Pinellas County Stormwater Management Manual Training Workshop

An Overview of Stormwater Management and the Role of Low Impact Design BMPs in Pinellas County Continued

6.6. LID BMP: Pervious Pavements

- Pervious concrete
- Pervious pavers
- Turf block
- Geoweb with sod

Pervious Pavement Considerations

Location

Design

Construction

Maintenance

Inspection

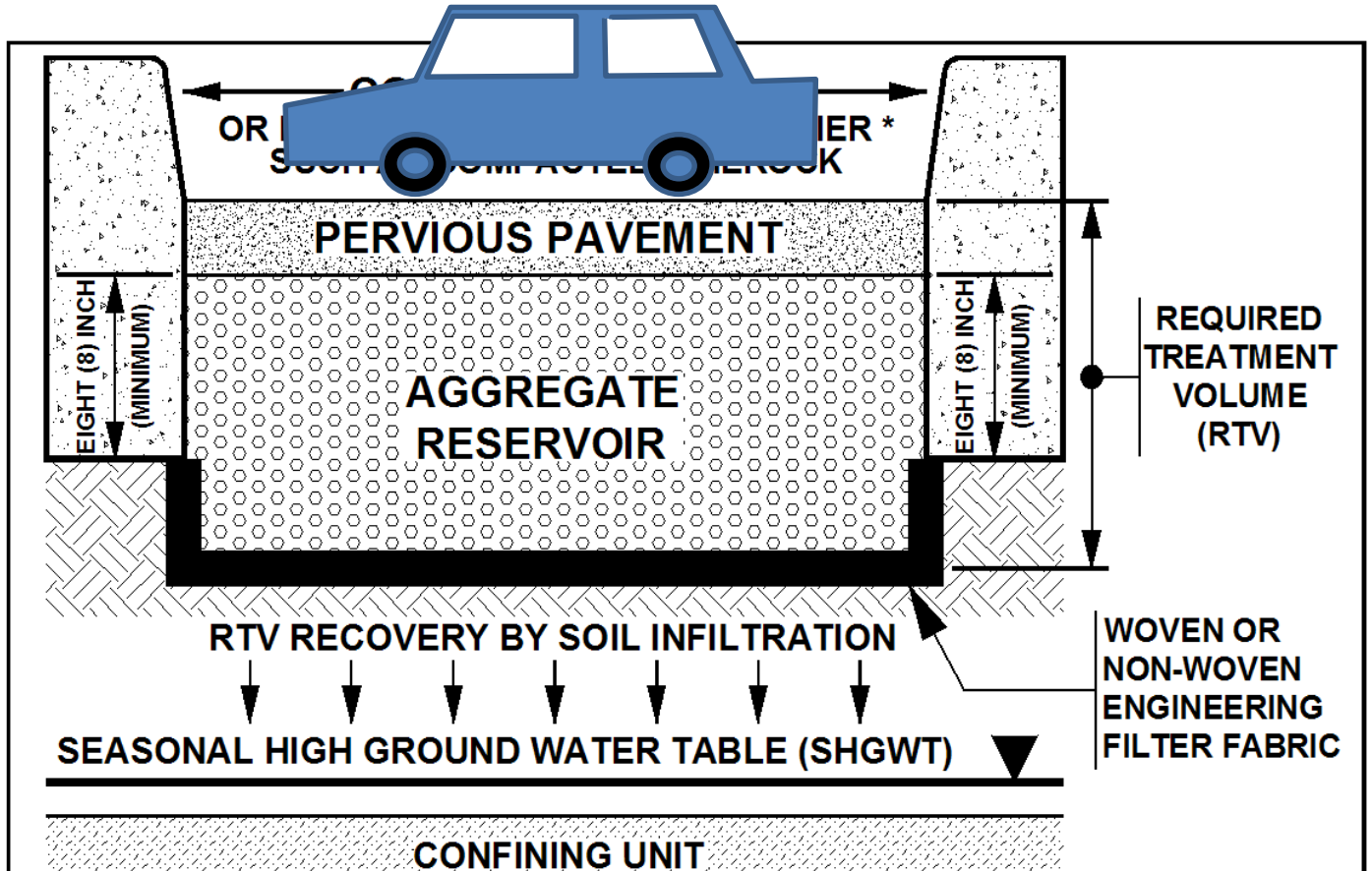
Pervious Pavement Considerations - Location

- Appropriate soils for retention systems
- Avoid high traffic volumes, frequent turning areas, heavy wheel loads
- Avoid areas with high potential for hazardous material spills
- Avoid areas with high levels of wind-blown sediment
- At least 75 feet from public or private potable water supply wells
- At least 15 feet from onsite wastewater disposal/treatment systems

Pervious Pavement Considerations – Design

- Flat or minimal slope
- SHWT at least 2’ below bottom
- Treatment volume based on retention curves
- Perc rate minimum 2”/hr
- Recovery in 72 hours (safety factor of 2)
- Edge constraint to prevent scour

Pervious Pavement Considerations – Design



Embedded Ring Infiltrometer Kit (ERIK)

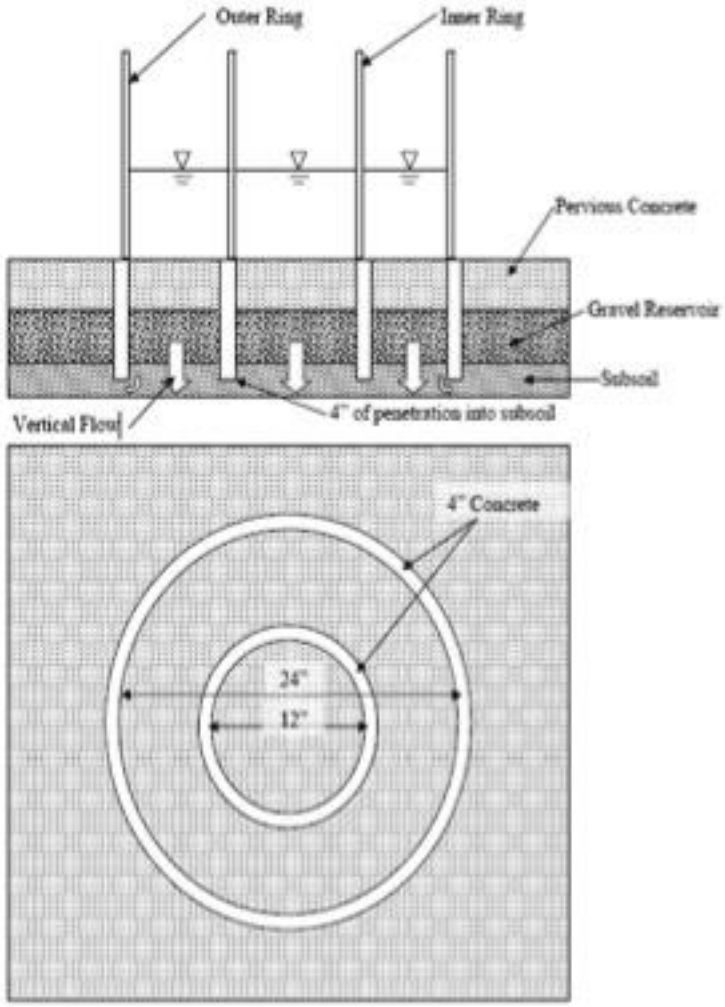


Figure 42: Design profile for Embedded Infiltrometer installation

For more information on this in-situ infiltration monitor (ERIK), refer to the UCF research paper entitled "*Construction and Maintenance Assessment of Pervious Concrete Pavements - Final Draft*", dated January, 2007, available at: http://stormwater.ucf.edu/research_publications.asp

Pervious Pavement Considerations - Construction

- Installation by certified trained personnel
- Excavate with light, wide tracked equipment
- Inspect bottom and install fabric, 24” overlap
- Install clean, washed 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

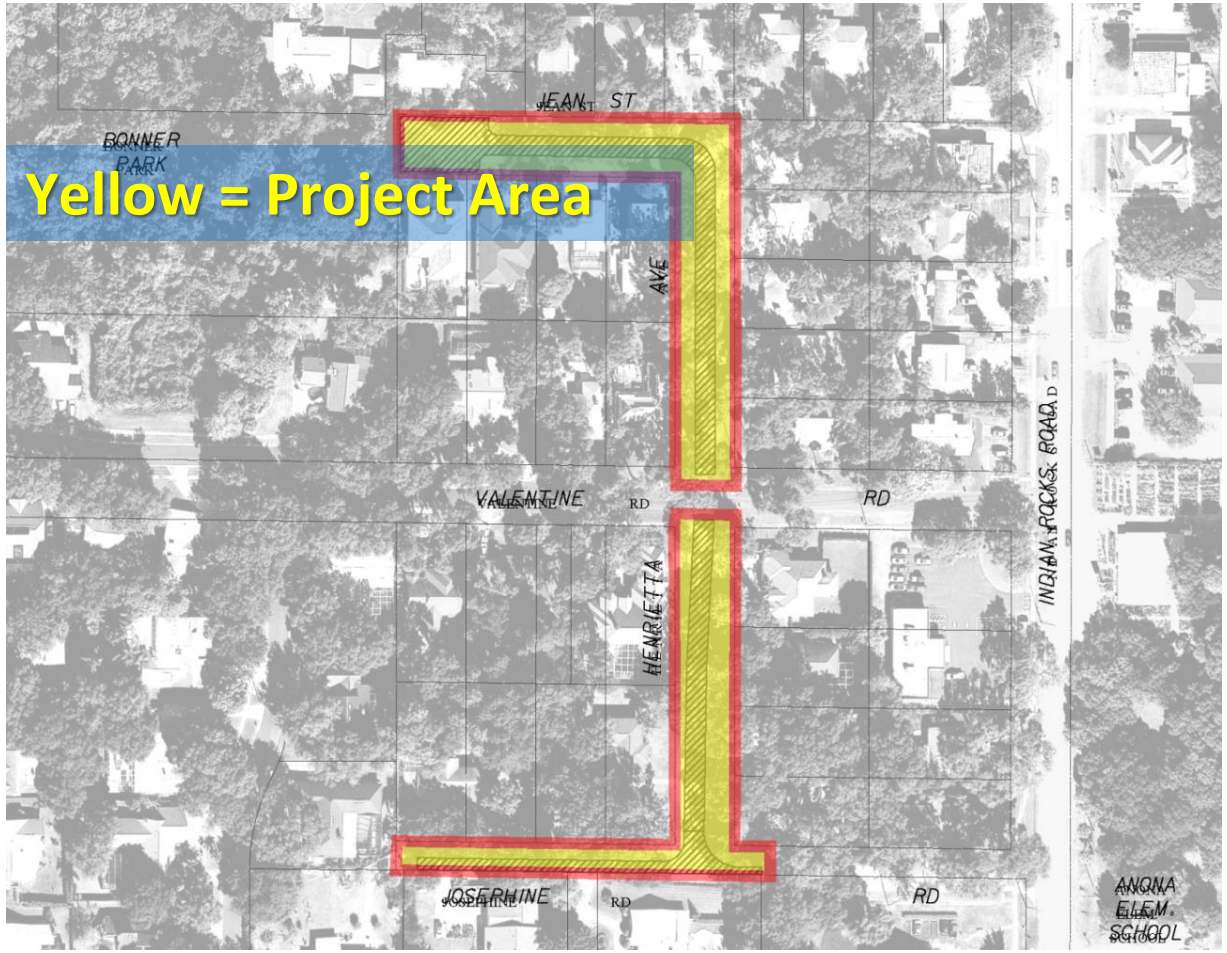
Placement, Striking, Pizza Cutter and 7 day Curing

ERIK
(Embedded Ring Infiltrometer Kit)

Pervious Pavement Considerations – Maintenance and Inspection

- Quarterly to annual vacuum sweeping
- Stabilization of contributing drainage area
- Check for nuisance ponding
- Check edge constraints and overflow areas for erosion
- ERIK testing
- Recertification

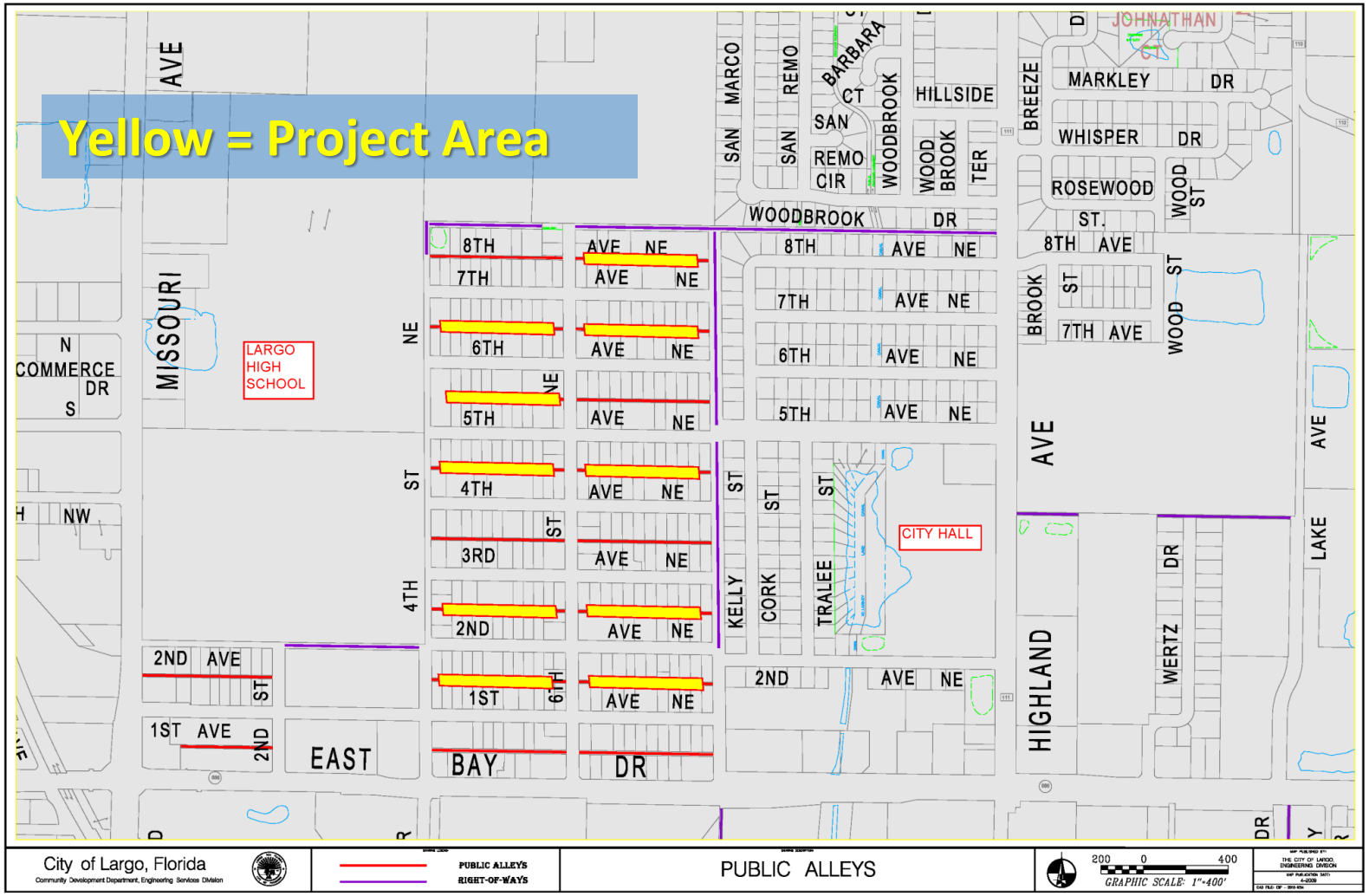
City of Largo
Unpaved Roads Improvements



Marcello Tavernari, P.E.

