LOW IMPACT DEVELOPMENT
WHY SHOULD I USE IT?
WHAT IS IT?
HOW DO I DO IT?

Eric H. Livingston
Watershed Management Services, LLC
Crawfordville, FL 32327
Phone 850/926-5310
stormwater.godfather@yahoo.com

In memory of Hank Higginbotham, PE
PRESENTERATION OUTLINE

• Florida stormwater rule history
• WHY are higher load reductions needed?
• HOW determine if needed?
• WHAT is “net improvement”?
• HOW achieve “net improvement”?
• Low Impact Development BMPs
## STATEWIDE STORMWATER TREATMENT PROGRAMS

<table>
<thead>
<tr>
<th>STATE</th>
<th>YEAR</th>
<th>STATE</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Florida</td>
<td>1979, 1982</td>
<td>Rhode Island</td>
<td>2002</td>
</tr>
<tr>
<td>Maryland</td>
<td>1984</td>
<td>Wisconsin</td>
<td>2002</td>
</tr>
<tr>
<td>Virginia</td>
<td>1990</td>
<td>New Jersey</td>
<td>2003</td>
</tr>
<tr>
<td>Delaware</td>
<td>1991</td>
<td>Pennsylvania</td>
<td>2007</td>
</tr>
<tr>
<td>South Carolina</td>
<td>1992</td>
<td>Michigan</td>
<td>2007</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>1998</td>
<td>Minnesota</td>
<td>2007</td>
</tr>
</tbody>
</table>

We Were the Model Program
FLORIDA’S STORMWATER RULES

1979  Chapter 17- 4.248, F.A.C.
1982  Chapter 17- 25, F.A.C.
1994  Chapter 62- 25, F.A.C.
2013  Chapter 62-330, F.A.C.

Water management district handbooks and rules

TECHNOLOGY BASED RULE
• Performance Standard
• BMP Design Criteria
• Presumption of compliance
PERFORMANCE STANDARD FOR NEW STORMWATER DISCHARGES
(62-40.432, F.A.C.)

Stormwater quality – Original Rule
- 80% average annual load reduction
- 95% average annual load reduction
  “Of Total Suspended Solids”

Stormwater quality – 1990 (62-40 adoption)
- 80% average annual load reduction
- 95% average annual load reduction
  “Of pollutants that cause or contribute”

BUT RULES WERE NEVER UPDATED
BMP DESIGN CRITERIA ARE DYNAMIC!

- 1979  17 - 4.248, FAC implemented
- 1982  17- 25, FAC implemented
- 1984  Modify BMP Design Criteria
- 1985  Wetland BMP Design Criteria

Florida’s BMP design criteria are very outdated and other state programs have passed us by!
This section provides an analysis of potential modifications to existing stormwater design criteria within the State of Florida to meet the performance objectives outlined in the Water Resource Implementation Rule (Chapter 62-40 FAC). This rule requires that stormwater management systems achieve at least an 80% reduction of the average annual load of pollutants that would cause or contribute to violations of State water quality standards. If the stormwater management system discharges to a designated OFW or other protected waterbody, the performance criteria increases to a 95% reduction. Based on the analyses presented in Section 5.2, with the exception of the SMRWMD design criteria for on-line dry retention, existing stormwater design criteria fail to consistently meet either the 80% or 95% target goals outlined in Chapter 62-40.
UNIFIED STORMWATER RULE CONCEPTS

• Increase nutrient load removal
• Clear language on impaired waters requirements
• BMP treatment train load reduction credits
• Credits for nonstructural and LID BMPs
  ✓ Preserving vegetation, minimize clearing
  ✓ Green roof/cistern systems
  ✓ Pervious concrete
  ✓ Florida Friendly Landscaping
  ✓ Disconnect impervious areas
• Redevelopment treatment section
• Compensating treatment (WQ Banking)
• Retrofit section
WHEN ARE HIGHER LEVELS OF STORMWATER TREATMENT REQUIRED?

Discharges to OFWs

- Must meet “antidegradation” standard
- Presumptive = 95% load reduction

Discharges to Impaired Waters

- Must meet “net improvement” standard
- Must demonstrate load reduction achieved
WHY ARE HIGHER LEVELS OF STORMWATER TREATMENT REQUIRED?

Section 402(p) of Federal Clean Water Act

- Establishes NPDES stormwater permits
- Construction permit requires treatment to meet WQS
- MS4 permit requires local governments to reduce pollutant loadings
- MS4 permit requires reducing pollutant loads to achieve TMDLs
- MS4 permit requires load tracking/reporting
WHY ARE HIGHER LEVELS OF STORMWATER TREATMENT REQUIRED?

SECTION 373.414(1)(b)3., Florida Statutes

3. If the applicant is unable to meet water quality standards because existing ambient water quality does not meet standards, the governing board or the department shall consider mitigation measures proposed by or acceptable to the applicant that cause net improvement of the water quality in the receiving body of water for those parameters which do not meet standards.
WHY ARE HIGHER LEVELS OF STORMWATER TREATMENT REQUIRED?

Section 373.414(1)(b)3., F.S.

- To discharge to an impaired water body, one can’t add more pollutants causing the impairment since it doesn’t meet WQS.
- Treatment level must cause “net improvement of the water quality in the receiving water body.”
- Post-development load < pre-development load.
HOW DETERMINE IF WATER BODY IS AN OFW, IS IMPAIRED, OR HAS AN ADOPTED TMDL?

• Use DEP’s Map Direct to determine if water body or WBID is an OFW or it’s impairment and TMDL status
• Use DEP’s Map Direct to see if project site is within the 12 unit HUC (subwatershed) of an impaired water body
• Use DEP’s TMDL Tracker system to see if a TMDL is adopted, or check 62-304, F.A.C.
• Use EPA’s Ask Waters system
Welcome to the Map Direct Gateway!

