The Stormwater Harvesting BMP - An Overview & Its Enhanced Importance in the Forthcoming Statewide Stormwater Treatment Rule

PREPARED FOR

ORANGE COUNTY UTILITIES

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INTRODUCTORY REMARKS

What Is Stormwater Harvesting ?

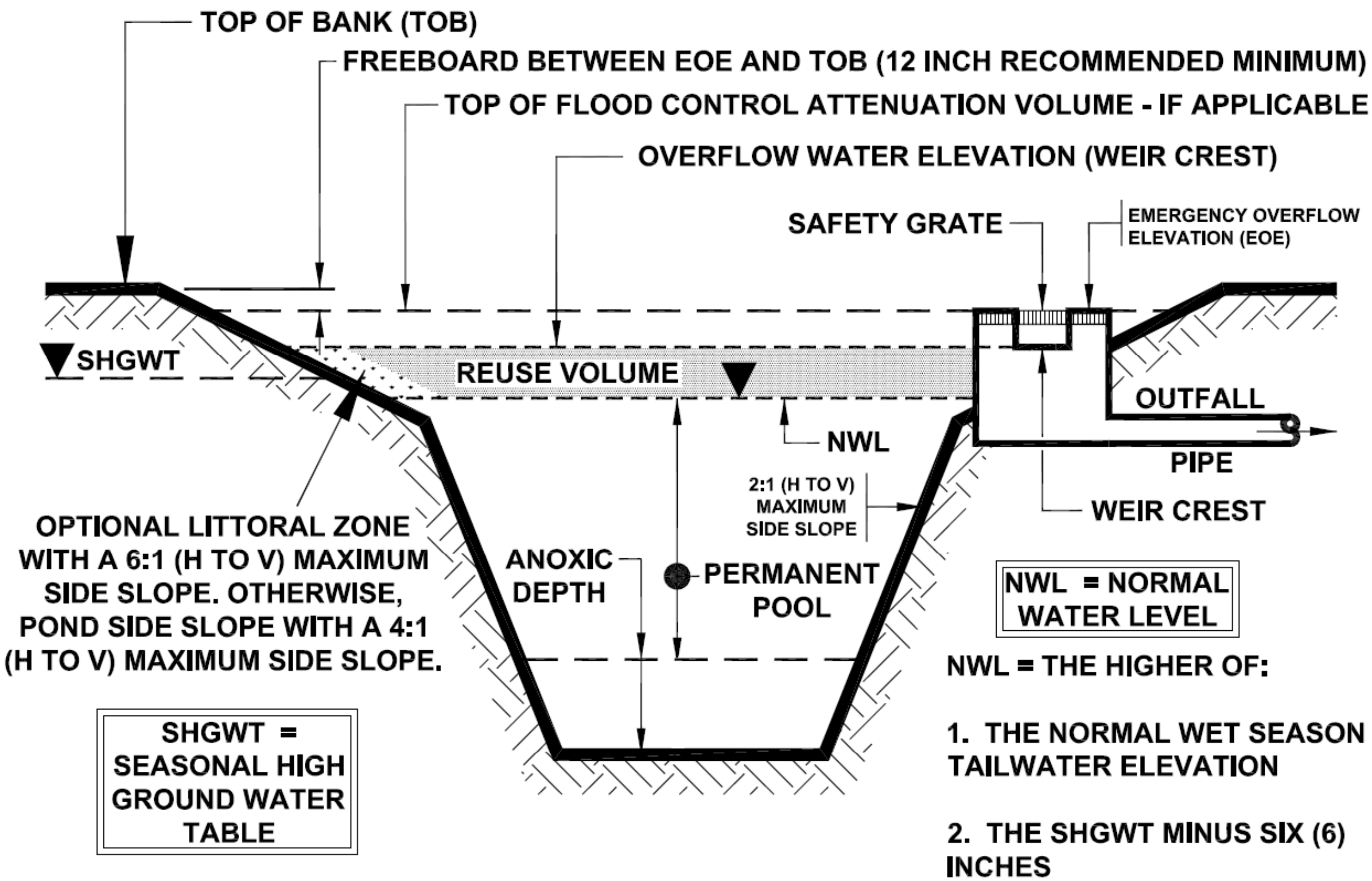
A stormwater harvesting pond is a retention pond which is also used as a source for irrigation water (or other non-potable use).

The reuse efficiency of a stormwater harvesting pond is a function of the volume of water which is consumed for irrigation which would otherwise have been discharged offsite. (There is an additional nutrient removal efficiency from wet retention.)

Design curves for estimating the efficiency of a stormwater harvesting pond are available in the FDEP handbook.

The maximum allowable application rate for irrigation is 0.7 in/wk.

Typical Stormwater Harvesting Pond



TYPICAL X-SECTION OF A STORMWATER HARVESTING SYTEM

From FDEP Stormwater Quality Applicant's Handbook

NOT TO SCALE

Benefits of Stormwater Harvesting

- Reduction of runoff volume discharged to the receiving waters.
- Reduction of pollutants discharged to the receiving waters.
- Substitution of stormwater use instead of potable ground water withdrawals.
- Potential economic savings from not having to pay user fees for potable water.

Example Uses For Stormwater Harvesting

- Irrigation: golf courses, cemeteries, highway medians, parks, retail nurseries, agricultural lands, residential and commercial properties, etc.
- Supplemental hydration of wetlands
- Low flow augmentation
- Cooling water
- Process water
- Wash water

REGULATORY PERSPECTIVE

Presented by

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Guidance for Water Quality Protection 62-40 F.A.C.

- Primary goal is to **maintain, to the maximum extent practical, during and after construction and development, the pre-development stormwater characteristics of a site**
- The performance standard for **erosion and sediment control during construction is to retain sediment onsite**, with a backstop that no discharge shall violate the state's water quality standard for turbidity.
- The stormwater treatment performance standard requires **removal of at least 80% of the average annual pollutant load for stormwater discharges to Class III** (recreational) waters.
- A **95% removal level was set for stormwater discharges to sensitive waters** such as potable supply waters (Class I), shellfish harvesting waters (Class II), and Outstanding Florida Waters (OFWs).