City of Largo
Unpaved Roads Improvements

City of Largo
Low Impact Alleys



Marcello Tavernari, P.E.

City of Largo
Low Impact Alleys 2011-Dec

Marcello Tavernari, P.E.

Pervious Pavement – Exceptions for Walks and Bike Paths

- No slope constraints
- No edge constraints
- No ERIK required
- For soils with SHGWT 0-18” below, 80% subtracted from contributing area
- For soils with SHGWT >18” below, 100% subtracted from contributing area
- Vacuum sweeping and re-certification normally not required

Pervious Concrete Information

- Florida Concrete & Products Assn.
- http://www.fcpa.org/
- www. ConcreteParkingLots.com
- Manuals
- Training classes
- Training videos

6.7. LID BMP - Green Roof with cistern

- Vegetated roof cover
- Active (Intensive): Deep media, intended for public access
- Passive (Extensive): Shallow media, intended for maintenance access only, designed for aesthetics

Benefits Of Green Roofs

- Economic benefit
- Stormwater management
- Improve air quality
- Moderate urban heat island effect
- Thermal insulation
- Reduce energy consumption
- Sound insulation
- Health and horticultural therapy
- Recreation
- Food supply
- Habitat and wildlife biodiversity
- Aesthetics

Energy Benefits Of Green Roofs In Florida

- Based on UCF green roof monitoring
- Control = New Energy Star roof
- Green roof benefits increase with age while Energy Star roof benefits decline
- Green roofs increase solar panel efficiency

Green Roof Heat Flux Reductions

	2005	2006
Summer	18.8%	43.3%
Winter		49.4%

Florida Pilot Green Roofs

South Florida – 2003 – Bonita Bay Shadow Wood Preserve

August 2003

August 2007

Central Florida – 2005 – UCF Student Union

North Florida – 2011 – Escambia County One Stop Building

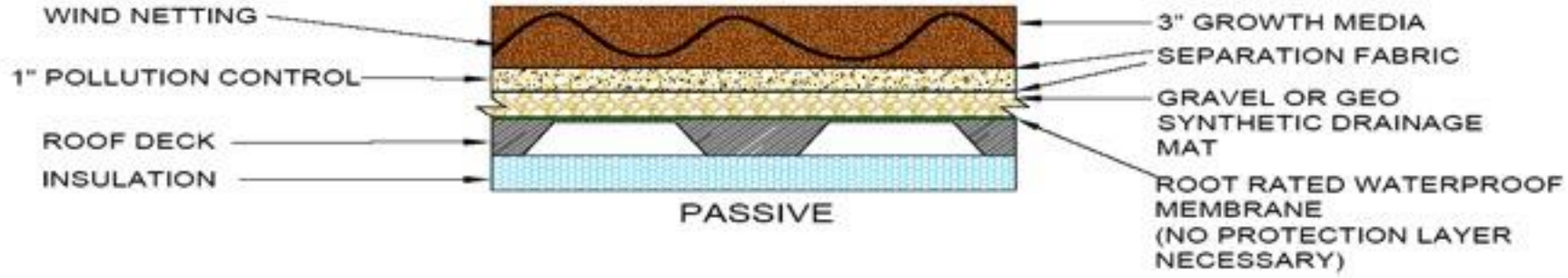
At Least 20 Green Roofs In Florida Since 2003

- UCF Student Union, physical science and Stormwater Lab (3)
- FSGE (Envirohome) (2) in Indialantic
- Bonita Bay
- New American Home in Orlando
- Charlotte County Stadium
- UF Perry Construction Yard Building
- Tecta-America Building in Sanford
- Romano Eco Center in Lake Worth
- Honda Headquarters in Clermont
- Escambia County Central Office 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
- WAWA stores in select locations
- Disney Starbucks

FSGE Integrated Site Design
green roofs, pervious pave, and landscape swales

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

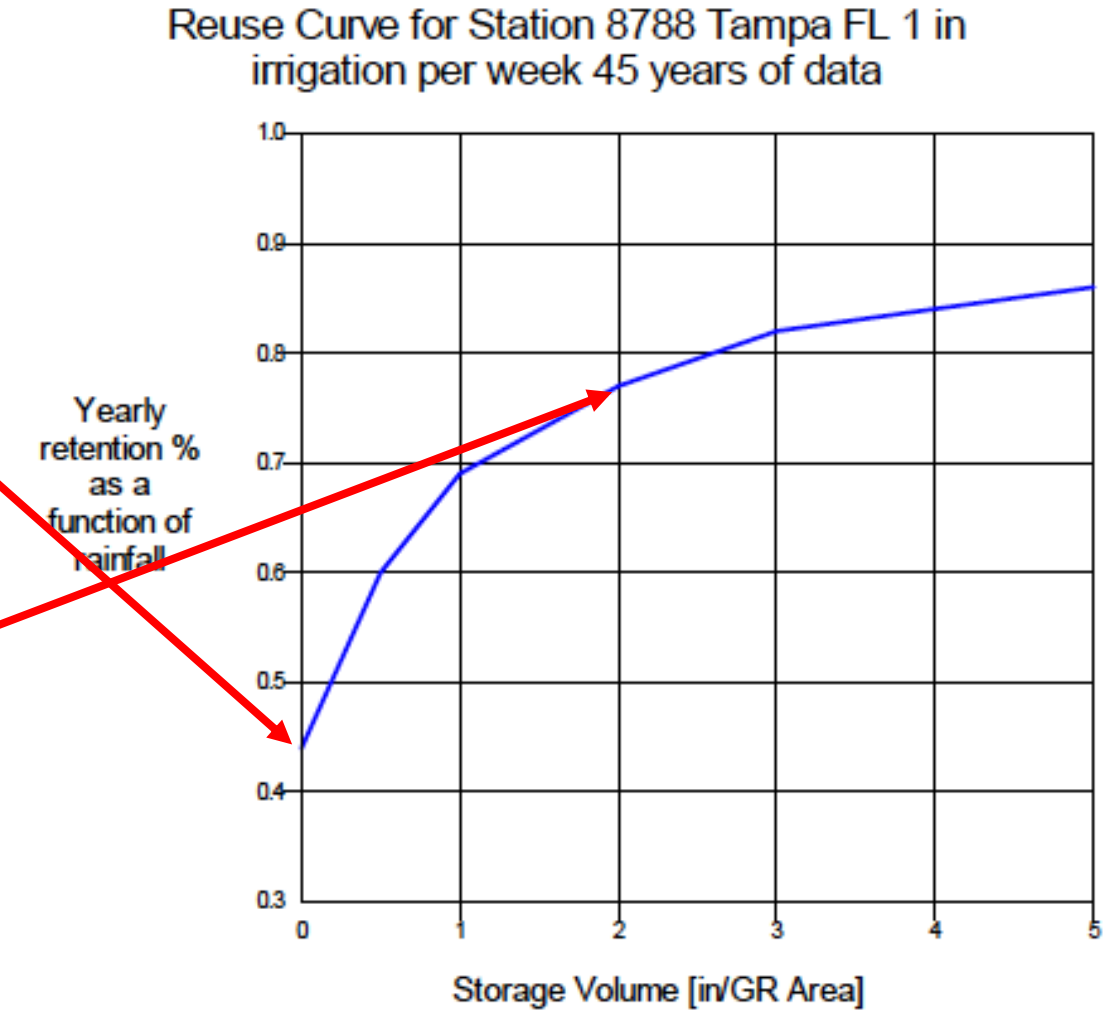
Up to 50 lbs/SF

Up to 25 lbs/SF

CSTORM Model for Green Roof Cistern Design

- **A green roof in Pinellas County will provide 44% annual retention of stormwater without a cistern.**

- **Combined with a cistern storing 2 inches of rainfall, 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.

http://clipart-library.com

Green Roof Stormwater Price Comparison

50,000 square foot roof				
	Down Town Orlando [Magnolia]	Lee Road and I-4	University Blvd.	International Drive
Pond Price (Including Land Cost)	$5,800,000.00	$1,550,000.00	$1,200,000.00	$2,100,000.00
Green Roof Price	$1,400,000.00	$1,400,000.00	$1,400,000.00	$1,400,000.00
Realized savings	$4,400,000.00	$150,000.00	-$200,000.00	$700,000.00

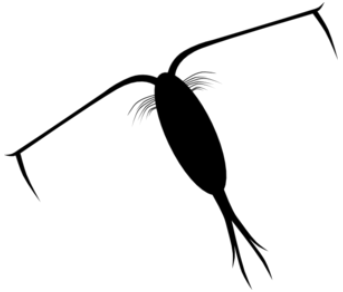
Green Roof price includes fifty years of maintenance while the Pond price does not include any maintenance or fencing, green roof cost = $28/sq ft.

6.8. Wet Detention System

DESCRIPTION: **A detention system with a permanent pool in which runoff is stored temporarily before discharge.**

