



# Technical Procedure Document

**Subject:** Low Impact Development and the Coastal SC LID Design Guide

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## Low Impact Development

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### What is Low Impact Development?

Low Impact Development (LID) is an integrated, comprehensive approach to land development or redevelopment that works with nature to manage stormwater as close to its source as possible (US EPA, 2014). LID practices aim to mimic the natural hydrology of an area through the use of stormwater best management practices (BMPs). These practices aim to recreate the predevelopment site conditions through techniques that promote evaporation, infiltration, localize storage, and runoff treatment. The general idea of LID is to have smaller BMPs throughout a development that can increase the water quality of stormwater and aesthetic appeal of a development while decreasing amount of stormwater runoff.

### Principles of Low Impact Development

LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product (US EPA, 2018). Below are the six principles of LID (MAPC, 2010).

- **Work with the Landscape:** Use existing natural systems as the integrating framework for site planning. Identify environmentally sensitive areas and important local features and outline them in a development envelope to protect those areas.
- **Focus on Prevention:** While runoff may not be preventable, it can be minimized by reducing road widths, using shared driveways, and reduce parking areas. Clearing and regrading can be minimized by clustering and reducing building footprints. To aid in reducing runoff, techniques like green roofs can store and evaporate rainfall before it reaches the existing ground/grade.
- **Micromanage Stormwater:** Creating smaller sub-watersheds on site will aid in micromanaging stormwater runoff through a series of small LID structures and maximize sheet flow to where there will be little to no runoff for low-intensity storms.
- **Keep It Simple:** Emphasize simple. Nonstructural, low-tech, and low-cost methods such as open drainage systems and filter strips, disconnection of roof runoff, rain barrels, street sweeping, public education, and reduce construction disturbance.
- **Practice Multi-tasking:** Design and create a multifunctional landscape with stormwater management practices that provide filtration, treatment, and infiltration. In doing so, additional aesthetic features can be multifunctional such as open space can be used for wildlife habitat and reducing heat island effects.
- **Maintain and Sustain:** Landscaping design should be incorporate native plants that are resistant to extreme conditions (wet and dry) and low maintenance. Vegetation should be selected that reduces the use of pesticides, herbicides, and fertilizers. Stormwater management practices should be easily maintained.



## Benefits

There are a wide variety of stakeholders that can benefit from incorporating LID practices and principles into design of developments and redevelopments (NCCE, 2009; US EPA 2013).

- **Developers** benefit by having reduced costs from land clearing, grading, infrastructure (streets, curbs, gutters, sidewalks), stormwater management, and environmental impact fees. Additionally, potential for increased lot yields and marketability.
- **Municipalities** benefit by protecting the native flora and fauna, balancing growth with environmental protection, reduces municipal infrastructure (streets, curbs, gutters, sidewalks, storm sewers), reduces system-wide operations and maintenance costs, reduces costs of combines sewer overflows, reduces runoff and flooding, and fosters public/private partnerships.
- **Home Buyers and Residents** benefit by preserving and protecting amenities that can translate into increased property value, lower energy costs for cooling due to increased shade from trees, reduced flooding, saves money through water conservation.
- The **Environment** can benefit through the preservation of ecological and biological systems, reduced demand on the water supply since natural groundwater recharge is encouraged, protects site and regional water quality by reducing sediment, nutrient, and toxic loads to water bodies, reduces impact on local terrestrial and aquatic plants and animals, preserves trees and natural vegetation, improves air quality through the addition of vegetation, reduces urban heat stress, and reduces sewer overflows
- **Social** benefits include enhanced aesthetics, stimulated economic development, creates green jobs, encourages more urban greenways, educates the public on their role in stormwater management, and reduces flooding.

## Environmental Benefits

Various studies have shown the benefits of different types of LID practices. Some of these LID practices reduce runoff, while others reduce pollutants (Ahiablame et al., 2012). Compared to traditional methods, LID reduces runoff depth and peak discharges, and produces a longer lag time to peak discharge. Proper LID practices incorporated into design can produce little to no discharge for small rainfall events (Selbig and Bannerman, 2008). LID practices better mimic pre-development hydrology and natural systems to help reduce stormwater pollution (Hood et al., 2007).

