WHEN ARE HIGHER LEVELS OF STORMWATER LOAD REDUCTIONS REQUIRED AND USING LID BMPs TO ACHIEVE THEM

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Orlando, January 2020
• Florida stormwater program
• What and where are impaired waters?
• Treatment requirements for impaired waters
• Design criteria for Low Impact Design BMPs
• LID design and BMPTRAINS load reduction effectiveness
THE STORMWATER PROBLEM

Humans cause:
• Changes in land use, clearing of land
• Compaction of soil, imperviousness
• Development in floodplains, wetlands
• Alteration of natural stormwater systems
• Addition of efficient “drainage” systems
• Addition of pollutants

Resulting in:
• Decreased recharge
• Increased speed of runoff
• Increased volume of runoff
• Increased pollutant loads
<table>
<thead>
<tr>
<th>Year</th>
<th>Chapter</th>
<th>Rule Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>Chapter 17</td>
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DEP/WMD Applicant Handbooks ERP

TECHNOLOGY BASED
- Performance Standard
- BMP Design Criteria
- Presumption of compliance
- Updating of BMP Design Criteria
PERFORMANCE STANDARD FOR NEW STORMWATER DISCHARGES (62-40.432, FAC)

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

Stormwater quality – 1990 – 62-40 revised
- 80% average annual load reduction
- 95% average annual load reduction
  “Of pollutants that cause or contribute to violations of water quality standards”

BUT BMP DESIGN CRITERIA WERE NEVER UPDATED
This section provides an analysis of potential modifications to existing stormwater design criteria within the State of Florida to meet the performances objectives outlines 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 water body, the performance criteria increase to a 95% reduction. Based on the analyses presented in Section 5.2, with the exception of the SJRWMD 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.”
BMP LOAD REDUCTION EFFECTIVENESS

Retention BMPs

- 0.5” treatment volume provides from 42.6% to 92.1% load reduction depending on % DCIA and non-DCIA CN

Wet detention systems

- Treatment related to residence time

\[
\text{Efficiency} = \frac{44.72 \cdot t_d}{5.46 + t_d} \quad R^2 = 0.808
\]

\[
\text{Percent Removal} = 40.15 + 6.366 \cdot \ln(t_d) + 0.214 \cdot (\ln(t_d))^2 \quad R^2 = 0.8941
\]
EVOLUTION OF STORMWATER BMPs

- Florida based BMP research and field monitoring
- Funded by DEP, FDOT, WMDs, local governments
- Focus on traditional and innovative BMPs
- FDEP 10-yr LID BMP research/monitoring program
- Results online:
  - http://stormwater.ucf.edu/
  - https://stars.library.ucf.edu/bmptrains/
2010 UNIFIED STORMWATER RULE CONCEPTS

- Increase nutrient load removal (TN, TP)
- 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 section
- LID BMP design, construction, OM criteria
WHEN ARE HIGHER LEVELS OF STORMWATER TREATMENT REQUIRED?

Discharges to OFWs
- Must meet “anti-degradation” standard
- Presumptive = 95% load reduction
- Net improvement also is anti-degradation

Discharges to Impaired Waters
- Must meet “net improvement” standard
- Must demonstrate load reduction achieved
IMPAIRED WATERS IN FLORIDA

- 2,776 spreadsheet lines of water bodies in cumulative FDEP 303(d) list!
- Most common impairments are nutrients, DO and fecal coliforms
# Impaired Waters in Florida

## Table 7.4b. Acres of Lakes Impaired by Cause

<table>
<thead>
<tr>
<th>Identified Cause</th>
<th>Waterbody Type</th>
<th>Units</th>
<th>Number of Lake Segments Identified as Impaired</th>
<th>Total Water Size for Lake Segments Identified as Impaired</th>
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<tbody>
<tr>
<td>Trophic Status</td>
<td>Lake</td>
<td>Acres</td>
<td>224</td>
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<td>DO</td>
<td>Lake</td>
<td>Acres</td>
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<td>Mercury (in fish tissue)</td>
<td>Lake</td>
<td>Acres</td>
<td>91</td>
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<td>Historic TSI</td>
<td>Lake</td>
<td>Acres</td>
<td>43</td>
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<td>TSI Trend</td>
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<td>Acres</td>
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<td>Fecal Coliform</td>
<td>Lake</td>
<td>Acres</td>
<td>11</td>
<td>1,533</td>
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<td>Iron</td>
<td>Lake</td>
<td>Acres</td>
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<td>Lead</td>
<td>Lake</td>
<td>Acres</td>
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<td>Copper</td>
<td>Lake</td>
<td>Acres</td>
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<td>Turbidity</td>
<td>Lake</td>
<td>Acres</td>
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<td>Unionized Ammonia</td>
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<td>Silver</td>
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<td>Acres</td>
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<td>Nutrients (Other)</td>
<td>Lake</td>
<td>Acres</td>
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<td>pH</td>
<td>Lake</td>
<td>Acres</td>
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<td>Thallium</td>
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<td>538</td>
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## Table 7.4c. Acres of Estuaries Impaired by Cause

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<th>Identified Cause</th>
<th>Waterbody Type</th>
<th>Units</th>
<th>Number of Estuary Segments Identified as Impaired</th>
<th>Total Water Size for Estuary Segments Impaired (without Canal)</th>
<th>Total Water Size for Estuary Segments Impaired (with Canal)</th>
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<tbody>
<tr>
<td>Mercury (in fish tissue)</td>
<td>Estuary</td>
<td>Acres</td>
<td>473</td>
<td>1,331,200</td>
<td>1,331,200</td>
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<td>DO</td>
<td>Estuary</td>
<td>Acres</td>
<td>166</td>
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<td>Fecal Coliform</td>
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<td>Acres</td>
<td>113</td>
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<td>Nutrients (Chlorophyll a)</td>
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<td>Bacteria (SEAS Classification)</td>
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<td>Nutrients (Historic TSI)</td>
<td>Estuary</td>
<td>Acres</td>
<td>33</td>
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<td>Copper</td>
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<td>Iron</td>
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<td>Lead</td>
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<td>Nutrients (Other)</td>
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<td>Acres</td>
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<td>Dioxin (in fish tissue)</td>
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<td>Nickel</td>
<td>Estuary</td>
<td>Acres</td>
<td>1</td>
<td>2,808</td>
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<tr>
<td>Turbidity</td>
<td>Estuary</td>
<td>Acres</td>
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<td>878</td>
<td>878</td>
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<tr>
<td>Total</td>
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<td>1,043</td>
<td>2,597,957</td>
<td>2,597,957</td>
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</table>
WHEN IS A PROJECT SUBJECT TO THE “NET IMPROVEMENT” TREATMENT PERFORMANCE STANDARD?

- Current ERP rules and AH’s DO NOT specify when net improvement is required or what it means
- Check with DEP or the applicable WMD
- Net Improvement may be needed if your project is within:
  - The 12 digit HUC (subwatershed)
  - The impaired WBID
  - An impaired WBID with an adopted TMDL
  - A WBID within the area for an adopted BMAP
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 discharges to an impaired water body or water body with an adopted TMDL. Is project within the WBID boundary, the 12 unit HUC (subwatershed), or the BMAP boundary.
- Use DEP’s **TMDL Tracker** system to see if a TMDL is adopted, or check **Chapter 62-304, F.A.C.**
Select DEAR
Then select Verified List WBIDs and TMDLs
SELECT BASEMAP AND DATA LAYERS

1. Select Basemap from options at arrow in left bottom of map.
2. Open Data Layers by clicking on arrow at upper left of map, and then on + More Data.
1. From NHD Data Layer
   Select HUC 12 sub-watershed
2. From Watershed Assessment
   a. Select WBIDs
   b. Select BMAPs
1. Be sure desired data layers are turned “on”
2. Enter address into search box in upper right hand corner
3. Results for each data layer will be shown
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 from master drainage system
- MS4 permit requires reducing pollutant loads to achieve TMDLs and BMAPs
- 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.
WHAT IS “NET IMPROVEMENT”? 