Wet Detention System 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

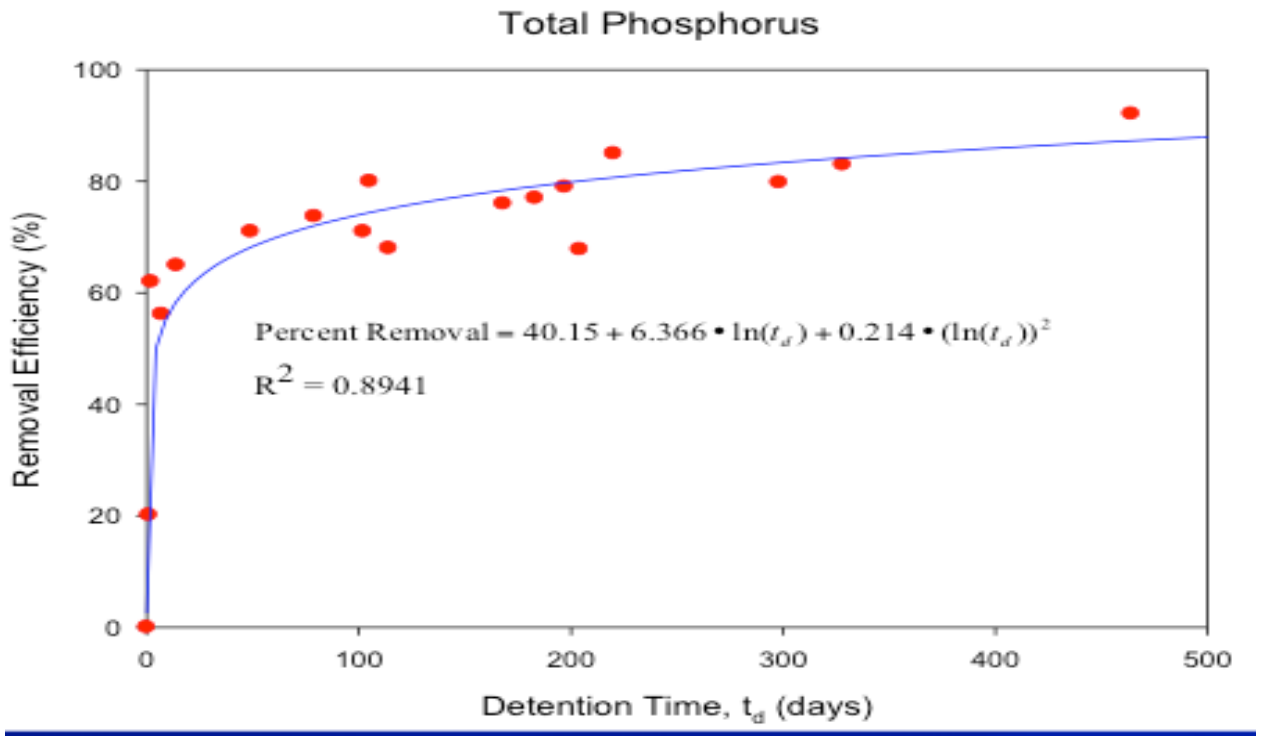


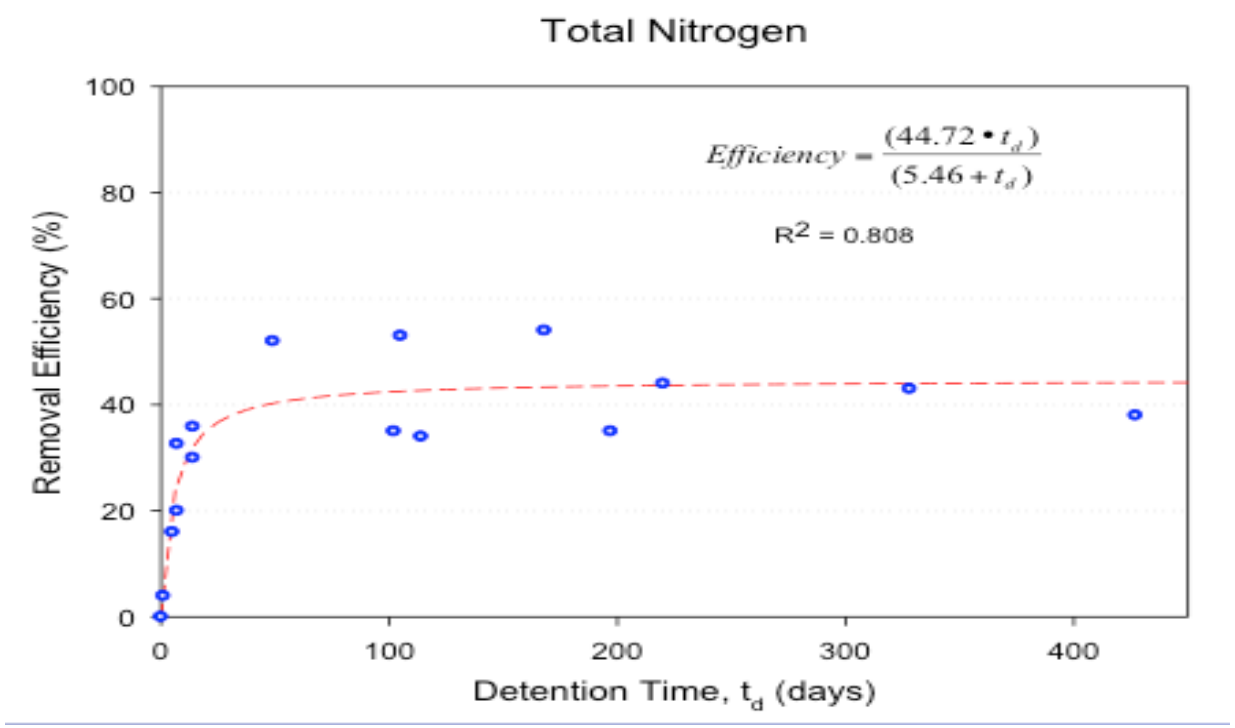
- Gravity settling
  - Pond geometry, volume, residence time, particle size
- Chemical flocculation
- Adsorption onto bottom sediments
- Biological processes
  - Metabolized by microorganisms
  - Uptake by aquatic plants, algae

http://clipart-library.com

Wet Detention Pollutant Removal

Average annual residence time is key factor





Max P removal is about 80%

BUT…

Max N removal is about 40%

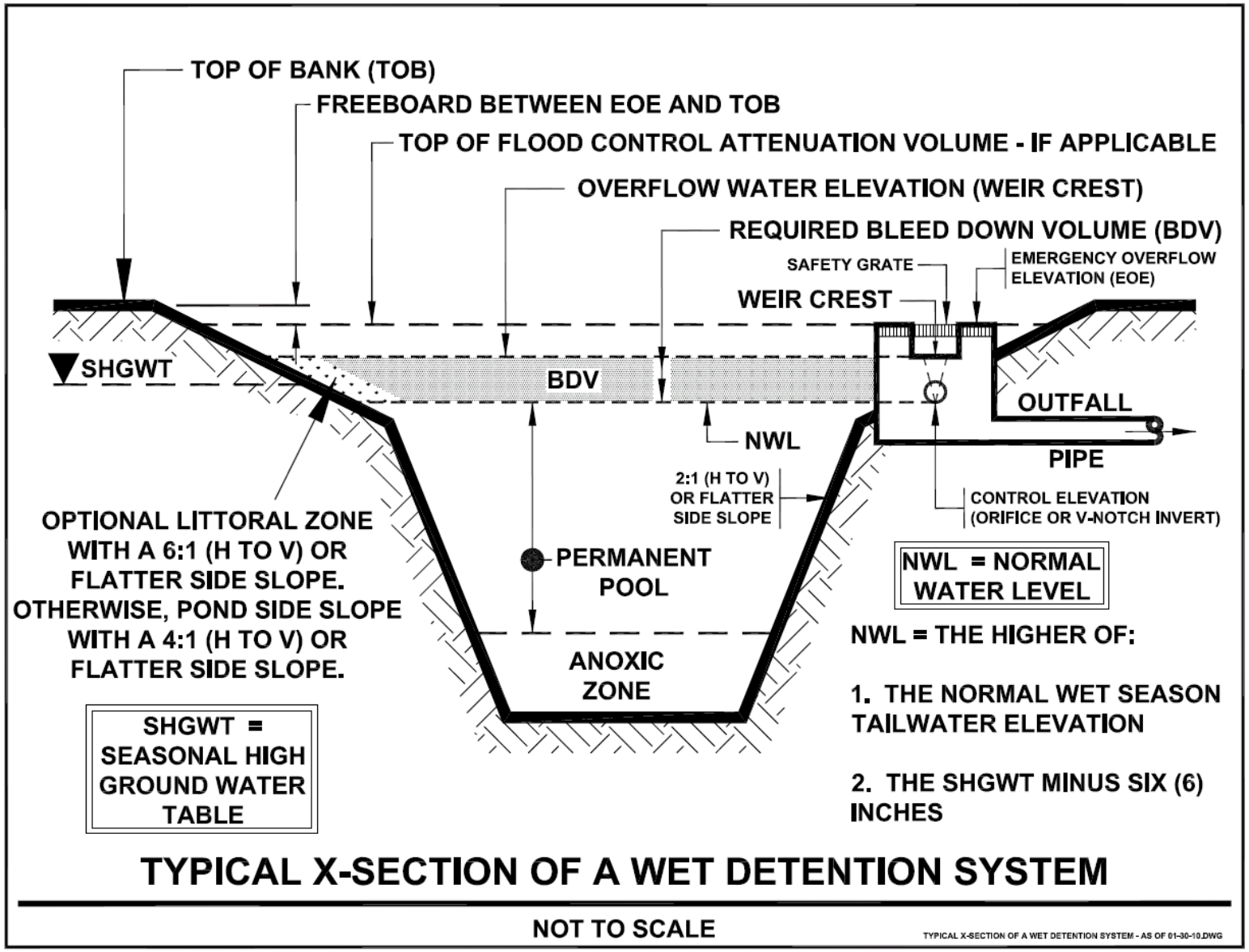
Wet Detention Design Considerations

- Must have a permanent pool of water
- Appropriate soil type with high water table
- Use BMP Treatment Train to maximize treatment
- Increase performance by enlarging surface area to gain more volume instead of deepening
- Avoid short circuiting
- Increase efficiency with stormwater harvesting

Wet Detention Design Criteria

- **Treatment efficiency based on residence time using graphs (Figures 6.8.2 and 6.8.3)**
- **Residence time: Rt = V/Q (V=Perm pool volume, Q = average annual flow rate)**
- **Control elevation: greater of normal wet season tailwater elevation or SHWT minus 6”**
- **Discharge: 1/2 BDV within 24 to 30 hrs.**
- **Mean pond depth > 6 feet**
- **Max depth < 12 feet or within aerobic zone**
- **Flow Path Ratio > 0.8 (Equation 6.8.2)**
- **Vegetated littoral zones optional**

Wet Detention Design Criteria



Wet Detention System Construction

- Verify location and dimensions; ensure all setbacks are met
- During excavation verify soil types are suitable
- If embankment is used, ensure proper compaction and use of anti-seep collars to prevent seepage
- Verify all elevations are consistent with permitted plan specifications
- Stabilize and vegetate around all inlets, outlets, structures
- Stabilize and vegetate side slopes

