The Implementation of Low Impact Development (LID) Practices along the South Carolina Coast

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Hydrology of a Forested Watershed

WATER BUDGET

Rainfall ➔ Evapotranspiration (PET) ➔ Runoff ➔ Subsurface flow ➔ Groundwater recharge

HYDROGRAPH

Runoff (m$^3$ s$^{-1}$ km$^{-2}$) vs. Time (hrs)

*Rainfall = 4.5 in/24hr*
Hydrology of a Developed Watershed

WATER BUDGET

- Rainfall
- Evapotranspiration (PET)
- Runoff
- Subsurface flow
- Groundwater recharge

HYDROGRAPH

*Rainfall = 4.5 in/24hr*
Stormwater Regulations

Suggest use of stormwater Best Management Practices (BMPs)
Low Impact Development (LID) Practices

- LID is a stormwater management approach that integrates the use of a network of Best Management Practices (BMPs) to disperse stormwater throughout the site.
- Designed to promote infiltration, recharge groundwater sources, and mimic pre-development hydrologic conditions.
Oak Terrace Preserve

- Infill development
- Zoned under PUD
  - Cluster development
  - Tree preservation
  - Flexibility in setbacks
- Stormwater managed through network of LID practices
Bioretention swale
Pervious alley
Pocket Park
Forebay
Oak Terrace Preserve: A Case Study

- LID implementation obstacles and options
- Information gaps:
  - LID comparative performance and efficiency
  - Cost comparison
  - LID design and installation guidelines
  - Homeowner perceptions and educational needs
Implementation Obstacles and Options

Assisted by Debra Hernandez, P.E.

1. Map the process for implementing stormwater management strategies along the South Carolina coast (design, permitting, construction, and maintenance).

2. Interview regional professionals (19) and vet results to larger audience (51) in needs-assessment workshop.

3. Summarize and analyze by qualitative content analysis (coded by themes & summative quotes)
Obstacles to utilizing LID

“Regulations make innovation impossible”

- Educational need: 27%
- Regulatory constraints: 22%
- Lack of information
- Cost
- Maintenance
- Geographic/hydrologic challenges
- Resistance to change
It’s a learning process!
Stakeholders that have the biggest influence

“There are so many regulations and approvals needed that the development strategy becomes how to get through the regulatory process”

- Consumer: 33%
- Regulatory agencies: 28%
- Developer: 18%
- Engineer: 13%
- Researchers: 10%
- Contractors & Manufacturers: 6%
- Environment: 6%
When discussing the appeal of the green features of Oak Terrace, a homeowner said “…that is why I spent a lot more money on this house than I expected or wanted to.”
Knowledge Level of Oak Terrace Preserve Homeowners

- Created wetlands
- Bioretention swales
- Green roofs
- Rain barrels
- Rain gardens
- Pervious materials

Low            Medium          High
“When developing the mindset is: 1) easier is better and 2) what incentives are there to develop one way versus another”
Paired Catchment Study
Method: Data collection

RAIN EVENT: ≥ 13 MM WITH < 0.3 MM PREVIOUS 72 HOURS

- Rain volume & intensity
  - Rain gage

- Runoff volume
  - Flow gages
  - SCS Curve Number Method (NRCS, 2001)

- Runoff Samples
  - 12 bottle autosampler
Methods: Sample Processing

• TDN and TDP
  – USC Baruch Institute

• Fecal Coliform
  – CCEHBR Microbiology Lab, mFC method

• Atrazine and 2,4-D
  – CCEHBR Ecotoxicology Lab, RaPID Assay Kits

• TSS
  – SCDNR MRRI
## Methods: Data analyses

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Response Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment (treatment, reference)</td>
<td>Runoff Volume (m&lt;sup&gt;3&lt;/sup&gt;m&lt;sup&gt;-2&lt;/sup&gt;)</td>
</tr>
<tr>
<td>Date</td>
<td>First flush concentration (mass per unit volume)</td>
</tr>
<tr>
<td></td>
<td>Average event concentrations (mass per unit volume)</td>
</tr>
<tr>
<td></td>
<td>Yield (mass per area)</td>
</tr>
</tbody>
</table>

**Statistics:** (1) Two-way ANOVA and (2) Wilcoxon ranked-sum test
Runoff Volume

NO DIFFERENCE IN VOLUME BETWEEN CATCHMENTS
Suspended Sediment Concentrations

<table>
<thead>
<tr>
<th>TSS (g L⁻¹)</th>
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</thead>
<tbody>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.2</td>
</tr>
<tr>
<td>0.25</td>
</tr>
<tr>
<td>0.3</td>
</tr>
</tbody>
</table>

**First flush**

**Subsequent flush**

- Treatment (OTP)
- Reference (WCT)

*
Fecal Coliform Concentrations

**Figure Description:**

- **Y-axis:** FC [CFU (100mL)^{-1}]
- **X-axis:** Treatment (OTP) vs. Reference (WCT)
- **Legend:**
  - First flush
  - Subsequent flush

**Observations:**

- The graph compares Fecal Coliform Concentrations between Treatment (OTP) and Reference (WCT) for First flush and Subsequent flush.
- The Treatment (OTP) shows lower concentrations compared to the Reference (WCT) for both flushes.
- A significant difference is observed in the Reference (WCT) with the Subsequent flush showing a notable increase in concentration, marked by an asterisk (*) indicating statistical significance.