Open Map Direct Lite Standard Map (new Map Direct)  |  Open Map Direct v5 Standard Map (old Map Direct)

Please note that the Standard Map has no data layers initially visible. Just a basemap. Go to the Data Layers Tab at the left of the map, and use the Add Data or More Data tools to show layers on the map.

***Choose a Map from here to open it immediately***

Browse Maps by Gallery

- Air Quality
- Beaches & Coastal Systems
- Geology
- Mining & Mitigation

The Florida Department of Environmental Protection, the lead agency for environmental management and stewardship, is one of the more diverse agencies in state government - protecting our air, water and land. DEP is divided into three primary areas: Regulatory Programs, Land and Recreation, and Water Policy and Ecosystem Restoration. Florida's environmental priorities include:

* Developing a consistent and effective regulatory process
* Ensuring the quality and quantity of our state's water resources
* Increasing the access to our award-winning state parks
1. Select HUC 12 watershed
2. Select Verified Impaired WBIDs
3. Select Florida TMDLs
EPA ASK WATERS WEB SITE
http://iaspub.epa.gov/apex/waters/f?p=ASKWATERS:

Use the Expert Query Tool
DEP TMDL TRACKER WEB SITE

http://www.dep.state.fl.us/water/watershed/assessment/tmdl-tracker.htm

<table>
<thead>
<tr>
<th>Watershed Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TMDL Tracker</strong></td>
</tr>
</tbody>
</table>

Release 2.0 of the TMDL Tracker web application is now available through the FDEP Business Portal. With this release easy access to watershed assessment and TMDL information from Florida’s Department of Environmental Protection is now provided to the public through the internet.

Use this web application’s TMDL Reports and Dashboards to access TMDL status, Assessment, and Permit information.

You may also be able to determine if a WBID is impaired. Click on this link to get easy to follow instructions on how to access this information.

» The TMDL Report provides access to downloadable TMDL documents.
» Under the Dashboard link, the Water Quality Tab provides a snapshot of TMDL information allowing results to be filtered by DEP District, TMDL Document Status, or Pollutant.
» Under the Dashboard link, the Assessment Tab provides a snapshot of Assessment information allowing results to be filtered by DEP District, Assessment Category, or Basin Group.
» Also under the Dashboard link, the Permit Tab allows for searches based on Waterbody Name, WBID (waterbody segment id), Wastewater Facility ID or Wastewater Facility Name.
» This powerful tool also provides spatial searches using latitude and longitude coordinates.
» Search results can be confirmed through links to the MapDirect map browser.

**Access the TMDL Tracker Web Application**

For more information, send e-mail to Kevin O’Donnell (Kevin.ODonnell@dep.state.fl.us)

Watershed Assessment
2600 Blair Stone Road - Mall Station 3560
Tallahassee, FL 32399-2400
Phone: (850) 245-8433

Also can check Chapter 62-304, FAC
WHAT IS “NET IMPROVEMENT”?

Verified impaired water body

• DEP/WMDs require one pound less loading of the pollutant(s) causing impairment after development
• Recommend at least 10% reduction in post-development loading to meet statutory intent.

Impaired water body with adopted TMDL

Post-development load < pre-development load – WLA % reduction
VERY HIGH LEVEL OF TREATMENT

- Typical wet ponds get 35% TN, 55% TP removal
- Net Improvement can require as much as 90% removal to meet TMDL (26% WLA)
- Need to use combination of structural and nonstructural pollution prevention BMPs including Low Impact Development BMPs
POLLUTANT LOAD = (CONCENTRATION) * (VOLUME)

Stormwater volume factors:

- **Rainfall variables**: when, where, how long, how intense, time between storms
- **Natural stormwater variables**: include soils, geology, SHWT, topography, vegetation
- **Human stormwater variables**: include land use, site design, soil compaction, percent imperviousness, % DCIA

### Table 9-5  Runoff curve numbers for urban areas

<table>
<thead>
<tr>
<th>Cover description</th>
<th>Average percent impervious area</th>
<th>CN for hydrologic soil group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover type and hydraulic condition</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Fully developed urban areas (vegetation established)</td>
<td>68</td>
<td>79</td>
</tr>
<tr>
<td>Open space (lawns, parks, golf courses, cemeteries, etc.)</td>
<td>68</td>
<td>79</td>
</tr>
<tr>
<td>Poor condition (grass cover &lt; 50%)</td>
<td>49</td>
<td>64</td>
</tr>
<tr>
<td>Fair condition (grass cover 50% to 75%)</td>
<td>49</td>
<td>64</td>
</tr>
<tr>
<td>Good condition (grass cover &gt; 75%)</td>
<td>49</td>
<td>64</td>
</tr>
<tr>
<td>Impervious areas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paved parking lots, roofs, driveways, etc. (excluding right-of-way)</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td>Streets and roads:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paved; curbs and storm sewers (excluding right-of-way)</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td>Paved; open ditches (including right-of-way)</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td>Gravel (including right-of-way)</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td>Dirt (including right-of-way)</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td>Western desert urban areas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural desert landscaping (impervious areas only)</td>
<td>56</td>
<td>57</td>
</tr>
<tr>
<td>Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)</td>
<td>56</td>
<td>57</td>
</tr>
<tr>
<td>Urban districts:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial and business</td>
<td>85</td>
<td>89</td>
</tr>
<tr>
<td>Industrial</td>
<td>72</td>
<td>81</td>
</tr>
<tr>
<td>Residential districts by average lot size:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 acre or less (town houses)</td>
<td>60</td>
<td>63</td>
</tr>
<tr>
<td>1/4 acre</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>1/3 acre</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>1/2 acre</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>1 acre</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>2 acres</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Developing urban areas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newly graded areas (impervious areas only, no vegetation)</td>
<td>77</td>
<td>86</td>
</tr>
</tbody>
</table>
# STORMWATER EVENT MEAN CONCENTRATIONS