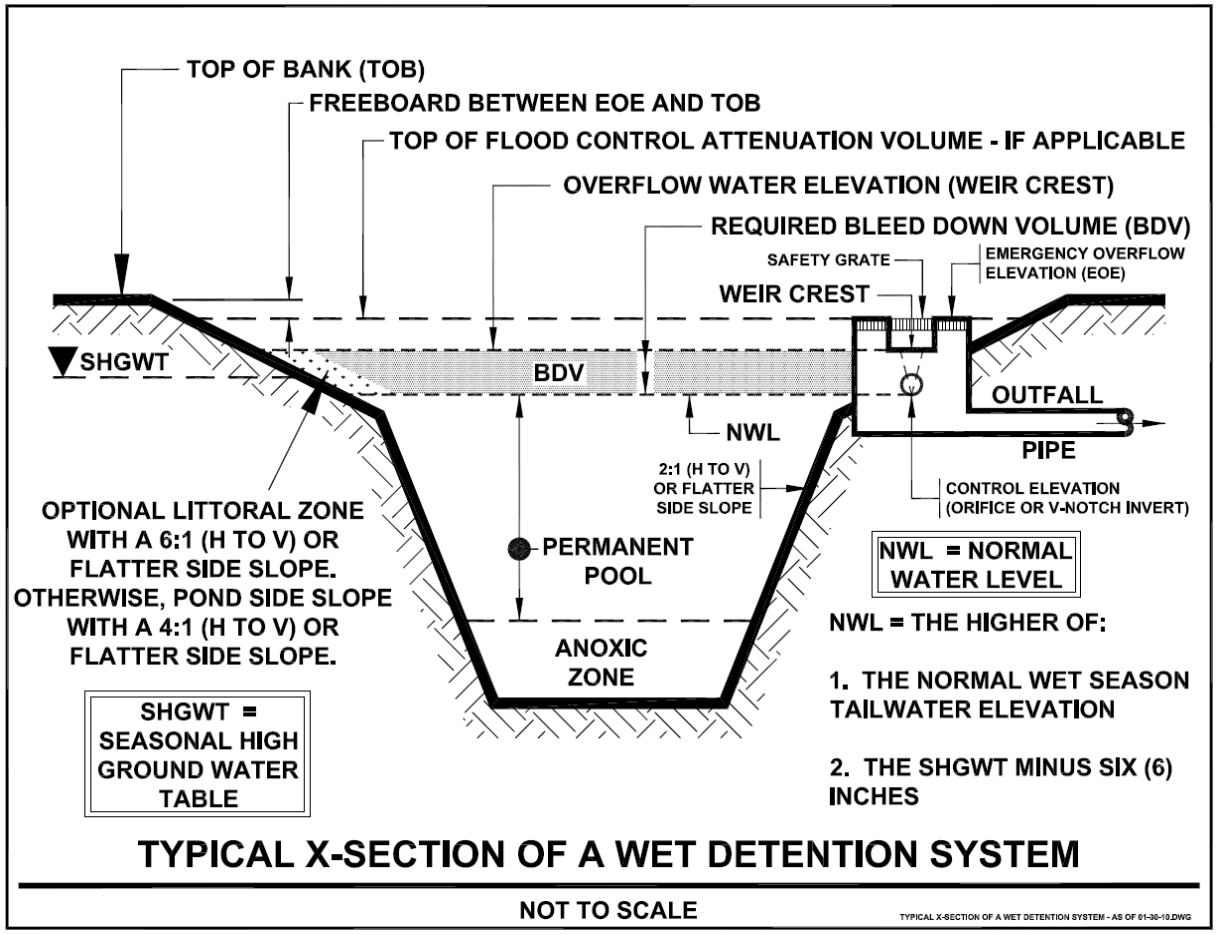
6.9. LID BMP - Stormwater Harvesting

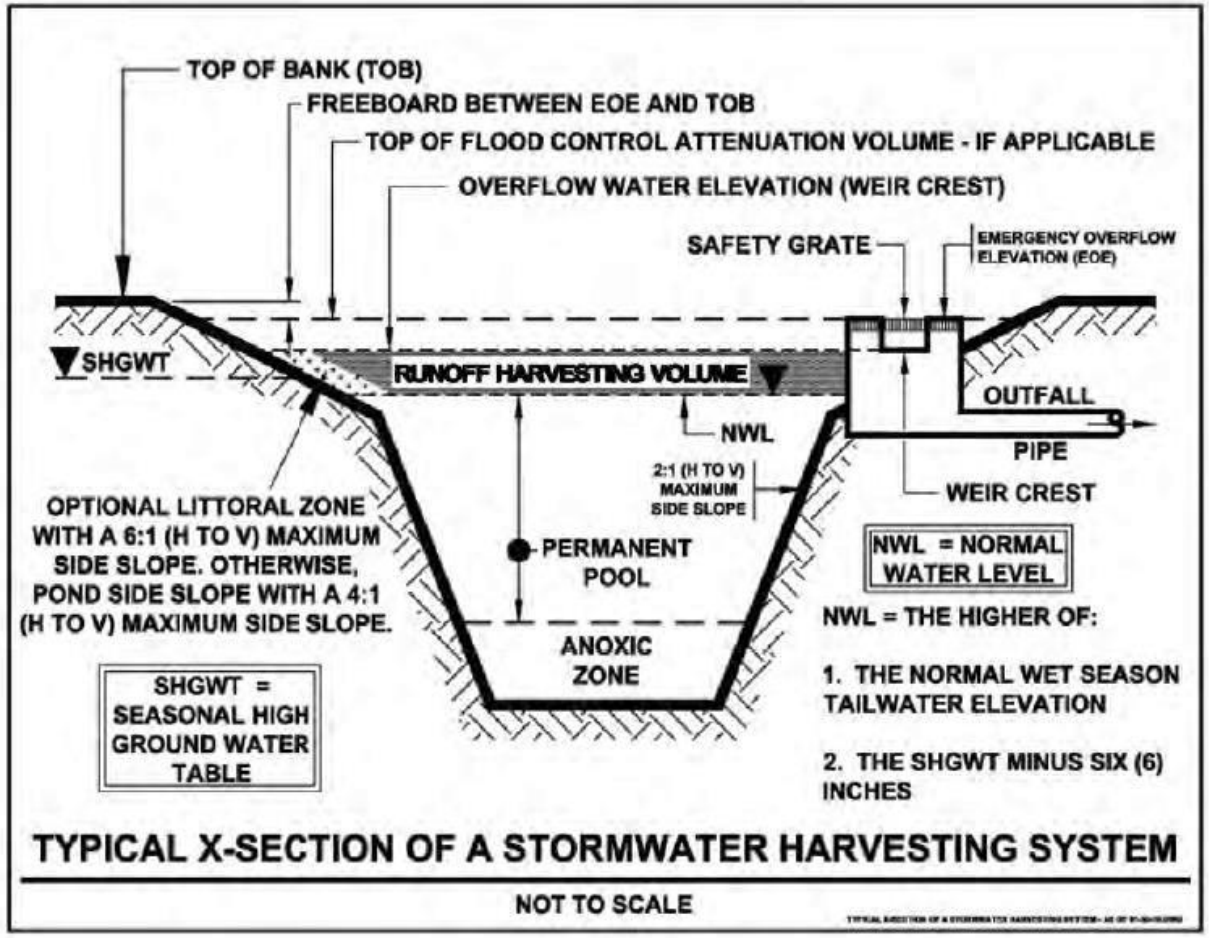
DESCRIPTION: Harvesting retained or detained stormwater for non-potable uses, such as irrigation, car washing, toilet flushing, etc.

ADVANTAGES:

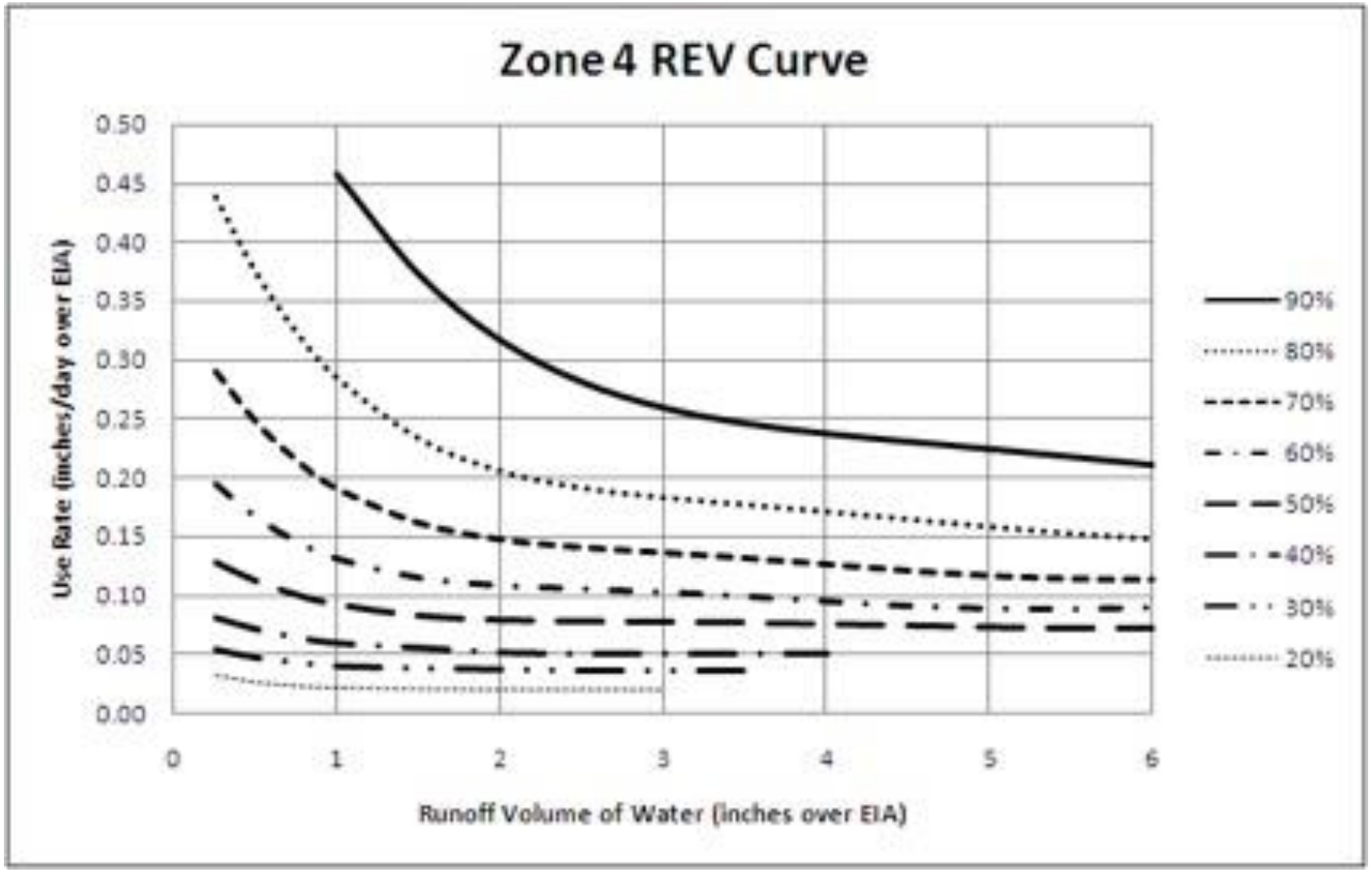
1. Lowers irrigation costs.
2. Increases BMP effectiveness (wet detention).
3. Reduces stormwater pollution into surface waters.
4. Saves potable water.
5. Enhances landscape vegetation.
6. Reduces groundwater use and salt water intrusion.

Wet Detention Design vs. Stormwater Harvesting Design



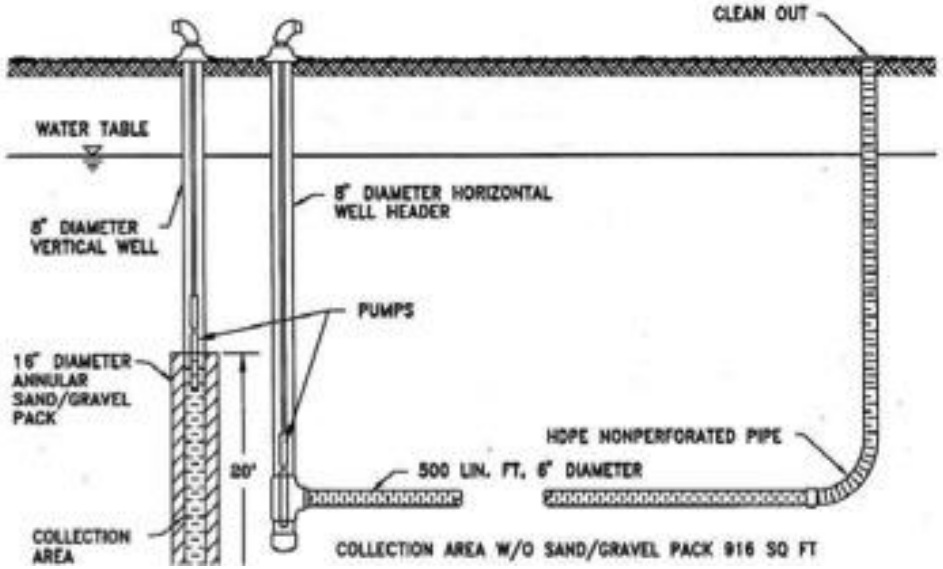


Stormwater Harvesting Design Considerations



Stormwater Harvesting Design Criteria

- Follow Wet Detention design criteria except for 6.8.4.(h) [recovery time] and (i) [outlet structure]
- 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



Project SMART - Florida

COLLECTS RUNOFF WATER

Regional wet detention pond serving roadway and commercial property

Wet detention pond cleaned, reshaped, revised to allow stormwater harvesting

Test case to verify design REV criteria

CONTROLS POLLUTION

Water harvesting for irrigation of lawns
Community saved potable water as well as money.

AND REUSES THE WATER

Examples: Over 300 in Florida

Sources: Horizontal Subsurface Systems and G. Hartman

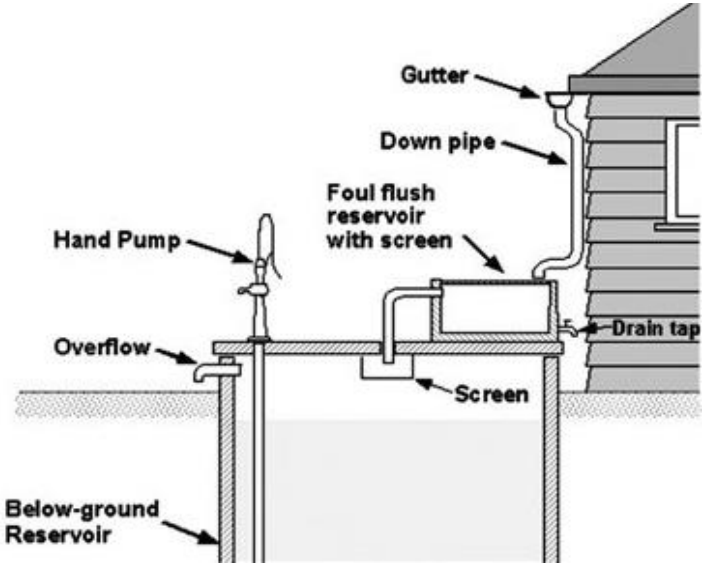
www.stormwater.ucf.edu

1. South Bay Utilities

- Upscale residential irrigation demand
- No CUP
- No FPSC
- No FDEP
- 50¢/1,000 gallons
- Shallow wells
- Customer agreements 900 homes - HOA
- Coastal / fragile resource

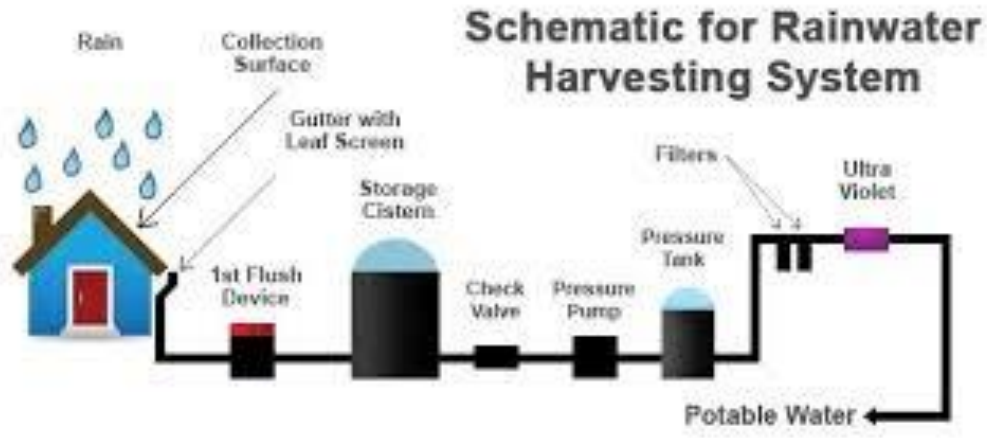
6.14. LID BMP – Rainwater Harvesting

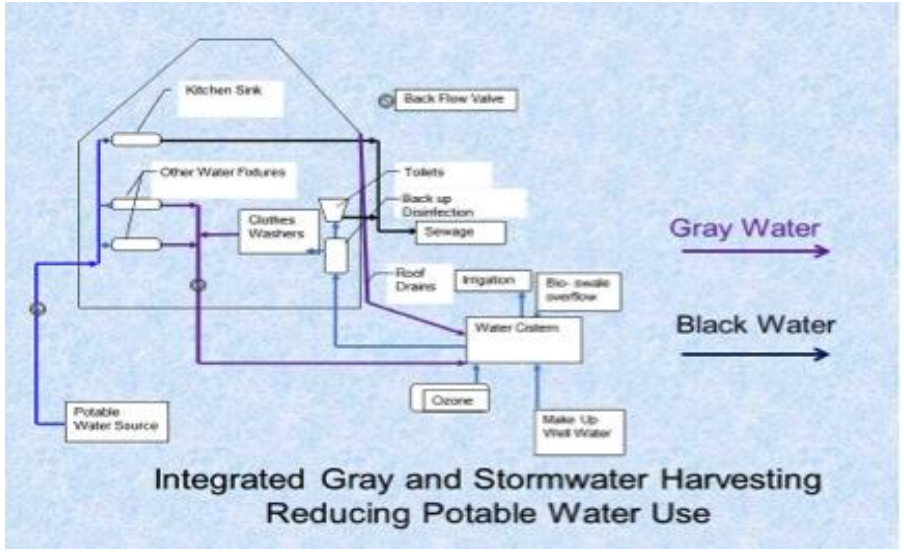
- **The collection and storage of roof runoff to reuse**
- **Reduces DCIA, runoff volume, loading, use of potable water**
- **Variety of uses from irrigation to potable uses**