Verified impaired water body

- DEP/WMDs require one pound less loading of the pollutant(s) causing impairment after development
- Pinellas and Alachua County define as post-development load is at least 10% less than the pre-development loading to help meet TMDL and BMAP load reductions.

Impaired water body with adopted TMDL

- Post-development Load < Pre-development load – WLA % reduction
NET IMPROVEMENT = VERY HIGH LEVEL OF STORMWATER 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** include when, where, how long, how intense, time between storms
- **Natural site variables** include soils, geology, SHWT, topography, vegetation
- **Human site variables** include land use, site design, soil compaction, percent imperviousness, % DCIA
## Stormwater Event Mean Concentrations

**Florida EMC data base – June 2016**

**AWT wastewater**

**TN = 3mg/l**

**TP = 1 mg/l**

<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>
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<td>Low Density Residential(^1)</td>
<td>1.64</td>
<td>0.270</td>
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<td>Single Family</td>
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<td>37.50</td>
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<td>Multi-Family</td>
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<td>0.520</td>
<td>11.30</td>
<td>77.90</td>
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<td>Low Intensity Commercial</td>
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<td>7.60</td>
<td>59.90</td>
<td>0.017</td>
<td>0.083</td>
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<td>High Intensity Commercial</td>
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<td>69.70</td>
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<td>Light Industrial</td>
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<td>7.60</td>
<td>60.00</td>
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<td>46.00</td>
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<td>Natural - Wet Prairie</td>
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<td>Natural – Wet Flatwoods</td>
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<td>Natural – Radiata Upland Pine</td>
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1. Average of single-family and undeveloped values
HOW DO WE REDUCE STORMWATER LOADING?

• Reduce stormwater pollutant concentrations
• Reduce stormwater volume

• Better site design – integrate stormwater into site
• Minimize imperviousness, especially DCIA
• Reduce pollutants using source controls including public education
• BMP Treatment Train with nonstructural and structural stormwater BMPs
WHAT IS LOW IMPACT DESIGN?

- Comprehensive watershed or site planning approach
- Hydrology is integrating framework
- Maintain predevelopment volume, hydrology, loadings
- 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 DESIGN 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 don’t work throughout Florida

LID is NOT a new idea

- “Designing with Nature” 1969 book by Ian McHarg
- FL SW program always has promoted retention BMPs
WHY LID?
ADDED BMPS IN YOUR 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 PROJECTS IN FLORIDA

Madera, Gainesville

Baldwin Park, Orlando

River Forest, Bradenton

Town of Harmony
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
- Local government Land Development Code incentives
BEST MANAGEMENT PRACTICES (BMPs)

• Control techniques used for a given set of conditions to manage stormwater quantity and quality in the most cost effective manner.
• Florida’s ERP handbooks only include design criteria for traditional BMPs – retention basins, wet detention ponds, sand filters
• How do I design LID BMPs?
  • Pinellas County Stormwater Manual
  • Alachua County Stormwater Treatment Manual
  • Escambia County LID Manual
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<td>SP1</td>
<td>Inventory Site Assets: Hydrology</td>
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<td>Inventory Site Assets: Topography</td>
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<td>SP5</td>
<td>Preserve Open Space</td>
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<td>SP6</td>
<td>Natural Area Conservation - Retain Tree Canopy and Native Landscapes</td>
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<td>SP7</td>
<td>Cluster Design</td>
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<td>SP8</td>
<td>Maximize Gross Density</td>
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<td>Minimize Building Footprint</td>
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<td>SP10</td>
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<td>SC1</td>
<td>Protect Surface Waters and Wetlands</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SC2</td>
<td>Retain Natural Landscape Depressions</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SC3</td>
<td>Minimize Clearing and Grading</td>
<td></td>
<td>N/A</td>
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</tr>
<tr>
<td>SC4</td>
<td>Minimize Soil Disturbance and Compaction</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SC5</td>
<td>Build with Landscape Slope</td>
<td></td>
<td>N/A</td>
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<tr>
<td>SC6</td>
<td>Retain Native Landscapes at the Lot Level</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SC7</td>
<td>Florida-friendly Landscapes and Fertilizers</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC8</td>
<td>Rainfall Interceptor Trees</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC9</td>
<td>Install Efficient Irrigation Systems</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SC10</td>
<td>Use Non-potable Water Supply for Irrigation</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SC11</td>
<td>Community and Home Owner Education</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Structural BMPs</th>
<th>Structural Stormwater BMPs</th>
<th>Completed or Used</th>
<th>N/A</th>
<th>Load Reduction Credit</th>
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<tbody>
<tr>
<td>SW1</td>
<td>Retention Basin</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SW2</td>
<td>Exfiltration Trench</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SW3</td>
<td>Underground Storage and Retention</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>SW4</td>
<td>Rain Gardens</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SW5</td>
<td>Treatment Swales</td>
<td></td>
<td>N/A</td>
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</tr>
<tr>
<td>SW6</td>
<td>Vegetate Natural Buffers</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SW7</td>
<td>Pervious Pavements</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SW8</td>
<td>Green Roofs with Cisterns</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SW9</td>
<td>Rainwater Harvesting/Cisterns</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>SW10</td>
<td>Wet Detention Systems</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SW11</td>
<td>Stormwater Harvesting/ Horizontal Wells</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>SW12</td>
<td>Up-Flow Filter Systems</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SW13</td>
<td>Managed Aquatic Plant Systems</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>SW14</td>
<td>Biofiltration Systems/Tree Box Filters</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
NATURAL AREA CONSERVATION

• Credit for preserving natural areas
PLANTING TREES IN URBAN AREAS
INTERCEPTS AND EVAPORATES RAIN AND REDUCES STORMWATER VOLUME AND LOADS

Interceptor Tree BMP
Up to 18% reduction in stormwater volume

NEED MORE DATA AND SITES!
## TREES ARE STORMWATER BMPS!
American Forests (www.americanforests.org)

### Table 1: Land Cover Changes in City of Jacksonville

<table>
<thead>
<tr>
<th>Land Cover Type</th>
<th>1992 Acres</th>
<th>2002 Acres</th>
<th>% Change of Landcover Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest/woody</td>
<td>234,262.4</td>
<td>205,320.0</td>
<td>-12.4%</td>
</tr>
<tr>
<td>Forest/wetlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Space</td>
<td>48,692.9</td>
<td>59,825.0</td>
<td>22.9%</td>
</tr>
<tr>
<td>Developed Area</td>
<td>150,869.8</td>
<td>175,685.3</td>
<td>16.4%</td>
</tr>
<tr>
<td>Open Wetlands</td>
<td>49,745.5</td>
<td>45,816.7</td>
<td>-7.9%</td>
</tr>
<tr>
<td>Water</td>
<td>56,772.9</td>
<td>55,787.0</td>
<td>-1.7%</td>
</tr>
</tbody>
</table>

### Table 2: Stormwater Management Values in City of Jacksonville

<table>
<thead>
<tr>
<th>Land Cover Type</th>
<th>Forest/Woody Wetlands (acres)</th>
<th>Stormwater Management Value (cu.ft.)</th>
<th>Stormwater Management Value** ($)</th>
<th>Air Pollution Annual Removal Value (lbs.)</th>
<th>Air Pollution Annual Removal Value ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Jacksonville 1992</td>
<td>234,262</td>
<td>984 million</td>
<td>$1.97 billion</td>
<td>22.3 million</td>
<td>$55.4 million</td>
</tr>
<tr>
<td>City of Jacksonville 2002</td>
<td>205,320</td>
<td>928 million</td>
<td>$1.86 billion</td>
<td>19.6 million</td>
<td>$48.5 million</td>
</tr>
<tr>
<td>Change</td>
<td>-12.4%</td>
<td>-56 million</td>
<td>-113 million</td>
<td>-2.76 million</td>
<td>-6.84 million</td>
</tr>
</tbody>
</table>
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

