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

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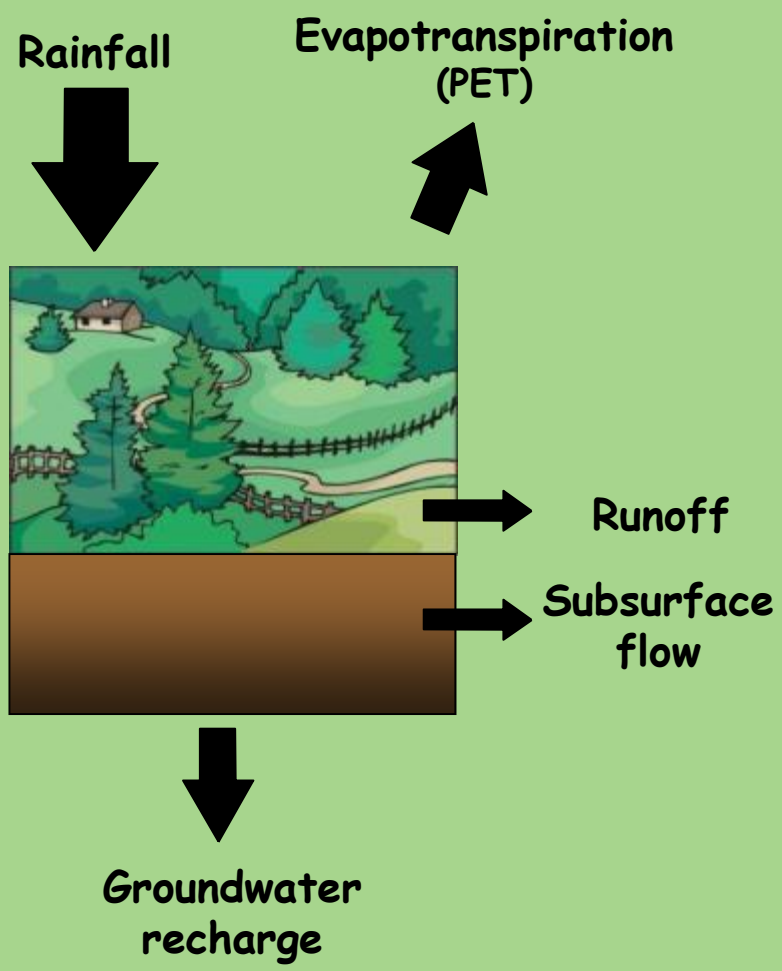
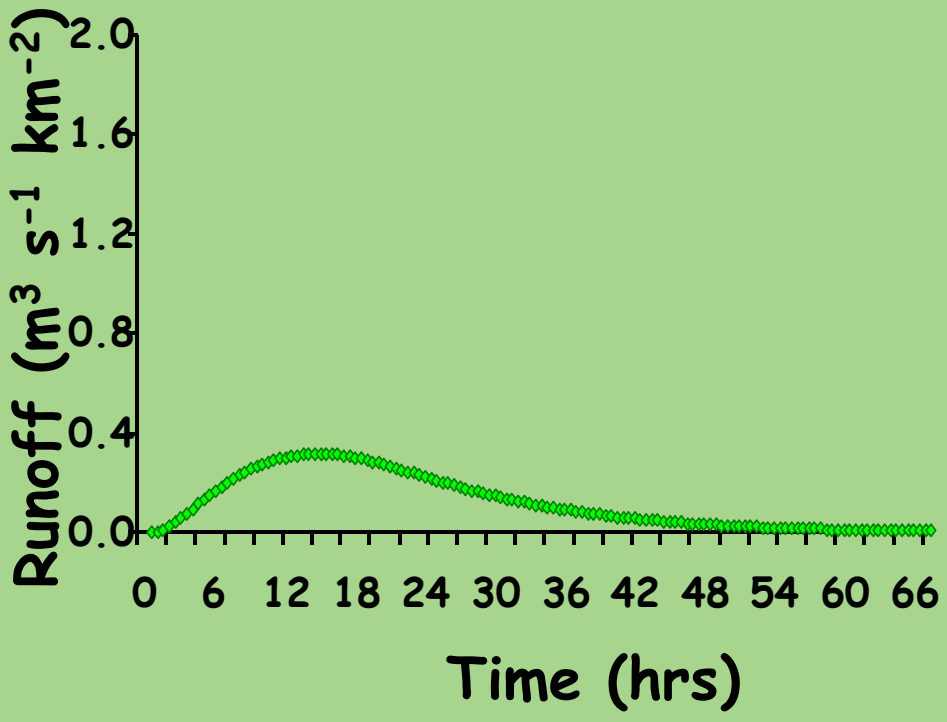
Hydrology of a Forested Watershed