The types of services that LID provides includes:

- **Provisioning Services:** food, water, timber, fiber
- **Regulating Services:** climate, floods, disease, wastes, water quality
- **Cultural Services:** recreational, aesthetic, spiritual
- **Supporting Services:** soil formation, photosynthesis, nutrient cycling

LID provides a host of “ecosystem services” that are not typically incorporated in cost-benefit analyses of projects. LID contributes to ecosystems services by reducing flooding, improving water quality, reducing ambient air temperatures, and improving air quality (ECONorthwest, 2007). LID also promotes infiltration with the benefit of sustaining stream baseflow and can reduce the number of combined sewer overflows incidences. Current development practices can short circuit hydrological processes, and thus produce faster and larger volumes of stormwater runoff, which in turn leads to flashy stream flow conditions (Callahan et al., 2011) and potentially increased flooding. Other benefits not typically considered is the restoration of habitats and vegetation that are important to wildlife.



**Table 1. Stormwater Management Practice Performance**

BMP	Pollutant Removal <sup>1</sup> (%)				
	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Metals	Pathogens
Bioretention	80-90	55-90	65-90	N/A	55-90
Permeable Pavement	80	60-80	60-80	N/A	45-75
Infiltration	80-95	65-95	55-90	N/A	65-95
Green Roofs	80	45-60	45-60	N/A	45-60
Rain Water Harvesting	Varies				
Disconnection	80	25-50	25-50	25-50	N/A
Open Channels	40	40-45 <sup>2</sup>	20-35 <sup>3</sup>	30	N/A <sup>4</sup>
Stormwater Filtering Systems	90	65	45	50	80
Dry Detention <sup>5</sup>	N/A	N/A	N/A	N/A	N/A
Wet Ponds	85	75	40	40	70
Wetlands	80	50	30	50	70

<sup>1</sup>expected annual pollutant removal

<sup>2</sup>range, with best removal for the wet or dry swales

<sup>3</sup>range, with best removal for grassed channels

<sup>4</sup>no data available, but expected poor pollutant removal

<sup>5</sup>available data suggest minimal pollutant removal

Source: Ellis et al., 2014

## Economic Benefits

The United States Environmental Protection Agency (EPA) found that developers, property owners, and communities save money and protect and restore water quality when well-chosen LID practices are implemented (US EPA, 2007). In 2007, the EPA reviewed 17 case studies of developments that included LID practices and concluded that applying LID techniques could reduce project cost and improve environmental performance. In most cases, LID practices were shown to be both fiscally and environmentally beneficial to communities. In the vast majority of cases, significant savings were realized due to the reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping. Savings ranged from 15-80% when LID methods were used in a holistic approach to the design and planning process. Little to no savings were realized when LID methods were used sparingly within designs that had mostly conventional stormwater management practices. In these few cases, the cost of LID practices was higher than those for conventional stormwater practices (Ellis et al, 2014).

The table below is a BMP cost summary of both conventional and LID stormwater practices. The information presented in the table was determined from various design manuals (Greenville County Storm Water Management Design Manual (2013), North Carolina Department of Environment and Natural Resources Stormwater Best Management Practices Manual (2007), and the Maryland Department of the Environment Stormwater Design Manual (2000). Although these are standardized cost estimates, each BMP is tailored to the local site characteristics, such as type of soil, watershed size, and pollutant of concern (Wossink and Hunt, 2003). An example of this is the increased cost to construct a bioretention cell in clay soils compared to sandy soils, although a bioretention cell in clay soil may still produce better results for pollutant removal, runoff volume control, and peak flow attenuation than a wet or dry pond.



**Table 2. BMP Cost Summary**

<b>BMP</b>	<b>Standard Size</b>	<b>Standardized Cost</b>
Dry Pond	¼ Acre	\$12,629
Wet Pond	¼ Acre	\$16,271
Bioretention Cell	500 ft <sup>2</sup>	\$3,122
Bioswale	100 ft <sup>2</sup>	\$280
Buffer Strip	100 ft <sup>2</sup>	\$7
Constructed Wetland	1,000 ft <sup>2</sup>	\$8,016
Green Roof	100 ft <sup>2</sup>	\$1,732
Infiltration Trench	100 ft <sup>2</sup>	\$555
Porous Pavement	100 ft <sup>2</sup>	\$810
Interlocking Pervious Pavers	1,000 ft <sup>2</sup>	\$19,000
Rain Barrel (average)	55 gallons	\$193
Sand Filter	100 ft <sup>2</sup>	\$3,490

*Source: Greenville County Stormwater BMP Report*

Initial costs for adopting and designing LID practices may be higher, there is evidence that LID practices are cost effective in the long term. Developers tend to see higher profits with subdivisions that have a design based with conservation efforts. These subdivisions tend to be less expensive to build, sell more quickly, and the lots tend to have and retain higher property values than lots in a traditional conventional subdivision.

