INCORPORATING LOW IMPACT DESIGN (LID) INTO FLORIDA'S STORMWATER RULES

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THE STORMWATER PROBLEM

Humans cause:

- Changes in land use
- Development in floodplains
- Alteration of natural stormwater systems
- Compaction of soil, imperviousness
- "Drainage" systems
- Addition of pollutants

Resulting in:

- Decreased recharge
- Increased speed of runoff
- Increased volume of runoff
- Increased pollutants

EVOLUTION OF STORMWATER MANAGEMENT IN FLORIDA

- Drainage
- Erosion and sediment control
- Stormwater treatment
- Stormwater retrofitting

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.
Water management district ERP rules

TECHNOLOGY BASED

- Performance Standard
- BMP Design Criteria
- Presumption of compliance

Performance Standard for New Stormwater Discharges

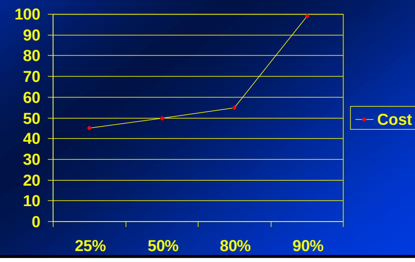
Erosion and sediment control
- Retain sediment on-site
- Not violate turbidity standard

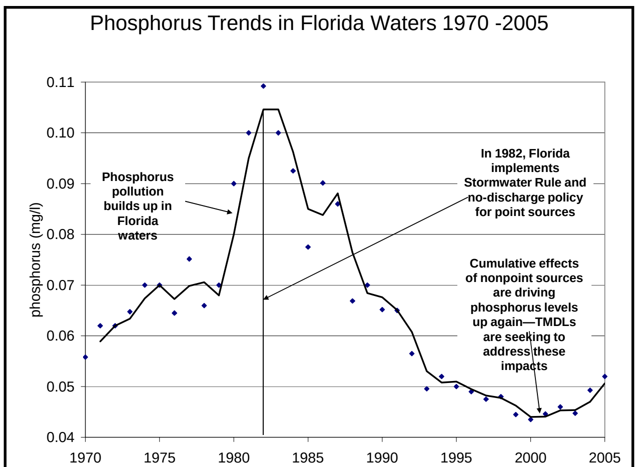
Stormwater quantity
- Discharge rate WMD or local standards
- Volume control

Stormwater quality
- 80% average annual load reduction
- 95% average annual load reduction
- Basin specific requirements

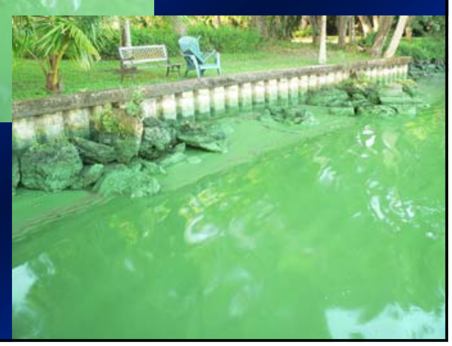
WHY 80% TSS LOAD REDUCTION?

- Equitability with point sources
  - Min treatment = secondary = 80% TSS
- Cost effectiveness
  - 80% = "knee of the treatment curve"





Caloosahatchee River October 15, 2005



CURRENT STATUS OF IMPAIRED WATERS (Through Group 5)

Group	# of Segments (WBIDs)	Verified Impair Para-meters	Delisted Para-meters	Para-meters on Plan List	Newly Verified Impaired Parameters	Potentially Impaired Parameters Added to List
1	1746	258	185	213	140	1082
2	1657	446	235	167	352	1671
3	1217	196	182	255	154	1964
4	1088	163	146	TBD	114	TBD
5	575	224	119	TBD	TBD	TBD
Total	6283	1287	865	635	760	4717

IMPAIRED WATERS: PROBLEMS AND POLLUTION SOURCES

MAJOR POLLUTANTS OF CONCERN

- Nutrients, nutrients, nutrients!
- Oxygen demanding substances
- Bacteria

MAJOR SOURCES OF POLLUTANTS

- Stormwater – existing development
- Stormwater – future development
- Stormwater – agricultural
- Leaching – agriculture, landscape, OSDS

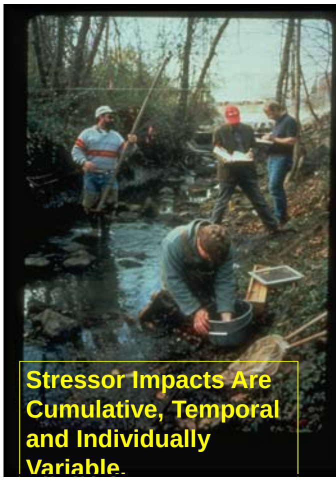
EXAMPLE PROJECT

	PRE DEVELOP	POST DEVELOP	POST WITH BMPs
LAND USE	90 ac forest 10 ac wetlands	95 ac SF 5 ac SWM	95 ac SF 5 ac SWM
% IMP		25%	25%
RUNOFF	82 ac ft/yr	123 ac ft/yr	123 ac ft/yr
TN LOAD	109 kg/yr	330 kg/yr	231 kg/yr
TP LOAD	5 kg/yr	51 kg/yr	18 kg/yr

Assume BMPs are wet detention

HIGHER LEVELS OF STORMWATER TREATMENT – WHY?