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>Total N</th>
<th>Total P</th>
<th>BOD</th>
<th>TSS</th>
<th>Copper</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Density Residential(^1)</td>
<td>1.61</td>
<td>0.191</td>
<td>4.7</td>
<td>23.0</td>
<td>0.008</td>
<td>0.031</td>
</tr>
<tr>
<td>Single Family</td>
<td>2.07</td>
<td>0.327</td>
<td>7.9</td>
<td>37.5</td>
<td>0.016</td>
<td>0.062</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>2.32</td>
<td>0.520</td>
<td>11.3</td>
<td>77.8</td>
<td>0.009</td>
<td>0.086</td>
</tr>
<tr>
<td>Low Intensity Commercial</td>
<td>1.18</td>
<td>0.179</td>
<td>7.7</td>
<td>57.5</td>
<td>0.018</td>
<td>0.094</td>
</tr>
<tr>
<td>High Intensity Commercial</td>
<td>2.40</td>
<td>0.345</td>
<td>11.3</td>
<td>69.7</td>
<td>0.015</td>
<td>0.160</td>
</tr>
<tr>
<td>Light Industrial</td>
<td>1.20</td>
<td>0.260</td>
<td>7.6</td>
<td>60.0</td>
<td>0.003</td>
<td>0.057</td>
</tr>
<tr>
<td>Highway</td>
<td>1.64</td>
<td>0.220</td>
<td>5.2</td>
<td>37.3</td>
<td>0.032</td>
<td>0.126</td>
</tr>
<tr>
<td>Natural Vegetated Community</td>
<td>1.15</td>
<td>0.055</td>
<td>1.4</td>
<td>4.7</td>
<td>0.003</td>
<td>0.007</td>
</tr>
</tbody>
</table>

### Agricultural Land Uses

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>Total N</th>
<th>Total P</th>
<th>BOD</th>
<th>TSS</th>
<th>Copper</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>3.47</td>
<td>0.621</td>
<td>5.1</td>
<td>94.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Citrus</td>
<td>2.24</td>
<td>0.183</td>
<td>2.55</td>
<td>15.5</td>
<td>0.003</td>
<td>0.012</td>
</tr>
<tr>
<td>Row Crops</td>
<td>2.65</td>
<td>0.593</td>
<td>-</td>
<td>19.8</td>
<td>0.022</td>
<td>0.030</td>
</tr>
<tr>
<td>Conventional rooftops</td>
<td>1.05</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Average of single-family and undeveloped values

Florida EMC data base – June 2012
HOW DO WE REDUCE STORMWATER LOADING?

- Reduce stormwater pollutant concentrations
- Reduce stormwater volume
- Reduce pollutants using source controls and public education
- Better site design – integrate stormwater into site and its landscaping
- Minimize imperviousness, especially DCIA
- Structural stormwater BMPs
WHY LID?
ADDED BMPs IN TOOL BOX

• Promote development and redevelopment through greater flexibility
• Build local economy and promote “urban regeneration”
• Get higher levels of stormwater treatment
• Keep loads out of MS4
• Protect local taxpayers and water bodies

City of Palmetto
Urban regeneration project

• Pervious Pavement
  • Concrete
  • Pavers
• Rain Gardens / Bio Swales
• Street Infiltration Basins
• Bio Filtration Planter Boxes
• Green Gutters
LOW IMPACT DESIGN
HOW DO IT?

Mederra, Gainesville

Baldwin Park, Orlando

River Forest, Bradenton
WHAT IS LOW IMPACT DEVELOPMENT?

- Comprehensive watershed approach
- Hydrology is integrating framework
- Maintain predevelopment volume and hydrology
- Combine nonstructural pollution prevention BMPs with structural BMPs
- Control stormwater at the source
- Create multifunctional landscape and infrastructure

Pollution and Hydrologic Prevention
WHAT LOW IMPACT DEVELOPMENT IS NOT

LID is NOT a silver bullet solution to all stormwater problems

• Additional nonstructural and structural tools in the BMP tool box

• Infiltration BMPs do not work everywhere

LID is NOT a new idea

• “Designing with Nature” 1969 book by Ian McHarg

• FL stormwater program has always promoted retention BMPs
LOW IMPACT DEVELOPMENT PRINCIPLES TO REDUCE STORMWATER VOLUME/LOADS

- Consider stormwater as a resource
- Protect/avoid sensitive areas
- Minimize disturbed areas / soil compaction
- Minimize loss of vegetation and trees
- Plant more trees – intercept rainfall
- Maximize infiltration/stormwater harvesting
- Minimize imperviousness, especially DCIA
- Integrate stormwater BMPs into landscaping
- Cluster development
- Use innovative planning tools (TDR)
SOURCE CONTROLS FOR POLLUTION PREVENTION

• Minimize clearing, removal of trees, vegetation
• Include urban reforestation
• Minimize imperviousness, esp. DCIA
  • Minimize soil compaction
  • Narrow streets, pervious parking, recessed tree islands
• Greenroof/cistern systems for large roofs
• Roof runoff to cisterns, pervious areas
• Minimize pollutants
  • Florida-friendly landscaping & fertilizers
  • Proper use of reclaimed water
  • Pet waste pick up and disposal
NATURAL AREA CONSERVATION OR REFORESTATION

- Credit for preserving natural areas
- Debit for clearing/landscaping – soil compaction
THE STORMWATER BENEFITS OF TREES

Planting trees in urban areas intercepts and evaporates rain and reduces stormwater volume and loads.

Interceptor Tree BMP
Up to 15% reduction in stormwater volume

NEED DATA!
I-TREE TOOLS

http://www.itretools.org/

What is i-Tree?

i-Tree is a state-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. The i-Tree Tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide.