WATER BUDGET



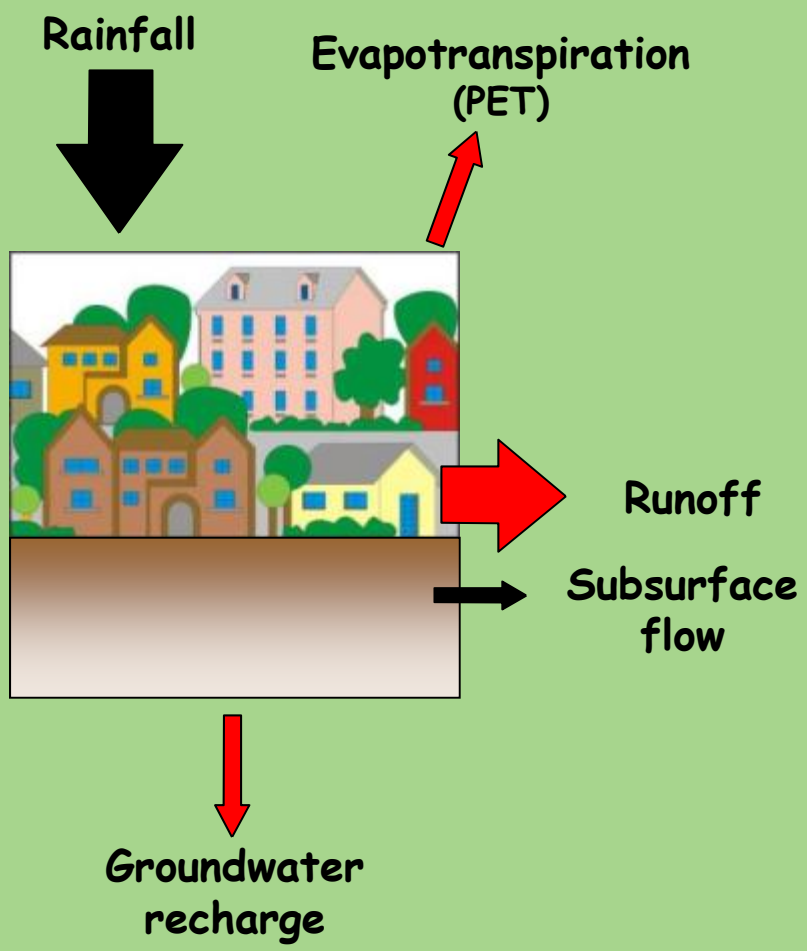
HYDROGRAPH



**Rainfall = 4.5 in/24hr*

Hydrology of a Developed Watershed

WATER BUDGET



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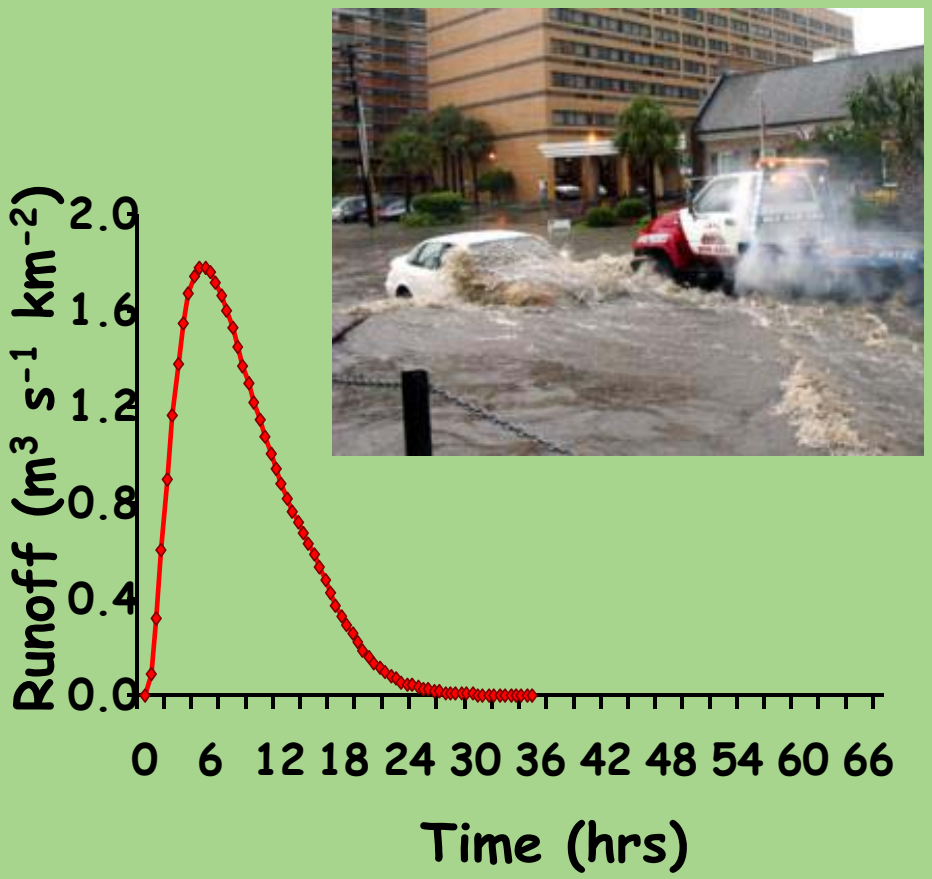
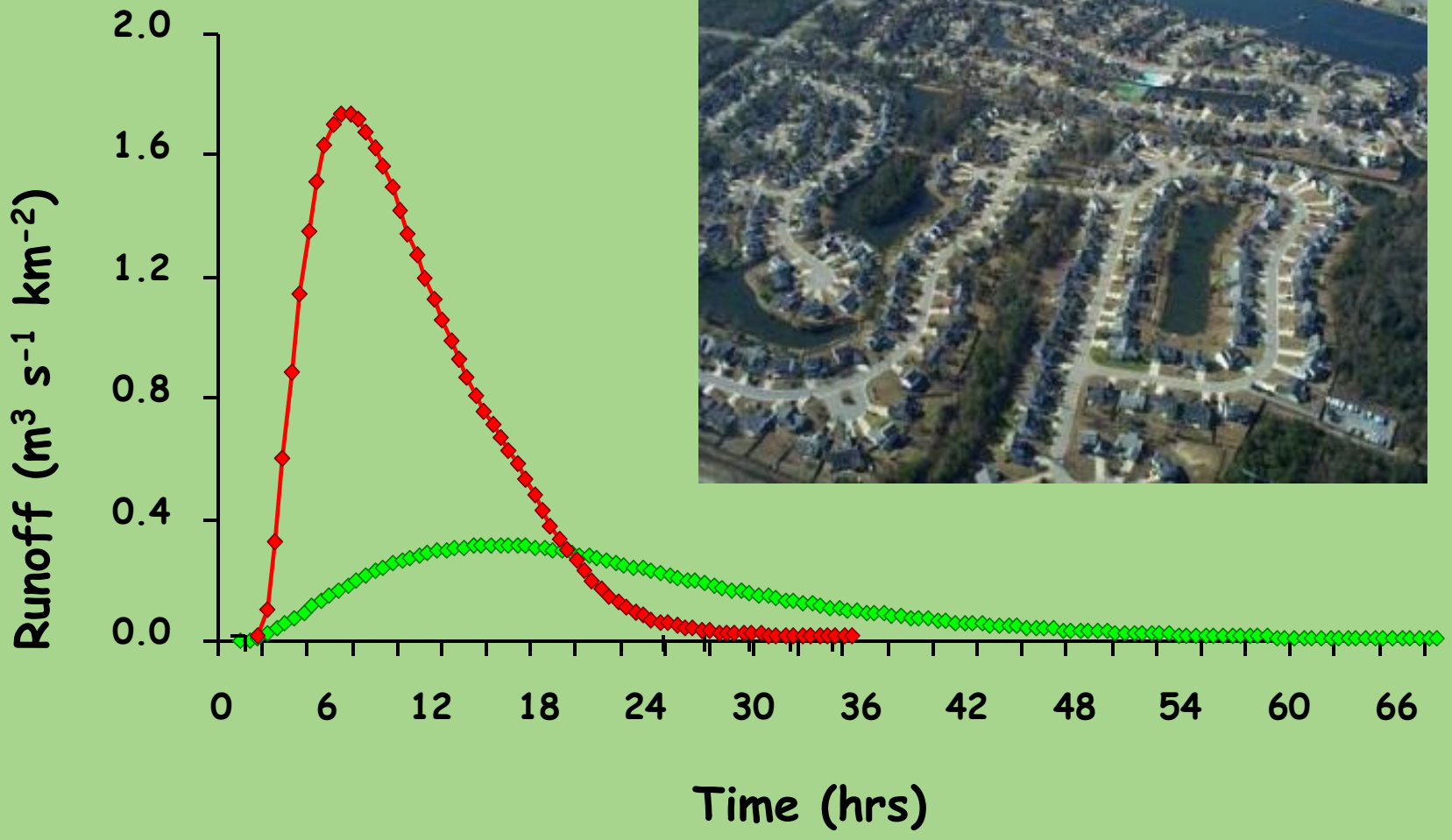


**Rainfall = 4.5 in/24hr*

Stormwater Regulations

Suggest use of stormwater Best Management Practices (BMPs)