- Nutrient impaired surface waters (TMDLs)
- Elevated nitrates in springs
- Harmful algal blooms
- Lake Okeechobee Protection Act
- LO Estuary Recovery Inititative
- SW Florida EIS/EPA refusal to accept SFWMD stormwater permits as "401 WQ certification"
- Continuing high growth rate – cumulative effects



Stressor Impacts Are Cumulative, Temporal and Individually Variable.

Maintaining Ecological Integrity

Impact Mitigation or Function Restoration / Preservation?

Hydrology
- Volume, Frequency, Recharge, Velocity

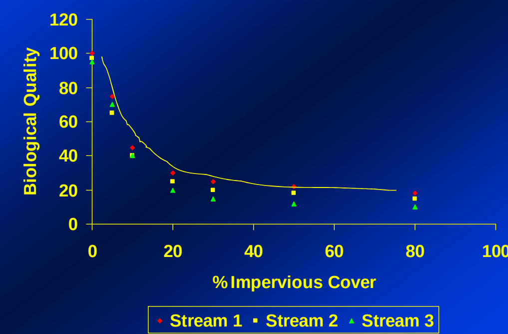
Habitat Structure
- Physical, Biological

Water Quality
- Chemical Pollutants, Temperature

Energy Sources
- Nutrients / Food Chain

Biotic Interactions
- Competition / Disease

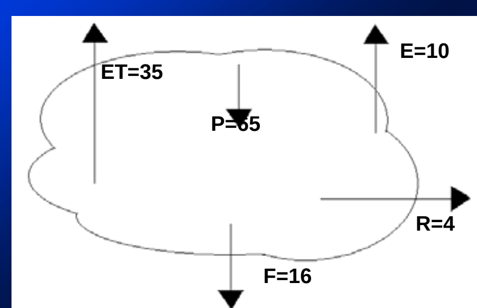
RELATIONSHIP OF IMPERVIOUSNESS TO BIOLOGICAL COMMUNITY HEALTH



EFFECTS OF STORMWATER AND STORMWATER BMPs ON SMALL STREAMS

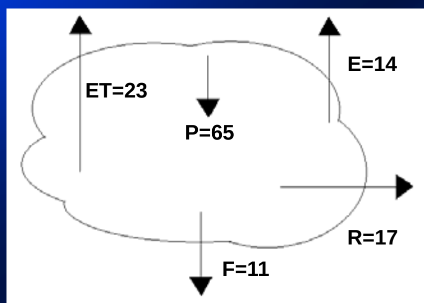
- Study sites in Montgomery County, MD; Austin, TX; Vail, CO; Puget Sound,WA
- Major effects on biota are caused by hydrologic changes
- No % impervious threshold effect
- Minimize impervious surfaces
- Retain forests and wetlands
- Maintain 100' riparian buffer
- BMPs more important as urbanization increases

WATER BUDGET
Undeveloped Watershed



Yearly rates expressed as inches

WATER BUDGET
Developed Watershed



20% DCIA, no Water Budget Management

THE SOLUTION? STATEWIDE STORMWATER TREATMENT RULE

POST ≤ PRE

- Peak discharge rate
- Volume
- Recharge
- *Pollutant loading (nutrients)

*In effect in Lake Apopka, Lake Okeechobee, and SW Florida

EVOLUTION FOR STORMWATER/WATERSHED MANAGERS

- It's the volume!
- Secondary treatment inadequate
- Structural BMPs have limitations
- Return to basics
- Multiple objectives
- Stormwater is an asset

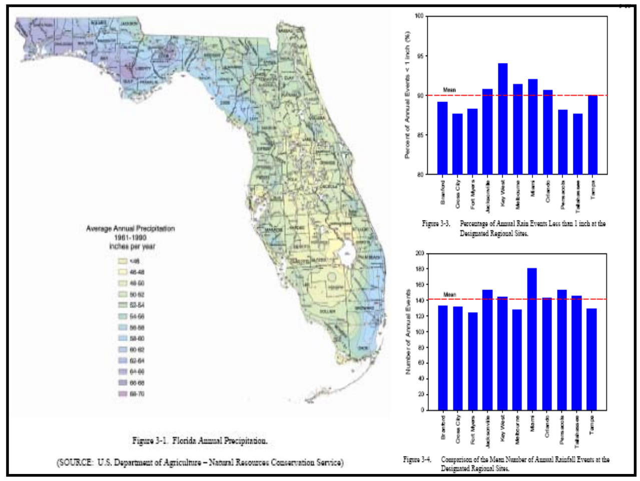
Evaluation of Current Stormwater Design Criteria within Florida Harper Study (2006)