Stormwater Regulation Background

- SJRWMD adopted Chapter 40C-42 Florida Administrative Code in 1986 to regulate stormwater management systems
- Contained design standards for design of stormwater management system BMPs
- Design standards were updated in 1991

Water Quality Criteria

Will not adversely affect the quality of receiving waters such that the water quality standards set forth in chapters 62-3, 62-4, 62-302, 62-520, 62-522, and 62-550, F.A.C., including any antidegradation provisions of sections 62-4.242 (1)(a) and (b), 62-4.242(2) and (3), and 62-302.300, F.A.C., and any special standards for Outstanding Florida Waters and Outstanding National Resource Waters set forth in sections 62-4.242(2) and (3), F.A.C., will be violated

Presumptive Criteria for Water Quality

- Demonstrate the system provides water quality treatment (retention, underdrain, exfiltration, wet detention, swales, or dry detention) in accordance with the design standards set forth in rule 40C-42.026 F.A.C.
- Allows for use of alternative treatment systems that provide equivalent treatment
- Last significant update was in 1991

Statewide Stormwater Rule

In 2007, FDEP in consultation with the state's water management districts began development of a statewide stormwater treatment rule to address nutrient enrichment of Florida's surface and ground waters and update stormwater BMP's

Statewide Stormwater Rule Goals

- Increased nutrient removal
- Statewide consistency
- Permit streamlining
- Promote "smart growth"
- Update BMPs based upon current science
- Increase "BMP tools" available

Proposed Performance Standard

- Provide for at least an 85% reduction in the average annual nutrient load OR demonstrate that the post-development nutrient load will not exceed the pre-development nutrient load, (the pre-development load is based upon the native vegetative community condition), whichever is lesser.
- For Discharge to OFW's: - the post-development nutrient load cannot exceed the pre-development nutrient load

Additional/Newer Technology BMPs Developed

- Calculation of removal efficiency for treatment train approach
- Stormwater harvesting (re-use)
- Vegetated natural buffers
- Pervious pavement, concrete, pavers, etc.
- Green roofs
- Floating wetland mats, islands
- Algal turf scrubbers
- Chemical treatment systems

SJRWMD Current Stormwater Reuse Design Guidelines

- Chapters 20 and 31 of the current SJRWMD Applicant's Handbook for regulation of Stormwater Management Systems
- Similar to a wet detention design, except the orifice drawdown volume is replaced by the "reuse" volume
- Rate-Efficiency-Volume Curves, 25 rainfall stations throughout the state, 9 are within SJRWMD

Stormwater Harvesting vs. Stormwater Reuse

- Change from Stormwater Reuse to Stormwater Harvesting needed due to National use of terminology
- Eliminates the confusion with the wastewater reuse terminology

Proposed Stormwater Rule vs. Current SJRWMD CUP Rule

- From a stormwater treatment standpoint the goal is to maximize the stormwater volume used for irrigation
- From a CUP standpoint the goal is to maximize the wastewater reclaimed volume used for irrigation
- Conflict can also occur due to the capitol costs already incurred by local governments for installation of the wastewater reclaimed lines
- Proposed Stormwater rule provides a methodology for treating stormwater, and if a CUP threshold is exceeded, then CUP program will play a part in the final design of a stormwater harvest system
- There are provisions within the SJRWMD CUP rule to apply for a CUP permit to request more frequent irrigation of green space

Statewide Stormwater Rule Development Schedule

- Sept. 2009 – Concluded TAC Meetings
- Dec. 2009 – Jan 2010 – Develop final draft of rule and applicant's handbook based upon comments from TAC and Workgroup
- Feb. 2010 to March 2010 – Conduct Rule workshops throughout the state
- July 2010 – Rule Adoption
- Oct. 2010 – Jan 2011 – Rule becomes effective

UTILITY PERSPECTIVE

Presented by

Todd Swingle, P.E.

City of St. Cloud

Public Services Administrator

Utility Perspective

- The utility perspective for taking stormwater into reclaimed lines (FDEP regulations).
- Treatment through horizontal wells (or filtration).
- Pond size thresholds - economics tied to harvesting yields.
- Capital costs.
- Maintenance costs.
- Who does the water belong to? Fees to be charged.

STORMWATER ENGINEERING PERSPECTIVE

Presented by

Devo Seereeram, Ph.D., P.E.

Devo Engineering

New FDEP Stormwater Rule for Calculating Pollution Treatment Volumes

New stormwater regulations are set to take effect which will :

- Limit the postdevelopment discharge of nutrients in stormwater to less than or equal to predevelopment, i.e., Post = Pre, or
- Require a specified reduction in postdevelopment nutrient discharge
  - 85% reduction in postdevelopment phosphorous discharge
  - 60 to 65% reduction in postdevelopment nitrogen discharge