Low Impact Development (LID) Practices

Green roof,
Bowens Island

Constructed wetland,
SCDOT Rivers Avenue

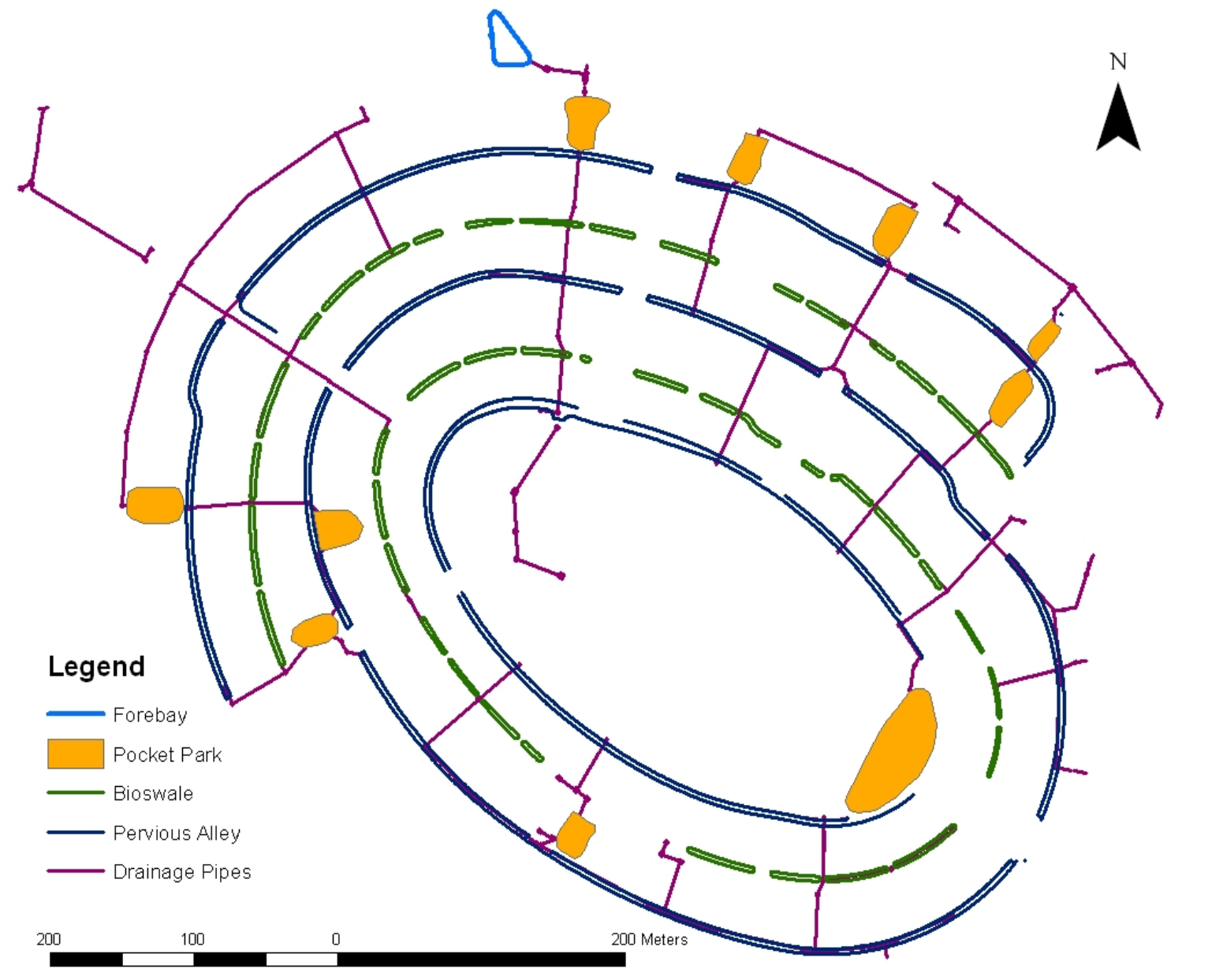
Carolina Yard,
Ladson Exchange Park

- 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

Oak Terrace Preserve



Bioretention swale

Pervious alley

Pocket Park

Forebay

Oak Terrace Preserve: A Case Study

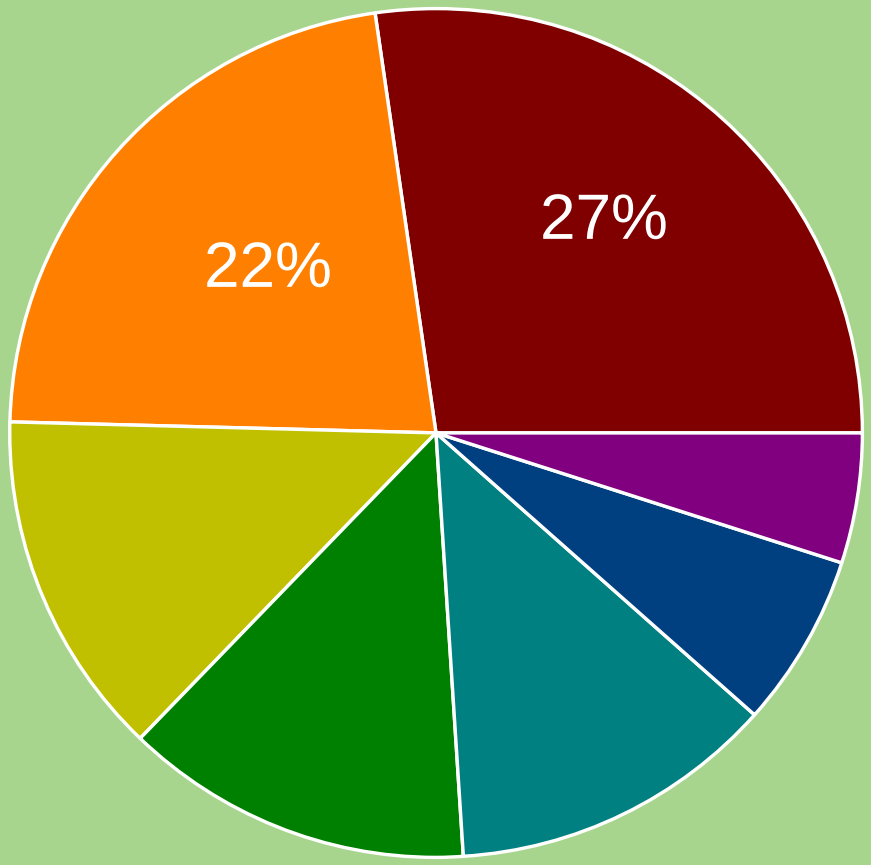
- **LID implementation obstacles and options**
- Information gaps:
  - **LID comparative performance and efficiency**
  - Cost comparison
  - LID design and installation guidelines
  - Homeowner perceptions and educational needs

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



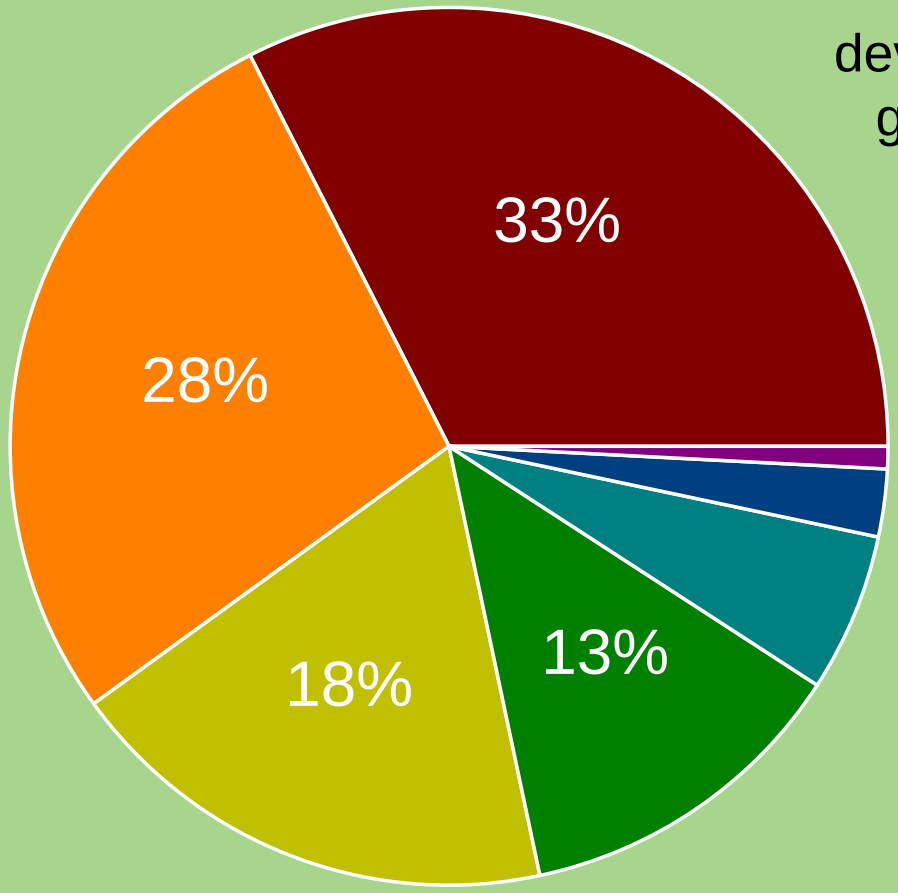
"Regulations make innovation impossible"

- Educational need
- Regulatory constraints
- Lack of information
- Cost
- Maintenance
- Geographic/hydrologic challenges
- Resistance to change

It’s a learning process!

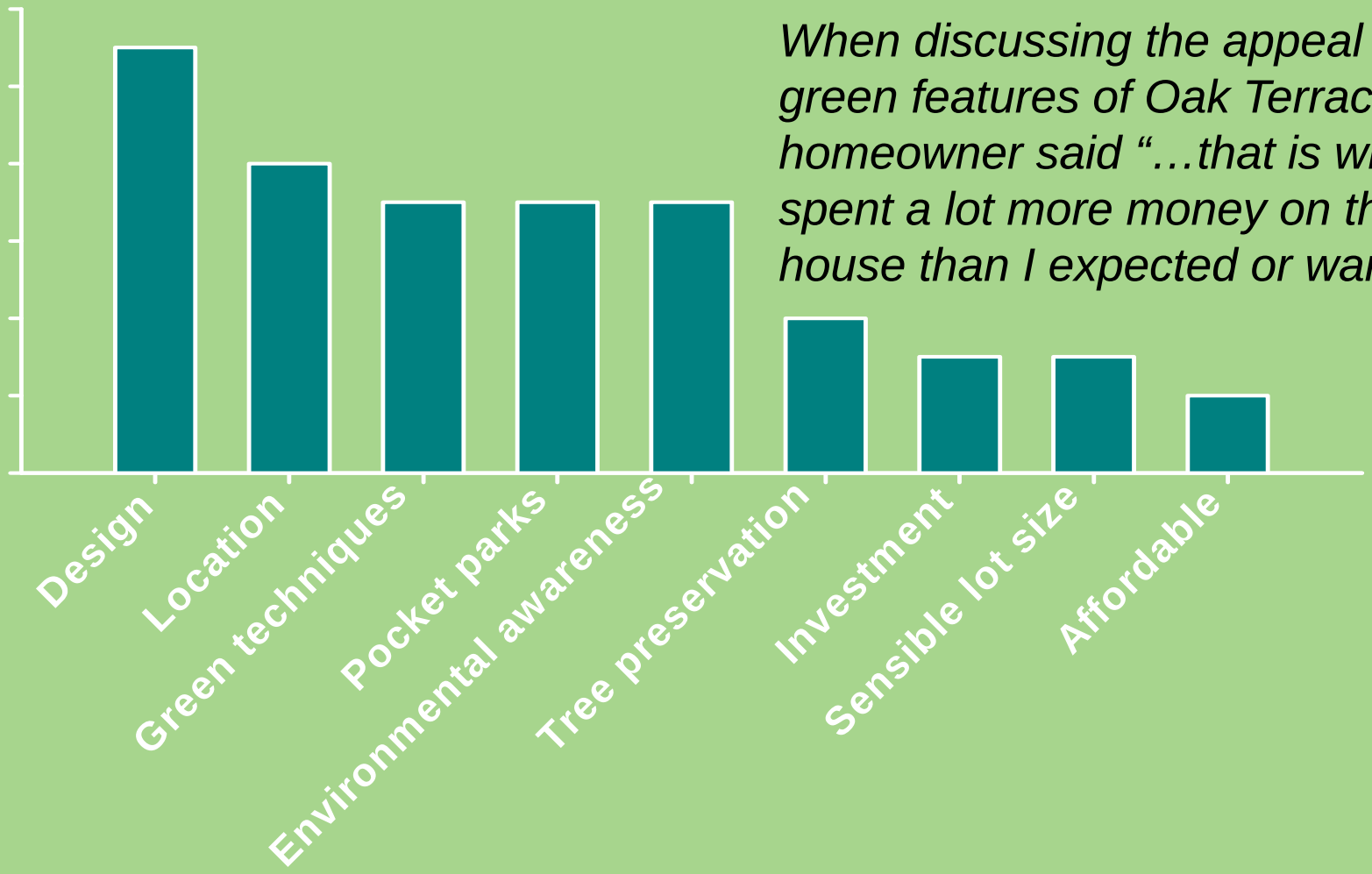
Stakeholders that have the biggest influence