Objectives

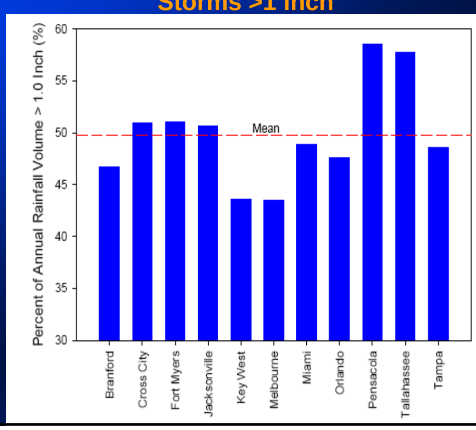
- Review current BMP design criteria of DEP/WMDs
- Update Florida stormwater EMC data
- Update/analyze Florida rainfall data
- Estimate predevelopment hydrology and stormwater loadings
- Update Florida BMP effectiveness data
- Model BMP treatment effectiveness
- Evaluate BMP design criteria changes needed to achieve 80%,95%, no net increase in nutrients

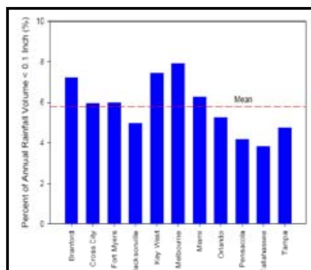
MAJOR FINDINGS

- Rainfall more highly variable than previously thought
- EMCs are updated
- Runoff coefficients more variable than previously thought = loadings more variable
- Current rules do not provide for 80 to 95% removal of nutrients
- Infiltration BMPs can meet higher levels but will have to retain more runoff
- BMP treatment train/reuse needed for wet ponds to meet higher levels of nutrient removal



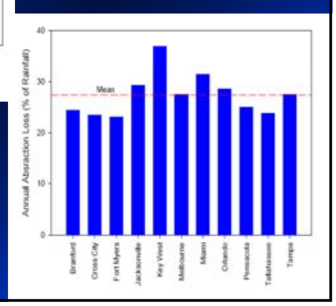
% Of Annual Average Rainfall Volume Generated by Storms >1 inch





% Of Annual Average Rainfall Volume Generated by Storms <0.1 inch

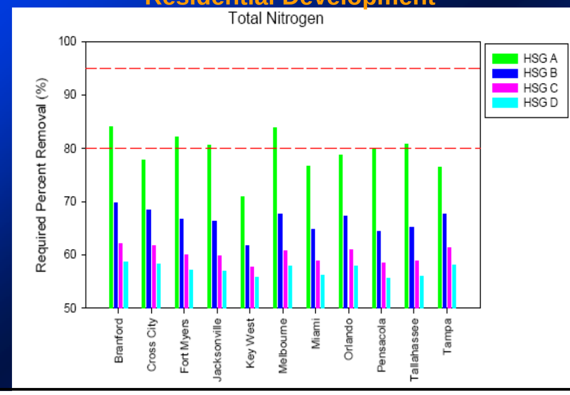
% Of Annual Rainfall Depth Lost to Initial Abstraction on Impervious Surfaces



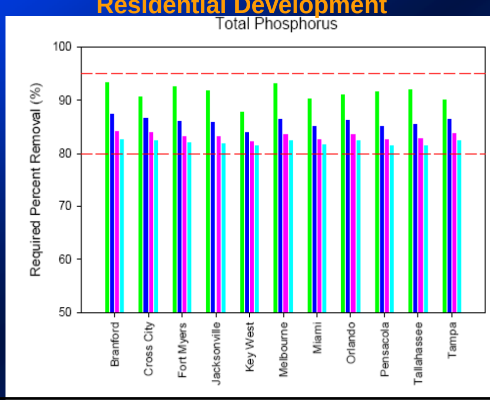
MAJOR FINDINGS – TREATMENT LEVELS

- Current rules do not get 80% nutrient treatment
- Recommends that the Performance Standard should be post-development nutrient load = pre-development nutrient load
- If set to 80%, BMPs will provide much higher TN removals than needed
- If set to 95%, BMPs will provide much higher TN and TP removals than needed

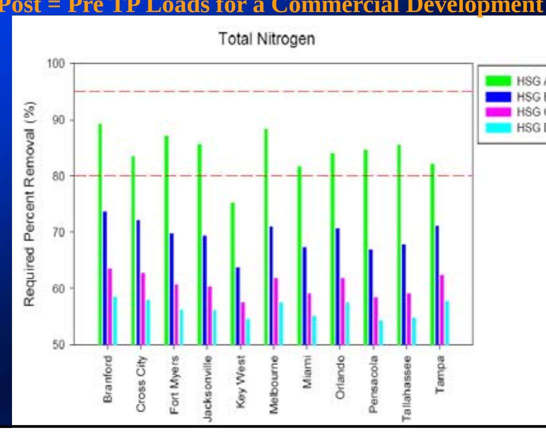
Estimated Annual Mass Removal Efficiencies to Achieve Post = Pre TN Loads for a SF 25% Imp Residential Development