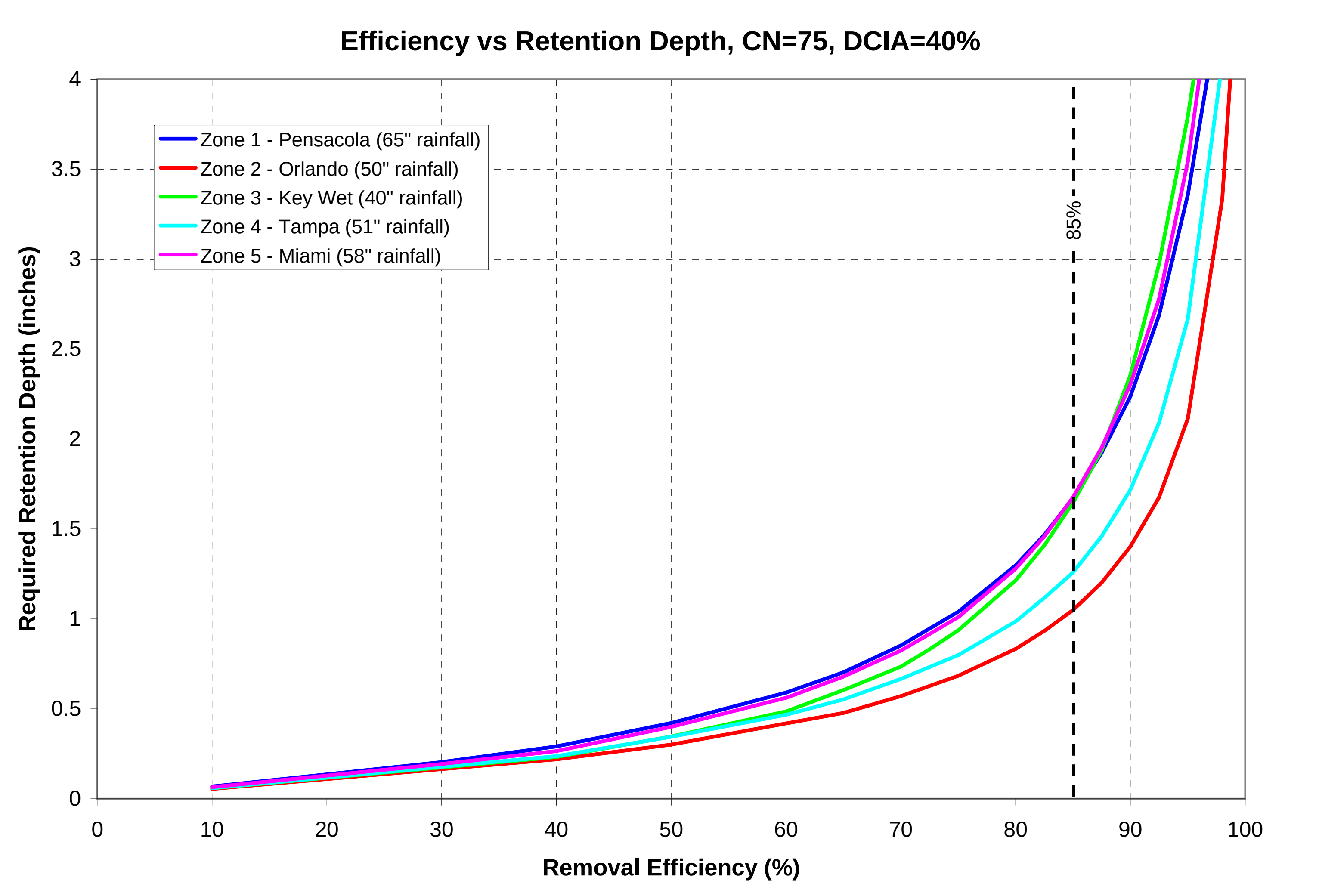
New FDEP Stormwater Rule for Calculating Pollution Treatment Volumes

Direct discharges to Outstanding Florida Waters shall provide a minimum level of treatment that results in the post-development average annual loading of total phosphorus not exceeding the loading from representative native landscapes (e.g., post=pre).