Since the initial release of the i-Tree Tools in August 2006, numerous communities, non-profit organizations, consultants, volunteers and students have used i-Tree to report on individual trees, parcels, neighborhoods, cities, and even entire states. By understanding the local, tangible ecosystem services that trees provide, i-Tree users can link urban forest management activities with environmental quality and community livability. Whether your interest is a single tree or an entire forest, i-Tree provides baseline data that you can use to demonstrate value and set priorities for more effective decision-making.

i-Tree Tools are in the public domain and are freely accessible. We invite you to explore this site to learn more about how i-Tree can make a difference in your community.

Follow i-Tree on Twitter

What's New?

Check out updated April 2015
i-Tree User Maps
International user map and United States user map

i-Tree Eco: Modelling the Lungs of our Cities - Part1
The importance of U.K. urban forest assessments>

i-Tree Eco: Modelling the Lungs of our Cities - Part2
The London i-Tree Eco project>

Breathe Easy: Urban Forests for Human Health
Archived ACT webinar featuring Dave Novak>

Baltimore Gas and Electric provide over 4,200 free trees
BGE promotes Energy-Saving trees planting programs>

Delmarva Power to provide 1,500 free trees
Energy-Saving Trees program in Delaware & Maryland>
FLORIDA LANDSCAPES ARE PPP SOURCES

Florida Friendly Landscaping and Fertilizers
FLORIDA-FRIENDLY LANDSCAPING PRINCIPLES

1. Right plant, right place
2. Water efficiently, use stormwater
3. Fertilize properly
4. Mulch
5. Attract wildlife
6. Manage yard pests properly
7. Recycle clippings and leaves
8. Reduce runoff
9. Protect the waterfront

http://www.floridayards.org
USE FLORIDA-FRIENDLY FERTILIZERS

<table>
<thead>
<tr>
<th>(N) Total Nitrogen</th>
<th>(P₂O₅) Phosphorus</th>
<th>(K₂O) Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0</td>
<td>15</td>
</tr>
</tbody>
</table>

DACS Urban Turf Fertilizer Label Rule

- **Effective July 1, 2009**
- **Only specified fertilizers on turf**
  - No or low phosphorus (< 0.5%)
  - Slow release nitrogen
- **Maximum application rates**
  - 0.25 lbs P/1000 sf per app
  - 0.50 lbs P/1000 sf per year
  - 0.7 lbs available N/1000 sf

**GUARANTEED ANALYSIS**

- TOTAL NITROGEN (N) .................. 14.00 %
  - 14.45% Urea Nitrogen (N)*
- SOLUBLE POTASH (K₂O) .............. 26.00 %
- SULFUR (S) Total ................... 19.70 %
  - 10.50% Free sulfur (S)
  - 9.20% Combined sulfur (S)
- IRON (Fe) Total ...................... 0.96 %
  - 0.19% Water Soluble Iron (Fe)
- MANGANESE (Mn) Total ................ 0.48 %
  - 0.1% Water Soluble Manganese (Mn)
- DERIVED FROM: Polymer Coated Sulfur
  Coated Urea, Sulfate of Potash, Iron Oxide,
  Manganese Oxide.
- CHLORINE (Cl) Max .................. 2.00%
  - 7.00% Slowly Available Urea Nitrogen from
    Polymer Coated Sulfur Coated Urea.
PET WASTE: A major source of nutrients and bacteria pollutants

- Pets deposit up to 0.5 lbs/day of pet waste
- Contributes to bacterial & nutrient pollution

<table>
<thead>
<tr>
<th>Animal</th>
<th>Average fecal coliform per gram of feces</th>
<th>Fecal coliform load per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>13,000,000</td>
<td>1,921,920,000</td>
</tr>
<tr>
<td>Dog</td>
<td>23,000,000</td>
<td>7,728,000,000</td>
</tr>
<tr>
<td>Cow</td>
<td>230,000</td>
<td>5,358,080,000</td>
</tr>
<tr>
<td>Horse</td>
<td>12,600</td>
<td>293,529,600</td>
</tr>
</tbody>
</table>
## SOIL COMPACTION AND INFILTRATION RATES

<table>
<thead>
<tr>
<th>SOIL TYPE</th>
<th>INFILTRATION RATE (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pitt et. al.</td>
</tr>
<tr>
<td>Sandy soils</td>
<td>13.0</td>
</tr>
<tr>
<td>Compacted sandy soils</td>
<td>1.4</td>
</tr>
<tr>
<td>Clay soils</td>
<td>9.8</td>
</tr>
<tr>
<td>Compacted or wet clay soils</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source: Pitt, Chen, and Clark, 2001; Gregory et al, 2006
### THE INFLUENCE OF DCIA ON STORMWATER VOLUME

**Zone 4**

Mean Annual Runoff Coefficients (C Values) as a Function of DCIA Percentage and Non-DCIA Curve Number (CN)