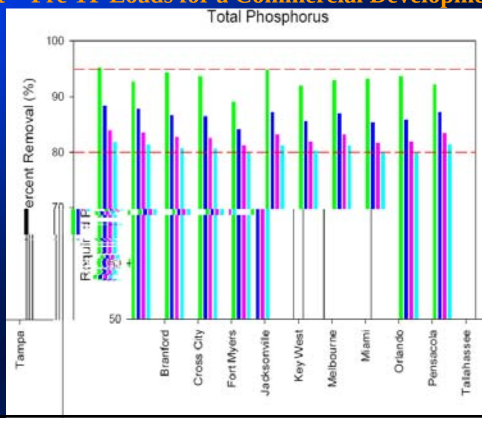
Estimated Annual Mass Removal Efficiencies to Achieve Post = Pre TP Loads for a SF 25% Imp Residential Development



Estimated Annual Mass Removal Efficiencies to Achieve Post = Pre TP Loads for a Commercial Development



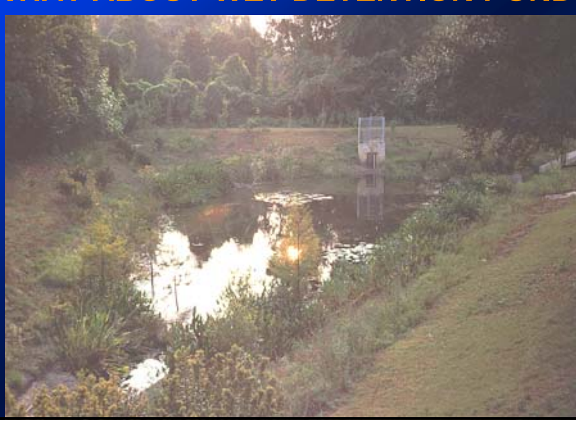
Estimated Annual Mass Removal Efficiencies to Achieve Post = Pre TP Loads for a Commercial Development



Potential Changes in Treatment Volume

TREATMENT LEVEL	RETENTION VOLUME PENSACOLA	ORLANDO	KEY WEST
80%	DEP	SJRWMD	SFWMD
A. Existing	0.50”	0.5 to 1.0”	0.50”
B. Future	1.28”	0.84”	1.55”
95%			
A. Existing	0.75”	0.75 to 1.50”	0.75”
B. Future	3.06”	2.43”	>4.00”
Post < Pre	TN= 69%	TN=69%	TN=57%
A. Removal	TP= 87%	TP=87%	TP=82%
B. T Volume	1.78”	1.22”	1.74”

WHAT ABOUT WET DETENTION PONDS



WET DETENTION SYSTEMS PROCESSES POLLUTANT REMOVAL

- Occurs during quiescent period between storms
- Permanent pool crucial
  - Reduces energy, promoting settling
  - Habitat for plants and microorganisms
  - Must maintain aerobic bottom conditions
- Gravity settling
  - Pond geometry, volume, residence time, particle size
- Chemical flocculation
- Biological processes
  - Filtering
  - Adsorption onto bottom sediments
  - Metabolized by microorganisms
  - Uptake by aquatic plants, algae

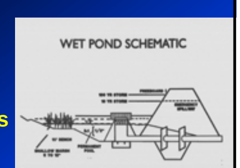


Figure 5-10. Removal Efficiency of Total Phosphorus in Wet Detention Ponds as a Function of Residence Time.

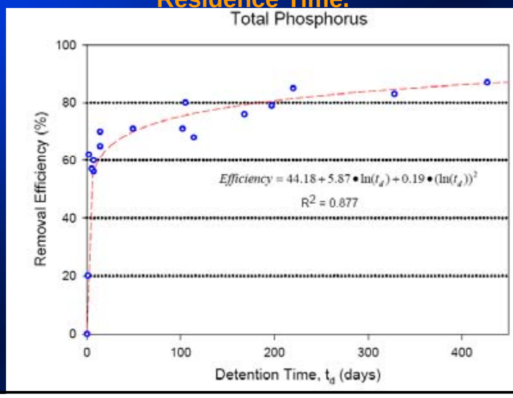
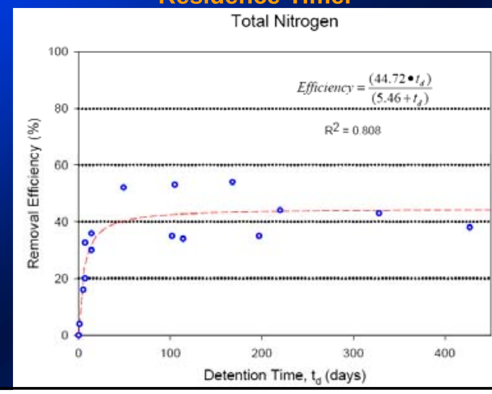


Figure 5-11. Removal Efficiency of Total Nitrogen in Wet Detention Ponds as a Function of Residence Time.