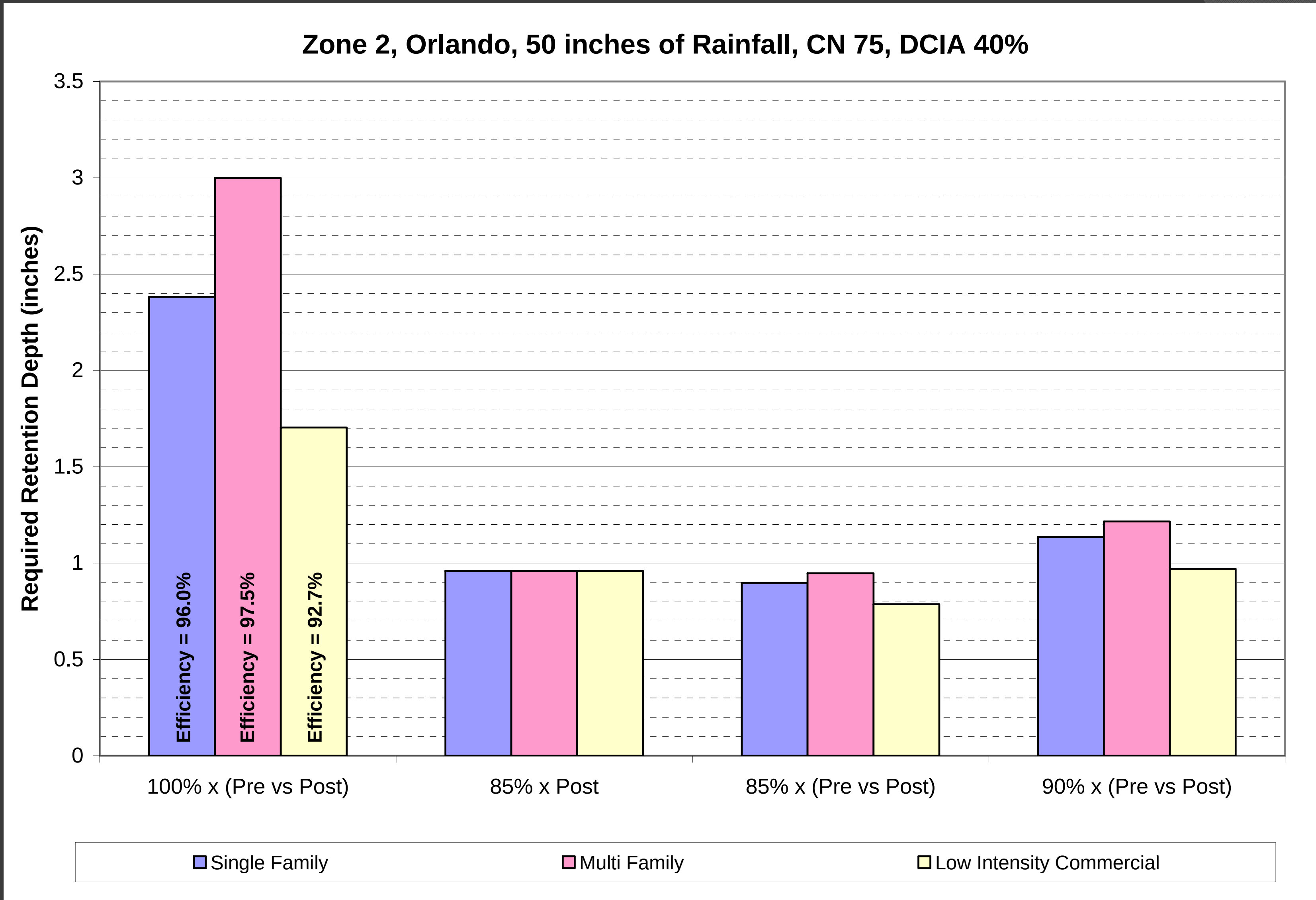
Stormwater Performance Standards

CLASS 3	OFW	IMPAIRED	TMDL ADOPTED	BMAP ADOPTED
New development Infill development 85% or Post=Pre, Whichever is less	New development Infill development Post = Pre	New development Infill development Post = Pre	New development Infill development Post = Pre	New development Infill development Post= Pre unless BMAP specifies otherwise
CLASS 3 Redevelopment Net Improvement	**OFW** Redevelopment Net improvement	**IMPAIRED** Redevelopment Net improvement	**TMDL ADOPTED** Redevelopment Net improvement or TMDL % reduction, Whichever is greater	**BMAP ADOPTED** Redevelopment Net improvement or TMDL % reduction, Whichever is greater, unless BMAP specifies otherwise

The Problem With Achieving High Efficiencies (Dry Pond)



Comparison of Efficiency Criteria (example)



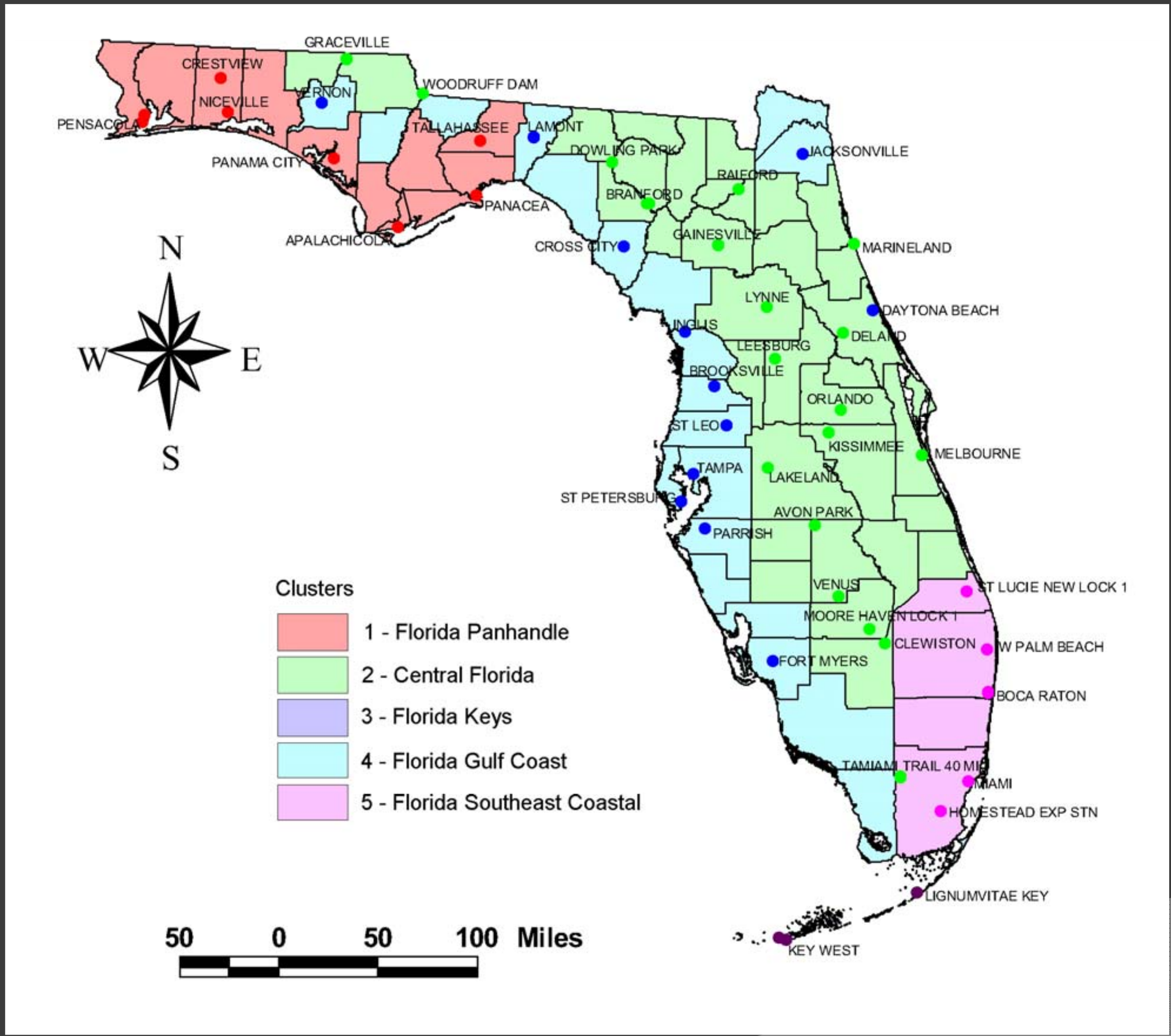
Proposed Methodology

The new rules provide a procedure for calculating the treatment volume requirements for stormwater ponds within the State of Florida.

The methodology divides the State of Florida into five distinct climate zones based on similarities in the average yearly rainfall distribution, etc.

1. Florida Panhandle
2. Central Florida
3. Florida Keys
4. Florida Gulf Coast
5. Florida Southeast Coastal

Climate Zones



Types of Pond Configurations

- Dry Pond
- Wet Pond
- Treatment Train
- Stormwater Harvesting Pond
- Chained Wet Ponds

Dry Ponds - Efficiency

Dry pond removal efficiency is simply the percentage of the annual runoff volume which is retained and infiltrated for an average rainfall year.