**Note:** The graph visually represents the data with error bars for each category.
## Pollutant Yields

<table>
<thead>
<tr>
<th>Catchment</th>
<th>2009 Date</th>
<th>Runoff volume (m³m⁻²)</th>
<th>TDN (kg m⁻²)</th>
<th>TDP (kg m⁻²)</th>
<th>FC (CFU m⁻²)</th>
<th>TSS (kg m⁻²)</th>
<th>Atrazine (kg m⁻²)</th>
<th>2,4-D (kg m⁻²)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (OTP)</td>
<td>4/14</td>
<td>1.7×10⁻⁴</td>
<td>2.1×10⁻⁹</td>
<td>4.2×10⁻¹⁰</td>
<td>1.9×10⁴</td>
<td>1.4×10⁻⁵</td>
<td>1.7×10⁻¹⁰</td>
<td>4.8×10⁻⁹</td>
<td>0.31</td>
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<tr>
<td></td>
<td>6/5</td>
<td>9.3×10⁻⁵</td>
<td>1.0×10⁻⁹</td>
<td>8.6×10⁻¹¹</td>
<td>2.3×10⁴</td>
<td>7.1×10⁻⁶</td>
<td>5.6×10⁻¹²</td>
<td>4.6×10⁻¹¹</td>
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<tr>
<td></td>
<td>8/13</td>
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<td>3.3×10⁻¹⁰</td>
<td>2.6×10⁴</td>
<td>4.1×10⁻⁵</td>
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<td>0</td>
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<tr>
<td></td>
<td>10/14</td>
<td>8.9×10⁻⁴</td>
<td>5.3×10⁻⁷</td>
<td>9.8×10⁻⁸</td>
<td>1.7×10⁵</td>
<td>6.8×10⁻⁵</td>
<td>4.2×10⁻¹¹</td>
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<td>12/2</td>
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<tr>
<td>Reference (WCT)</td>
<td>4/14</td>
<td>3.8×10⁻⁵</td>
<td>5.5×10⁻¹⁰</td>
<td>3.5×10⁻¹⁰</td>
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<td>10/14</td>
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<td>0.44</td>
<td>0.06</td>
<td>0.37*</td>
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</table>
So what does the science say?

Regulatory apprehension of LID implementation

- Dampening of first flush concentrations of TSS and FC
- But...underdrains conveyed similar volume of stormwater
- Resulting in similar pollutant yields
- It’s the volume of stormwater that matters!
Comprehensive Stormwater Management Strategies

NO ONE SIZE FITS ALL STORMWATER STRATEGY

• Reduce stormwater volume at the source
  – Reduce impervious cover
  – Rainwater harvesting

• Reduce stormwater velocity
  – Temporary stormwater retention and peak flow reduction

• Improve stormwater quality
  – Education to reduce pollutant loads at the source
  – Pollutant filtration, sorption, settling, transformation, decay, uptake
Regional needs and opportunities

- **Regional Information Gaps**
  - LID performance and efficiency (including long-term study, development of models and standards, identifying long-term maintenance needs)
  - Guidelines for LID design, permitting, and construction phasing
  - Guidelines for LID maintenance and enforcement

- **Regional needs**
  - Education of regulatory staff, municipal officials, contractors, engineers, developers, and consumers/homeowners
  - Regulatory backing of LID in the form of incentives and/or flexibility to address stormwater at the site scale
LID manual for SC coast

- **LID design and installation guidelines**
  - Reduce the volume of stormwater
  - Water table depth and underdrains

- **LID regulatory and permitting guidance**
  - Standards and models
  - Model stormwater ordinances

- **LID maintenance and homeowner education**
  - Reduce pollutant input at the source
Assessment of Stormwater Management in Coastal South Carolina: A Focus on Stormwater Ponds and Low Impact Development (LID) Practices

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,
- designers,
- 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, 2008. The workshop identified informational, regulatory, and educational needs of stormwater professionals regarding both traditional and alternative stormwater management technologies. Following 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.

South Carolina Stormwater Management

South Carolina 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 1/4 inch of runoff on sites or 1 inch of runoff from the built-up area (whichever is greater) to maintain pre-development discharge rates and remove 80 percent of suspended solids during construction (SMI/EC, 1994; SCDEQ, 2000, 2001, 2005, 2009). The selection and implementation of BMPs in the South Carolina coastal zone must take into consideration regional characteristics such as 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 modified as a mechanism to treat stormwater and protect adjacent water quality (SCDEQ, 2004). Stormwater ponds can be categorized into two general types:
1. detention ponds with a permanent pool of water that gradually discharges into adjacent water bodies through an overflow structure or
2. retention ponds with a permanent pool of water...
OTP Homeowner Education and Maintenance Program

Maintenance of Low Impact Development (LID) Stormwater Practices

Guidance for Homeowners Associations Based on Oak Terrace Preserve
Acknowledgements

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