BMP TREATMENT TRAIN REQUIRED FOR WET DETENTION

Runoff & Load Generation → Conveyance and Pretreatment → Additional Treatment & Attenuation → Final Treatment and Attenuation

Runoff & Load Generation	Conveyance and Pretreatment	Additional Treatment & Attenuation	Final Treatment and Attenuation
Source controls	Swales	Storage tank	Retention
Public ed	Catch basins	Sediment sump	Detention
Erosion control	Filter inlets	Alum/PAM	Wetlands
Roof runoff	Oil/water separators		
Florida Yards			
LID			

PROPOSED RULEMAKING APPROACH

- Single statewide stormwater treatment rule adopted by DEP and implemented by WMDs
- More stringent basin specific rules adopted by WMD, if needed
- Rule conceptual draft (April 2007)
- DEP/WMD work group to develop draft rule (April – Aug, 2007)
- DEP Sec/WMD ED “issues” briefing (Sept)
- Formation of TAC/PAC (Oct-Dec 2007)
- Rule workshops (Jan – May 2007)
- Rule adoption by Secretary (June 2008)

UNIFIED STORMWATER RULE ISSUES

- Level of treatment – 80%, 95%, pre/post?
- Should size threshold apply to pre/post?
- Should size threshold apply to impaired waters?
- Application to urban redevelopment?
- How define “pre-development” land use?
- How quantify nonstructural BMPs and provide credits within rule?
- Legislative authority to adopt rule
- Burt Harris Act implications

LIMITS OF STRUCTURAL STORMWATER MANAGEMENT

- Limited treatment capabilities
- Lack of flexibility in site design
- Loss of useable land area
- Connection of impervious areas
- Disregard site resource benefits
- Altered site hydrology/pollutant loads
- Cost
- Maintenance obligations

UNIFIED STORMWATER RULE CONCEPTS

- One storm does not fit all
- BMP treatment train required
- Credits for nonstructural BMPs
  - Green roofs
  - Pervious concrete
  - Florida Friendly Landscaping
  - Disconnect impervious areas
  - Higher CN for cleared areas (compaction)
- Compensating treatment (WQ Banking)
- Retrofit section

RETURN TO BASICS: FOCUSING ON POLLUTION PREVENTION

Reduce stormwater volume

- Conservation or Low Impact Design
- Reduce Directly Connected Imp. Area
- Stormwater reuse

Reduce stormwater pollutants

- Source controls (FYN, street sweeping)
- Operation and maintenance

Retain/enhance natural stormwater system

- Riparian buffers, revegetation
- Wetland and floodplain protection
- Protect and plant vegetation

PREVENTING STORMWATER POLLUTION USING NONSTRUCTURAL BMPs

LAND USE MANAGEMENT – PROMOTE LID
- Protect natural SWM system
- Protect natural areas, wetlands, riparian buffers
- Minimize impervious surfaces, veg clearing

SOURCE CONTROLS
- Street sweeping, litter control
- Minimize fertilizer & pesticide use
- Florida Friendly fertilizers (low P)
- Florida Friendly Landscaping (FYN Program)
- Prevent illicit connections& discharges

PUBLIC EDUCATION
- Storm sewer stenciling
- Roof runoff to pervious areas
- Aquascaping littoral areas

Low Impact Development

- Comprehensive approach
- Hydrology is integrating framework
- Micro-scale or precession management
- Control stormwater at the source
- Use simple, nonstructural methods
- Decentralized / disbursed flows
- Create multifunctional landscape and infrastructure

Pollution and Hydrologic Prevention

LID Uniform Distribution of Micro Controls

LOW IMPACT DESIGN

APPROACHES - Preventive
- Watershed planning
- Local planning
- Site (lot) planning
- Concurrency!
- Reduce imperviousness
- Min. disturbance
- Protect vegetation, trees
- Reduce soil compaction

PRACTICES - Mitigation
- Infiltration basins
- Bioretention
- Biofiltration
  - Swales
  - Filter strips
  - Terraforming
  - Natural areas
- Wet detention
- Stormwater reuse

LOW IMPACT DESIGN PRINCIPLES

- Protect/avoid sensitive areas
- Minimize loss of vegetation
- Minimize disturbed areas
- Maximize infiltration
- Minimize imperviousness, especially DCIA
- Reduce setbacks
- Cluster development
- Use innovative planning tools (TDR)

LOW IMPACT DESIGN REDUCING 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

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

REFERENCES

- *Conservation Design for Stormwater Management* (1997). Delaware DNREC and Brandywine Conservancy.
- *Low Impact Development Design Strategies* (2000). Prince George's Co., Md. EPA 841-B-00-003.
- *Low Impact Hydrologic Analysis* (2000). Prince George's Co., Md. EPA 841-B-00-002.
- http://lowimpactdevelopment.org/
- http://www.greenroofs.org

FLORIDA LID PROJECTS
LID – HOW?