Wet Ponds

Wet pond removal efficiency of nitrogen and phosphorous is a function of annual residence time.

Uptake of nitrogen and phosphorous in a wet pond is initially fairly rapid but tapers off with time (primarily a function of sedimentation).

Definition of Annual Residence Time

$$\text{Annual Residence Time} = \frac{\text{Wet Pond Volume}}{\text{Yearly Runoff Volume}}$$

Example:

Pond Volume = 50 ac-ft

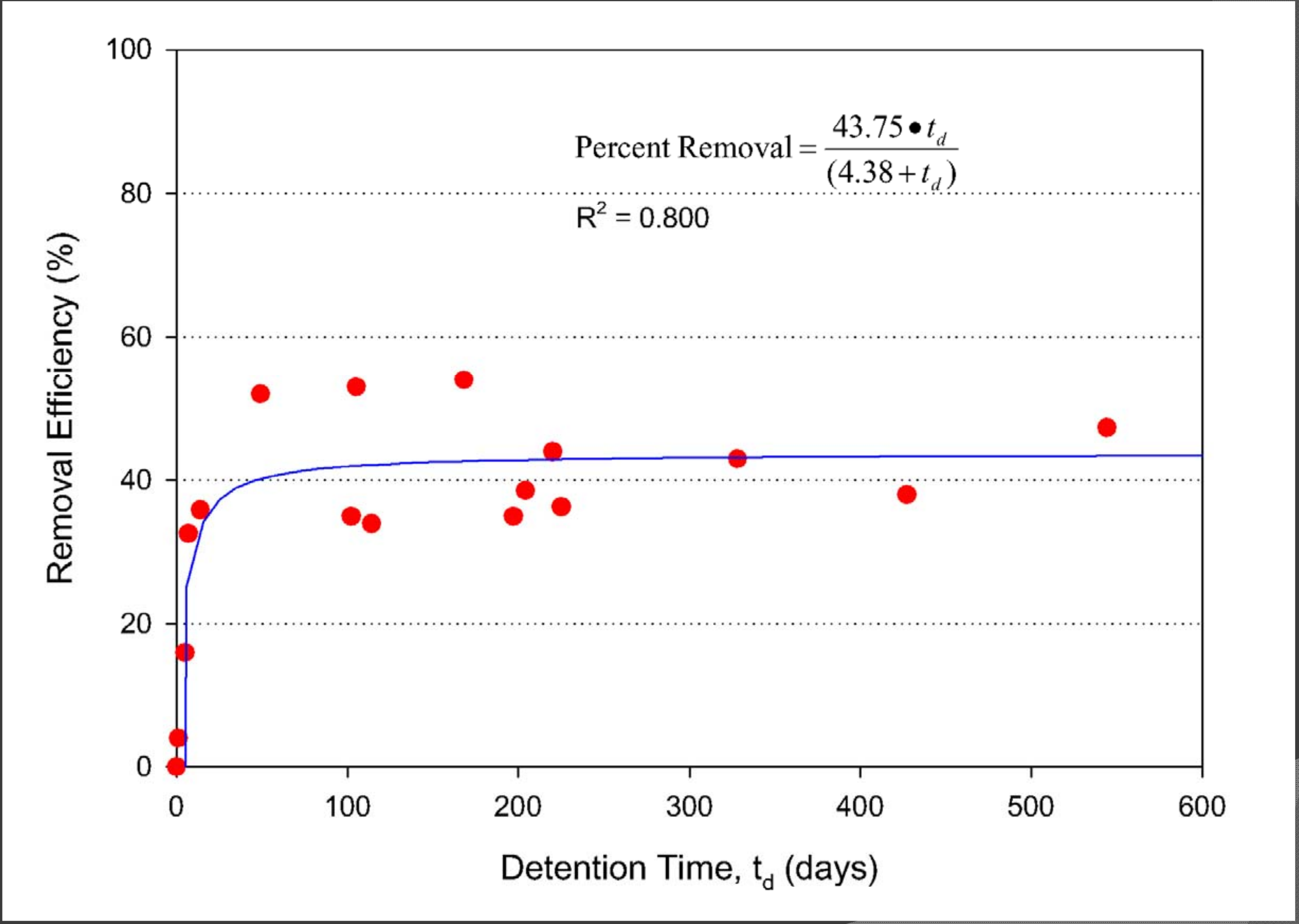
Yearly Runoff = 91.25 ac-ft/yr

$$\text{Annual Residence Time} = \frac{50\ \text{ac-ft}}{91.25\ \text{ac-ft/yr}} = 200\ \text{days}$$