Land Development Codes must be revised
The Influence of DCIA on Stormwater Volume Zone 2 Runoff Coefficients

<table>
<thead>
<tr>
<th>Agriculture land use (pasture)</th>
<th>SF residential land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>- No DCIA, CN for D soils = 85</td>
<td>¼ acre lots - DCIA = 40%, CN for lawns, D soils = 85</td>
</tr>
<tr>
<td>C = .160</td>
<td>C = .420</td>
</tr>
</tbody>
</table>

| NDCIA  | 0    | 5    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   | 50   | 55   | 60   | 65   | 70   | 75   | 80   | 85   | 90   | 95   | 100  |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| CN     | 0.002| 0.043| 0.083| 0.123| 0.164| 0.204| 0.244| 0.285| 0.325| 0.366| 0.406| 0.446| 0.487| 0.527| 0.567| 0.608| 0.648| 0.688| 0.729| 0.769| 0.809|
| 35     | 0.004| 0.044| 0.085| 0.125| 0.165| 0.205| 0.246| 0.286| 0.326| 0.366| 0.407| 0.447| 0.487| 0.528| 0.568| 0.608| 0.648| 0.688| 0.729| 0.769| 0.809|
| 40     | 0.007| 0.047| 0.087| 0.127| 0.167| 0.207| 0.248| 0.288| 0.328| 0.368| 0.408| 0.448| 0.488| 0.528| 0.568| 0.608| 0.648| 0.688| 0.729| 0.769| 0.809|
| 45     | 0.010| 0.050| 0.090| 0.130| 0.170| 0.210| 0.250| 0.290| 0.330| 0.370| 0.410| 0.450| 0.490| 0.530| 0.570| 0.610| 0.650| 0.690| 0.729| 0.769| 0.809|
| 50     | 0.015| 0.055| 0.095| 0.134| 0.174| 0.214| 0.254| 0.293| 0.333| 0.373| 0.412| 0.452| 0.492| 0.531| 0.571| 0.611| 0.651| 0.690| 0.729| 0.769| 0.809|
| 55     | 0.022| 0.061| 0.101| 0.140| 0.179| 0.219| 0.258| 0.298| 0.337| 0.376| 0.416| 0.455| 0.494| 0.534| 0.573| 0.613| 0.652| 0.691| 0.731| 0.770| 0.809|
| 60     | 0.030| 0.069| 0.108| 0.147| 0.186| 0.225| 0.264| 0.303| 0.342| 0.381| 0.420| 0.459| 0.498| 0.537| 0.576| 0.615| 0.654| 0.693| 0.731| 0.770| 0.809|
| 65     | 0.042| 0.080| 0.119| 0.157| 0.195| 0.234| 0.272| 0.311| 0.349| 0.387| 0.426| 0.464| 0.502| 0.541| 0.579| 0.618| 0.656| 0.694| 0.731| 0.771| 0.809|
| 70     | 0.057| 0.095| 0.133| 0.170| 0.208| 0.245| 0.283| 0.321| 0.358| 0.396| 0.433| 0.471| 0.509| 0.546| 0.584| 0.621| 0.659| 0.697| 0.734| 0.772| 0.809|
| 75     | 0.079| 0.116| 0.152| 0.189| 0.225| 0.262| 0.298| 0.335| 0.371| 0.408| 0.444| 0.481| 0.517| 0.554| 0.590| 0.627| 0.663| 0.700| 0.736| 0.773| 0.809|
| 80     | 0.111| 0.146| 0.181| 0.216| 0.251| 0.285| 0.320| 0.355| 0.390| 0.425| 0.460| 0.495| 0.530| 0.565| 0.600| 0.635| 0.670| 0.705| 0.740| 0.774| 0.809|
| 85     | 0.160| 0.192| 0.225| 0.257| 0.290| 0.322| 0.355| 0.387| 0.420| 0.452| 0.485| 0.517| 0.550| 0.582| 0.614| 0.647| 0.679| 0.712| 0.744| 0.777| 0.809|
| 90     | 0.242| 0.270| 0.299| 0.327| 0.355| 0.384| 0.412| 0.440| 0.469| 0.497| 0.526| 0.554| 0.582| 0.611| 0.639| 0.667| 0.696| 0.724| 0.753| 0.781| 0.809|
| 95     | 0.404| 0.424| 0.444| 0.464| 0.485| 0.505| 0.525| 0.546| 0.566| 0.586| 0.606| 0.627| 0.647| 0.667| 0.688| 0.708| 0.728| 0.749| 0.769| 0.789| 0.809|
| 88     | 0.595| 0.605| 0.616| 0.627| 0.638| 0.648| 0.659| 0.670| 0.680| 0.691| 0.702| 0.713| 0.723| 0.734| 0.745| 0.756| 0.766| 0.777| 0.788| 0.799| 0.809|
REDUCING PARKING LOT IMPERVIOUSNESS AND DCIA
DISCONNECTING DIRECTLY CONNECTED IMPERVIOUS AREAS (DCIA)
RECESSED ROAD MEDIANS AS BMPs
SOURCE CONTROL BMPs

SC1 – Protect waters/wetlands
SC2 - Retain depression storage
SC3 – Selective clearing/grading
SC4 - Minimize compaction
SC5 - Build with slope
SC6 - Retain native plants

SC7 - Florida-friendly landscape
SC8 - Rainfall interception trees
SC9 - Install efficient irrigation
SC10 - Harvest and use stormwater
SC11 - Public education
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 design
  - Florida-friendly fertilizers
  - Proper use of reclaimed water
  - Pet waste pick up and disposal
LAND CLEARING, VEGETATION REMOVAL AND SOIL COMPACTION

80% compaction on first pass of equipment
## Soil Compaction and Infiltration Rates

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Infiltration Rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy soils</td>
<td>Pitt et. al. 13.0</td>
</tr>
<tr>
<td></td>
<td>Gregory 14.8 – 25</td>
</tr>
<tr>
<td>Compacted sandy soils</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>0.3 - 6.9</td>
</tr>
<tr>
<td>Clay soils</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Compacted or wet clay soils</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>NA</td>
</tr>
</tbody>
</table>

Source: Pitt, Chen, and Clark, 2001; Gregory et. Al, 2006
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

DACS Urban Turf Fertilizer Label Rule

- Effective July 1, 2009
- Only specified fertilizers on turf
  - No or low phosphorus (< 0.5%)
  - Slow release nitrogen encouraged
- Maximum application rates
  - 0.25 lbs P/1000 sf per application
  - 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 Nitrigen (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.

