is a need for education across all sectors including consumers, developers, engineers, and local elected and appointed municipal officials. Most notably there is a need for marketing of LID to promote their implementation. From the regulatory side, the lack of collaboration between the South Carolina Department of Health and Environmental Control (SCDHEC), local municipalities, and intra-governmental departments of those municipalities (e.g., fire, building codes, zoning, and planning) creates initial obstacles when attempting to implement something new and unfamiliar, such as LID practices. The creation of guidelines for the design, permitting, and maintenance of LID practices would assist in the intergovernmental struggles between the state and local municipalities. Attendees also suggested a need for flexibility in federal and state regulations to accommodate regional needs and provide "regulations based on science," rather than their current prescriptive basis. Additional obstacles were identified and included a need for information (e.g., standard models and guidelines) (13%), costs associated with LID (13%), maintenance concerns (12%), regional geographic and hydrologic challenges (7%), and a general resistance to change (5%).

Of all potential stakeholders that can influence the implementation of LID practices, attendees suggested that both consumers (33%) and regulatory agencies (28%) would have the greatest impact. It is necessary for the consumers to have initial buy-in to LID practices, and then regulatory backing of those stormwater features would assist in the selection of LID over more traditional stormwater features and improve the permitting process. With support from consumer and regulatory agencies, developers and engineers would more likely select, design, and implement LID practices within their development.

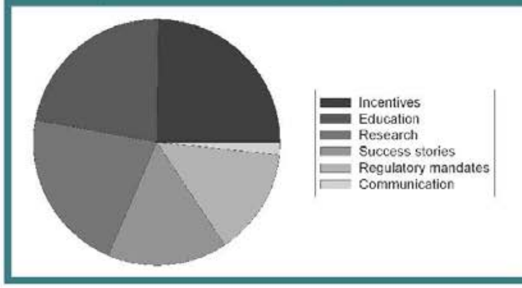
Attendees suggested that the creation of incentives (e.g., bonus density, tax incentive, expedited review, flexibility in enforcement while LIDs are new, and lower impact fees) would offer opportunities to increase the prevalence of LID practices in the region (25%). Specifically, it was suggested that linking LIDs with Leadership in Energy and Environmental Design (LEED) certification

Stakeholders that Have the Biggest Influence on LID Implementation



could serve as a marketing tool for LID practices among developers, engineers, and contractors/suppliers. Since the consumer must initially buy-in to LID practices, it was also suggested that there could be a need for incentives for the consumer such as reduced stormwater utility bills for treating stormwater on site. Due to the lack of knowledge and information regarding the regional use of LID practices, education (22%), research (21%), and success stories (16%) are needed to provide the information and knowledge dissemination necessary to promote the use of LID practices. This information should be disseminated across all stakeholders, including stormwater professionals and the general public through forums such as the Urban Land Institute, American Society of Civil Engineers, American Society of Landscape Architects, American Planning Association, Carolina Clear, and Lowcountry Earth Force. Attendees also felt that regulatory mandates (14%) would assist in the regional implementation of LID practices, but there is a need for regionally relevant information to support such mandates. It was also noted that the internal politics of municipalities can serve as an obstacle to implementing LIDs. Therefore, increased communication between municipal departments would assist in their implementation (2%). Until then, Planned Unit Developments (PUDs) can serve as an amendment to local zoning and a means for implementing LID practices within larger developments.

Options for Increasing LID Use



The Oak Terrace Preserve community in North Charleston, S.C., was zoned and permitted under a PUD ordinance that allowed the developers to employ LID principles in the development and preserve up to 95% of the older, healthy trees on site. Photo/City of North Charleston

Table 1

Summary of the percentage of stormwater retention and pollutant reduction of various stormwater treatment systems.