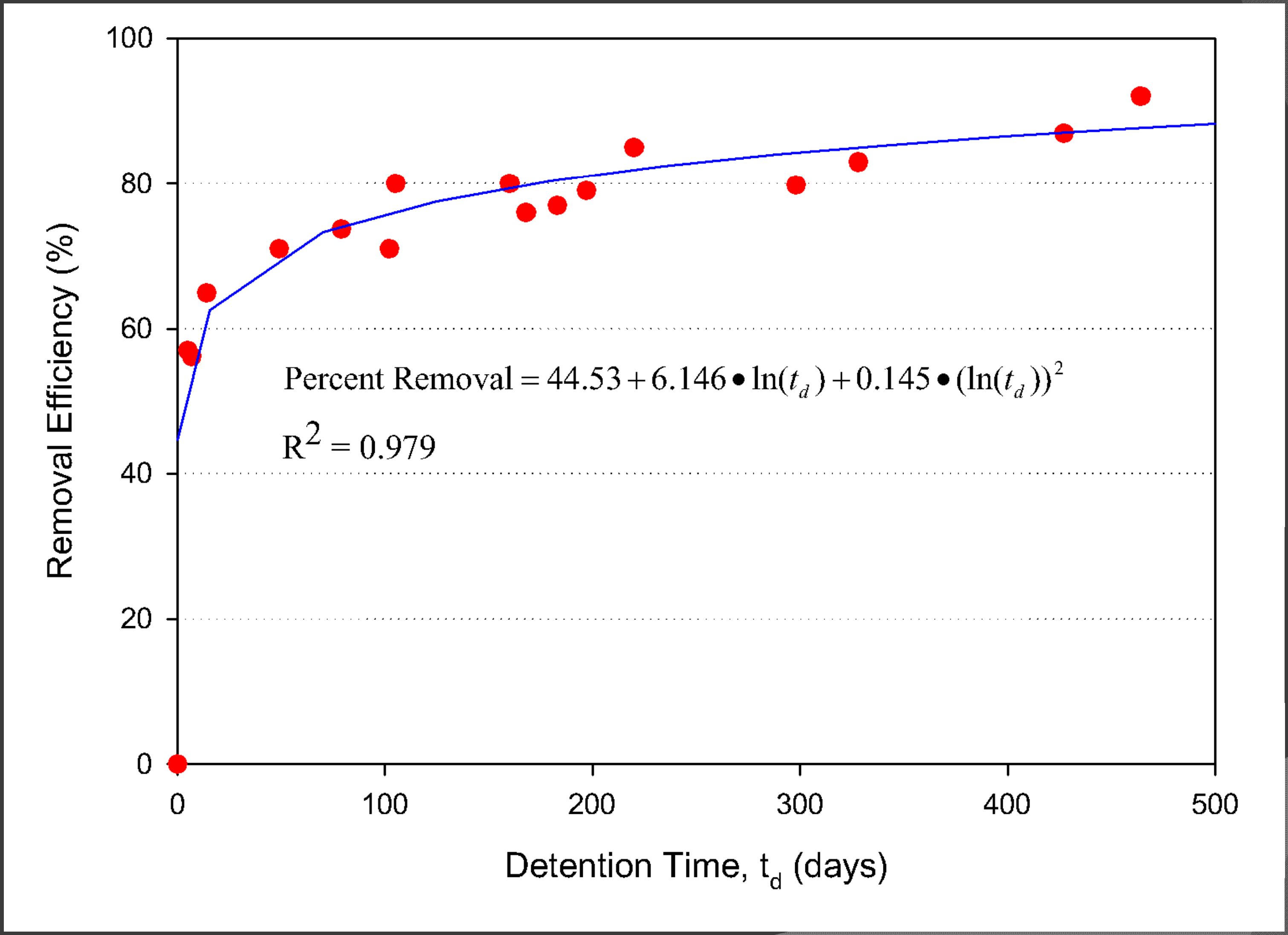
Annual Residence Time (continued)

Note that the residence time used in the calculations is the **annual** residence time as defined in the previous slide. This should not be confused with wet season residence time, or any other definition of residence time.

Nitrogen Removal Efficiency for Wet Pond



Phosphorous Removal Efficiency for Wet Pond



Note to Practitioners in SJRWMD

In SJRWMD, the current removal efficiency limit is 64.5% for a permanent pool volume that provides for a WET SEASON residence time of 21 days.

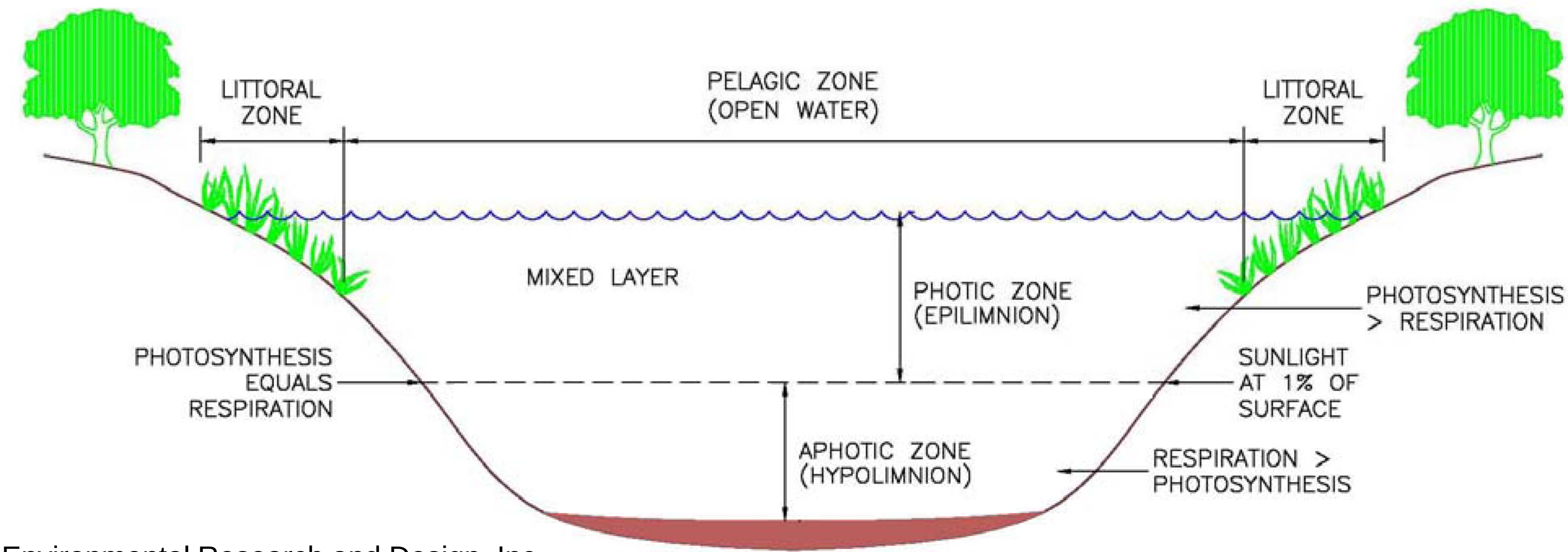
If the WET SEASON residence time is 14 days, then the removal efficiency would be 61.5%.

Also note that the Residence Time entered in the Wet Pond input data in this module is the ANNUAL residence time, not the WET SEASON residence time.