15 - 0 - 15

(N) Total Nitrogen
(P₂O₅) Phosphorus
(K₂O) Potassium
RAINFALL INTERCEPTOR TREES

Interceptor Tree BMP
Up to 18% reduction in stormwater volume

Interim BMP
Need more data!
Use in Pinellas and Alachua Counties
<table>
<thead>
<tr>
<th>Retention BMPs</th>
<th>Harvest &amp; Reuse BMPs</th>
<th>Filtration BMPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Basins</td>
<td>• Greenroof/cistern</td>
<td>• Managed aquatic plants</td>
</tr>
<tr>
<td>• Exfiltration trenches</td>
<td>• Rainwater harvesting</td>
<td>• Upflow filters</td>
</tr>
<tr>
<td>• Underground retention storage</td>
<td>• Wet detention</td>
<td>• Biofiltration with BAM</td>
</tr>
<tr>
<td>• Swales</td>
<td>• Stormwater harvesting</td>
<td></td>
</tr>
<tr>
<td>• Vegetated natural buffers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Rain gardens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pervious pavements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## LID BMPS AND GETTING AN ENVIRONMENTAL RESOURCE PERMIT

<table>
<thead>
<tr>
<th>LID BMP</th>
<th>WMD ACCEPTABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain garden (bioretention)</td>
<td>Retention BMP</td>
</tr>
<tr>
<td>Swales</td>
<td>Retention BMP</td>
</tr>
<tr>
<td>Vegetated Natural Buffers</td>
<td>Limited use, check with staff</td>
</tr>
<tr>
<td>Pervious pavements</td>
<td>Retention BMP</td>
</tr>
<tr>
<td>Green roof with cistern</td>
<td>Retention and reuse BMP</td>
</tr>
<tr>
<td>Rainwater harvesting</td>
<td>Retention BMP, not rain barrel</td>
</tr>
<tr>
<td>Stormwater harvesting</td>
<td>Check with staff</td>
</tr>
<tr>
<td>Biofiltration with BAM</td>
<td>Filtration BMP</td>
</tr>
</tbody>
</table>
RETENTION (INfiltration) PRACTICES

DESCRIPTION: Family of practices where the stormwater is infiltrated or evaporated rather than discharged.

PURPOSE:
- Reduce total volume
- Reduce pollutants

POLLUTANT REMOVAL:
- Percolation, evaporation
- Filtering and adsorption
- Effectiveness = % annual runoff retained
RETENTION BMP TREATMENT VOLUME AND LOAD REDUCTION EFFECTIVENESS

Required Treatment Volume
SWFWMD – off-line - 0.5” runoff
-- on-line – runoff from 1” rain
-- OFW - 50% more volume

Required Treatment Volume
SJRWMD – off-line – 1.25” * % Imp or 0.5” runoff
-- on-line – additional 0.5” runoff
-- OFW - 50% more volume

Mean Annual Mass Removal Efficiencies for 0.60-inches of Retention in Zone 2

<table>
<thead>
<tr>
<th>NDCIA CN</th>
<th>Percent DCIA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>72.7</td>
</tr>
<tr>
<td>35</td>
<td>70.3</td>
</tr>
<tr>
<td>40</td>
<td>68.0</td>
</tr>
<tr>
<td>45</td>
<td>65.3</td>
</tr>
<tr>
<td>50</td>
<td>64.5</td>
</tr>
<tr>
<td>55</td>
<td>62.3</td>
</tr>
<tr>
<td>60</td>
<td>60.4</td>
</tr>
<tr>
<td>65</td>
<td>58.7</td>
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<tr>
<td>70</td>
<td>57.3</td>
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<tr>
<td>75</td>
<td>55.9</td>
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<tr>
<td>80</td>
<td>54.7</td>
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<tr>
<td>85</td>
<td>53.5</td>
</tr>
<tr>
<td>90</td>
<td>52.1</td>
</tr>
<tr>
<td>95</td>
<td>49.8</td>
</tr>
<tr>
<td>100</td>
<td>47.8</td>
</tr>
</tbody>
</table>

Treatment effectiveness varies from 45.1% to 97%
### RETENTION BMP TREATMENT VOLUME TO GET 80% LOAD REDUCTION EFFECTIVENESS

Central (Zone 2)

<table>
<thead>
<tr>
<th>NDCIA CN</th>
<th>Percent DCIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.22, 0.24, 0.32, 0.40, 0.46, 0.51, 0.60, 0.67, 0.73, 0.80, 0.87, 0.94, 1.01, 1.08, 1.15, 1.22, 1.29, 1.36, 1.43</td>
</tr>
<tr>
<td>15</td>
<td>0.23, 0.24, 0.33, 0.41, 0.46, 0.52, 0.60, 0.67, 0.73, 0.80, 0.88, 0.94, 1.01, 1.08, 1.15, 1.22, 1.29, 1.36, 1.43</td>
</tr>
<tr>
<td>20</td>
<td>0.23, 0.26, 0.35, 0.42, 0.47, 0.53, 0.61, 0.68, 0.74, 0.81, 0.88, 0.95, 1.01, 1.09, 1.16, 1.22, 1.29, 1.36, 1.43</td>
</tr>
<tr>
<td>25</td>
<td>0.24, 0.28, 0.37, 0.43, 0.48, 0.55, 0.62, 0.69, 0.74, 0.82, 0.89, 0.95, 1.02, 1.09, 1.16, 1.22, 1.29, 1.36, 1.43</td>
</tr>
<tr>
<td>30</td>
<td>0.27, 0.32, 0.39, 0.45, 0.49, 0.57, 0.64, 0.70, 0.76, 0.83, 0.90, 0.96, 1.03, 1.10, 1.16, 1.23, 1.30, 1.37, 1.43</td>
</tr>
<tr>
<td>35</td>
<td>0.35, 0.38, 0.42, 0.47, 0.52, 0.59, 0.66, 0.71, 0.77, 0.84, 0.91, 0.97, 1.04, 1.11, 1.17, 1.23, 1.30, 1.37, 1.43</td>
</tr>
<tr>
<td>40</td>
<td>0.45, 0.44, 0.46, 0.50, 0.56, 0.62, 0.68, 0.73, 0.80, 0.86, 0.93, 0.98, 1.05, 1.11, 1.18, 1.24, 1.30, 1.37, 1.43</td>
</tr>
<tr>
<td>45</td>
<td>0.57, 0.52, 0.53, 0.56, 0.61, 0.66, 0.71, 0.76, 0.83, 0.89, 0.95, 1.00, 1.06, 1.13, 1.19, 1.25, 1.31, 1.37, 1.43</td>
</tr>
<tr>
<td>50</td>
<td>0.70, 0.65, 0.63, 0.65, 0.68, 0.72, 0.76, 0.81, 0.87, 0.92, 0.97, 1.03, 1.09, 1.14, 1.20, 1.25, 1.31, 1.37, 1.43</td>
</tr>
<tr>
<td>55</td>
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<tr>
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<tr>
<td>75</td>
<td>1.35, 1.34, 1.33, 1.33, 1.32, 1.32, 1.32, 1.33, 1.33, 1.34, 1.35, 1.36, 1.37, 1.38, 1.39, 1.41, 1.42, 1.43</td>
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<td>80</td>
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</tr>
</tbody>
</table>

**Required Treatment Volume from tables varies from 0.22” to 1.43” in Zone 2**
RETENTION BMP DESIGN CRITERIA

- Determine **Required Treatment Volume** from Tables based on required % load reduction
- Ensure both **RTV** and flood control volumes can be stored safely
- Recover **RTV** within 24-36 hrs if vegetated
- **SHGWT at least 2’ beneath bottom** of retention BMP, must consider mounding
- Sides and bottom must be stabilized by Florida-friendly vegetation, other pervious materials or as approved
- Do not construct within 50 feet of potable well or within 15 feet of OSTDS (Note: setback to private potable well is 75’
GETTING GOOD INFILTRATION DATA FOR RETENTION BMP DESIGN

- See Appendix A of Manual
- Measure at proposed bottom elevation
- Allowable data
  - Mass balance field data
  - Double ring infiltrometer *
  - Lab permeability tests *
  - NRCS soil survey - planning only
* Use half of the value
RETENTION BMP CONSTRUCTION

- Locate and mark locations of all retention BMPs
- Prevent traffic and equipment from entering to minimize soil compaction
- Excavate with lightweight equipment with tracks not tires
- Initially excavate to within 12” of design bottom
- Do not use for erosion/sediment control during construction
- Once drainage area stabilized, remove accumulated materials and excavate to final bottom elevation. Deep rake or till the bottom to compensate for compaction.
- Vegetate and landscape per plans.
EXFILTRATION TRENCH

DESCRIPTION: An underground retention system consisting of an inlet and perforated pipe within a gravel envelope where the stormwater is infiltrated rather than discharged.