Stormwater Treatment System	Reference	Stormwater	TSS	Phosphorus	Nitrogen	Metals	Other
Retention Pond				-16% (Total)	-54% (Total)	93% (Total Zn)	83% (Total HMW PAHs)
Single Detention Pond	Messersmith, 2007	7.5% (volume)	19%		-2.5% (Total)	n/a	14% (Fecal Coliform)
Series of Detention Ponds	Messersmith, 2007	-9% (volume)	88%	71% (Total)	39% (Total)	n/a	55% (Fecal Coliform)
Bioretention Swale	UNH Stormwater Center, 2007	82-85% (peak flow)	97-99%	5% (Total)	29-44% (DIN)	99% (Total Zn)	82-85% (Total HMW PAHs)
	Hunt & Lord, 2006 (tested soil media with varying P levels)	n/a	n/a	-240%-68% (Total)	33-68% (Total)	56-99% (Cu and Zn)	>90% (Fecal Coliform)
	EPA, 2000	n/a	n/a	85-89% (Total)	3-27% (Nitrate)	32-54% (Cu) & 22-100% (Zn)	n/a
	Dave, 2007; Davis, 2008	49-58% (peak flow)	47%	76% (Total)	83% (Nitrate)	57% (Cu) & 67% (Zn)	n/a
Porous Pavement	UNH Stormwater Center, 2007	68%	99%	38% (Total)	n/a	96% (Zn)	99% (Total HMW PAHs)
Cumulative use of LIDs	EPA, 2000	n/a	91%	3% (Total)	42% (Total Nitrogen)	81% (Cu) & 75% (Zn)	n/a

University of South Carolina researchers are studying the cumulative impacts of LID practices (e.g., bioretention swales, pervious pavers, pocket parks, pervious walkways) at Oak Terrace Preserve in North Charleston, S.C. Photo/City of North Charleston

The J Banks building on Hilton Head, S.C., uses pervious pavers to assist in achieving LEED Silver certification. The LEED Rating System has recently placed more emphasis on environmental factors which increase credits for LID stormwater strategies. Photo/J Banks

Conclusion

Input at the workshop from stormwater professionals and regulatory officials demonstrated agreement that ponds will continue to be a feature of future stormwater treatment systems. However, the current limitations of ponds should be addressed through homeowner education and regulatory enforcement regarding pond maintenance. In addition, ponds should be coupled with additional BMPs (e.g., created wetlands, LID practices, and grassy swales) to enhance the retention and removal of stormwater and its associated pollutants leaving a site. Overall, attendees agreed that stormwater management cannot be addressed through a "one-size-fits-all" prescriptive approach. Instead there should be more flexibility in state and local regulations to allow for site-scale management of stormwater based on the needs of a particular location (e.g., storm- water quantity or quality control) and the hydrologic conditions of the site (e.g., water table depth, soil storage capacity, soil infiltration rates, and proximity to adjacent water bodies).

Attendees agreed that LID practices could be a reasonable addition to ponds. However, LID practices should not be mandated at this time because there are still too many questions and uncertainties related to their performance, construction, and maintenance. Instead there needs to be more research, success stories, education of stakeholders, and incentives to promote the implementation of LID practices.

Literature Cited

Davis, A.P. 2007. Field Performance of Bioretention: Water Quality. *Environmental Engineering Science*. 24 (8): 1048-1064.

Davis, A.P. 2008. Field Performance of Bioretention: Hydrology Impacts. *Journal of Hydrologic Engineering*. 13 (2): 90-95.

Dietz, M.E. & J.C. Clausen. 2008. Stormwater runoff and export changes with development in a traditional and low impact subdivision. *Journal of Environmental Management* 87: 560-566.

Environmental Protection Agency (EPA). 2000. Low Impact Development (LID): A Literature Review. United States Environmental Protection Agency # EPA-841-B-00-005. Washington, DC: USEPA Office of Water.

Hsieh, C., and A.P. Davis. 2005. Evaluation and Optimization of Bioretention Media for Treatment of Urban Storm Water Runoff. *Journal of Environmental Engineering*. 131 (11): 1521-1531.

Hunt, W. F., and W. G. Lord. 2006. *Urban Waterways: Bioretention Performance, Design, Construction, and Maintenance.* N.C. Cooperative Extension, N.C. State University.

Messersmith, M. May 2007. College of Charleston Masters Thesis: Assessing the Hydrology and Pollutant Removal Efficiencies of Wet Detention Ponds in South Carolina. Committee: D. Sanger, G. DiDonato, D. White, S. Wilde.