<table>
<thead>
<tr>
<th>Percent DCIA</th>
<th>0.004</th>
<th>0.045</th>
<th>0.086</th>
<th>0.127</th>
<th>0.168</th>
<th>0.209</th>
<th>0.250</th>
<th>0.291</th>
<th>0.332</th>
<th>0.373</th>
<th>0.414</th>
<th>0.455</th>
<th>0.496</th>
<th>0.536</th>
<th>0.577</th>
<th>0.618</th>
<th>0.659</th>
<th>0.700</th>
<th>0.741</th>
<th>0.782</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.007</td>
<td>0.048</td>
<td>0.089</td>
<td>0.129</td>
<td>0.170</td>
<td>0.211</td>
<td>0.252</td>
<td>0.293</td>
<td>0.333</td>
<td>0.374</td>
<td>0.415</td>
<td>0.456</td>
<td>0.497</td>
<td>0.537</td>
<td>0.578</td>
<td>0.619</td>
<td>0.660</td>
<td>0.701</td>
<td>0.741</td>
<td>0.782</td>
<td></td>
</tr>
<tr>
<td>0.011</td>
<td>0.051</td>
<td>0.092</td>
<td>0.133</td>
<td>0.173</td>
<td>0.214</td>
<td>0.254</td>
<td>0.295</td>
<td>0.336</td>
<td>0.376</td>
<td>0.417</td>
<td>0.458</td>
<td>0.498</td>
<td>0.539</td>
<td>0.579</td>
<td>0.620</td>
<td>0.661</td>
<td>0.701</td>
<td>0.742</td>
<td>0.782</td>
<td></td>
</tr>
<tr>
<td>0.016</td>
<td>0.056</td>
<td>0.096</td>
<td>0.137</td>
<td>0.177</td>
<td>0.217</td>
<td>0.258</td>
<td>0.298</td>
<td>0.339</td>
<td>0.379</td>
<td>0.419</td>
<td>0.460</td>
<td>0.500</td>
<td>0.540</td>
<td>0.581</td>
<td>0.621</td>
<td>0.662</td>
<td>0.702</td>
<td>0.742</td>
<td>0.782</td>
<td></td>
</tr>
<tr>
<td>0.022</td>
<td>0.062</td>
<td>0.102</td>
<td>0.142</td>
<td>0.182</td>
<td>0.222</td>
<td>0.262</td>
<td>0.302</td>
<td>0.342</td>
<td>0.382</td>
<td>0.423</td>
<td>0.463</td>
<td>0.503</td>
<td>0.543</td>
<td>0.583</td>
<td>0.623</td>
<td>0.663</td>
<td>0.703</td>
<td>0.743</td>
<td>0.783</td>
<td></td>
</tr>
<tr>
<td>0.030</td>
<td>0.070</td>
<td>0.109</td>
<td>0.149</td>
<td>0.189</td>
<td>0.228</td>
<td>0.268</td>
<td>0.308</td>
<td>0.347</td>
<td>0.387</td>
<td>0.427</td>
<td>0.466</td>
<td>0.506</td>
<td>0.546</td>
<td>0.585</td>
<td>0.625</td>
<td>0.664</td>
<td>0.704</td>
<td>0.744</td>
<td>0.783</td>
<td></td>
</tr>
<tr>
<td>0.040</td>
<td>0.080</td>
<td>0.119</td>
<td>0.158</td>
<td>0.197</td>
<td>0.236</td>
<td>0.275</td>
<td>0.314</td>
<td>0.353</td>
<td>0.393</td>
<td>0.432</td>
<td>0.471</td>
<td>0.510</td>
<td>0.549</td>
<td>0.588</td>
<td>0.627</td>
<td>0.667</td>
<td>0.706</td>
<td>0.745</td>
<td>0.784</td>
<td></td>
</tr>
<tr>
<td>0.054</td>
<td>0.092</td>
<td>0.131</td>
<td>0.169</td>
<td>0.208</td>
<td>0.246</td>
<td>0.285</td>
<td>0.323</td>
<td>0.362</td>
<td>0.400</td>
<td>0.438</td>
<td>0.477</td>
<td>0.515</td>
<td>0.554</td>
<td>0.592</td>
<td>0.631</td>
<td>0.669</td>
<td>0.708</td>
<td>0.746</td>
<td>0.785</td>
<td></td>
</tr>
<tr>
<td>0.071</td>
<td>0.109</td>
<td>0.147</td>
<td>0.184</td>
<td>0.222</td>
<td>0.260</td>
<td>0.297</td>
<td>0.335</td>
<td>0.372</td>
<td>0.410</td>
<td>0.447</td>
<td>0.485</td>
<td>0.522</td>
<td>0.560</td>
<td>0.598</td>
<td>0.635</td>
<td>0.673</td>
<td>0.710</td>
<td>0.748</td>
<td>0.785</td>
<td></td>
</tr>
<tr>
<td>0.096</td>
<td>0.132</td>
<td>0.168</td>
<td>0.205</td>
<td>0.241</td>
<td>0.277</td>
<td>0.314</td>
<td>0.350</td>
<td>0.387</td>
<td>0.423</td>
<td>0.459</td>
<td>0.496</td>
<td>0.532</td>
<td>0.568</td>
<td>0.605</td>
<td>0.641</td>
<td>0.678</td>
<td>0.714</td>
<td>0.750</td>
<td>0.787</td>
<td></td>
</tr>
<tr>
<td>0.130</td>
<td>0.165</td>
<td>0.199</td>
<td>0.234</td>
<td>0.268</td>
<td>0.303</td>
<td>0.338</td>
<td>0.372</td>
<td>0.407</td>
<td>0.442</td>
<td>0.476</td>
<td>0.511</td>
<td>0.546</td>
<td>0.580</td>
<td>0.615</td>
<td>0.650</td>
<td>0.684</td>
<td>0.719</td>
<td>0.754</td>
<td>0.788</td>
<td></td>
</tr>
<tr>
<td>0.182</td>
<td>0.214</td>
<td>0.246</td>
<td>0.278</td>
<td>0.310</td>
<td>0.342</td>
<td>0.374</td>
<td>0.406</td>
<td>0.436</td>
<td>0.470</td>
<td>0.502</td>
<td>0.534</td>
<td>0.566</td>
<td>0.599</td>
<td>0.631</td>
<td>0.663</td>
<td>0.695</td>
<td>0.727</td>
<td>0.759</td>
<td>0.791</td>
<td></td>
</tr>
<tr>
<td>0.266</td>
<td>0.294</td>
<td>0.322</td>
<td>0.350</td>
<td>0.378</td>
<td>0.406</td>
<td>0.433</td>
<td>0.461</td>
<td>0.489</td>
<td>0.517</td>
<td>0.545</td>
<td>0.573</td>
<td>0.600</td>
<td>0.628</td>
<td>0.656</td>
<td>0.684</td>
<td>0.712</td>
<td>0.740</td>
<td>0.767</td>
<td>0.795</td>
<td></td>
</tr>
<tr>
<td>0.429</td>
<td>0.449</td>
<td>0.469</td>
<td>0.488</td>
<td>0.508</td>
<td>0.528</td>
<td>0.547</td>
<td>0.567</td>
<td>0.587</td>
<td>0.606</td>
<td>0.626</td>
<td>0.646</td>
<td>0.665</td>
<td>0.685</td>
<td>0.705</td>
<td>0.725</td>
<td>0.744</td>
<td>0.764</td>
<td>0.784</td>
<td>0.803</td>
<td></td>
</tr>
<tr>
<td>0.616</td>
<td>0.626</td>
<td>0.636</td>
<td>0.647</td>
<td>0.657</td>
<td>0.667</td>
<td>0.678</td>
<td>0.688</td>
<td>0.699</td>
<td>0.709</td>
<td>0.719</td>
<td>0.730</td>
<td>0.740</td>
<td>0.750</td>
<td>0.761</td>
<td>0.771</td>
<td>0.782</td>
<td>0.792</td>
<td>0.802</td>
<td>0.813</td>
<td></td>
</tr>
</tbody>
</table>