PURPOSE:
- Reduce total volume
- Reduce pollutants

POLLUTANT REMOVAL:
- Percolation, evaporation
- Filtering and adsorption
- Effectiveness = % annual runoff retained
Exfiltration Trench Design Criteria

1. Follow retention BMP requirements
2. RTV from Tables
3. 12” minimum perforated pipe diameter with minimum of 3’ of trench
4. Pretreatment is essential
5. Pipe not exceed 45° bend
6. Aggregate must be washed to remove fines
7. Trench enclosed within filter fabric
8. Must have OM access via manhole, inspection ports, or observation wells
9. Pretreatment baffle trash tee at inflow and 24” sump with 12” weep hole
UNDERGROUND STORAGE AND RETENTION SYSTEM

DESCRIPTION: An underground retention system consisting of an inlet and modular storage units with an open bottom allowing the stormwater to be infiltrated rather than discharged.

PURPOSE:
• Reduce total volume
• Reduce pollutants

POLLUTANT REMOVAL:
• Percolation, evaporation
• Filtering and adsorption
• Effectiveness = % annual runoff retained
Underground Retention Design Criteria

1. Follow Exfiltration Trench BMP requirements
2. RTV from Tables
3. Pretreatment essential
4. Follow manufacturer’s recommendations
5. 12” minimum perforated pipe diameter with minimum of 3’ of trench
6. Pipe not exceed 45° bend
7. Aggregate must be washed to remove finesds
8. Trench enclosed within filter fabric
9. Must have OM access via manhole, inspection ports, or observation wells
10. Pretreatment baffle trash tee at inflow and 24” sump with 12” weep hole
LID BMP RAIN GARDEN

- Small retention depressions integrated into the landscaping with deep rooted Florida-friendly vegetation.
- http://lowimpactdevelopment.org/raingarden_design/whatisarain garden.htm
RAIN GARDEN DESIGN CRITERIA

- Contributing DA <3 acres
- RTV from Tables
- Ponding depth – 4 to 10 inches
- Location – sunny, on slopes <10%, at least 10’ from buildings
- Vegetation – See table of plants. Depends on planting zones, dry to wet zones, need a good plan
- Mulch – use materials that won’t float
RAIN GARDEN DESIGN CALCULATIONS

- Contributing DA (<3 acres)
- Ponding depth (4 to 10 inches)
- Retention or detention system?
- BAM used? If yes, which one and % removal
- Sustainable void space - .20
- Water above media volume? (ponding depth)
- Media volume?

Treatment Volume and Load Reduction are calculated from above information
RAIN GARDEN CONSTRUCTION

- Determine final shape and location after locating utilities, mark on ground
- Excavate the garden, use soil for berm
- Prepare and add soil/media mixture (BAM)
- Install plants per the design, 1’ On Center
- Apply mulch (if used)
- Water plants regularly
- Check conveyance inflow, water storage, and infiltration rate
• A vegetated area with soil and water table conditions that allow filtering and infiltration of overland flows.
• Limited Use BMP - Used to treat rear roof and yard runoff when impractical to route to main stormwater system.
• Treatment based on retention volume that is infiltrated
• Infiltrate RTV from Tables
• SHGWT > two feet below bottom
• 1” minimum infiltration rate
• 25’ minimum flow length, = length of CA
• 100’ maximum width
• 6:1 maximum slope
• Legal easement for VNB
VEGETATED NATURAL BUFFERS CONSTRUCTION

- Verify location and dimensions of VNB
- Install erosion and sediment controls and divert flows until contributing area construction is complete/stabilized
- Mark VNB boundaries to prevent compaction from equipment
- Install upstream level spreader
- Ensure vegetation is healthy, add Florida-friendly plants as needed
A manmade trench which:
- Has a top width-to-depth ratio of 6:1 or greater
- Has areas of standing or flowing water only after a rain
- Is planted with vegetation suitable for soil stabilization, stormwater treatment, nutrient uptake
- Designed for soil erodibility, soil percolation, slope, slope length, and the drainage area
- Designed to prevent erosion and reduce pollutants
USE OF SWALES

Types:
• Linear retention treatment swale
• Conveyance swales

Uses:
• Along streets, rural road sections
• Residential subdivisions
• Pretreatment (BMP Treatment Train)
  ▪ Any land use type, parking lots
  ▪ Before infiltration trenches, wet ponds
• With enhancements
  ▪ Swale blocks
  ▪ Shallow longitudinal slopes (settling)
  ▪ Raised driveway culverts
SWALE DESIGN CRITERIA

OBJECTIVES
• Conveyance and Water quality

DESIGN CONSIDERATIONS
• Depends on type of swale
• Soil infiltration - HSG A,B soils
• Pavement edge protection
• Slope - flat as possible
• Cross-section - triangular, trapezoidal
• Side slopes - 3:1 or flatter
• Bottom width – usually at least 2 feet
• Vegetation - lawn grasses, native grasses, wildflowers, shrubs
Equation 5.7.2. Swale length for Trapezoidal Shaped Swales

\[ L = \frac{43,200 \, Q}{\frac{3}{16} \left\{ B + 2 \left( \frac{1.068 \, n \, Q \, (1 + Z^2)^{1/3}}{S^2 \, Z^{-1/3} \, 2 \, [(1 + Z^2)^{1/3} - Z]} \right) (1 + S^2)^{1/3} \right\}} \]

Where:
L = Length of swale (ft)
B = Bottom width of swale (ft)
Q = Average flow rate (cfs) from Equation 5.7.1
n = Manning’s Roughness Coefficient
Z = Side slope (horizontal distance for a one foot vertical change)
S = Longitudinal slope
i = Limiting infiltration rate of swale (inches/hour)
LID BMP: PERVIOUS PAVEMENTS

- Pervious concrete
- Pervious pavers
- Turf block
- Geoweb with sod
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
- RTV from retention tables
- Design per specs/perc rate – min 2”/hr
- Compaction – max 92-95% to min of 24 inches
- Master certified contractor
- Quarterly to annual vacuum sweeping
- ERIK testing and recertification
- Signage to keep muddy vehicles off
A single ring ERIK infiltrometer is acceptable provided that it is embedded into the subsoil as shown in Figure 42.

Refer to the previous slide for information on the ERIK device. Be sure to use non-calcareous stone in the reservoir layer.
PERVIOUS PAVEMENT
CONSTRUCTION RECOMMENDATIONS

• Installation by certified trained personnel
• Excavate with light, wide tracked equipment
• Inspect bottom and install fabric, 24” overlap
• Install clean, washed non-calcareous stone in < or = 12” lifts, compact subgrade to 92% - 95%
• Check mixtures, pour, and finish
• Cover to allow curing
• Stabilize contributing areas before use
• Post signs to educate users
PERVIOUS PAVEMENT
INSPECTION AND MAINTENANCE ACTIVITIES

Inspection
• Check design volume recovery time and occurrence of nuisance flooding
• Test vertical hydraulic conductivity with ERIK
• Check edge constraints and overflow areas for erosion

Maintenance
• Vacuum sweeping as needed
• Good housekeeping by users
• Stabilization of contributing drainage area
• Restoration if needed
PERVIOUS PAVEMENT LESSON LEARNED

Issue: Be aware of and plan for off-site runoff that can run on and overwhelm pervious pavement

Solution: Divert to take advantage of the entire pervious pavement area
Retention BMPs
- Basins
- Exfiltration trenches
- Underground retention storage
- Swales
- Vegetated natural buffers
- Rain gardens
- Pervious pavements

Harvest and Reuse BMPs
- Greenroof/cistern
- Wet detention
- Rainwater harvesting
- Stormwater harvesting

Filtration BMPs
- Managed aquatic plants
- Upflow filters
- Biofiltration with BAM
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
FLORIDA PILOT GREEN ROOFS