Prince George's County DER. 1999. Low Impact Development: An Integrated Design Approach.

Roseen, R. M., T. P. Ballestero, J. J. Houle, P. Avellaneda, R. Wildey, and J. Briggs. 2006. Infiltration and filtration-based stormwater control measures are top performers if appropriately sited – and a threat to groundwater when not. UNH Stormwater Center, presented at StormCon 2006, Denver, CO, July 24-27. www.unh.edu/erg/cstev/Presentations/index.htm.

SCDHEC. 2002. SCDHEC Standards for stormwater management and sediment reduction regulation 72-300 through 72-316. June 28, 2002. SCDHEC, Bureau of Water.

SCDHEC. 2003. South Carolina stormwater management and sediment control handbook for land disturbing activities. SCDHEC, Columbia, S.C.

SCDHEC. 2004. Water pollution control permits: R.61-9: NPDES, state, and land application permits regulation includes changes made in December 26, 2003 state register. SCDHEC, Bureau of Water. Available for download at www.scdhec.gov/environment/water/reg.htm.

SCDHEC. 2006. NPDES general permit for stormwater discharges from large and small construction activities. SCDHEC, Bureau of Water. SCR100000. www.scdhec.gov/water

SCDHEC-OCRM. 2007. State of the Knowledge Report: Stormwater Ponds in the Coastal Zone. SCDHEC-OCRM, Science and Policy Division.

T.C. Siewicki, T. Pullaro, W. Pan, S. McDaniel, R. Glenn, J. Stewart. 2007. Models of total and presumed wildlife sources of fecal coliform bacteria in coastal ponds. *Journal of Environmental Management*. 82: 120-132.

University of New Hampshire Stormwater Center. 2007. Annual Report.

Stormwater Management and Sediment Reduction Act (SMSRA). 1991. S.C. Code of Laws, Title 48, Chapter 14 – Environmental Protection and Conservation. www.scstatehouse.gov/code/t48c014.htm

Pocket Park Maintenace Needs:

Monthly	Once-a-year
• Mow grass • Remove trash and debris	• Clear vegetation around inlets and outlets to prevent clogging

Determine by Inspection:
- Reseed the pocket park to maintain dense turf.
- Remove accumulated sediment within the pocket park.

Well-established and functional pocket park

Well-established and functional forebay

Forebay Maintenace Needs:

Monthly
• Remove trash and debris

Determine by Inspection:
- Apply weed control if plant growth is choking the pond.
- Dredge the deepest portion of the forebay to maintain the permanently pooled area (suggested every 10 years).

References and Additional Resources:
- Best Management Practice (BMP) Maintenance: *www.lakecountyil.gov/Stormwater/Publications/BestManagementPractices.htm*
- LID Maintenance: *www.crwa.org/projects/greenstreets/Maintenance.pdf, www.psparchives.com/publications/our_work/stormwater/lid/D_RevisedMaintenanceofLIDFacilities.pdf*
- Pond Maintenance: *www.scdhec.gov/environment/ocrm/pubs/docs/ponds.pdf*
- Bioretention Maintenance: *www.lid-stormwater.net/bio_maintain.htm, http://www.mapc.org/search/node/bioretention%20maintenance*
- Pervious Paver Maintenance: *www.paversearch.com/permeable-pavers-maintenance.htm, www.lowimpactdevelopment.org/qapp/lid_design/permeable_pavers/permpavers_maintain.htm*
- Halfacre, A.C., D.R. Hitchcock, and J.A. Schuler. 2007. Community Associations and Stormwater Management: *www.urbanestuary.org.*
- Green Solutions to Pollution: Homeowner Practices for Managing Stormwater and Polluted Runoff. *www.dnr.sc.gov/marine/NERR/traininggarden.html*
- Carolina Yards and Neighborhoods. *www.clemson.edu/extension/natural_resources/water/carolina_yards*
- Carolina Clear. *www.clemson.edu/public/carolinaclear*
- Green Homes 101: *www.dnr.sc.gov/marine/NERR/traininggreenhomes.html*
- Clemson's Home and Garden Information Center. *www.clemson.edu/extension/hgic*
- Low Impact Development Center, Inc. *www.lowimpactdevelopment.org*