Note that this limitation imposed by SJRWMD may or may not become part of the final rule in SJRWMD.

Anoxic Depth of Pond or Lake

Anoxia is defined as dissolved oxygen concentrations less than 1 mg/l, for waterbodies in Central and South Florida.



Environmental Research and Design, Inc.

The volume of water below the anoxic depth does not provide treatment. Only the volume of water above the anoxic depth is used when calculating the permanent pool volume.

Wet Pond Limitations

Nitrogen removal efficiency for a wet pond quickly reaches a point of diminishing returns. Nitrogen removal efficiency is limited to about 43%.

Therefore, a wet pond alone will probably not work for most sites if nitrogen removal is considered in the analysis.

Treatment Trains

When a wet pond will not remove a sufficient percentage of nutrients on it's own, then pre-treatment of the stormwater runoff can be used. The most efficient way to achieve pre-treatment is by placing a dry pond in series with a wet pond.

→ Dry Pond → Wet Pond →

The dry pond must be sized to remove whatever mass of nutrient can not be removed by the wet pond.

Treatment Train Efficiencies

The total efficiency in a wet/dry treatment train is calculated as follows:

$$\text{Total Efficiency} = \text{Eff}_{dry} + (1 - \text{Eff}_{dry}) \times \text{Eff}_{wet}$$

Note that the wet and dry efficiencies are not simply added. The wet pond removes a percentage of whatever nutrient remains after pretreatment.

Stormwater Harvesting Pond

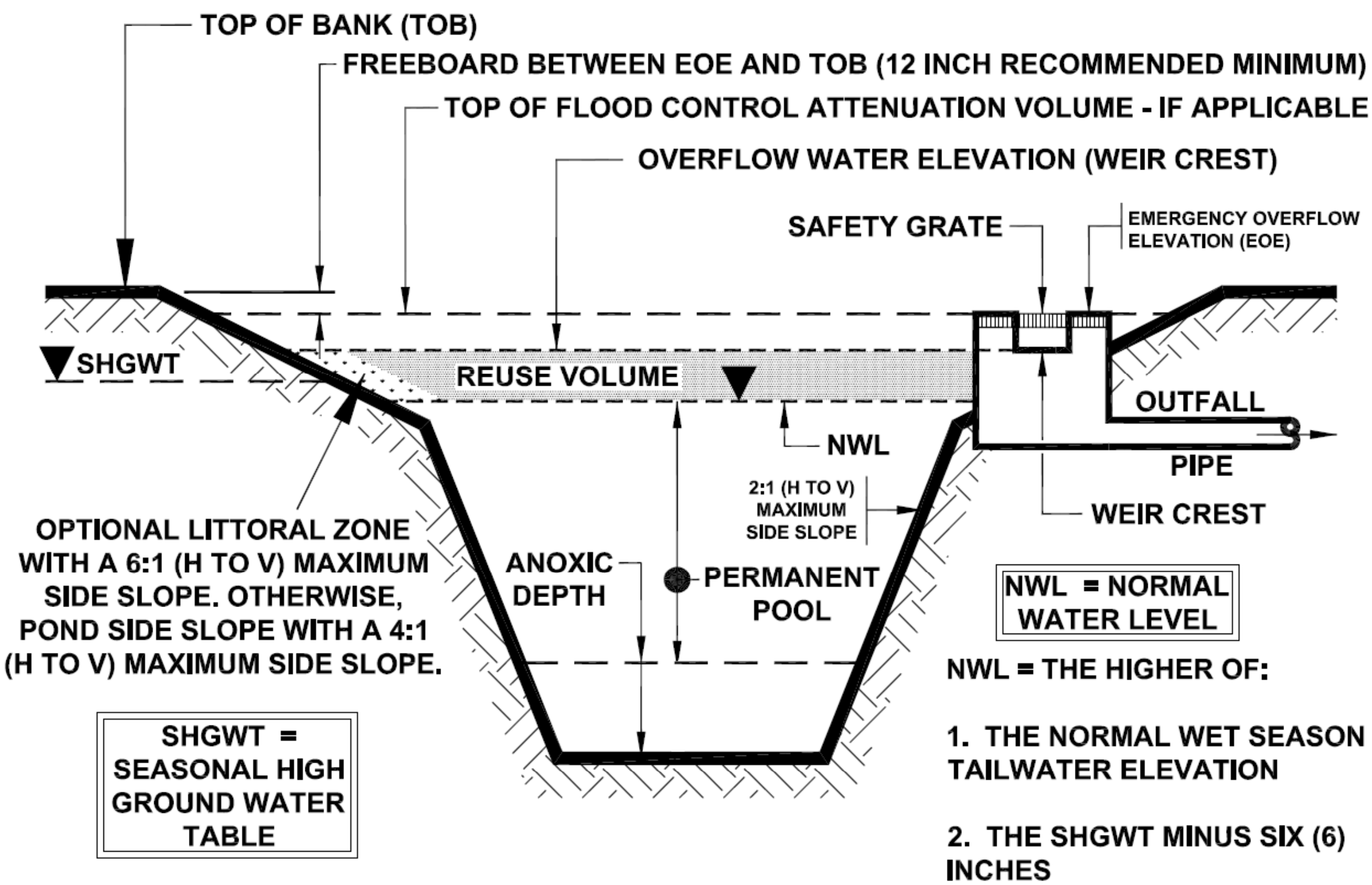
A stormwater harvesting pond (a.k.a. stormwater reuse pond) is a retention pond which is also used as a source for irrigation water (or other non-potable use).

The efficiency of a stormwater harvesting pond is a function of the volume of water which is consumed for irrigation which would otherwise have been discharged offsite. (There is an additional nutrient removal efficiency from wet retention.)

Design (R-E-V) curves for estimating the efficiency of a stormwater harvesting pond are available in the FDEP handbook.

The maximum allowable application rate for irrigation is 0.7 in/wk.