South Florida – 2003 – Bonita Bay Shadow Wood Preserve

Central Florida – 2005 – UCF Student Union

North Florida – 2011 – Escambia County One Stop Building

August 2003

August 2007
GREEN ROOF/CISTERN SYSTEM DESIGN CONSIDERATIONS

- Building structural integrity
- Treatment volume per retention BMPs or design curve
- 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 35 lbs/SF

Up to 50 lbs/SF

Up to 25 lbs/SF
Cistern Design

- Use CSTORM Model
- Choose desired yearly stormwater retention volume
- Use respective cistern volume
- Storage volume will vary with location
In Tampa, a green roof will provide 44% annual retention of stormwater. With a cistern, the annual retention percentage increases to about 76%.
MAINTENANCE OF GREEN ROOFS

• Initial irrigation schedule follows ground level schedule.
• If used for pollution control credit, must maintain a log of irrigation times.
• If using a dedicated cistern, inspect for functioning at least once per month, this is primarily for cistern leaks and pump operation.
• For the first two years, pull unwanted vegetation at least once per month. Usually only once per year thereafter.
• Every year, replace plants to “fill in” where others have not survived.
• Safety tips:
  • Wear shoes
  • Keep hydrated
  • Do not lean over sides
  • Watch for lightning
  • Use insect control.
# 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></td>
<td>Eff = 44.53 + (6.146<em>lnTd)+(0.145</em>(lnTd)^2)</td>
<td>Eff = (43.75*Td)/(4.38+Td)</td>
</tr>
<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>
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<td>30</td>
<td>66.42</td>
<td>38.18</td>
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<td>50</td>
<td>69.71</td>
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<td>150</td>
<td>76.78</td>
<td>42.51</td>
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<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.
1. Littoral Zones
2. Floating Wetland Mats

MANAGED AQUATIC PLANT SYSTEMS

Turning plants into pollution filters

Phosphorus and nitrogen are essential nutrients for aquatic life. But excessive growths of algae and weeds, forming a mat of plant debris, can diminish recreational values. Managed aquatic plant systems work with these mats, a natural彩票, to air floating vegetation mats for naturally filter out pollutants.

THE PLANTS
- Native species
- Seed plugs
- Nutrients
- Oxygen

THE ROOTS
- The plants grow in a container in attached tanks in the pond. When the roots are fully assembled, an anchor holds them in place.

THE FLOATING PLANT MAT
- The mats float on top of the water. They are a bed of plants that filter phosphorus, nitrogen, and other nutrients and debris. The mats are easily maintained and can be moved to different areas of the lake.

THE EXPERIMENT AT TALLGRAND RETENTION POND
- The pond is being used with enough plants to cover 5 acres of the lake.

AERIAL VIEW OF POND
- The pond is filled with oxygen. The plants and mats filter the water.

AERIAL VIEW POND
- The pond is filled with oxygen. The plants and mats filter the water.

AERIAL VIEW POND
- A pump is used to remove the pollution from the pond.

AERIAL VIEW POND
- A pump is used to remove the pollution from the pond.

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- A pump is used to remove the pollution from the pond.

AERIAL VIEW POND
- A pump is used to remove the pollution from the pond.
LID BMP – RAINWATER HARVESTING

- The collection and storage of roof runoff to reuse
- Reduces DCIA, runoff volume, loading, use of potable water
- Variety of uses from irrigation to potable uses
TYPES OF RAINWATER HARVESTING SYSTEMS

1. Non-potable residential with rain barrel
2. Non-potable outdoor use with cistern
3. Non-potable indoor/outdoor use with cistern – Health Dept approval

Integrated Gray and Stormwater Harvesting Reducing Potable Water Use

Schematic for Rainwater Harvesting System
RAINWATER HARVESTING DESIGN CRITERIA

- Effectiveness related to cistern volume and daily demand for harvested water
- 1” rain/SF = 0.6 gallons of water
- Divert first flush with diversion tee
RAINWATER HARVESTING DESIGN CRITERIA

- Cistern can be above or below ground with overflow drain and auxiliary supply
- Water supply line must have meter
- Filter system depends on use of water. If no asphalt shingle roofs, use fine filters (5-20 microns)
RAINWATER HARVESTING DESIGN CRITERIA

Safety Considerations

- Control access to cistern and pumps
- Label pipes “non-potable water”
- Separate from potable supply with backwater prevention, air gap

Permitting Considerations

- May require WMD water use permit
- May require County Health Department permit and building permit
RAINWATER HARVESTING CONSTRUCTION, OPERATION, MAINTENANCE, RECORD KEEPING

Construction
• Install catchment system and rain garden for overflow, irrigation system or other reuse system components
• Test to assure no leaks, proper operation

Inspection/Maintenance
• Inspect all components regularly and repair as needed

Record Keeping
• Maintenance log that includes flow meter data of volume harvested and used, inspection dates, maintenance performed, etc.
LID BMP - STORMWATER HARVESTING

WHAT? Using retained or detained stormwater for non-potable uses, such as irrigation, car washing, toilet flushing, wet-land 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.
• Follow design criteria for Wet Detention except for 6.8.4.(h) and (i)
• Use Rate-Efficiency-Volume (REV) Curves and methodology in Section 6.9.7
• Establish stormwater storage volume in inches over the EIA (Equivalent Impervious Area) = CA
• Include back up supply
• Determine irrigation schedule
• Must have filtration system – sand filter or horizontal well
STORMWATER HARVESTING DESIGN CONSIDERATIONS

- Design with REV curves
- REV Curve assumptions
  - Use rate is constant – rate/day over EIA
  - Irrigate twice/week
  - No irrigation after rain > use rate
  - If irrigate DA to the wet detention storage, decreases load reduction
STORMWATER HARVESTING CONSTRUCTION, MAINTENANCE, RECORD KEEPING

Construction
• Wet detention system
• Filter system
• Irrigation or reuse system

Inspection and Maintenance
• Inspect components regularly to ensure proper operation
• Repair components as needed

Record Keeping
• Maintenance log that includes flow meter data of volume harvested and used, inspection dates, maintenance performed, etc.
<table>
<thead>
<tr>
<th>Retention BMPs</th>
<th>Harvest &amp; Reuse BMPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Basins</td>
<td>• Greenroof/cistern</td>
</tr>
<tr>
<td>• Exfiltration trenches</td>
<td>• Wet detention</td>
</tr>
<tr>
<td>• Underground retention storage</td>
<td>• Managed aquatic plants</td>
</tr>
<tr>
<td>• Swales</td>
<td>• Rainwater harvesting</td>
</tr>
<tr>
<td>• Vegetated natural buffers</td>
<td>• Stormwater harvesting</td>
</tr>
<tr>
<td>• Rain gardens</td>
<td></td>
</tr>
<tr>
<td>• Pervious pavements</td>
<td><strong>Filtration BMPs</strong></td>
</tr>
<tr>
<td></td>
<td>• Upflow filters</td>
</tr>
<tr>
<td></td>
<td>• Biofiltration with BAM</td>
</tr>
</tbody>
</table>
DESCRIPTION: Filters used in conjunction with wet detention systems to increase the overall treatment effectiveness.