DNR www.dnr.sc.gov

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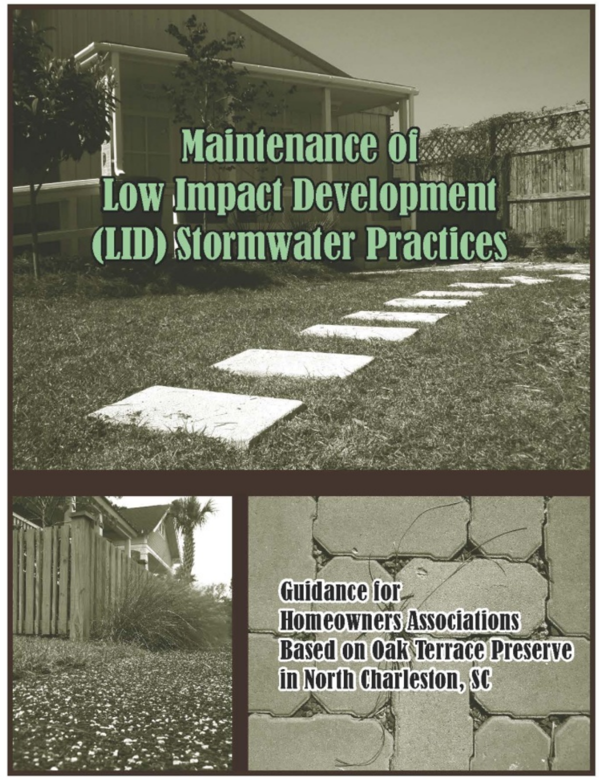

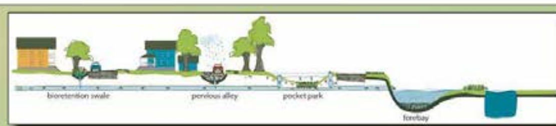

Courtesy of the City of North Charleston

Oak Terrace Preserve LID Stormwater Practices

Oak Terrace Preserve, in North Charleston, S.C., uses a network of Low Impact Development (LID) practices designed to disperse stormwater throughout the development to promote infiltration and groundwater recharge. These LID practices include bioretention swales, pervious alleys and walkways, pocket parks, and a forebay that are interconnected with perforated piping to continually promote infiltration and retention of stormwater on site, while also preventing flooding of adjacent properties.

Maintenance of LID Stormwater Practices

LID practices use natural processes (e.g., detention and infiltration of stormwater) to manage the stormwater runoff from the neighborhood, and as such, their maintenance needs are fairly minimal. However, because they are utilized as a stormwater management facility, and therefore minimize downstream pollution and flooding, routine maintenance is necessary and it is also important to continually inspect these systems to ensure that they are functioning properly. The maintenance needs of the individual LID practices vary and may require the assistance of a trained professional (e.g., landscape firm, street sweeper, and/or consultation with the supplier), which should be determined up-front to assure the appropriate maintenance of these practices. In addition, while a development is under construction, these practices should be inspected every month for maintenance needs (e.g., erosion, siltation, weeding, and watering). Following the completion and stabilization of a site, it will only need to be inspected on an annual basis.

It is important to note that this document is based on the maintenance needs of the LID practices within Oak Terrace Preserve and these guidlines have been developed based on the information provided by the documents listed in the "References and Additional Resources" section.

Bioretention Swale Maintenace Needs:

Monthly	Twice-a-year	Once-a-year
• Mow grass • Remove trash and debris	• Clean curb-cuts: remove debris from the gutter and entrance to swales • Remove and/or prune vegetation • Water plants • Weed	• Clear vegetation within one foot of inlets and outfalls

Determine by Inspection:
- Check retention of stormwater. Ponding is normal and to be expected, but should not exceed 2-3 days.
- Replace soil and/or plant material for erosion control.
- Remove sediment to maintain plant growth and water storage capabilities of the bioretention swale.
- Clean under-drains by jet-cleaning or vacuuming.
- Replace or amend soil to maintain stormwater infiltration and pollutant removal capacity of the bioretention swale. Inspections are required (visual, infiltration tests, soil tests) to check for pollutants and organic material.
- Rebuild or reinforce hard structures (e.g., drop inlets, gutters, outlets).
- Re-grade or re-contour side slopes to maintain designed slope and storage area.