4 Types of Rainwater Harvesting Systems

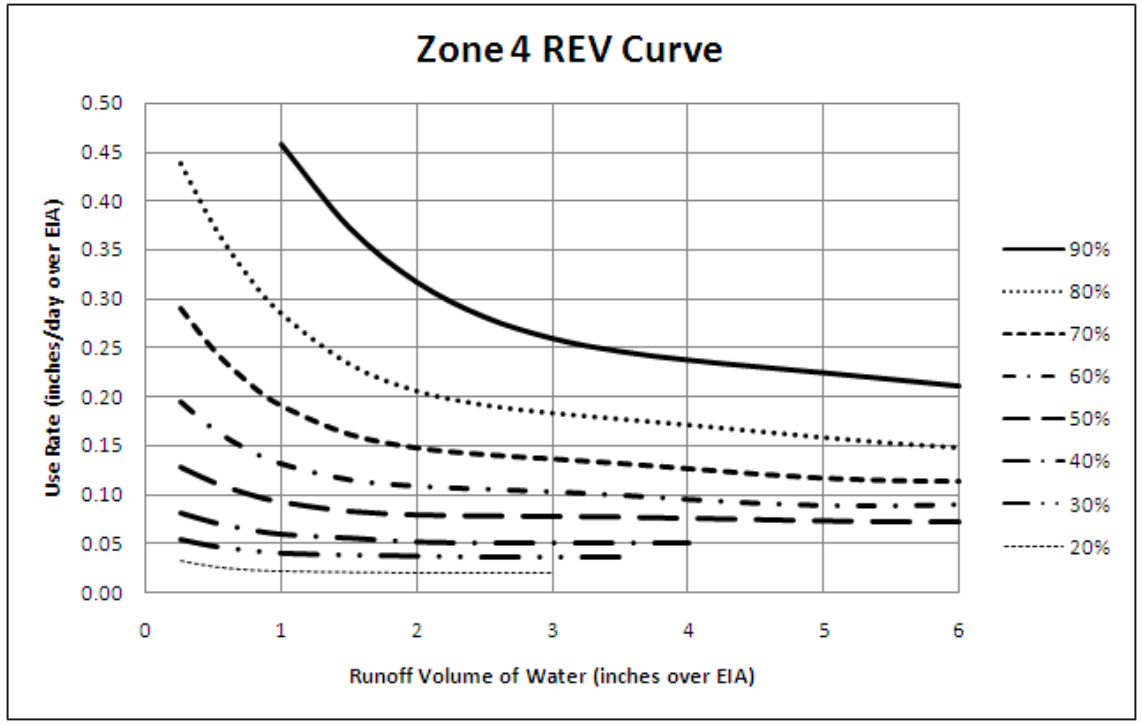
1. **Non-potable residential with rain barrel**
2. **Non-potable outdoor use with cistern**
3. **Non-potable indoor/outdoor use with cistern – Health Dept. approval**
4. **Potable use with cistern – Health Dept. approval**

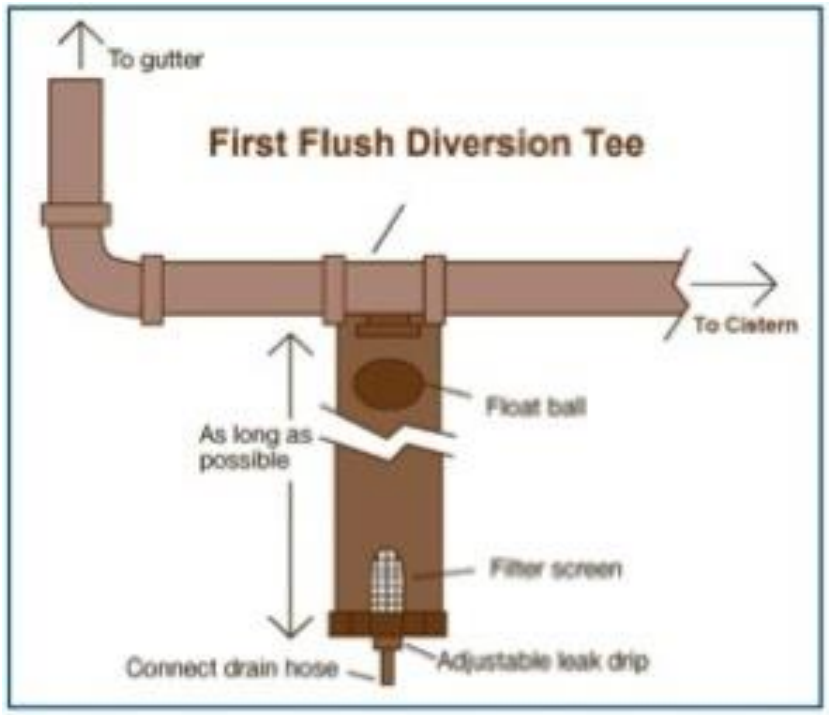




Rainwater Harvesting Design Criteria

- **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 SWFWMD water use permit
- May require approval by Pinellas County Health Department and Pinellas County Development Services

6.11. Managed Aquatic Plant Systems (MAPS)

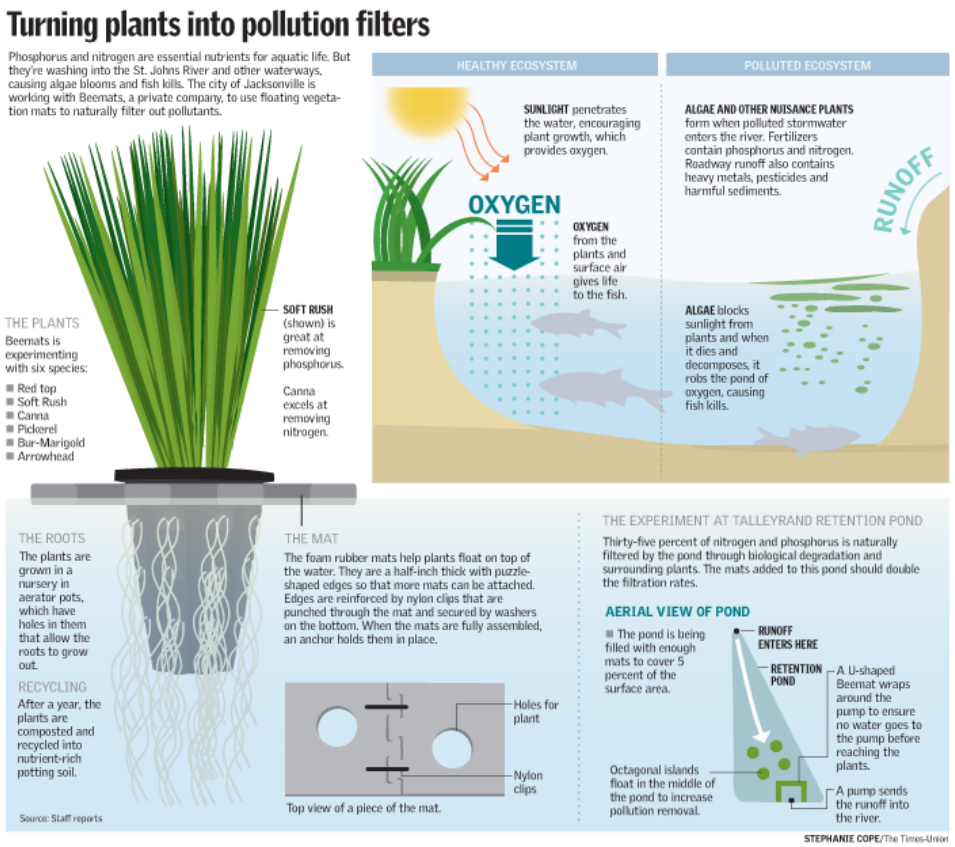
- **Vegetated Littoral Zones**
- **Floating Wetland Mats***

*Still under study by County

*No treatment credit at this time

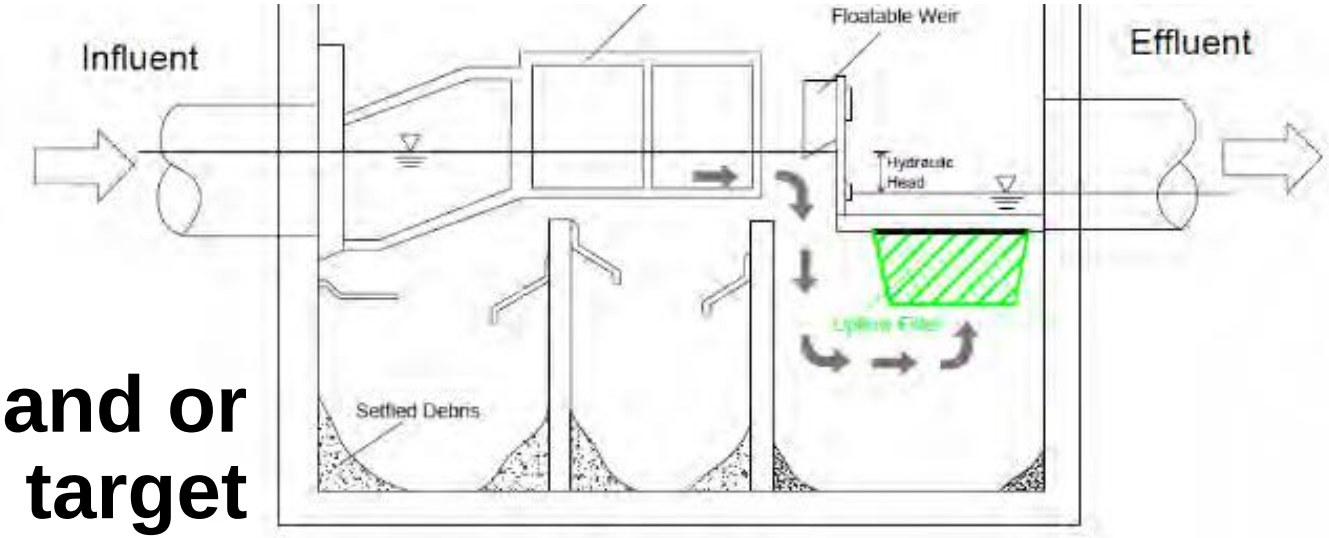
Vegetated Littoral Zones

BEEMATS – Floating Wetland Mats



6.10. Up-Flow Filter Systems

DESCRIPTION: **Filters used in conjunction with wet detention systems to increase the overall treatment effectiveness.**



ADVANTAGES:

- **Applicable to ultra-urban redevelopment**
- **Filter media can be either sand or mixed media depending on target pollutants**
- **Up-flow design reduces clogging and maintenance**

Up-Flow Filter Design Criteria

- **Effectiveness: Dependent on annual volume filtered and the filter media**
- **Treatment volume: Use Table 6.1.2 to get % RO volume**
- **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

DESCRIPTION OF MEDIA		PROJECTED TREATMENT PERFORMANCE *			TYPICAL OPERATING LIMITING FILTRATION RATE (in/hr)
Media and Typical Location in BMP Treatment Train	MATERIAL	TSS REMOVAL EFFICIENCY	TN REMOVAL EFFICIENCY	TP REMOVAL** EFFICIENCY	
B&G ECT [inf A] A first BMP, ex. Up-Flow Filter in Baffle box and a constructed wetland[#] (USER DEFINED BMP)	Expanded Clay[2] Tire Chips[1]	70%	55%	65%	96 in/hr
B&G OTE [inf A] Up-flow Filter at Wet Pond or Dry Basin Outflow (FILTRATION)	Organics[8] Tire Chips[1] Expanded Clay[4]	60%	45%	45%	96 in/hr
B&G ECT3 [inf C] After Wet Detention using Up-flow Filter	Expanded Clay[4] Tire Chip[1]	60%	45%	45%	96 in/hr
SAT [inf D] A first BMP, as a Down-flow Filter (FILTRATION)	Sand[3]	85%	30%	45%	2 in/hr
B&G CTS [inf E,F] Down-Flow Filters 12" depth*** at wet pond or dry basin pervious pave, tree well, rain garden, swale, and strips	Clay[6] Tire Crumb[5] Sand[7] & Topsoil[9]	90%	60%	90%	1.0 in/hr
B&G CTS [inf E,F] Down-Flow Filters 24" depth*** at wet pond or dry basin pervious pave, tree well, rain garden, swale, and strips	Clay[6] Tire Crumb[5] Sand[7] & Topsoil[9]	95%	75%	95%	1.0 in/hr

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%: **Phosphorus removal has limited life expectancy: ***24" depth has TN and TP removals of 75 & 95%
acronyms B&G - BOLD & GOLD; SAT - Sand Austin Tx; ECT- Expanded Clay and Tire; ECT3 Expanded Clay and Tire in Treatment Train
[1] Tire Chip 3/8" and no measurable metal content (approximate dry density = 730 lbs/CY)
[2] Expanded Clay 5/8 and 3/8 blend (approximate dry density = 950 lbs/CY)
[3] Sand ASTM C-33 with no more than 3% passing # 200 sieve (approximate dry density = 2200 lbs/CY)
[4] Expanded Clay 3/8 in blend (approximate density = 950 lbs/CY)
[5] Tire Crumb 1-5 mm and no measurable metal content (approximate density = 730 lbs/CY)
[6] Medium Plasticity typically light colored Clay (approximate density = 2500 lbs/CY)
[7] Sand with less than 5% passing #200 sieve (approximate density = 2200 lbs/CY)
[8] Organics: Either compost (approximate density of 700 lbs/CY) Class 1A Compost or wood chips (sawdust) without pesticides
[9] 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.