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



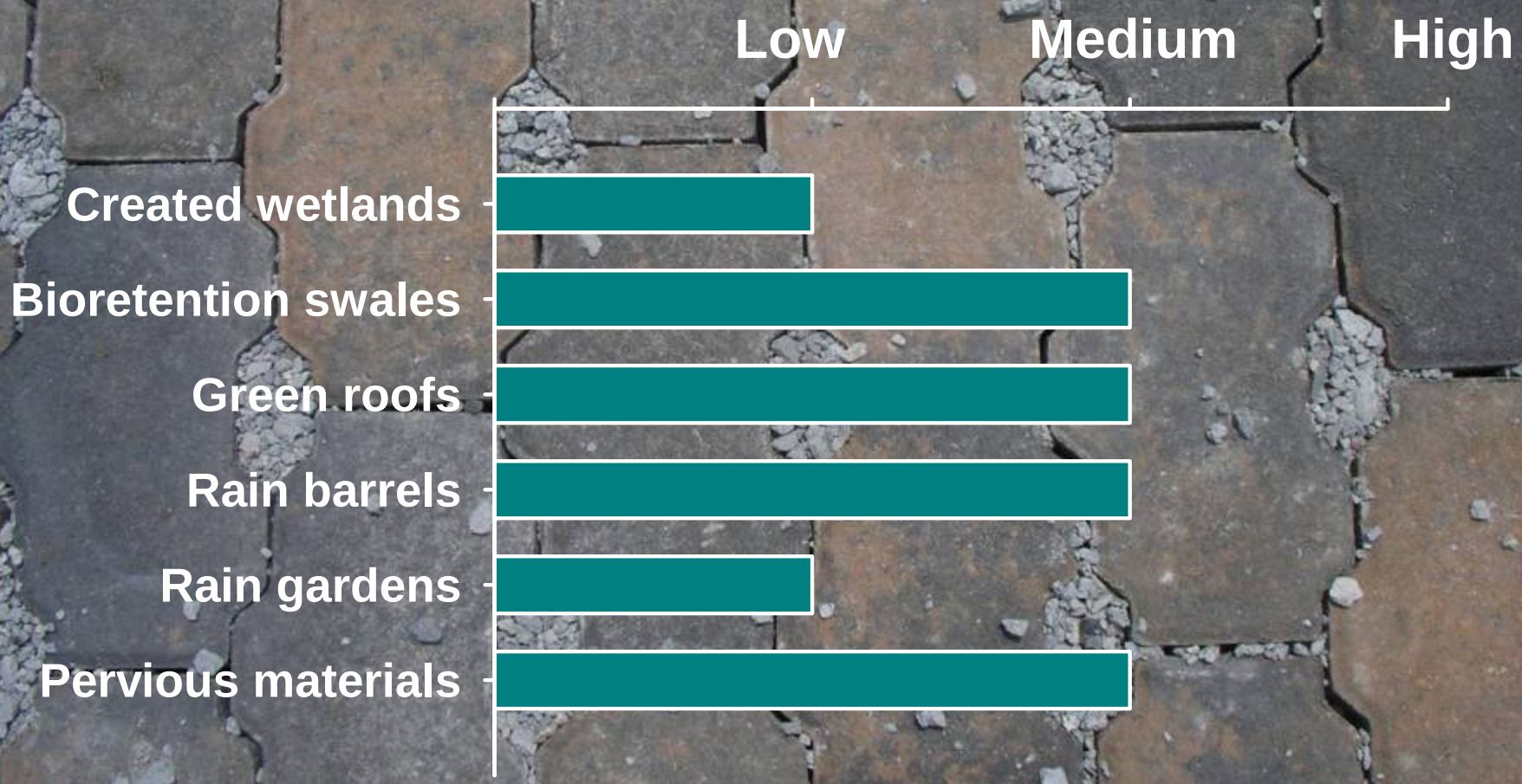
- Consumer
- Regulatory agencies
- Developer
- Engineer
- Researchers
- Contractors & Manufacturers
- Environment

Attributes used to describe Oak Terrace Preserve

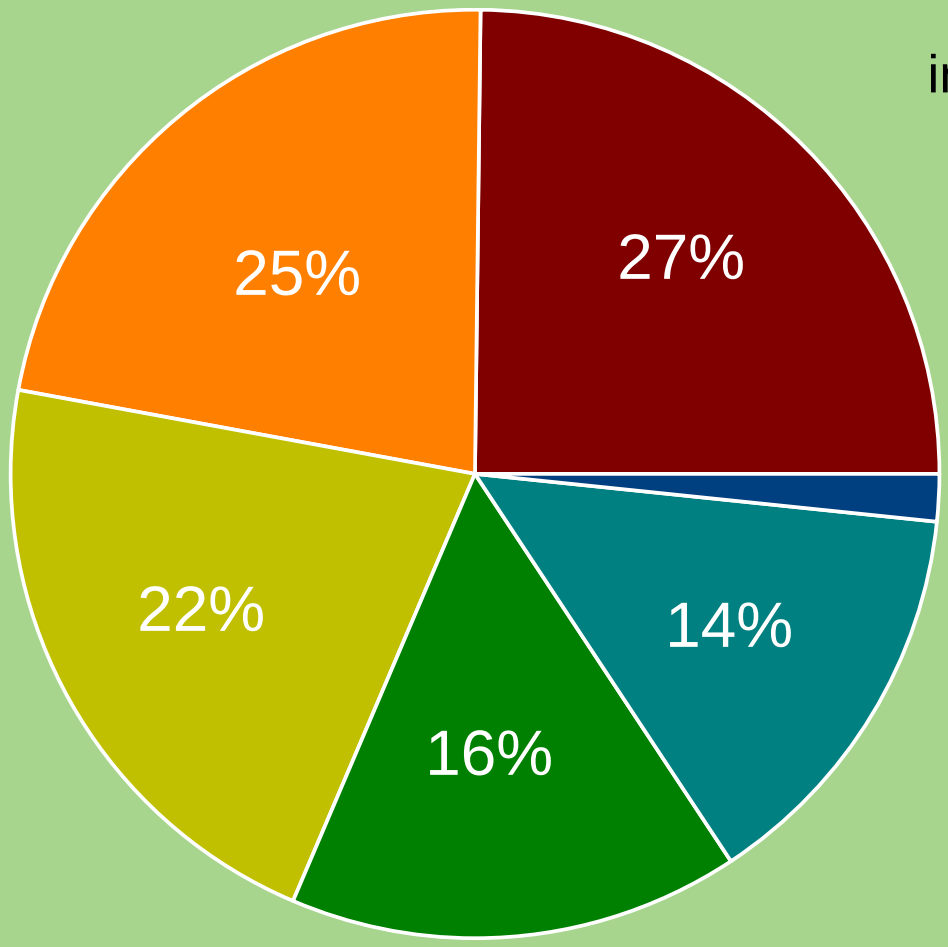


When discussing the appeal of the green features of Oak Terrace, a homeowner said "…that is why I spent a lot more money on this house than I expected or wanted to."