Eroding biorwale

Well-established functioning biorwale

Debris removal from curb-cut needed

Pervious Alley and Walkway Maintenace Needs:

Monthly	Once-a-year
• Remove trash and debris	• Maintain vegetated or mulched buffer along periphery of pervious materials. (During construction, silt-fencing should be used and maintained adjacent to pervious materials.) • Clean permeable materials (may be necessary up to 4 times-per-year); sweep and vacuum pervious pavers and apply top-coat to aggregate material if necessary; jet-spray walkways. ** These maintenance needs are specific to previous pavers and Flexi-pave®. If using a different type of pervious material consult with the manufacturer to determine the products maintenance needs.*

Determine by Inspection:
- Maintain the integrity of the infrastructure: replace broken pervious pavers and top-coat the pervious walkway if aggregate becomes loose.
- Remove plant growth among the pavers or walkways.
- Replace the aggregate in between the pavers to maintain the permeability of the alleys.

Fully-functional pervious pavers

Fully-functional Flexi-pave®

The construction site needs to be stabilized and the pervious pavers swept and vacuumed

Sediment-laden Flexi-pave® indicating a need to jet-spray

Loose aggregate that needs a top-coat applied

Low Impact Development

Distribution of rainwater

Conceptual water budgets for undeveloped and developed sites in the lowcountry. The size of the arrows is indicative of the volume of rainwater entering or leaving a site.

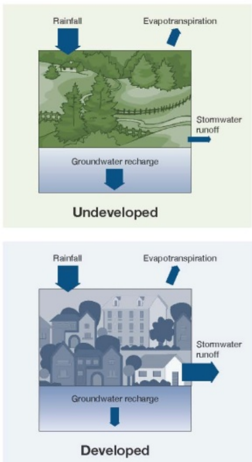

Figure 1

Additional Resources

Polluted Stormwater Brochure
www.scseagrant.org/pdf_files/NPSbrochure.pdf

Halfacre, A.C., D.R. Hitchcock, and J.A. Schuler. 2007. *Community Associations and Stormwater Management: A Coastal South Carolina Perspective*
www.urbanestuary.org

Green Solutions to Pollution: Homeowner Practices for Managing Stormwater and Polluted Runoff
www.dnr.sc.gov/marine/NERR/traininggarden.html

Green Homes 101
www.dnr.sc.gov/marine/NERR/traininggreenhomes.html

Carolina Yards and Neighborhoods
www.clemson.edu/extension/natural_resources/water/carolina_yards

Carolina Clear
www.clemson.edu/public/carolinaclear

Clemson's Home and Garden Information Center
www.clemson.edu/extension/hgic

Low Impact Development Center, Inc.
www.lowimpactdevelopment.org

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SCSGC-G-09-03

Green roof on Bowen's Island photo/Charleston Green Roofs

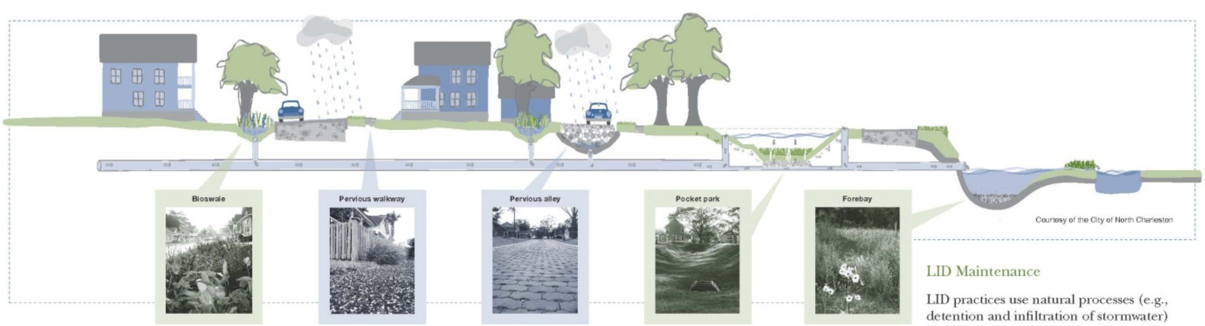
Rain garden at James Island Charter High School photo/USC

Carolina Yard at the Charleston Exchange Park photo/USC

What is low impact development?