- Bonita Bay – Bonita Springs
- Madera – Gainesville
- River Forest – Bradenton
- Baldwin Park - Orlando

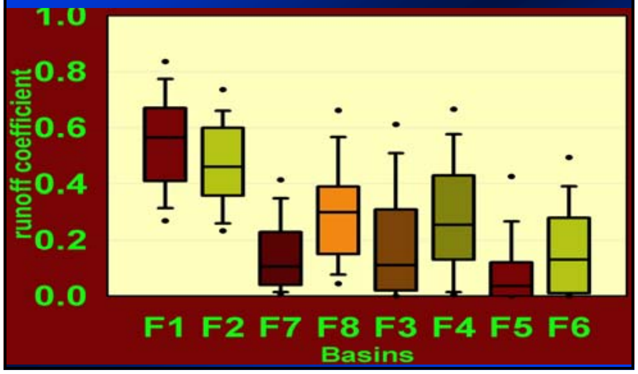
LID IMPEDIMENTS IN FLORIDA

- Effectiveness data
  - FYN, green roofs
  - Swales, rain gardens
  - Pervious pavement
  - Stormwater reuse
- State stormwater regulations
- Local land development regulations
  - Save the Swales!
  - Reduce imperviousness
  - Landscaping based on FYN/Green Industries BMP Program
  - Time to permit approval

URBAN STORMWATER BMP RESEARCH

- UCF Stormwater Management Academy
  - "Managed stormwater is good water"
  - http://stormwater.ucf.edu/
- FDEP stormwater research projects
  - Effectiveness of littoral zones
  - Improving nitrogen removal in BMPs
  - Stormwater reuse design/health risks
  - Evaluation of Florida Friendly landscapes
  - Evaluation of pervious concrete
  - Evaluation of green roofs
  - Turf grass fertilization/irrigation needs
- Florida Urban BMP Data Base

Runoff coefficients for basins in parking lot



PERVIOUS CONCRETE INFORMATION

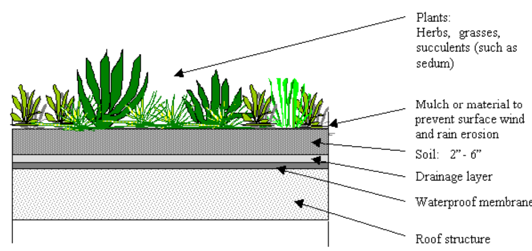
- Florida Concrete & Products Assn
- http://www.fcpa.org/
- Manuals
- Training classes – certification of contractors
- Training videos

Field Test Results

Test Location	Avg. Concrete Rate [in/hr] (Range)	Avg. Soil Rate [in/hr]	Limiting Factor
Site 1 – Area 1	25.7 (19 – 32.4)	34.5	Concrete
Site 1 – Area 2	3.6 (2.8 – 4.5)	14.8	Concrete
Site 2	5.9 (5.3 – 6.6)	5.4	Soil
Site 3	14.4 (2.1 – 22.5)	21.5	Concrete
Site 4 – Area 1	2.1 (0.7 – 4.5)	15.6	Concrete
Site 4 – Area 2	2.9 (0.9 – 4.9)	15.6	Concrete
Site 5	3.7 (1.7 – 5.4)	8.8	Concrete

*Age of concrete varies from 10 to 20 years (except for Site 4 – Area 1).

Ecoroof (Green-roof)



Section Not to Scale

August 2003

Shadow Wood Preserve Green Roof, Bonita Springs

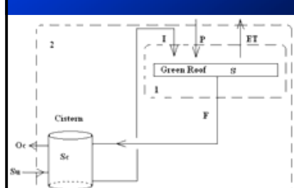
UCF Student Union Green Roof

BENEFITS OF ECOROOFS

- 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

STORMWATER BENEFITS OF GREEN ROOFS

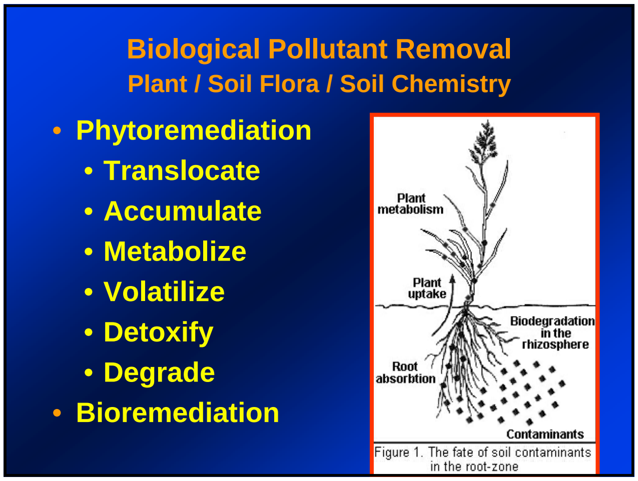
9 Month Mass Balance with Cistern and
% Discharge from Vegetated Black & GoldTM mix
Chamber B&GVR1