Knowledge Level of Oak Terrace Preserve Homeowners



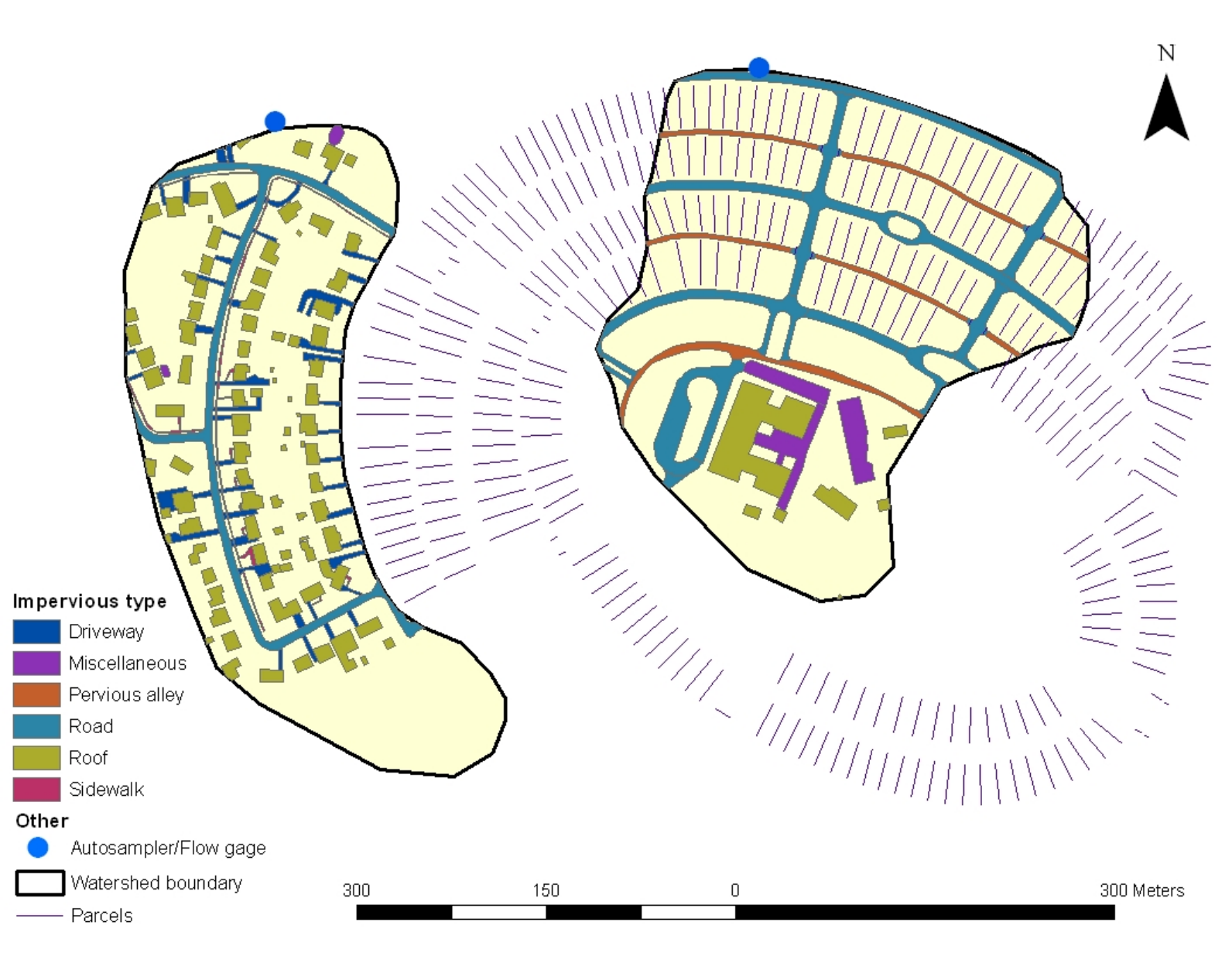
Options for increasing LID use



"When developing the mindset is: 1) easier is better and 2) what incentives are there to develop one way versus another"

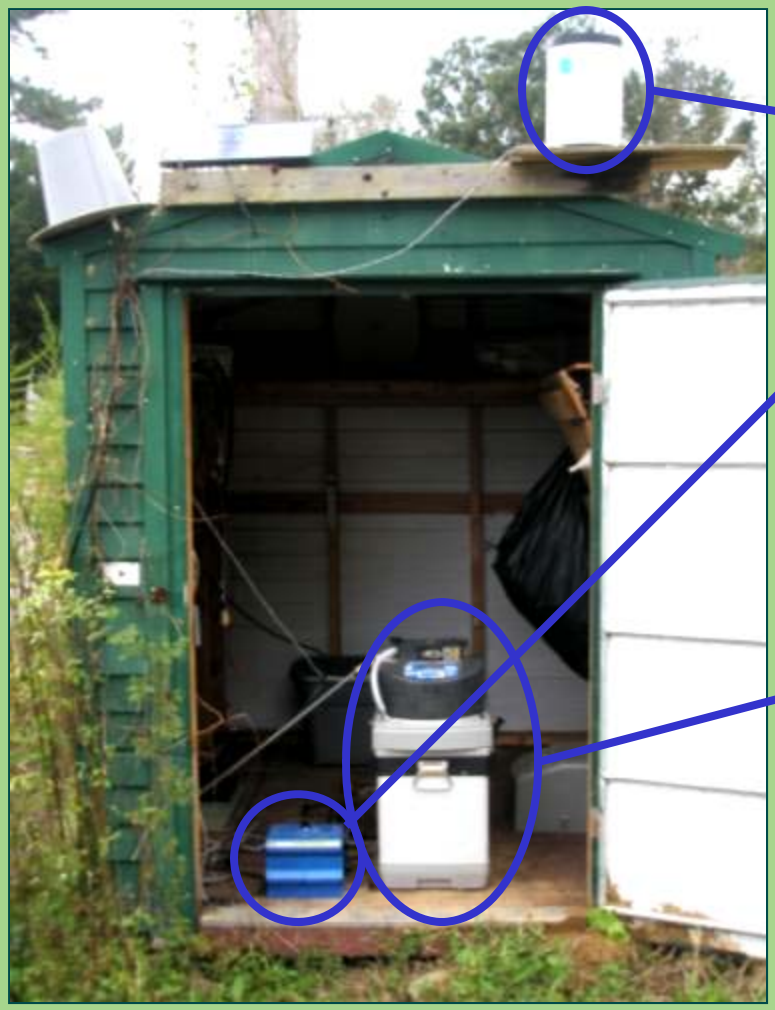
- **Incentives**
- **Education**
- **Research**
- **Success stories**
- **Regulatory mandates**
- **Communication**