ADVANTAGES:
- Applicable to ultra-urban redevelopment
- Filter media can vary depending on target pollutants
- Up-flow design reduces clogging and maintenance
IMPROVED TREATMENT USING UP-FLOW FILTERS WITH WET DETENTION

• Filters can be designed to remove nitrogen without media replacement
• For phosphorus, media replacement time is specified
• Can be used in BMP & LID Treatment Train Applications with other treatment
UP-FLOW FILTER DESIGN CRITERIA

- **Effectiveness**: Dependent on annual volume filtered and the filter media
- **Treatment volume**: Use retention tables to get % RO volume captured
- **Sizing of filter**: New aids to help with this
- **Use diversion structure** to divert treatment volume and to bypass higher flows
- **Filter media** – Table 6.10.1 (update in BMPTRAINS)
- **Filter depth** at least 30 inches, for nitrogen removal the filter must remain wet (anaerobic)
# UP-FLOW FILTER MEDIA SELECTION

## Filtration Media Table

<table>
<thead>
<tr>
<th>Description of Media</th>
<th>Material</th>
<th>Projected Treatment Performance</th>
<th>Typical Operating Limiting Filtration Rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TSS Removal Efficiency</td>
<td>TN Removal Efficiency</td>
</tr>
<tr>
<td>A first BMP, ex. Up-Flow Filter in Silt box and a constructed wetland (USER DEFINED BMP)</td>
<td>Expanded Clay/ Tite Chip</td>
<td>70%</td>
<td>55%</td>
</tr>
<tr>
<td>B&amp;G OTE***</td>
<td>Expanded Clay/Tite Chip</td>
<td>60%</td>
<td>45%</td>
</tr>
<tr>
<td>Up-Flow Filter at Wet Pond or Dry Basin Outflow (FILTRATION)</td>
<td>Expanded Clay/Tite Chip</td>
<td>60%</td>
<td>45%</td>
</tr>
<tr>
<td>After Wet Detention using Up-Flow Filter</td>
<td>Expanded Clay/Tite Chip</td>
<td>85%</td>
<td>30%</td>
</tr>
<tr>
<td>B&amp;G CTS 12***</td>
<td>Clay/Tite Chip</td>
<td>90%</td>
<td>60%</td>
</tr>
<tr>
<td>Down-Flow Filter 12&quot; depth*** at wet pond or dry basin</td>
<td>Sand/Tite Chip</td>
<td>95%</td>
<td>75%</td>
</tr>
<tr>
<td>Down-Flow Filter 24&quot; depth*** at wet pond or dry basin</td>
<td>Sand/Tite Chip</td>
<td>95%</td>
<td>75%</td>
</tr>
</tbody>
</table>

### Notes
- *No generally accepted BMP at this time. Also can be used as a downstream BMP but the removal must be lowered.*
- All Effectiveness Estimates to nearest 5%.
- All phosphorus removal has limited life expectancy.
- **24" depth has TN and TP removals of 75 & 95%.
- B&G Tite Chip: 1-3/8" and no measurable metal content (approximate density = 730 lbs/CY).
- Expanded Clay 5/16 and 3/8 blend (approximate density = 950 lbs/CY).
- Sand ASTM C-33 with no more than 3% passing #200 sieve (approximate density = 2200 lbs/CY).
- Expanded Clay 3/8 in blend (approximate density = 950 lbs/CY).
- Tire Chip 1-5 mm and no measurable metal content (approximate density = 730 lbs/CY).
- Medium Plasticity typical light colored Clay (approximate density = 2500 lbs/CY).
- Sand with less than 5% passing #200 sieve (approximate density = 2200 lbs/CY).
- Organics: Either compost (approximate density of 700 lbs/CY), Class 1A Compost or wood chips (sawdust) without pesticides.
- Local top soil is used over CTS media in dry basins, gardens, swales and strips, is free of roots & debris but is not used in other BMPs.

### References
- D - City of Austin Environmental Criteria Manual, Section 1.6.5, Texas, 2012
- F - Improving Nitrogen Efficiencies in Dry Ponds, Williams and Wanisfita, Florida Stormwater Association, June 18 2015

### BMP Mixes

<table>
<thead>
<tr>
<th>MIX</th>
<th>TN Removal %</th>
<th>TP Removal %</th>
<th>Water Storage Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>B&amp;G CTS 12</td>
<td>75</td>
<td>95</td>
<td>0.3</td>
</tr>
<tr>
<td>B&amp;G CTS 24</td>
<td>75</td>
<td>95</td>
<td>0.3</td>
</tr>
<tr>
<td>UDM1*</td>
<td>55</td>
<td>65</td>
<td>0.3</td>
</tr>
<tr>
<td>UDM2*</td>
<td>45</td>
<td>45</td>
<td>0.3</td>
</tr>
<tr>
<td>UDM3*</td>
<td>45</td>
<td>45</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*User Defined Media Mix*
UP-FLOW FILTER CONSTRUCTION AND MAINTENANCE

Construction:
• Construct wet detention system
• Construct up-flow filter per manufacturer and permitted plans and specifications

Inspection:
• Inspect pre-treatment BMPs and up-flow filter flow rate
• Inspect inlet and outlet structures for proper operation

Maintenance and Record Keeping:
• Clean all inlets and outlets
• Replace filter media (for P removal) every 2 years or as needed
• Owner/operator must keep maintenance log that includes annual stormwater volume filtered vs bypassed, inspection dates and forms, maintenance dates and activities
The Upflow Filter Design Allows for Easy Inspection and Service of the Media
UP-FLOW INPUT FROM WET DETENTION TO FILTER

- **Performance**
  - Concentration
  - Averages based on field data
  - Annual average yearly based on 1.0 inch design for filter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TN</th>
<th>TP</th>
<th>TSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Influent Concentration (mg/L)</td>
<td>1.83</td>
<td>0.73</td>
<td>42.7</td>
</tr>
<tr>
<td>Expected Average Pond Removal (%)</td>
<td>38</td>
<td>63</td>
<td>79</td>
</tr>
<tr>
<td>Average Pond + Filter Removal (%)</td>
<td>70</td>
<td>72</td>
<td>91</td>
</tr>
<tr>
<td>Average Annual System Performance</td>
<td>67</td>
<td>70</td>
<td>89</td>
</tr>
</tbody>
</table>
LID BMP – BIOFILTRATION USING BIOSORPTION ACTIVATED MEDIA (BAM)

• Suite of offline BMPs with engineered media (BAM) to enhance pollutant removal of native soils or filters
• Retention or detention BMPs
• Include rain gardens, landscape planter boxes, tree box filters, up-flow filters
• In areas with high SHGWT, use liner to separate from ground water to create anoxic zone in bottom to promote nitrate removal
Biofiltration BMP Components

- Pretreatment BMPs
- Ponding area – 3 to 12 inches deep
- Overflow/spillway – divert larger storms
- Planting media – depends on plants, 2 - 12” deep with >2”/hr permeability
- BAM Media bed – type varies, 18 - 24” thick
- Woody and herbaceous Florida-friendly plants
- Underdrain/discharge pipe
- Control structure – create anoxic layer in bed
- Energy-dissipation mechanisms
Stormwater management:
• Typically for stormwater treatment not flood control
• Can be retention or detention design
• Recover treatment volume within 36 hours

Physical Constraints:
• Drainage area – 0.25 to 2 acres
• SHGWT – separated by structural means
• Soils/Media – minimum 2” top soil, 2” – 6” planting soil, 24” of filter media with a carbon source
• Discharge – into appropriate conveyance system
LID BMP – BIOFILTRATION USING BIOSORPTION ACTIVATED MEDIA (BAM)

- Engineered media tailored for specific WQ enhancements
- Includes a wide range of materials with sorption properties and carbon source ranging from soils to expanded clay to tire crumb to activated carbon
- UCF publication for SWFWMD “Alternative Stormwater Sorption Media for the Control of Nutrients”
• Part of a BMP Treatment Train
• Use graph to determine capture volume (CV)
• Use BAM effectiveness – depends on blend and its thickness
• Efficiency = CV % * BAM % removal
  Efficiency = 53% * 75% TN = 40% removal
BIOFILTRATION SYSTEM INSPECTION, OPERATION, MAINTENANCE

- Depends on whether retention or detention and the system components
- Inspect in spring for clogging, erosion, plant health, infiltration vs ponding, ensure underdrain and discharge are working
- Maintenance activities include pruning and weeding, replace plants, mowing buffers, replace mulch, stabilize erosion, remove sediments, flush underdrains
- Test planting soil pH every 3 years, adjust as needed
- If retention, verify infiltration rate every 3 years
LID BMP – PLANTER BOX BIOFILTRATION SYSTEMS