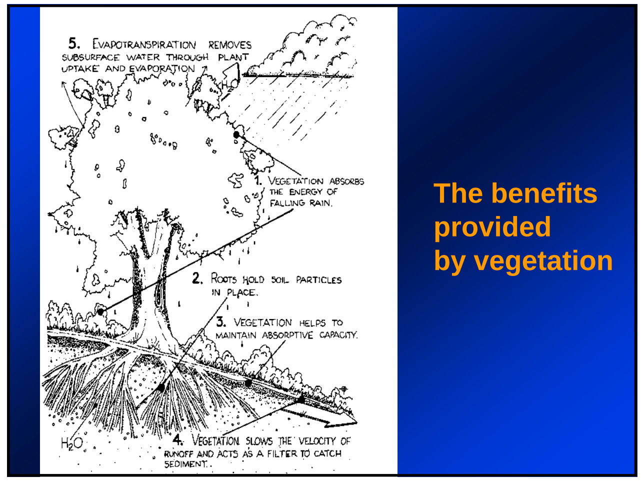


Sc1+P1+Su1-Oc1-ET1=Sc2

For a 9 month period July - Apr
P is approximately 32.4 inches
Su is approximately 7.5 inches
*Note: inches are inches per green roof area

Estimated are:
1. ET is approximately 31.1 inches
2. Oc = 8.1 inches
3. % of water leaving the system as runoff = ~ 20% or retention of 80%


Biological Pollutant Removal
Plant / Soil Flora / Soil Chemistry
• Phytoremediation
• Translocate
• Accumulate
• Metabolize
• Volatilize
• Detoxify
• Degrade
• Bioremediation
Plant metabolism
Plant uptake
Biodegradation in the rhizosphere
Root absorbtion
Contaminants
Figure 1. The fate of soil contaminants in the root-zone


5. Evapotranspiration removes subsurface water through plant uptake and evaporation.
1. Vegetation absorbs the energy of falling rain.
2. Roots hold soil particles in place.
3. Vegetation helps to maintain absorptive capacity.
4. Vegetation slows the velocity of runoff and acts as a filter to catch sediment.
H_2O
The benefits provided by vegetation


MAY 18 2001
Buckman Heights courtyard with infiltration garden


Parking Lot Bioretention Landscaping

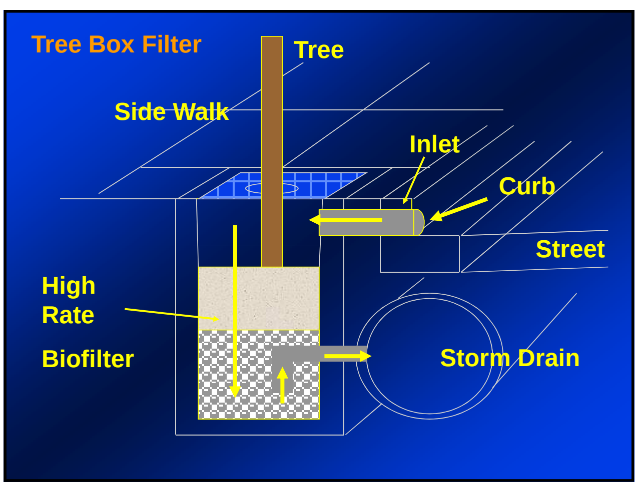
TREES ARE STORMWATER BMPs!

Urban Ecosystem Analysis, Jax (2005)

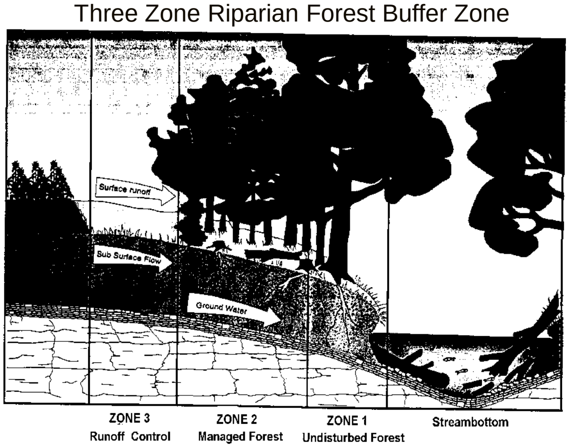
American Forests (www.americanforests.org)

City of Jacksonville Land Cover***	1992 Acres	2002 Acres	% Change of landcover type
Forest/woody wetlands	234,262.4	205,320.0	-12.4%
Open Space	48,692.9	59,825.0	22.9%
Developed Area	150,869.8	175,685.3	16.4%
Open Wetlands	49,745.5	45,816.7	-7.9%
Water	56,772.9	55,787.0	-1.7%