**Agriculture land use (pasture)**

No DCIA, CN for D soils = 89  
C = .249

**SF residential land use**

¼ acre lots - DCIA = 40%, CN for lawns, D soils = 84  
C = .431
DISCONNECTING DIRECTLY CONNECTED IMPERVIOUS AREAS (DCIA)
USING LOW IMPACT DEVELOPMENT TO REDUCE IMPERVIOUSNESS

- Tailor and decrease road width
- Minimize road length
- Use pervious pavements for parking
- Reduce required parking spaces
- Reduce parking space size
- Use one way angled parking
- Minimize paved driveways/size
- Side walks on one side only
LID STRUCTURAL BMPS

- Infiltration BMPs
  - Green roof/cistern systems
  - Pervious pavements
  - Rain gardens

- Biofiltration BMPs
  - Street tree filters
  - Landscape filter boxes
  - Upflow filters

- Detention with stormwater harvesting
REDUCING IMPERVIOUSNESS IN PARKING LOTS

Nonstructural tools
- Reduce required parking spaces
- Reduce parking space size
- Use one way angled parking

Structural tools
- Use pervious pavements for parking
  - Pervious concrete
  - Turf block/pavers
  - Geoweb and sod

BUT, THIS MAY REQUIRE CODE OR CULTURAL CHANGE
REDUCING PARKING LOT IMPERVIOUSNESS AND DCIA
RECESSED ROAD MEDIANS AS BMPs
LID BMP = POROUS PAVEMENTS

- Pervious Concrete
- Flexi-pave™
- Permeable Concrete Pavers
- Pervious Asphalt
- Others
Good design is important, but you have to locate it properly, build it right and you have to maintain it.
PERMEABLE PAVEMENT DESIGN REQUIREMENTS

- Is the site appropriate?
- SHWT at least 2’ below bottom
- Treatment volume using retention curves
- Design per specs/perc rate – min 2”/hr
- Compaction – max 92-95% to min of 24 inches
- Master certified contractor
- Quarterly vacuum sweeping
- ERIK testing and recertification
- Signage to keep muddy vehicles off
PERCENT YEARLY RETENTION

Dc = 8”
Dwt = 24”
Fsoil = 5.4 in/hr
Fwt = 0.16

2.0 in/hr
3.5 in/hr
Recommendations – Pervious Pavement

- **Parent soil** - MAXIMUM compaction of 92% - 95% Modified Proctor density (ASTM D-1557) to a total depth of 24 - 36 * inches.

- **Redevelopment projects** – existing pavement section (including compacted base & stabilized sub-grade) to be removed. Underlying soils to be scarified to a minimum 24 - 36 * inch depth and re-graded / proof rolled to a MAXIMUM compaction of 92% Standard Proctor density (ASTM D698-00a).

- **Heavy wheel loads** – if proposed (not recommended), then alternate methods of pavement design must be utilized (i.e. structural / permeable geo-fabrics above the parent soil).

* As a point of reference, the North Carolina DENR requires a vertical saturated hydraulic conductivity \( \geq 0.52 \text{ in/hr} \) for the soil horizon below the base of the pavement system to a total depth of 36 inches.

---

**Figure 1:** Typical Pervious Pavement Cross Section

- **PERVIOUS PAVEMENT**
- **RESERVOIR LAYER**
- **PARENT SOIL**
- **FILTER FABRIC** (IF RESERVOIR LAYER IS USED)

Rear Ripper / Scarifier
http://safety.cat.com/cda/files/861819/7/140M.pdf

Maximum ripping depth = 16.8 inches.

---

Twelve (12) Inches
Two (2) to Twelve (12) Inches
Zero (0) to Thirty-Six (36) Inches
Two (2) to Forty Eight (48) Inches
Two (2) to Forty Eight (48) Inches (Minimum)
Two (2) to Forty Eight (48) Inches (Minimum)
Two (2) to Forty Eight (48) Inches (Minimum)
Two (2) to Forty Eight (48) Inches (Minimum)
The issue of placing pervious pavement systems over HSG “B/D” soils.

For both storm water QUALITY and QUANTITY computations.
Fluctuation of the SHGWT in HSG “B/D” Soils

HSG = “C” with a SHGWT 24” - 42” B.L.S.

HSG = “B/D” with a SHGWT 0” - 12” B.L.S.
Recommendations – pervious pedestrian walks & bicycle paths

- For water quality credit on HSG = “B/D” soils (SHGWT depth of 0” to 12” below the bottom of the pervious pavement system): 80% (credit) of the pervious pedestrian walk & bike path areas can be subtracted from the total contributing area when computing the storm water treatment volume.

- For water quality credit on HSG = “A”, “B” or “C” soils (SHGWT depth of greater than 24” below the bottom of the pervious pavement system): 100% (credit) of the pervious pedestrian walk & bike path areas can be subtracted from the total contributing area when computing the storm water treatment volume.