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## **Low Impact Development in Coastal South Carolina: A Planning and Design Guide**

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### **What is Included?**

The Low Impact Development in Coastal South Carolina: A Planning and Design Guide (LID Design Guide) includes a variety of information that ranges from an overview of LID to planning and regulatory strategies to principles and site design to individual stormwater best management practices to case studies of areas using LID practices.

### **Regulatory Strategies**

The regulatory strategy to maintain the integrity of waterbodies is the National Pollutant Discharge Elimination System (NPDES) permitting program that is enforced by the EPA. South Carolina is authorized by the EPA to implement NPDES programs and is managed by the Department of Health and Environmental Control (SCDHEC). If a local program meets or exceeds the Federal and State, the State may delegate authority to the local stormwater water management programs. The City of Charleston (City) Department of Stormwater Management has received this authority from SCDHEC to discharge from the municipal separate storm sewer system (MS4) within city limits. Projects in an MS4 must design, construct, and maintain stormwater management practices that control rainfall on-site, and prevent the discharge of 1" of runoff from the site's disturbed area (Construction General Permit Section 72-307 C).



Conventional design included hard-infrastructure, end-of-pipe, and site-focused practices that are dictated by the peak flow rate and suspended solids concentration control. Only consideration of design at the site-level without looking at the watershed or regional scale has been known to put more waterbodies on the impaired lists over time (US EPA, 2013). The increase in waterbodies can have negative economic impacts at local and state levels, which is why a comprehensive approach needs to be taken toward design (e.g., modeling stormwater impacts to where the project site is 10% of the total watershed as stated in Section 3.9.4 of the 2020 City of Charleston Stormwater Design Standards Manual (SWDSM)). The comprehensive approach to stormwater design should include an examination of a locality's land development regulations, policies, and ordinances to coincide with water quantity and quality goals.

## Neighborhood Planning Considerations

When planning neighborhoods, strategies for improved stormwater management is to use innovative community and subdivision designs, such as compact development. Compact development generates less stormwater per unit development and provide opportunities to localize hydrologic impacts. The City currently has an existing Cluster Development Zoning to permit unique residential developments that:

- Utilize creative and flexible site design compatible with surrounding development patterns;
- Accommodate and preserve features of historical, cultural, archeological, and/or environmental significance;
- Provide common open space of high quality with multiple access points;
- Decrease stormwater runoff and nonpoint source pollution by reducing the amount of impervious surface in the development and incorporating LID;
- Reduce infrastructure costs by integrating predevelopment site hydrology into the stormwater management design for the development; and
- Maintain unobstructed scenic views or vistas, especially from street rights-of-way.

In an effort to progress the existing ordinance, the City is currently working through the final revisions to a Conservation Development Ordinance that will replace the existing Cluster Development ordinance. This ordinance utilizes the same LID site design principles and expands upon the previous Zoning Ordinance.

Additionally, any new development and redevelopment project can incorporate more LID approaches to control stormwater and improve the aesthetic appeal. For example, the City has recently permitted mixed use site plans that incorporate LID principles within the urban setting as well as residential subdivisions. For example, the Sea Aire Cluster Subdivision off Pearl Channel Loop on James Island utilizes bioswales for individual lot drainage and a bioretention area in the open space/common area of the subdivision that can be used for recreation during dry weather. Design guidance for roadways, sidewalks, driveways, parking surfaces, and landscaping can be found in the LID Design Guide.