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



Three Zone Riparian Forest Buffer Zone



LID IMPEDIMENTS IN FLORIDA

- Effectiveness data
  - FYN, green roofs
  - Swales, rain gardens
  - Pervious pavement
  - Stormwater reuse
- State stormwater regulations
- Local land development regulations

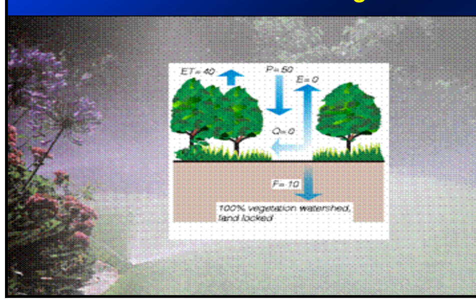
KEY ELEMENTS FOR RESTORING YOUR COMMUNITY'S WATERS

Reducing Impacts from New Development

- Revise Land Development Regs - Promote Low Impact Design
  - Minimize clearing, protect vegetation
  - Promote clustering
  - Reduce imperviousness – road widths, parking
  - Save the swales
  - Landscaping per FYN Program, Green Industry BMP Program – Model Landscape Code on web site
  - http://www.dep.state.fl.us/water/nonpoint/pubs.htm
  - Expedited approvals

STORMWATER REUSE

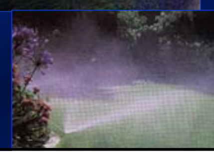
- Irrigation uses nearly 50% of the potable supply
- Potable supplies are decreasing
- Reclaimed water is being used to a maximum
- Thus use stormwater to irrigate



Maintain the Balance

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

LOW IMPACT DESIGN – WHY? COST SAVINGS

Cost Savings
- Less ponds
- Less piping
- Fewer structures
- Less curb / gutters
- Less paving
- Less grading
- BMP maintenance
- Energy conservation

Cost increases
- Design
- Grading
- Site Investigation
- Landscaping
- Maintenance

EXAMPLE CASE STUDY SITE CHARACTERISTICS

- Size: 84 acres
- Veg: Forests, cropland, grasses
- Soils: HSG B & D
- Hydrology: Generally S → N, 5 subbasins with natural swale conveyances
- Water: Stream on northern border
- Critical areas: Wetland, floodplain

EXAMPLE CASE STUDY
CONVENTIONAL DESIGN

- Lots: 90 SF on 50 acres
- Lot size: 18,975 ft^2
- Natural area: 34 acres, stream corridor
- Road length/width: 7,579 feet/28 feet
- Imperviousness: 26.2%
- SWM: Curb/gutter/storm sewers with 3 wet detention ponds

EXAMPLE CASE STUDY
CONSERVATION DESIGN

- Lots: 90 SF on 35 acres
- Lot size: 10,000 - 18,975 ft^2
- Lot configuration: around open space
- Natural area: 49 acres, stream corridor, natural conveyances
- Road length/width: 6,333 feet/20 feet
- Imperviousness: 10.7%
- SWM: Open space swales, storm sewers, retention, reforestation

CASE STUDY
90 SF lots on 50 acres
COMPARISON OF HYDROLOGY

Parameter	Predevelop Conditions	Conventional Design	Conservation Design
Precipitation	99,630,858	99,630,858	99,630,858
Runoff	2,637,659	25,064,175	11,494,456 (-54%)
Recharge	33,921,626	25,108,208	30,491,589 (+17%)
ET	63,056,866	49,454,425	57,640,772 (+14%)

CASE STUDY
COMPARISON OF COSTS

CONVENTIONAL	DESIGN COSTS	TOTAL COST
6,800 ft streets	$150/linear foot	$1,020,000
3 wet detention pond	$16,000 each	$ 48,000
7,400 ft storm sewer	$22/linear foot	$ 162,800
41 endwalls/inlets	$1,300 each	$ 53,300
TOTAL		$1,284,100
CONSERVATION	DESIGN COSTS	
4,000 ft streets	$100/linear foot	$ 400,000
1,500 ft streets	$85/linear foot	$ 127,500
4,000 ft storm sewer	$22/linear foot	$ 88,000
22 endwalls/inlets	$1,300 each	$ 28,600
1,900 ft of berms	$10/linear foot	$ 19,000
3,900 ft of swales	$4.50/linear foot	$ 17,550
16.2 ac reforestation	$2,925/acre	$ 47,385
TOTAL		$ 728,035

THE BIG Cs OF WATERSHED MANAGEMENT

- Cumulative
- Catchment
- Comprehensive
- Continuity
- Consistency
- Communication
- Cooperation
- Coordination
- Creativity
- Common Sense
- Cash
- Cultural Change
- Confession
- Challenge
- **Commitment**