A - Demonstration Bio Media for Ultra-urban Stormwater Treatment, Wanielista, et al. FDOT Project BDK78 977-19, 2014
B - Nutrient Reduction in a Stormwater Pond Discharge in Florida, Ryan, et al, Water Air Soil Pollution, 2010
C - Up-Flow Filtration for Wet Detention Ponds, Wanielista and Flint, Florida Stormwater Association, June 12, 2014.
D - City of Austin Environmental Criteria Manual, Section 1.6.5, Texas, 2012
E - Nitrogen Transport and Transformation in Retention Basins, Marion Co, Fl, Wanielista, et al, State DEP, 2011
F - Improving Nitrogen Efficiencies in Dry Ponds, Williams and Wanielista, Florida Stormwater Association, June 18 2015

MIX:	TN Removal %	TP Removal %	Water storage fraction
B&G ECT	55	65	0.3
B&G OTE	45	45	0.3
B&G ECT3	45	45	0.3
SAT	30	45	0.3
B&G CTS12	60	90	0.3
B&G CTS24	75	95	0.3
UDM1*			
UDM2*			
UDM3*			
UDM4*			

* User Defined Media Mix

Up-Flow Filter Construction and Maintenance

Construction:

- Construct wet detention system or vault
- 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

Upflow Filter Installation by Suntree Technologies

Improved Treatment Using Up-flow Filters with Wet Pond

Filters Work to remove more

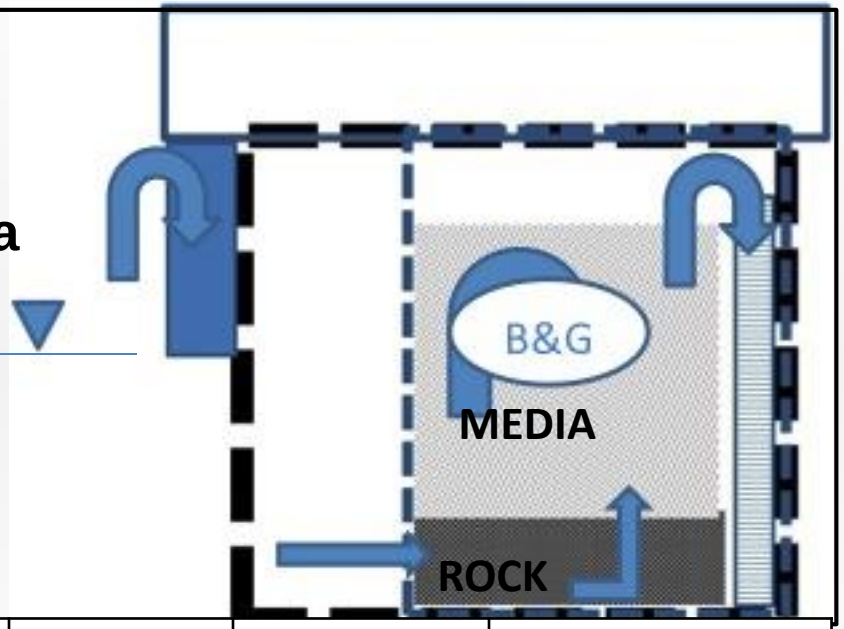
- **Filters can be designed to remove nitrogen without media replacement**
- **For phosphorus, media replacement time is specified**
- **Can be used in BMP & LID Treatment Train Applications with other treatment**

Suntree Technologies Inc.

Up-Flow Input from Wet Detention to Filter

- **Performance**
  - Concentration
  - Averages based on field data
  - Average yearly based on

  1.0 inch design for filter



Parameter	TN	TP	TSS
Average Influent Concentration (mg/L)	1.83	0.73	42.7
Expected Average Pond Removal (%)	38	63	79
Average Pond + Filter Removal (%)	70	72	91
Average Annual System Performance	67	70	89

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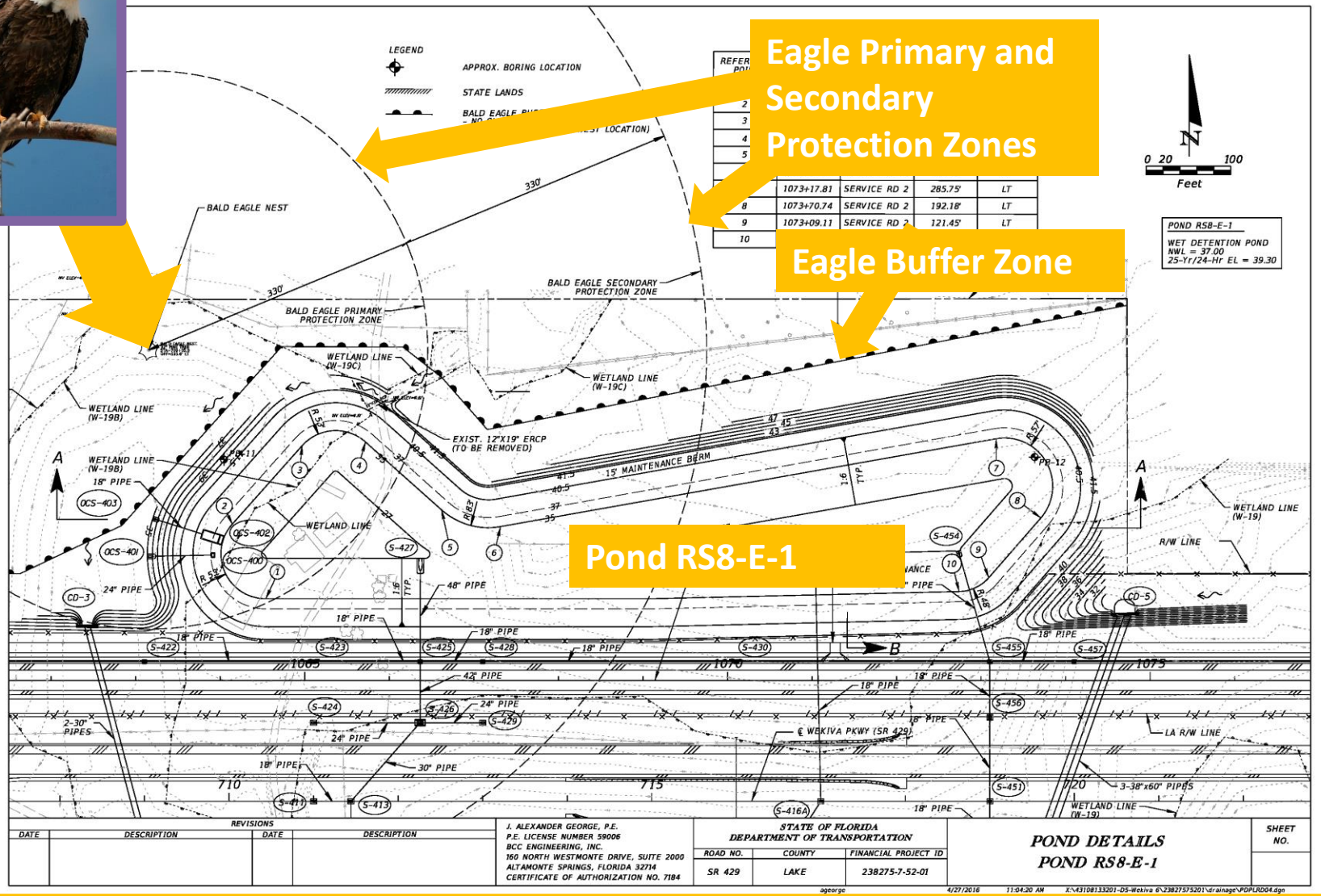
FDOT InterState Section 6