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## Implementation of Planning and Design Guide

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### Integration into Existing Developments

LID can be incorporated into existing developments through retrofitting and redevelopment. Developments that have no or outdated stormwater controls are opportunities to incorporate LID



practices. As more impervious areas increase due to development, retrofitting existing watersheds with LID practices may be used address existing stormwater management problems. The Retrofit Reconnaissance Investigation manual (Schueler et al., 2007) is a nationally recognized and commonly used resources to assess stormwater retrofit potential in an area. The step by step process should be tailored to meet conditions in the City. Redevelopment has the opportunity to address areas where stormwater management problems occur by upgrading deteriorating and aging infrastructure and integrating LID techniques to reduce runoff and non-point source pollution.

In an effort to achieve greater reductions in runoff and non-point source pollution, the City has incorporated incentives into the design process. New development and redevelopment incorporating specific design practices, such as green roofs, will be able to use the compliance to reduce the post-development curve number, thereby reducing the post-development runoff volume and peak flow rates. The City has also incorporated a tiered approach in regards water quality control. Depending on the approach chosen, the developer/designer must capture a minimum rainfall depth for water quality control. Since LID and green infrastructure design techniques promote infiltration, those design elements will be sized to a lower rainfall depth and volume. For BMPs that solely promote a store and release approach, such as ponds, those practices will be sized to contain a higher rainfall depth and volume.

**Table 3. Tiered approach rainfall depths based on a 24-hour duration storm event**

Tier	Rainfall Depth (inches)
I – Green Infrastructure	1.0
I – Green Infrastructure with 1,000 feet of shellfish beds	1.5
II – Green Infrastructure with an Underdrain	2.0
III – Detention Practices	2.8
IV – Pass Through Devices	Peak flow from 2.8

Source: City of Charleston, 2020

## Stormwater Best Management Practices

There are eleven types of BMPs listed in the LID Design Guide that are also listed in SWDSM Section 3.12: (1) bioretention, (2) permeable pavement systems, (3) stormwater infiltration, (4) green roofs, (5) rainwater harvesting, (6) impervious surface disconnection, (7) open channel systems, (8) stormwater filtering systems, (9) dry detention practices, (10) wet detention practices, and (11) stormwater wetlands. Every BMP listed in the LID Design Guide has the capability to meet State and local water quality standards. The site conditions, costs, and pollutant removal goals may dictate which BMP to use over another. The LID Design Guide includes ten (10) sections for each of the BMPs so that a designer/developer can make appropriate choices and effective designs.

These sections are:

1. Introduction of the BMP
2. Key Considerations for the BMP
3. Feasibility Criteria
4. Conveyance Criteria
5. Pretreatment Criteria
6. Design Criteria
7. Landscaping Criteria



8. Construction Sequence
9. Maintenance Criteria
10. References and Additional Resources

## Compliance Calculator

A compliance calculator was created by the Center for Watershed Protection to allow a design to quickly analyze multiple LID options. With the different design requirements, equations, and standards for each LID BMP, the tool also allows the designer to check each option against state water quality requirements. The compliance calculator is not a model and should not replace fully designing a BMP, but it is a tool that can help find the best set of LID BMP options for a development. Detailed instructions on how to use the compliance tool can be found in Appendix A of the Low Impact Development in Coastal South Carolina: A Planning and Design Guide (Ellis et al, 2014). Information to better utilize the compliance tool for each BMP can be found in their respective section in Chapter 4 of the Low Impact Development in Coastal South Carolina: A Planning and Design Guide (Ellis et al, 2014). The compliance calculator can be found online at:

<http://www.northinlet.sc.edu/compliance-calculator-for-sms4-and-statewide-regulations-april-2014/>

There are differences in methodologies between the Compliance Calculator and the requirements in the SWDSM. The Compliance Calculator uses runoff volume to determine an appropriate water quality volume while the SWDSM uses a tiered approach (**Section 3.9.2**) depending on what category BMPs is being use on the project site. The Compliance Calculator can quickly give a general idea of the amount of volume and how much your site would be credited for specific BMPs to achieve the water quality volume detention to estimate in the conceptual design process, but it up to the designer to calculate the water quality volume through the tiered approached in the SWDSM for final designs and calculation submitted during the Permitting Process.

There are instances where the default or constant values in the Compliance Calculator will need to be verified to adhere to the 2020 SWDSM. In the Site data worksheet, the curve numbers need to be verified and updated, if appropriate. In the Flooding and Channel Protection worksheet, the Storm Event rainfall depths will need to be updated to the rainfall depths stated in the **SWDSM Section 3.4.2** to include a 10% factor of safety.

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