- Perimeter curbs will NOT be required for pervious walks & bike paths.

- Unless there are public safety concerns, slopes should not be an issue for pervious pedestrian walks & bike paths.
Recommendations – pervious pavement parking lots and access drives

- Consider these types of applications as dry “retention systems” for up - gradient treatment train credit

- For water quantity credit (Curve Number (CN) or Rational “C” coefficient computations) the SHGWT shall be greater that 24” below the bottom of the pervious pavement system

- The Required Treatment Volume (RTV) shall be recovered (to the bottom of the pervious pavement system) within seventy two (72) hours, with a safety factor of two (2.0)
Refer to the next slide for information on the ERIK device.

**Non-Standard Rectangular Curb**

Raised curb - to allow "nuisance" flooding (a secondary means of encouraging the owner to maintain the pervious pavement system should the void spaces become clogged).

- Two (2) inches

**Pervious Pavement**
- Flat slope (0.0%)

**Reservoir Layer**
- Two (2) to Twelve (12) Inches
- Filter Fabric (if reservoir layer is used)
- Zero (0) to Thirty-Six (36) Inches

**Parent Soil**
- Parent soil compacted to a maximum of 92% - 95% Modified Proctor density (ASTM D-1557).

**Seasonal High Ground Water Table (SHGW)**

**Potential Pervious Pavement Cross Section #1**

Scale: None
A single ring ERIK infiltrometer is acceptable provided that is embedded into the subsoil as shown in Figure 42.

ERIK
(Embedded Ring Infiltrometer Kit)
Placement, Striking, Pizza Cutter and 7 day Curing
PERVIOUS CONCRETE INFORMATION

- Florida Concrete & Products Assn
- http://www.fcpa.org/
- www.ConcreteParkingLots.com
- Manuals
- Training classes – certification of contractors-Master
- Training videos
- Min. 2”/hr perc rate
Pervious concrete is different
- Batching
- Pouring/finishing
- Maintenance
- Contractor training and certification are essential
- Must be regularly swept with vacuum sweeper
WHAT IS A GREEN ROOF?

• Vegetated roof cover
• Active (Intensive): Deep media, intended for public access
• Passive (Extensive): Shallow media, intended for maintenance access only, designed for aesthetics
FLORIDA PILOT GREEN ROOFS

South Florida – 2003 – Bonita Bay Shadow Wood Preserve
August 2003

Central Florida – 2005 – UCF Student Union
August 2007

North Florida – 2011 – Escambia County One Stop
Building
BENEFITS OF GREEN ROOFS

- Economic benefit
- Stormwater management
- Improve air quality
- Moderate urban heat island effect
- Building insulation
- Reduce energy consumption
- Sound insulation
- Health and horticultural therapy
- Recreation
- Food supply
- Habitat and wildlife biodiversity
- Aesthetics
GREEN ROOF/CISTERN SYSTEM DESIGN CONSIDERATIONS

- Building structural integrity
- Treatment volume per retention BMPs
- Waterproof membrane, drainage layer, pollution control media, growth media
- Preventing wind uplift – 3’ tall parapet
- Plants – selection, spacing, density
- Roof drain to cistern or other storage
- Irrigation – roof plants, excess for landscape
ROOF SUPPORT FOR A GREEN ROOF

Up to 70 lbs/SF

Up to 50 lbs/SF

Up to 35 lbs/SF

Up to 25 lbs/SF
CSTORM Model for Green Roof Cistern Design

• Cistern Design
  • Use CSTORM Model
  • Choose desired yearly stormwater retention volume
  • Use respective cistern volume
  • Storage volume will vary with location
GREEN ROOFS IN FLORIDA

- Introduced to Florida in 2003: Now, at least 20 locations in Florida and others underway
  - UCF Student Union, physical science and Stormwater Lab (3)
  - FSGE (Envirohome) (2) in Indialantic
  - Bonita Bay (first one and has been modified for irrigation)
  - New American Home in Orlando
  - Charlotte County Stadium
  - UF Perry Construction Yard Building
  - Tecta-America Building in Sanford (tray vs. continuous)
  - Romano Eco Center in Lake Worth
  - Honda Headquarters in Clermont
  - Escambia County One Stop Permit Building
  - Residence on Casey Key
  - Orlando Fire Station #1
  - Environmental Center, Key West
  - Kimley-Horn in Vero Beach
  - Gulf Coast College in Panama City
FSGE Integrated Site Design

green roofs, pervious pave, and landscape swales

- 4500+ gallons
# GREEN ROOF STORMWATER PRICE COMPARISON

100,000 square foot roof

<table>
<thead>
<tr>
<th>Location</th>
<th>Down Town Orlando [Magnolia]</th>
<th>Lee Road and I-4</th>
<th>University Blvd.</th>
<th>International Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond Price (Including Land Cost)</td>
<td>$5,800,000.00</td>
<td>$1,550,000.00</td>
<td>$1,200,000.00</td>
<td>$2,100,000.00</td>
</tr>
<tr>
<td>Green Roof Price</td>
<td>$1,400,000.00</td>
<td>$1,400,000.00</td>
<td>$1,400,000.00</td>
<td>$1,400,000.00</td>
</tr>
<tr>
<td>Realized savings</td>
<td>$4,400,000.00</td>
<td>$150,000.00</td>
<td>-$200,000.00</td>
<td>$700,000.00</td>
</tr>
</tbody>
</table>

Green Roof price includes the first year of maintenance while the Pond price does not include any maintenance or fencing, green roof cost = $14/sq ft.
IMPROVING WET DETENTION NUTRIENT REMOVAL EFFECTIVENESS