Eagle Primary and Secondary Protection Zones

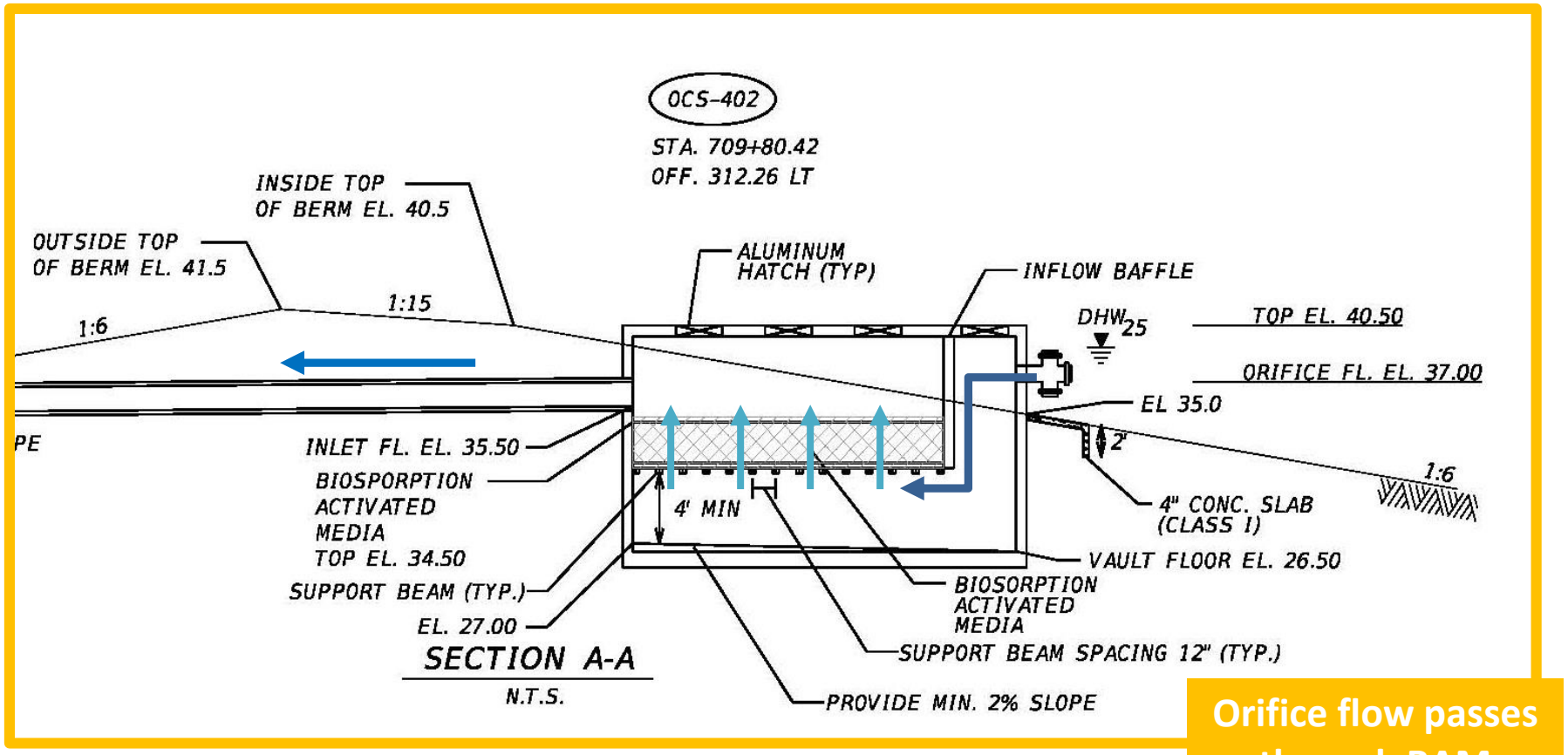
Eagle Buffer Zone

Pond RS8-E-1



FDOT InterState Section 6

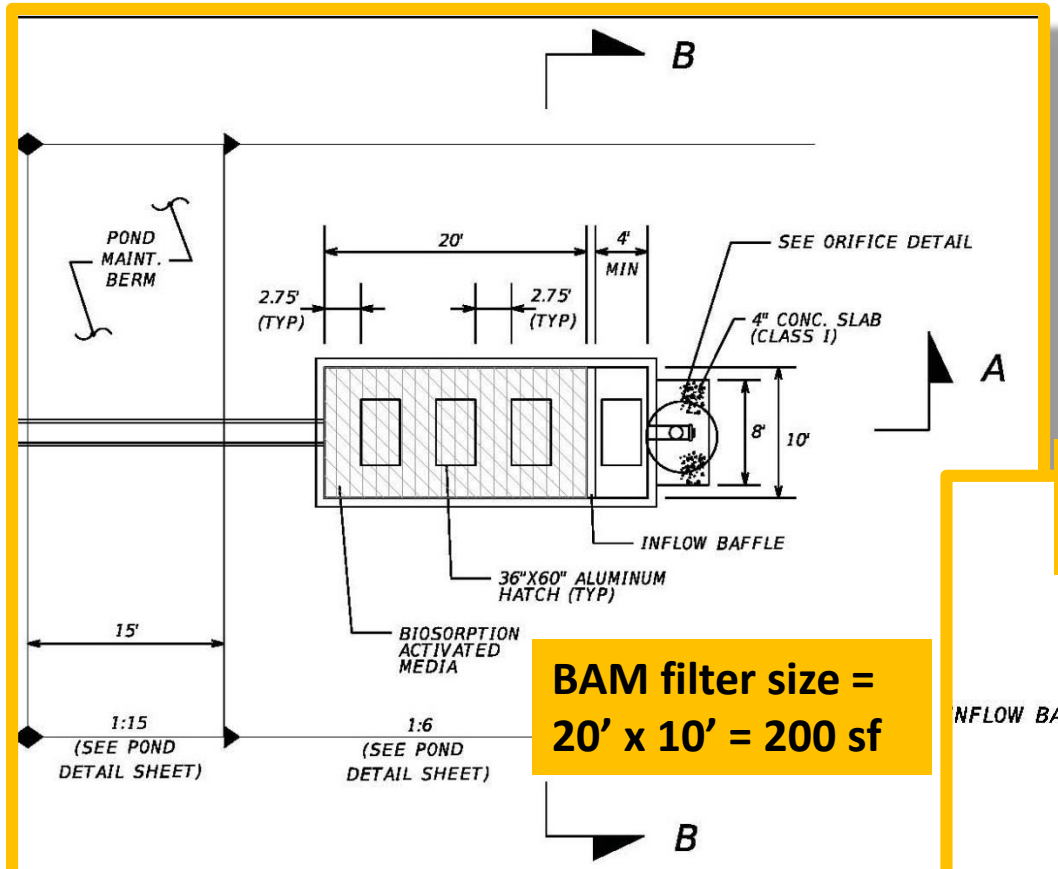
- **NRFS Control Structure (OCS-402)**



Orifice flow passes through BAM

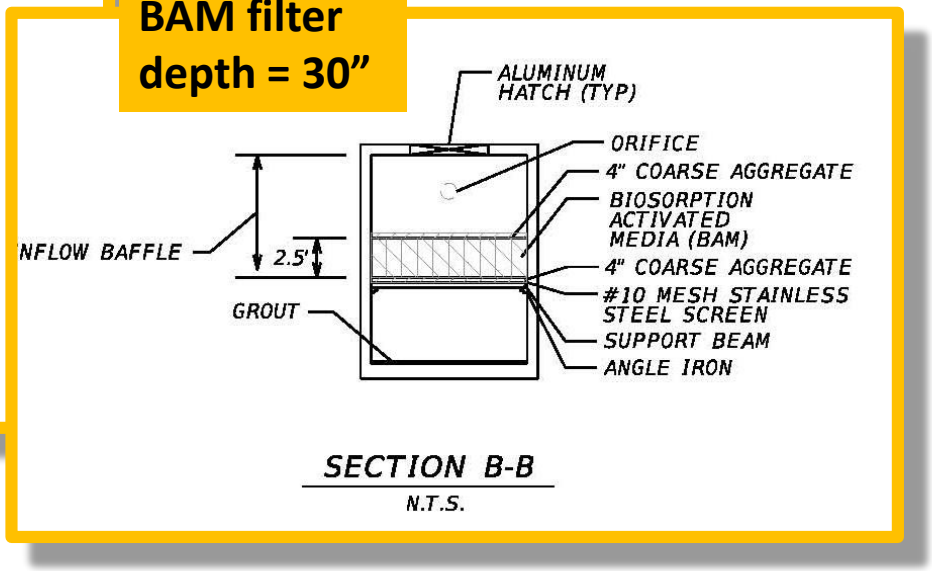
FDOT Nutrient Removal Filtration System (NRFS)

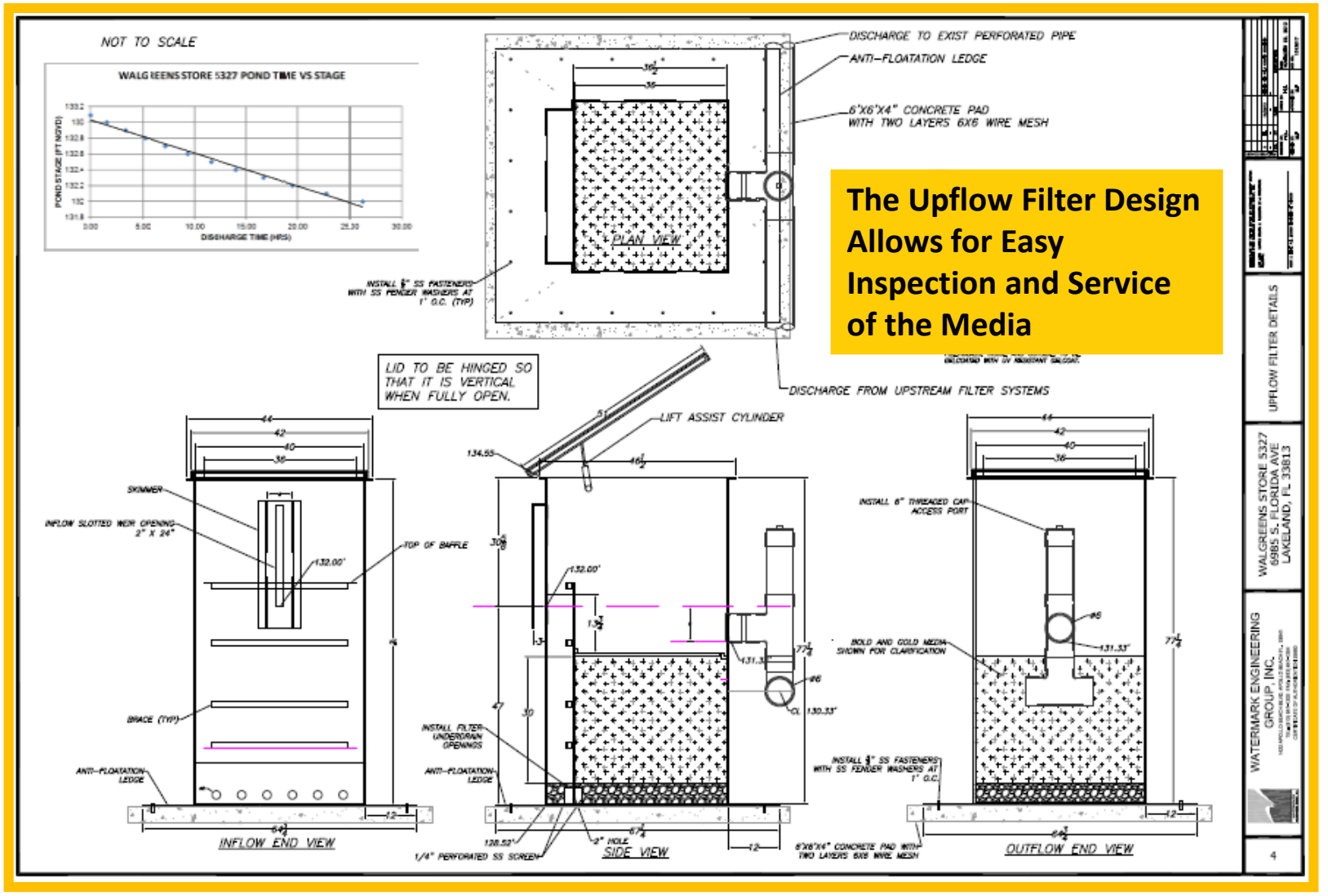
- **NRFS Control Structure (OCS-402)**



BAM filter size = 20’ x 10’ = 200 sf

BAM filter depth = 30”



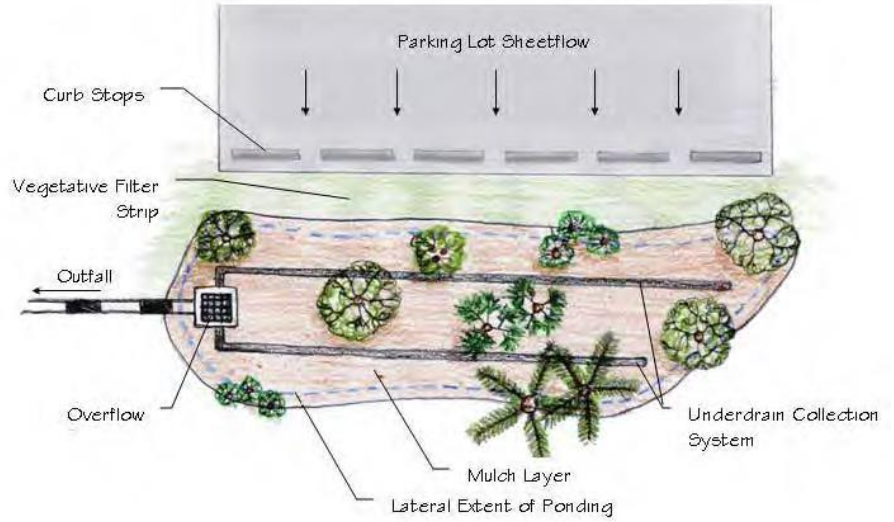


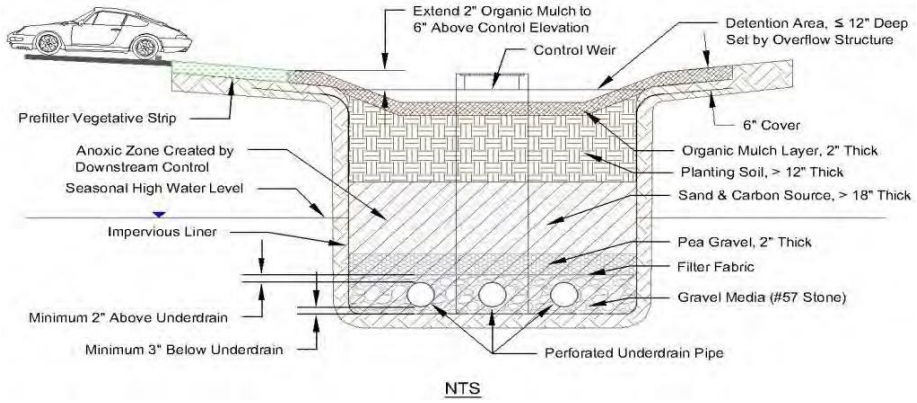
The Upflow Filter Design Allows for Easy Inspection and Service of the Media

WATERMARK ENGINEERING GROUP, INC.

6.12. LID BMP – Biofiltration using Biosorption Activated Media (BAM)

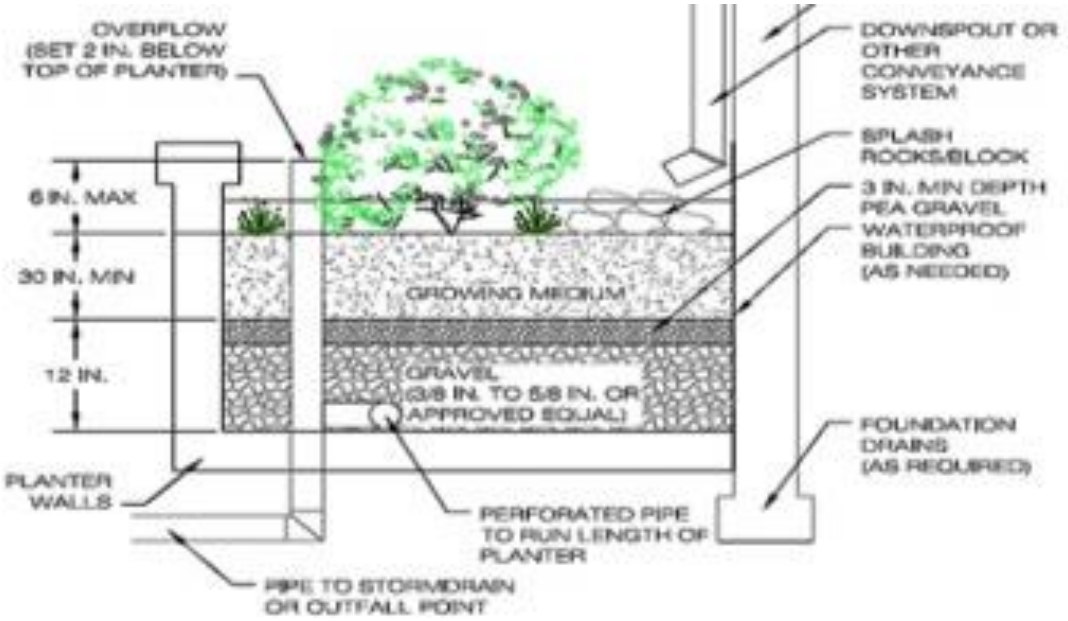
- **Offline BMP with engineered media (BAM) to enhance pollutant removal**
- **Retention or detention BMPs**
- **Include rain gardens, planter boxes, tree box filters, up-flow filters**





Biofiltration BMP Components

- Pretreatment BMPs
- Ponding area 3-12 inches deep
- Planting media over BAM
- Florida-friendly plants
- Overflow/spillway – divert larger storms
- Control structure to create anoxic layer in bed
- Energy-dissipation mechanism



LID BMP - 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"**
- **https://stormwater.ucf.edu/wp-content/uploads/2014/09/AlternativeMedia2008.pdf**

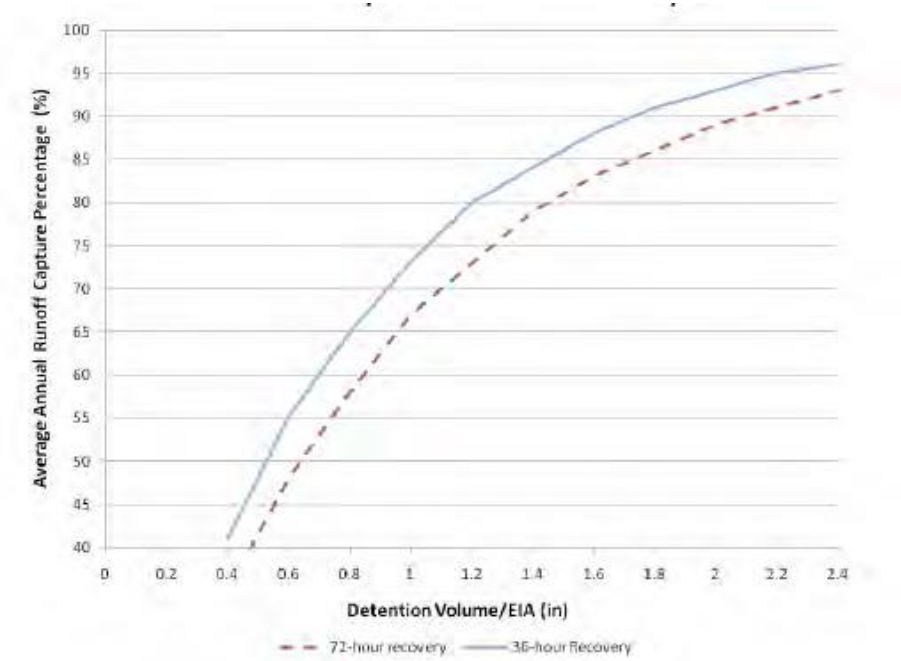
DESCRIPTION OF MEDIA		PROJECTED TREATMENT PERFORMANCE *			TYPICAL OPERATING LIMITING FILTRATION RATE (in/hr)
Media and Typical Location in BMP Treatment Train	MATERIAL	TSS REMOVAL EFFICIENCY	TN REMOVAL EFFICIENCY	TP REMOVAL** EFFICIENCY	
B&G ECT [ref A] A first BMP, ex. Up-Flow Filter in Baffle box and a constructed wetland[6] (USER DEFINED BMP)	Expanded Clay[1] Tire Chips[2]	70%	55%	65%	96 in/hr
B&G OTE [ref A] Up-flow Filter at Wet Pond or Dry Basin Outflow (FILTRATION)	Organics[3] Tire Chips[2] Expanded Clay[1]	60%	45%	45%	96 in/hr
B&G ECT3 [ref A] After Wet Detention using Up-flow Filter	Expanded Clay[1] Tire Chip[2]	60%	45%	45%	96 in/hr
SAT [ref A] A first BMP, as a Down-flow Filter (FILTRATION)	Sand[5]	85%	30%	45%	3 in/hr
B&G CTS [ref B,J] Down-Flow Filters 12" depth*** at wet pond or dry basin pervious pave, rain wall, rain garden, swale, and strips	Clay[4] Tire Crumb[2] Sand[5] & Topsoil[3]	90%	60%	90%	1.0 in/hr
B&G CTS [ref B,J] Down-Flow Filters 24" depth*** at wet pond or dry basin pervious pave, rain wall, rain garden, swale, and strips	Clay[4] Tire Crumb[2] Sand[5] & Topsoil[3]	95%	75%	95%	1.0 in/hr