Paired Catchment Study



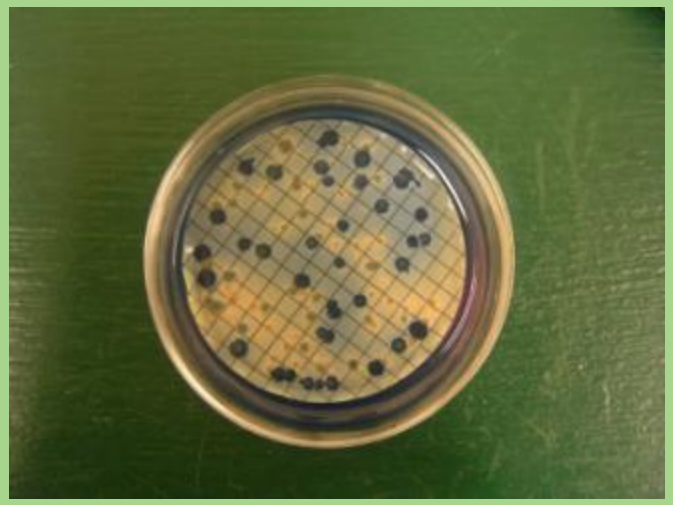
Method: Data collection

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

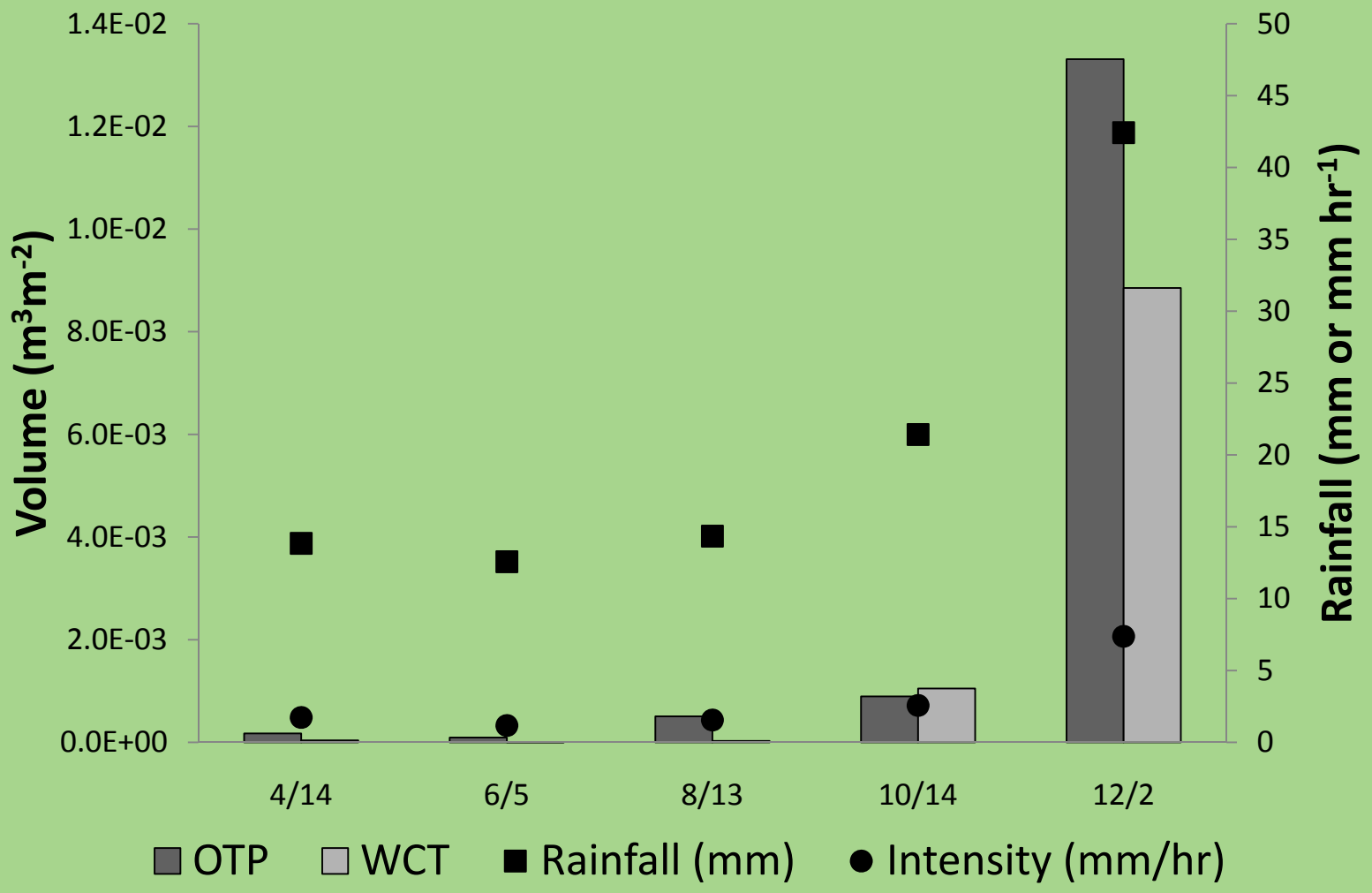
Methods: Data analyses

Predictor Variables	Response Variables
Catchment (treatment, reference)	Runoff Volume (m^3m^{-2})
Date	First flush concentration (mass per unit volume)
	Average event concentrations (mass per unit volume)
	Yield (mass per area)

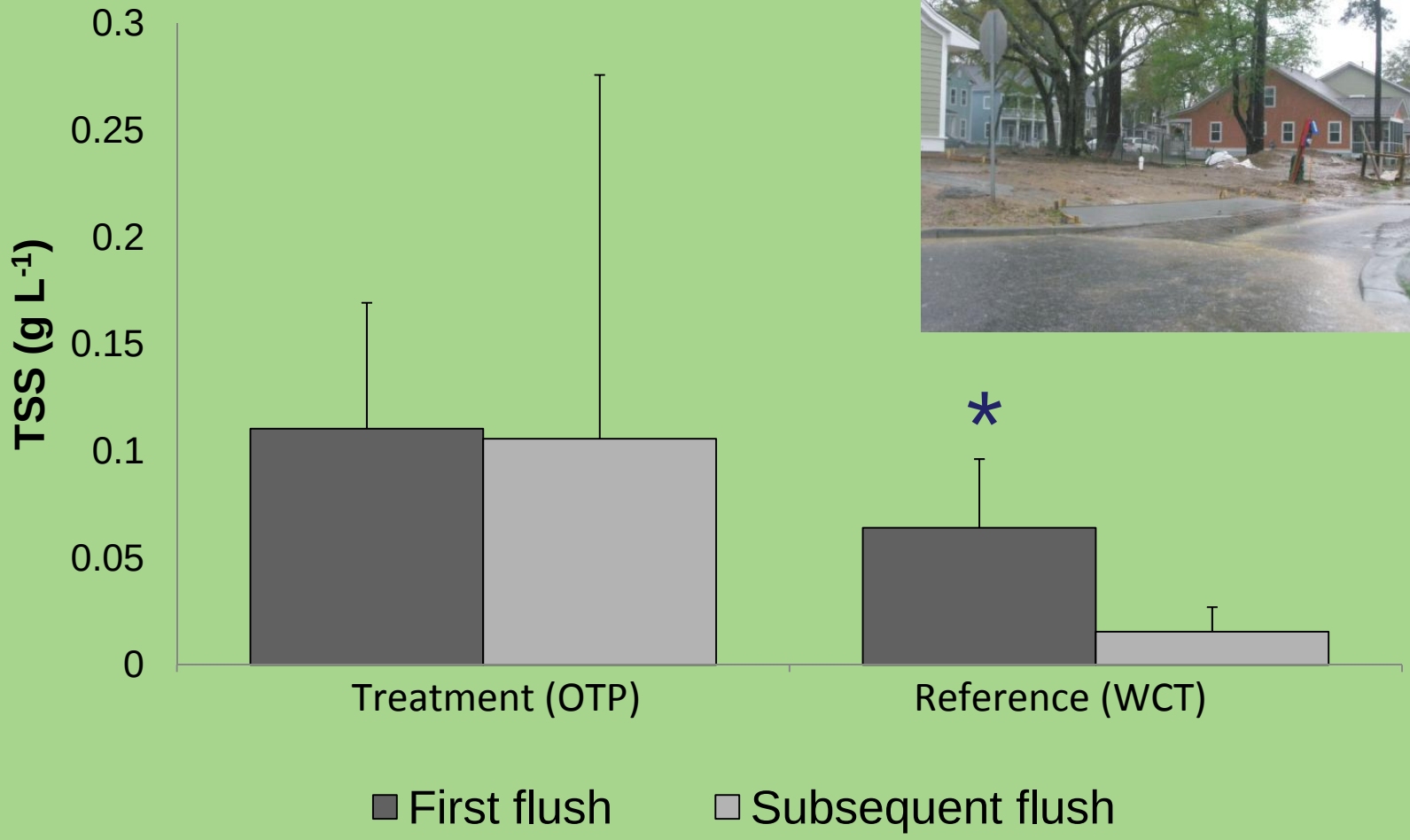
Statistics: (1) Two-way ANOVA and (2) Wilcoxon ranked-sum test