- **Weir**
- **Collection Area**
- **BAM Media**
- **Vault** (filter area < vault area)
PLANTER BOX BIOFILTRATION DESIGN CONSIDERATIONS

• Can be either retention or detention BMP
• Setback 10’ from buildings unless lined flow-through
• Contributing DA < 2,500 SF; larger with permitting agency OK
• Retention biofiltration RTV per retention BMPs
• Detention biofiltration effectiveness depends on filter media and annual volume of stormwater treated
• Minimum width of 30” with 6 – 12” of storage volume and 2” of freeboard
• Walls of impermeable material but not pressure treated wood
• If used, liner with 30 to 40 mil PVC or HDPE
• Florida-friendly plants may include trees
Example Calculations for a 14 SF filter.
Column 3: Max CFS = 1 GPM/SF x 0.002228 CFS/GPM x 14 SF = 0.0312 CFS
Column 4: Release in 1\textsuperscript{st} day = 0.0312 CFS x 86,400 sec/day / 2 = 1347 CF
Column 5: Remaining half is released, thus 1347, extended value is 1347.49
Column 6: Sum of water released in 3 days (round off values)

<table>
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<tr>
<th>Inside Dim</th>
<th>Filter Area</th>
<th>Max CFS</th>
<th>Release (CF) 1st Day*</th>
<th>Release (CF) next 2 days</th>
<th>Release (CF) 3 days (CF) Total volume</th>
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note: rate of maximum filtration is 0.002228 CFS/SF
* half the maximum

Note: filter area < vault area
Tree Box (Well) Filter Retention Design

- Flow to Tree Wells
- Overflow
- Flow to Tree Well
- Overflow
Pre-cast concrete boxes with biofiltration media installed below grade at the curb line. Also includes planting soil, BAM mix, observation and cleanout pipes, underdrain pipe, tree, and grate landscape cover

Sized and spaced like catch basins, size for specific stormwater treatment volume

Contributing DA typically < 0.25 acre

Soil volume is critical – up to 1500 ft³

Trees per local government Land Development Code
NEW RESOURCE
HTTP://TREESANDSTORMWATER.ORG/

The natural solution is the best solution

Trees intercept rainfall and help increase infiltration and the ability of soil to store water. By retaining water in their canopy – even for a short time – trees can disperse precipitation over a longer time period and reduce velocity of the water when it does fall.

Why should you implement community forestry practices as part of your community’s stormwater management plan?
BMPTRAINS MODEL

• Model developed in cooperation with DEP, WMDs, FDOT
• Model is in the public domain
• Model incorporates the latest information relative to designing stormwater treatment systems in Florida:
  • Uses Harper Methodology for calculations
  • Florida annual rainfall by zones
  • Statewide Event Mean Concentrations
  • Statewide stormwater BMP effectiveness data
  • Latest LID BMP effectiveness data
  • Incorporates latest stormwater LID BMP design criteria
BMPTRAINS 2020 MODEL
Major Changes And Improvements

• Moved from Excel to C++ programing platform
• Loaded onto https://stars.library.ucf.edu/bmptrains/ together with BMP publications related to BMP design and effectiveness.
• No limit on number of watersheds and subwatersheds
• Increase number of BMPs to 4 per catchment
• Optional component – nutrient loading to ground water
• BMPs in series load reduction effectiveness checks improved
• Improved hydrology associated with upstream retention
• Wet detention permanent pool volume now an input to calculate residence time
• Composite Curve Number calculation improved; volume related
• Improved User Interface; Output reports; user experience; and User Manual
Major Changes And Improvements

1. BMPs upstream of downstream BMPs affect downstream removals. Can only remove the particulate fraction in the upstream BMP. No removal in downstream BMP.
2. Tools Media Service Life: Replaced Sorption Rate with Removal Rate and an upper limit on removal from 5.0 to 10.0 ug/L.
3. For exfiltration trench, another check created to limit the aggregate Void % <100 and clarify it is a %.
4. For permeable pavement, added other pavement types - User Defined 20 & User Defined 30. The 20 and 30 refers to the sustainable void space.
5. Save most recent .bmpt runs in case you forget the folder they are in. Access on the main page from the bottom button labeled as open project.
6. Can store and use a pre-development land use with existing BMP. Use the button called open pre-BMP.
7. The catchment name now appears with the catchment number.
8. Groundwater loading may affect loading at a site. On the catchment worksheet, you can now enter phosphorus and nitrogen groundwater loading.
USE OF BMP TRAINS MODEL

- Calculate pre-development, post-development TN, TP loads
- Quantify TN, TP load reduction of traditional & LID BMPs
- Evaluate site planning/BMP treatment train options
- Evaluate load reduction of BMP treatment train options
- Evaluate costs of BMP treatment train options
- Used to evaluate ERP/BMP options for projects in Lee County, Pinellas County, Alachua County
- Used to evaluate BMP options for St. Joe Sector Plan in Bay County
- Used to evaluate whether a project is meeting “Net Improvement” for impaired waters
- Used to challenge BMP designs in administrative hearings
Current “presumptive BMP design criteria” do not achieve high level of treatment needed for discharges to impaired water bodies – need LID BMPs
• No LID BMP Design Criteria in ERP Handbooks
• 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 BMP treatment effectiveness and demonstrate “net improvement” is met
• Must be able to evaluate BMP treatment trains that use complementary BMPs to increase pollutant load reduction
INSIDE BMPTRAINS: UNDERSTANDING THE UNDERLYING DATA AND ASSUMPTIONS

1. How do I calculate runoff volume and pollutant loading?
   • Use Harper Methodology, annual rainfall zones, DCIA not CN

2. How do I determine what land use type I have? See tables

3. What is the natural vegetative community?
   • See Appendix A of User Manual, Info tables in Model
   • Use FLUCCS, convert to EMC land use categories
   • Use FLUCCS with EMC Natural Community

4. How do I calculate a weighted EMC?
   • Dr. Hardin will show us later

5. How are BMP design criteria and effectiveness related?
   • Example, wet detention uses average ANNUAL residence time not wet season residence time (Multiply wet season RT by 1.5)
INSIDE BMPTRAINS: UNDERSTANDING THE UNDERLYING DATA AND ASSUMPTIONS

BMP design criteria and effectiveness?

- Most of BMPs in BMPTRAINS are new, LID BMPs
- LID BMPs not in current ERP Applicant Handbooks
- BMP design criteria from 2010 Statewide Stormwater Treatment draft Applicant Handbook but refined to reflect new data/experience.
- See Pinellas, Alachua, or Escambia Stormwater Manuals for LID BMP Design Criteria
- Uses Harper methodology to calculate loadings and load reductions
- BMP effectiveness is based on Florida monitoring data or long term modeling
BMP Design and Effectiveness Example – Stormwater Harvesting Systems

- Effectiveness based on 1991 report “Design Curves for the Reuse of Stormwater” – convert wet detention to partial retention system
- Assumes irrigate twice/week, not after rain
- Must reduce efficiency if irrigate contributing DA
- More than just a PVC pipe and pump!
- Different control structure, horizontal well or sand filter, pumps, flow meters, irrigation system, record keeping to verify “retention volume”
BMP TRAINS FLEXIBILITY ALLOWS EASY EVALUATION OF MULTIPLE BMP TREATMENT OPTIONS

- LID BMP workshop Case Study
- Evaluate BMP options on site with HSG A and C/D soils
  - Retention basin
  - Rain garden (bioretention)
  - Vegetated Natural Buffer
  - Swales
  - Pervious pavement
  - Wet detention
  - Stormwater harvesting
  - Biofiltration
  - Up-flow filter