NOTES: *No currently accepted BMP at this time. Also can be used as a pretreatment BMP but the removal must be known

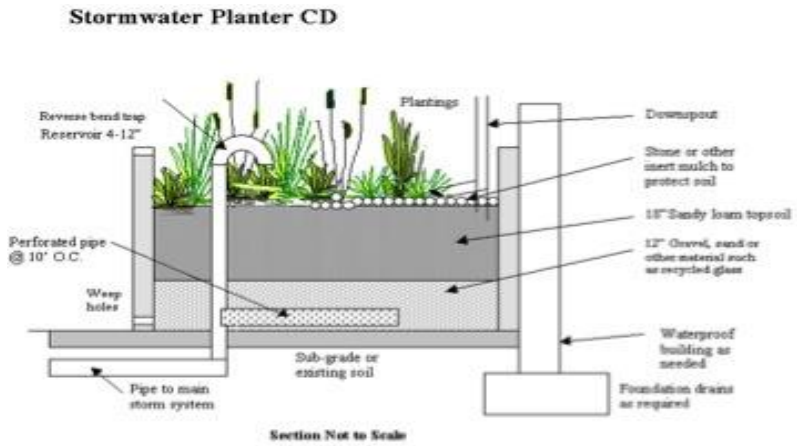
Biofiltration Treatment Effectiveness

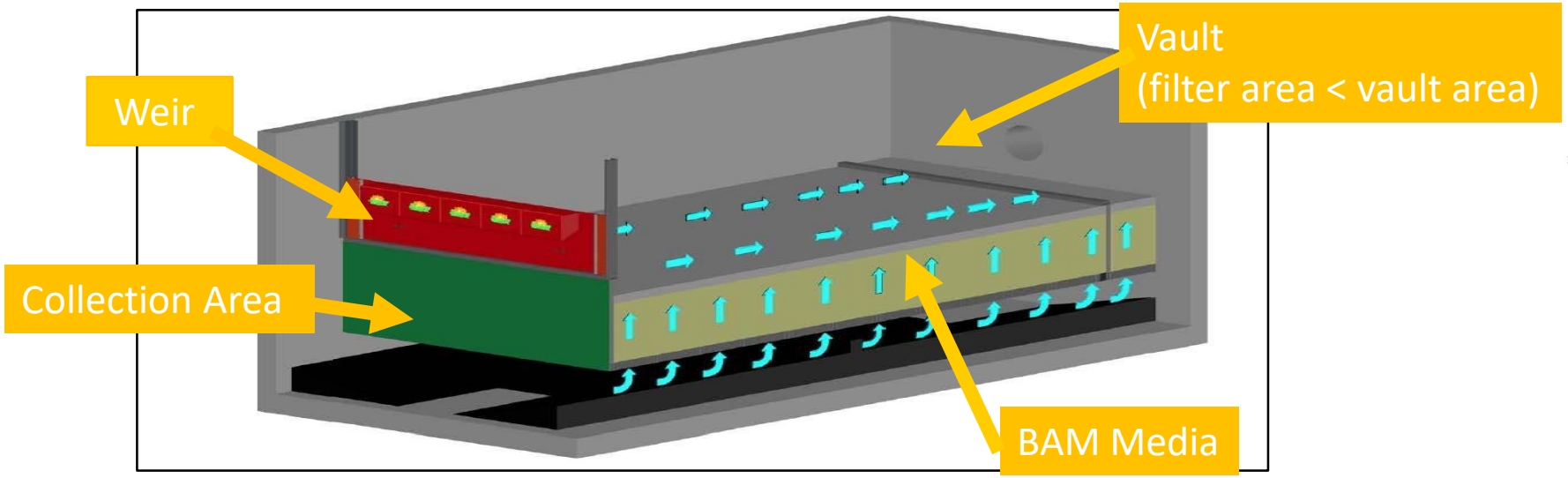
- Part of a BMP Treatment Train
- Use graph to determine capture volume (CV)
- Use BAM effectiveness – depends on blend and its thickness
- Efficiency = CV % * BAM % removal

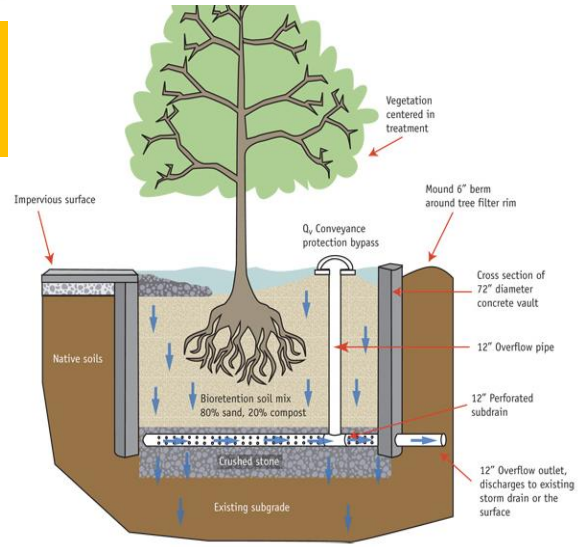
Efficiency = 53% * 75% TN = 40% removal



LID BMP – Planter Box Biofiltration Systems







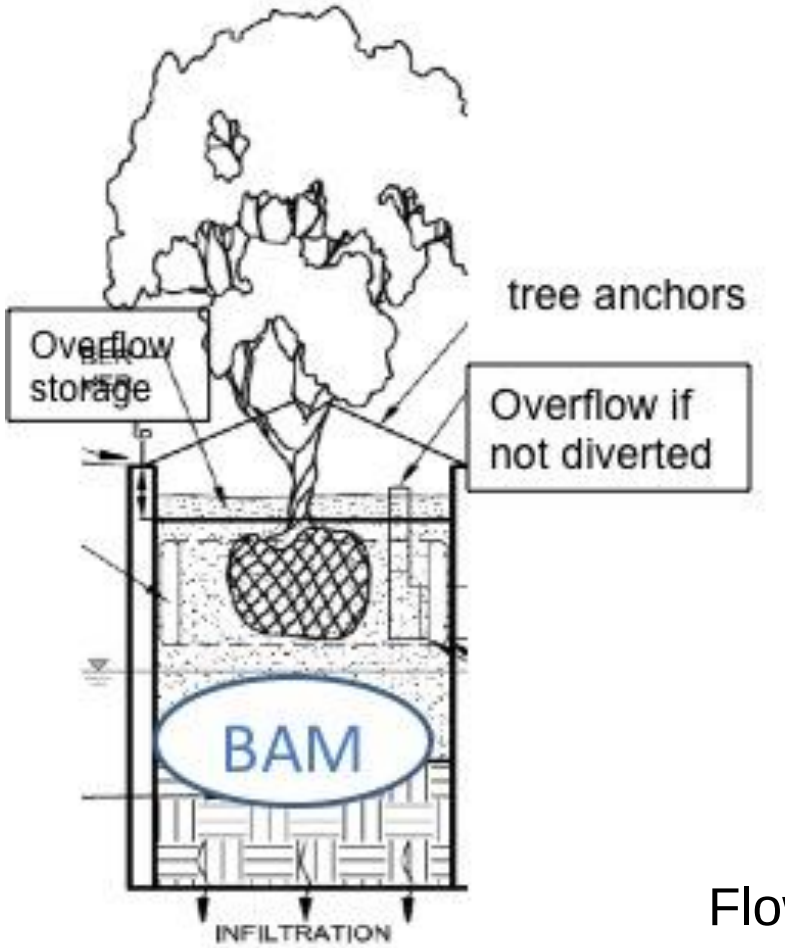
Planter Box Biofiltration Design Considerations

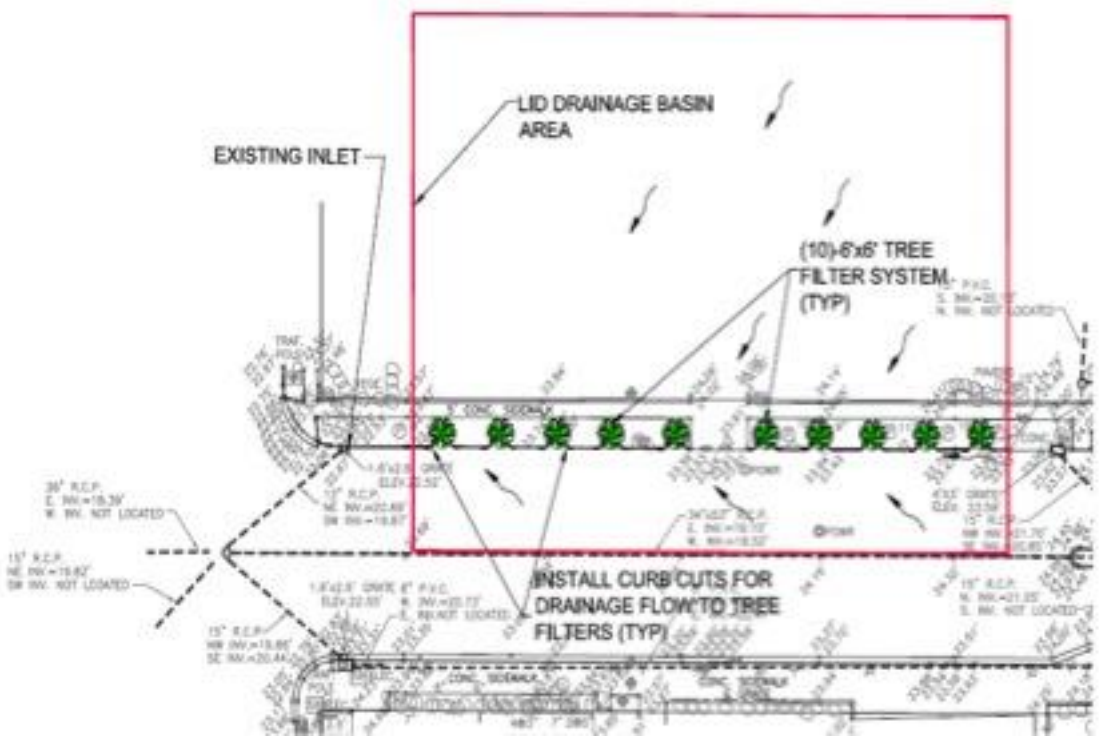
- Can be either retention or detention BMP
- Setback 10’ from buildings unless lined flow-through
- Contributing DA < 2,500 SF; larger with County OK
- Retention biofiltration RTV per retention BMPs
- Detention biofiltration effectiveness depends on filter media and annual volume of stormwater treated
- 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

Tree Box (Well) Filter System Design Considerations

- **Pre-cast concrete boxes**
- **BAM installed below grade at the curb line.**
- **Sized for specific stormwater treatment volume**
- **Contributing DA typically < 0.25 acre**
- **Soil volume is critical – up to 1500 ft^3**
- **Trees per Section 138-3664 of Article X Design Standards**

Tree Box (Well) Filter Retention Design





6.15. Rainfall Interceptor Trees

DESCRIPTION:

- **Existing or planted trees located adjacent to impervious areas where they can intercept rainfall and reduce stormwater volume and pollutant loading**

DESIGN:

- **Generally follow tree box filter or biofiltration planter box design criteria**

Rainfall Interceptor Trees Stormwater Treatment Credits

- **Calculate load reduction VR * EMC * Conversion Factors**

TREE TYPES	*NEW TREES INTERCEPTION CREDIT*	*EXISTING TREES INTERCEPTION CREDIT*
Oaks or similar species	13%	~~18%~~ 26%
Pines or similar species	10%	~~15%~~ 20%
Palms or similar species	8%	~~13%~~ 15%

1. Determine impervious surface area tree canopy will cover in 20 years
2. Select percent interception credit by tree type
3. Calculate annual rainfall volume reduction VR (ac ft) = A *R* % interception*Conversion Factors

   Where A = canopied impervious area in acres, R = annual rainfall in inches, % interception decimal, Conversion factor = 1 ft/12 inches

Rainfall Interceptor Trees Stormwater Treatment Credits

- **Not approved by SWFWMD – Can only be used to meet County requirements**
- **County allows no more than 10% of impervious area to be mitigated through the use of trees.**

Pinellas County Stormwater Management Manual Workshop

Questions, Remarks And Discussion