Runoff Volume

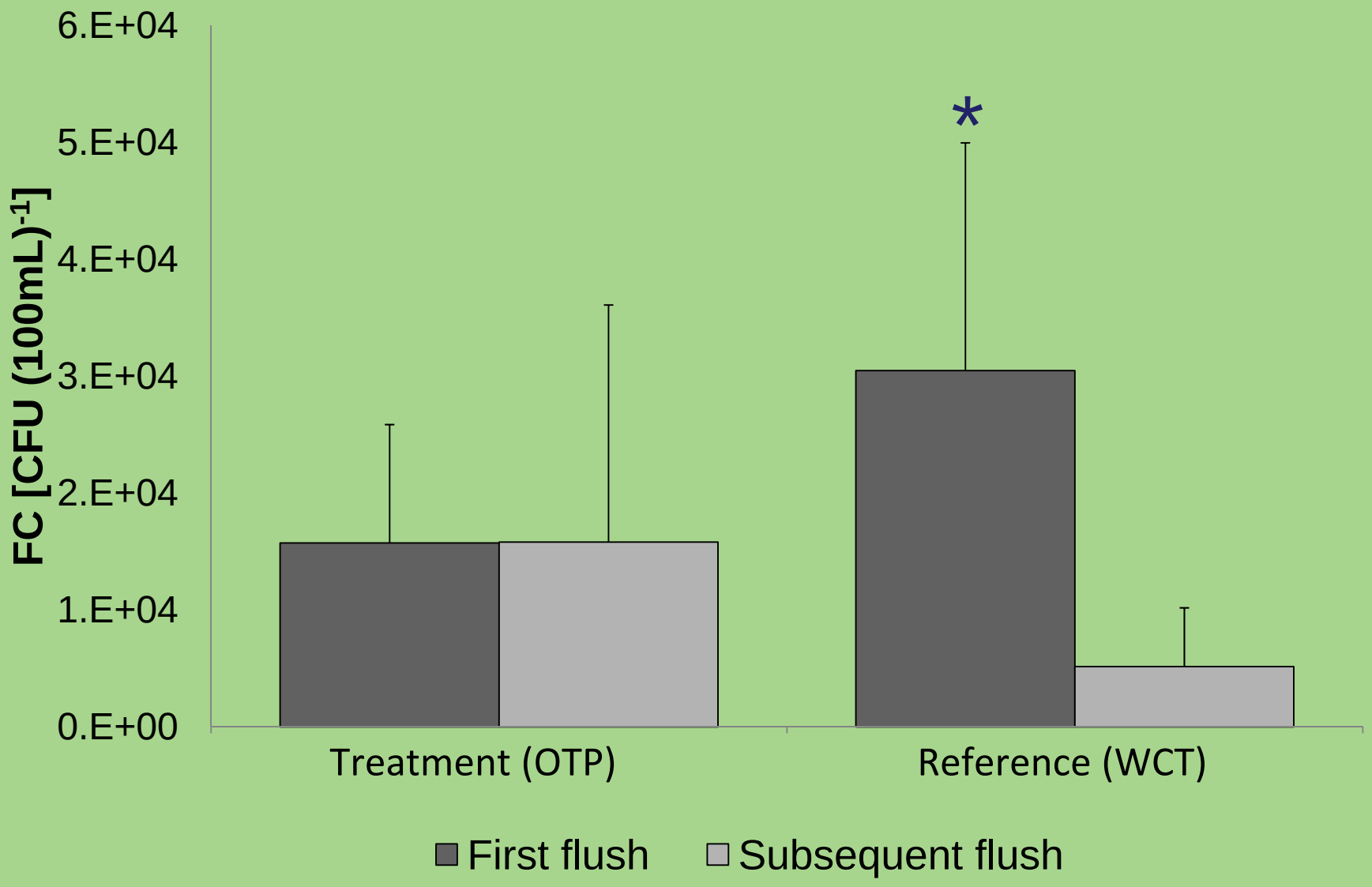
NO DIFFERENCE IN VOLUME BETWEEN CATCHMENTS



Suspended Sediment Concentrations



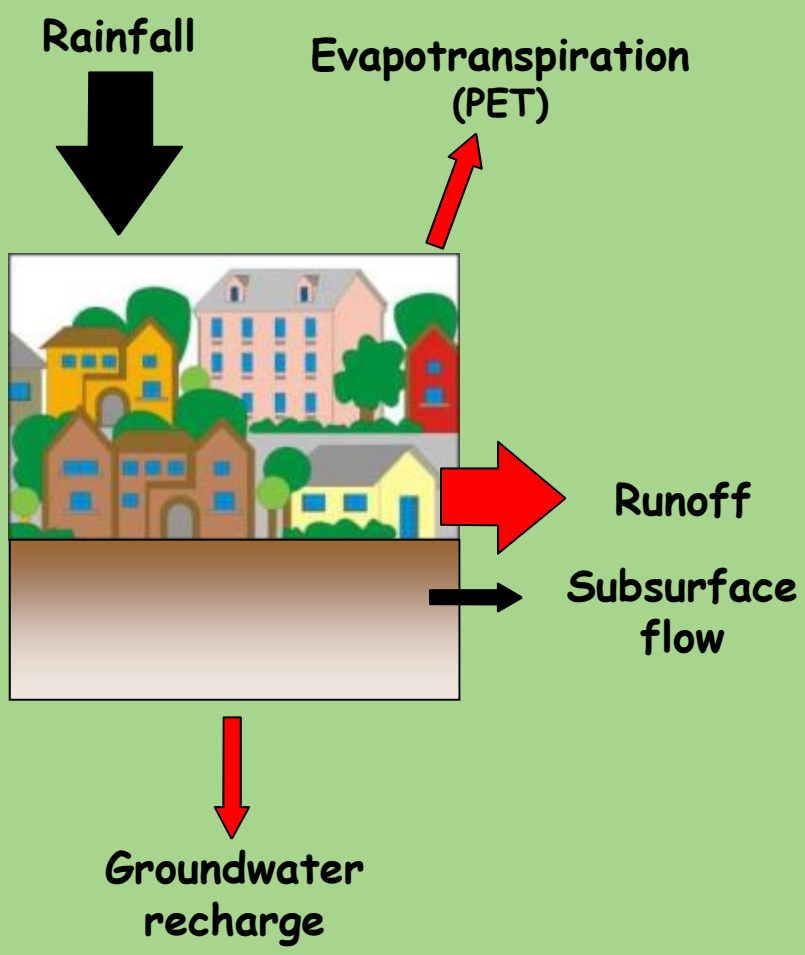
Fecal Coliform Concentrations



Pollutant Yields

Catchment	2009 Date	Runoff volume (m^3m^{-2})	TDN ($kg\ m^{-2}$)	TDP ($kg\ m^{-2}$)	FC ($CFU\ m^{-2}$)	TSS ($kg\ m^{-2}$)	Atrazine ($kg\ m^{-2}$)	2,4-D ($kg\ m^{-2}$)
Treatment (OTP)	4/14	1.7×10^{-4}	2.1×10^{-9}	4.2×10^{-10}	1.9×10^{4}	1.4×10^{-5}	1.7×10^{-10}	4.8×10^{-9}
	6/5	9.3×10^{-5}	1.0×10^{-9}	8.6×10^{-11}	2.3×10^{4}	7.1×10^{-6}	5.6×10^{-12}	4.6×10^{-11}
	8/13	5.1×10^{-4}	6.5×10^{-9}	3.3×10^{-10}	2.6×10^{4}	4.1×10^{-5}	0	0
	10/14	8.9×10^{-4}	5.3×10^{-7}	9.8×10^{-8}	1.7×10^{5}	6.8×10^{-5}	4.2×10^{-11}	0
	12/2	**1.3×10^{-2}**	**7.2×10^{-6}**	**1.7×10^{-6}**	**1.4×10^{6}**	**1.0×10^{-3}**	**2.7×10^{-10}**	0
Reference (WCT)	4/14	3.8×10^{-5}	5.5×10^{-10}	3.5×10^{-10}	2.9×10^{3}	1.7×10^{-6}	1.3×10^{-11}	0
	6/5	4.1×10^{-8}	8.1×10^{-13}	4.0×10^{-13}	9.4	1.2×10^{-9}	1.3×10^{-14}	0
	8/13	2.7×10^{-5}	3.1×10^{-10}	2.6×10^{-10}	4.0×10^{3}	4.2×10^{-7}	5.9×10^{-13}	0
	10/14	1.0×10^{-3}	6.4×10^{-7}	3.3×10^{-7}	1.9×10^{5}	2.8×10^{-5}	1.7×10^{-9}	0
	12/2	**8.9×10^{-3}**	**5.6×10^{-6}**	**5.7×10^{-6}**	**1.0×10^{6}**	**3.0×10^{-4}**	**7.0×10^{-9}**	0
p-value		**0.31**	**0.44**	**0.81**	**0.44**	**0.06**	**0.63**	**0.37***

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

Stormwater Assessment Report

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

By Lisa Vandiver[1] and Debra Hernandez[2]
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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

OTP Homeowner Education and Maintenance Program

Stormwater Series **Polluted Stormwater**

Where does NPS pollution come from?

Everybody is responsible for contributing to NPS pollution. In rural regions, agricultural practices provide contributions of nutrients, toxic chemicals, and waste from the application of fertilizers, pesticides, and animal husbandry practices. Suburban and urban contributions of pollutants are most influenced by the people who reside there. Homeowners, through traditional gardening practices (e.g., mowing, fertilizing, watering, and pesticide application,) generate a variety of nutrients and toxic chemicals that eventually make their way into nearby waterways. Other toxic chemicals come from the use, storage, and improper disposal of automobile fluids, paint, and everyday household products. In suburban and urban areas, bacteria can come from pet waste or improperly designed or maintained septic systems. It is also important to note that a significant amount of pollutants such as nutrients, toxic chemicals, bacteria, sediment, and debris accumulates on roads, parking lots, rooftops, driveways, and sidewalks. All of these surfaces easily convey these pollutants to local waterbodies.

Runoff debris photo/S.C. Sea Grant Extension

What can we do?

Everyone can play a large role in reducing our impact on receiving waterbodies. Limit your load of pollutants into the environment through these activities:

1. Apply fertilizers and pesticides sparingly and according to directions. For more information, contact your local Clemson University Cooperative Extension Service www.clemson.edu/extension.
2. Reduce bacteria by picking up after your pets and disposing of the pet waste appropriately.
3. Wash your car on your lawn (or other pervious areas) where the chemicals can be absorbed into the soil rather than draining into the nearest creek or pond.
4. Dispose of lawn clippings in a compost pile.
5. Harvest rooftop rain water through rain barrels or rain gardens. For additional information, visit www.rainbarrelguide.com or www.lid-stormwater.net
6. Do not dump paint, oil, antifreeze, debris, or other household chemicals into street gutters or storm drains—these outlets drain to the nearest local waterbody and these toxins are detrimental to aquatic environments.
7. Clean up spilled brake fluid, oil, grease, and antifreeze. Do not hose

Rain barrel photo/Mark Maassmann

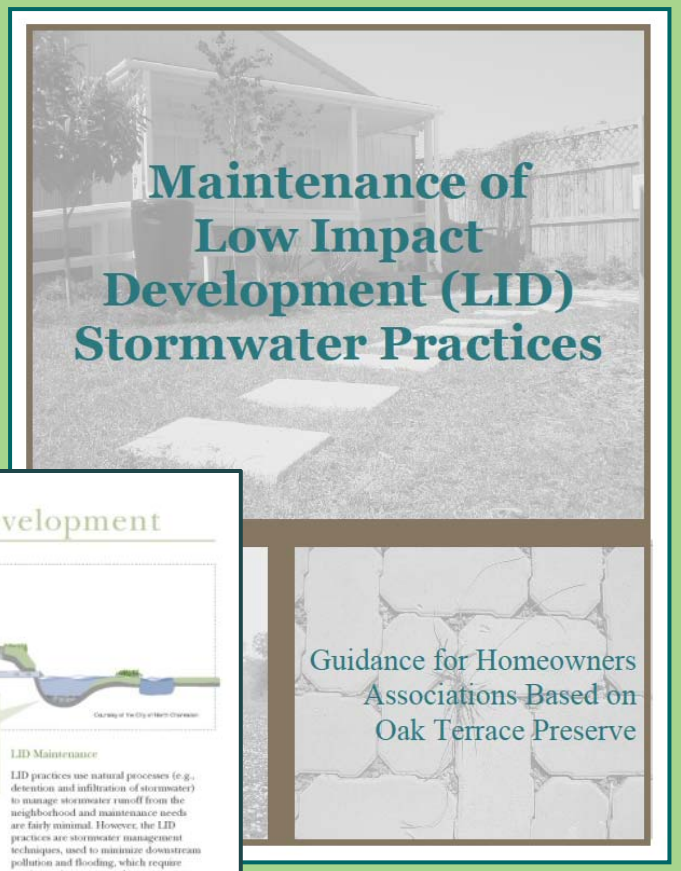
Pocket park photo/S.C. Sea Grant Extension

Why should we care?