Get 35% TN load reduction and 55% TP load reduction

<table>
<thead>
<tr>
<th>DETENTION TIME</th>
<th>TP REMOVAL</th>
<th>TN REMOVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>57.04</td>
<td>26.91</td>
</tr>
<tr>
<td>14</td>
<td>61.51</td>
<td>33.32</td>
</tr>
<tr>
<td>21</td>
<td>64.12</td>
<td>36.20</td>
</tr>
<tr>
<td>30</td>
<td>66.42</td>
<td>38.18</td>
</tr>
<tr>
<td>50</td>
<td>69.71</td>
<td>40.23</td>
</tr>
<tr>
<td>100</td>
<td>74.01</td>
<td>41.91</td>
</tr>
<tr>
<td>150</td>
<td>76.78</td>
<td>42.51</td>
</tr>
<tr>
<td>200</td>
<td>78.63</td>
<td>42.81</td>
</tr>
<tr>
<td>250</td>
<td>80.07</td>
<td>43.00</td>
</tr>
</tbody>
</table>

Can either reduce TN/TP concentrations or reduce volume discharged

\[
\text{Eff} = 44.53 + (6.146 \times \ln Td) + (0.145 \times (\ln Td)^2) \\
\text{Eff} = \frac{(43.75 \times Td)}{(4.38 + Td)}
\]
BEEMATS – FLOWING WETLAND MATS

Turning plants into pollution filters

Phytoplankton and microalgae are essential nutrients for aquatic life. But they're also harmful. For St. Johns River and other estuaries, causing algal blooms and fish kills. The city of Jacksonville is working with Bloomer's Aquatic Company to use floating vegetation mats to naturally filter out pollutants.

The plants

- Float by floating roots
- Red top
- Silt Rush
- Canna
- Phlomis
- Bar Marsh Plant
- Canaveral

The mat

- Floating mats help plants float on top of the water. They are a lightweight, thick plastic that creates an oxygen pocket, helping plants grow.

The experiment at Talleyrand retention pond

- Fifty-five percent of nitrogen and phosphorus is naturally filtered by the pond through biological degradation and surrounding plants. The mats added to this pond should double the filtration rate.

Aerial view of pond

- The pond is being filtered with enough mats to cover 75% of the surface area.
LID BMP - RAINWATER HARVESTING

WHAT? Capturing roof runoff for non-potable uses, such as irrigation, car washing, toilet flushing, and potable uses.

WHY?
1. To capture and use valuable freshwater resource
2. To reduce volume of stormwater discharged off-site
3. Save and maintain groundwater.
4. Save and enhance vegetation
5. Reduce salt water intrusion.
Runoff Use Consumption Reduction

Save $100 / yr.
LID BMP - STORMWATER HARVESTING

WHAT? Using retained or detained stormwater for non-potable uses, such as irrigation, car washing, toilet flushing, wetland enhancement, etc.

WHY?
1. To lower the cost of water supply.
2. Increase BMP effectiveness and reduce stormwater pollution into surface waters.
3. Save and maintain groundwater.
4. Save and enhance vegetation.
5. Reduce salt water intrusion.
STORMWATER HARVESTING
DESIGN CONSIDERATIONS

• Design with REV curves
• Determine EIA = C*A to get storage volume
• Must be pretreated = horizontal well or equiv
• Over 600 horizontal wells in Florida
• Determine irrigation schedule
South Bay Utilities Inc.

- Upscale residential
- Some Commercial
- No CUP
- No FPSC

- $0.50/1,000 gallons
- Shallow horizontal wells
- Customer agreements
  900 homes - HOA
Schroeder Manatee Utilities, Inc.

- Approximately 32,000 acre service area
- Lower potable water requirements
- Exclusive service area

- 27¢/1,000 gallons - FPSC
- Horizontal wells, lakes, canals, shallow 4” wells
- Use of approximately 4 MGD
Regional wet detention pond serving roadway and commercial property

Water harvesting for irrigation of lawns
Community saved potable water as well as money.
Golf Course and I-4 Stormwater Management Plan

• Plan – Provide water on golf course to improve the play and image of the course.
• FDOT – We got the water for you.
• WIN WIN  FDOT and a high school gets stormwater plans, citizens get a real golf course.
• All get stormwater treatment and saving of potable water that would otherwise be used for irrigation.
• And oh yes, Wekiva is protected.
Enhanced Nitrogen Removal of a Detention Pond by Harvesting the Detained Water

- 88% of water not discharged: N mass removed is $100[1-\{(1-.88)(1-.4)\}] = 93$
- 88 acre-feet supplied to 48 acres (from 24 acres, 50 inch rain, @ 88%)
- @$2.00/1000$ gallons, net revenue is about $1000/acre irrigated/year.*
- make up water is = Need – Harvested = 145.6 – 88 = 57.6 Acre-Feet.

*Assumes a production and delivery cost of about $0.45/1000$ gallons.
KEY POINTS

- The harvesting pond is considered as a supplemental water supply.
- Can be managed to benefit downstream and local users.
- Water use agreements are needed (supplemental supply).
- Must have a storage area (existing pond or new area) and storage can be underground.
- Since pumps are used, must maintain operating records using meters or flow time operation.
- Over 600 Systems have been designed and permitted in the State.
HOW TO DESIGN EFFECTIVE STORMWATER BMP TREATMENT TRAINS AND QUANTIFY LOAD REDUCTIONS

• Presumptive design criteria not useful for discharges to impaired water bodies
• Must be able to quantify the pre-development stormwater loadings
• Must be able to quantify the post-development stormwater loadings
• Must be able to quantify and demonstrate “net improvement”
BMPTRAINS MODEL

- Model developed in cooperation with DEP, WMDs
- Model is in the public domain
- Model incorporates the latest information relative to designing stormwater treatment systems in Florida:
  - Florida annual rainfall by zones
  - Statewide Event Mean Concentrations
  - Statewide stormwater BMP effectiveness data
  - Latest LID BMP effectiveness data
  - Stormwater LID BMP design criteria (developed for Statewide Stormwater Rule and refined)
Water is the lifeblood of Florida