Runoff from rainwater, often referred to as stormwater, is a primary contributor to nonpoint source (NPS) pollution of our waterways. Low Impact Development (LID) is a strategy designed to minimize the impact of development on a site by limiting the amount of stormwater and NPS pollution that is transported to our streams, rivers, lakes, and coastal waters. Typically, when it rains an undeveloped site generates less stormwater runoff because significant amounts of water seep into the ground (groundwater recharge) and moisture from soil, trees, shrubs, and grasses evaporates into the air (process of evapotranspiration). Increased development alters the landscape, removing and replacing vegetation with impervious cover, such as roads, driveways, rooftops, and sidewalks. These impervious surfaces inhibit groundwater recharge while increasing the quantity of stormwater runoff (see Figure 1). The LID approach to land development integrates the use of better site design techniques (e.g., cluster development, tree preservation) and stormwater management practices (e.g., bioswales, pervious materials, rainwater harvesting) to maintain the natural distribution of rainwater, and treat stormwater runoff on site.

Stormwater Series Low Impact Development



Oak Terrace Preserve LID Stormwater Management Practices

Oak Terrace Preserve, a community in North Charleston S.C., employs a network of LID practices designed to disperse stormwater throughout the development to promote infiltration and groundwater recharge. These LID practices include bioswales, pervious alleys, pocket parks, and a forebay, and are interconnected with perforated piping to continually promote infiltration and retention of stormwater on site, while also preventing flooding of adjacent properties. In addition, a pervious walkway and on-site rainwater harvesting techniques (e.g., rain barrels) are used throughout the site but they are not connected to the piped network.

Bioswales (often referred to as bioretention swales) receive stormwater runoff from roads and the front of homes. The swales, combined with soils and plants, provide an area for temporary retention of stormwater, promote infiltration, and filtration and uptake of pollutants.

Oak Terrace Preserve is surrounded by a **pervious walkway**, Flexi-pave®, made of recycled tires and aggregate stone, which is filled with voids and installed on top of pervious stones to promote infiltration and retention of stormwater and its associated pollutants.

Pervious alleys, placed behind the homes in Oak Terrace Preserve, are designed with void spaces and underlined with pervious stones to promote infiltration and groundwater recharge.

Depressional areas, or **pocket parks**, are found throughout Oak Terrace Preserve and serve dual purposes, both functional (stormwater detention) and aesthetic (natural areas). These pocket parks are connected to the drainage network, and in the event of heavy rainfall, temporarily detain stormwater.

A terminal pond, or **forebay**, is located at the end of the network of LID practices and offers another opportunity to retain stormwater and its pollutants before flowing into the adjacent forested wetland, and ultimately, a tidal creek (Filbin Creek). This pond is designed with a deeper pooling area to promote settling of sediments and sediment-associated pollutants within the stormwater, as well as a vegetated buffer, to promote pollutant and stormwater uptake through the plants.

LID Maintenance

LID practices use natural processes (e.g., detention and infiltration of stormwater) to manage stormwater runoff from the neighborhood and maintenance needs are fairly minimal. However, the LID practices are stormwater management techniques, used to minimize downstream pollution and flooding, which require routine maintenance and inspections to ensure that they are functioning properly. Generally, LID practices require bi-annual to annual maintenance which is dependent on the type of LID practice used and is based upon routine inspections. A list of specific maintenance guidelines has been developed for the LID stormwater practices of Oak Terrace Preserve and is available online at **www.scseagrant.org/pdf_files/LID maintenance.pdf** or call S.C. Sea Grant Consortium at (843) 953-2078.