According to the United States Environmental Protection Agency, NPS pollution is the single largest contributor to the deterioration of our nation's water quality.[3] The effects of polluted runoff are not limited to large lakes or estuaries. In fact, chances are that you don't have to look any farther than your neighborhood creek or stormwater pond. Water pollution in your town, and perhaps in your own backyard, can result in anything from weed-choked ponds and fish kills to closed shellfish beds and contaminated drinking water.

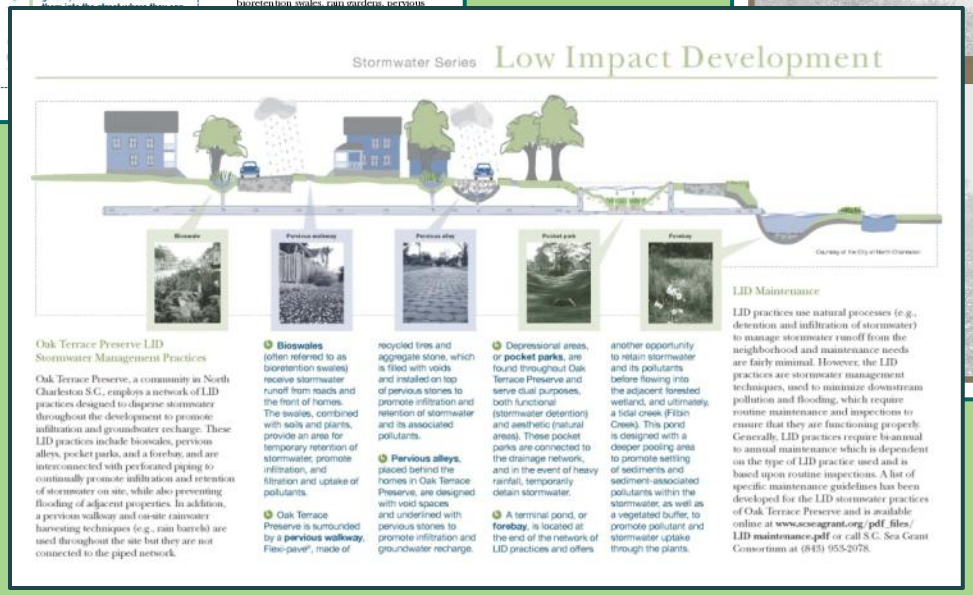
What are coastal communities doing to minimize NPS pollution?

Through federal, state, and local policies, developers and engineers are required to manage stormwater runoff from rain events. Traditional management strategies have included detention ponds and vegetative buffers; however, new development practices are leaning towards alternative strategies such as Low Impact Development (LID). LID practices promote the infiltration of stormwater to minimize the impacts of development. LID practices include the use of tree preservation, bioretention swales, rain gardens, pervious



Maintenance of Low Impact Development (LID) Stormwater Practices

Guidance for Homeowners Associations Based on Oak Terrace Preserve



Stormwater Series **Low Impact Development**

Courtesy of the City of North Charleston

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.

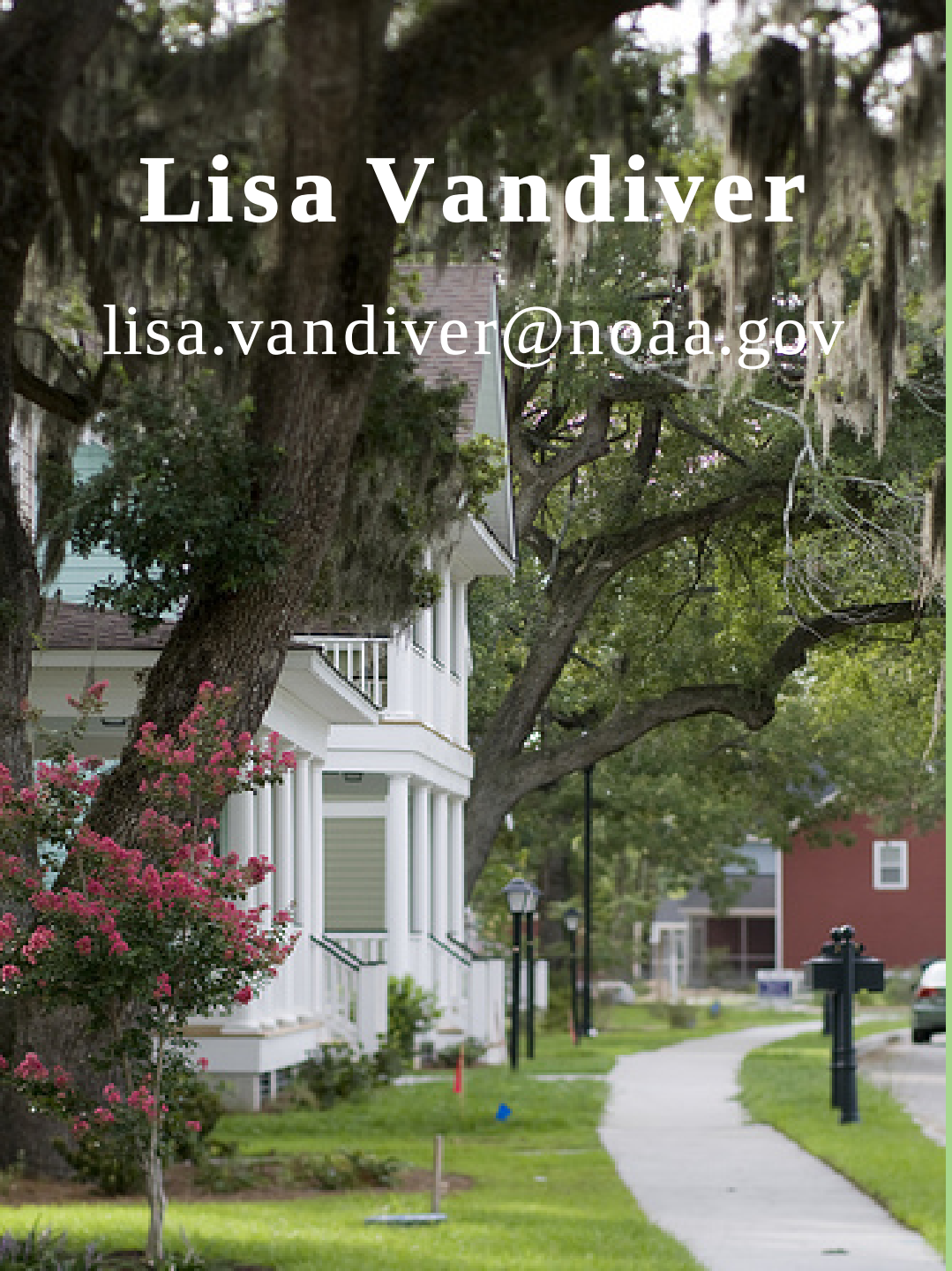
LID Maintenance

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.

Acknowledgements

Committee: Drs. Fred Holland, Steven McCutcheon, Dwayne Porter, Denise Sanger, Geoff Scott, Virginia Shervette

Elias Deeb, Mike Horton, Art Titus, Sadie Dresher, Mark Messersmith, Anne Blair, Guy DiDonato, Jeff Pollack, Jeff Baxter, John Knott, Erik Smith, Ben Lakish, CCEHBR Microbiology Lab, Paul Drewes, Jeremy Pulli, Paul Conrads, Jessi Adair, Anthony Doyle, Katie Giacalone, Dan Hitchcock, Dave Joyner, Debra Hernandez, Angela Halfacre, April Turner, Bob Bacon, Becky Szivak, Anna Martin, Nicole Saladin, Anne Rone, Margaret Bergin, Teresa Donelan, Family & Friends



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