Typical Stormwater Harvesting Pond



TYPICAL X-SECTION OF A STORMWATER HARVESTING SYTEM

From FDEP Stormwater Quality Applicant's Handbook

NOT TO SCALE

Operational and Design Water Levels

- The pump-off elevation is usually the lower elevation of the reuse volume or no more than 1 foot below that elevation. If the reuse volume is set to begin at the seasonal high water table level then, pumping to 1 foot' below the lower elevation of the reuse volume is allowed. If the reuse volume is set below the seasonal high water table level then the pump off is usually the bottom of the reuse volume.
- There are currently no design guidelines for the maximum depth of the reuse volume, but if the pond has a planted littoral shelf the plant tolerances for water fluctuation need to be considered. (Mounding impact should be considered).
- For the storm event routing calculations, the beginning water level in the pond for routing purposes should be the weir elevation or top of the reuse volume (currently).

Benefits of Stormwater Harvesting

- Reduction of runoff volume discharged to the receiving waters;
- Reduction of pollutants discharged to the receiving waters;
- Substitution of stormwater use instead of potable ground water withdrawals; and
- Potential economic savings from not having to pay user fees for potable water.

Example Uses For Stormwater Harvesting

- Irrigation: golf courses, cemeteries, highway medians, parks, retail nurseries, agricultural lands, residential and commercial properties, etc.
- Supplemental hydration of wetlands
- Low flow augmentation
- Cooling water
- Process water
- Wash water

Efficiency of Stormwater Harvesting Pond

Definitions:

- Stormwater Reuse Efficiency (E_R) is the volume of water which is reused and not discharged.
- Wet pond nutrient removal efficiency is the reduction in nutrient loading in the discharged water due to wet pond processes. Can apply to nitrogen (E_N) or phosphrous (E_P), etc.
- Total system efficiency (E_T) is calculated based on the combination of reuse efficiency and nutrient removal efficiency, for example:

$$E_T = E_R + (1-E_R) \times E_N \quad \text{(for nitrogen)}$$
$$E_T = E_R + (1-E_R) \times E_P \quad \text{(for phosphorous)}$$

Efficiency of Stormwater Harvesting Pond

Example:

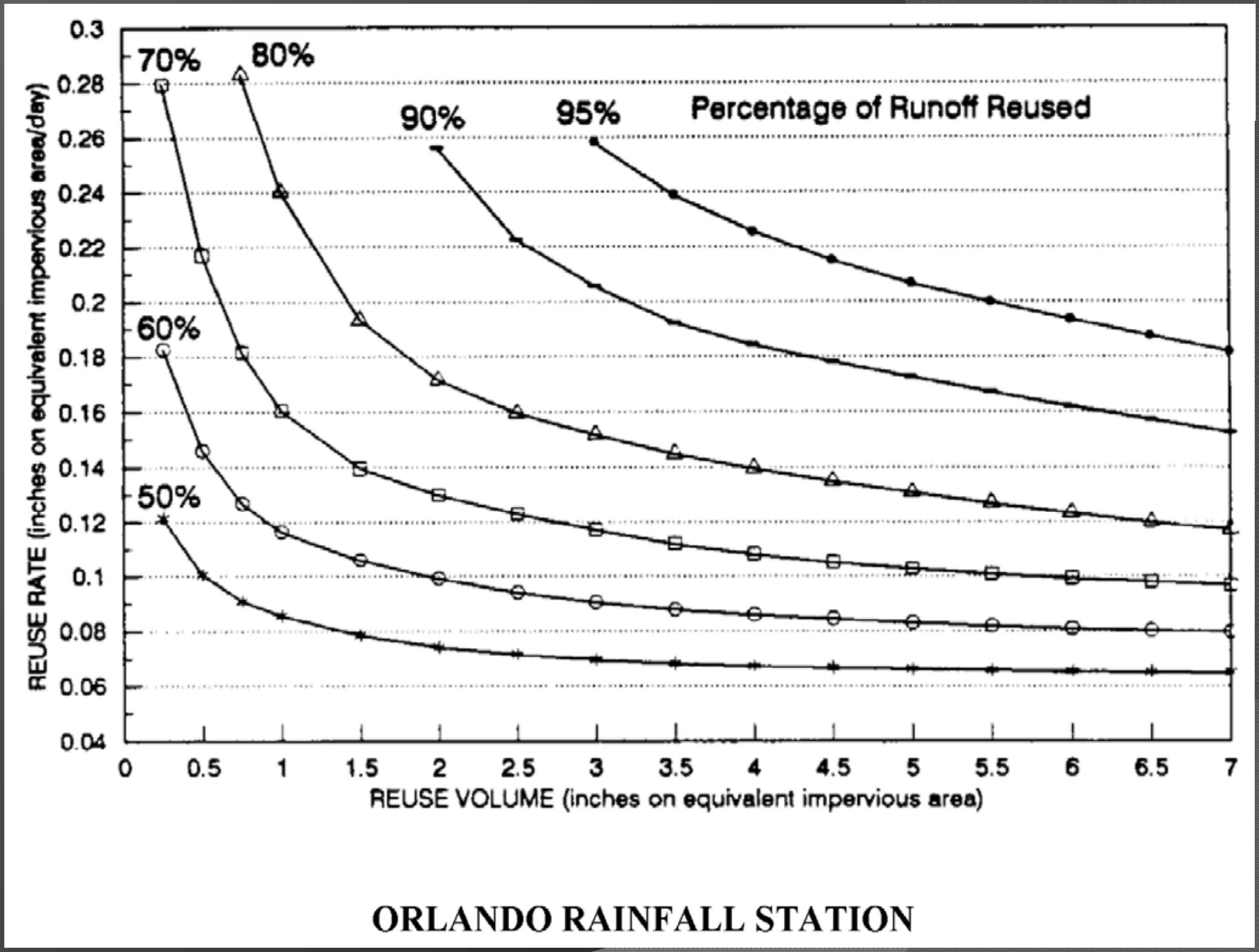
- For a pond water reuse efficiency (E_R) of 70%
- And a wet pond nitrogen removal efficiency (E_N) of 42.5%
- The total nitrogen removal efficiency (E_T) is:

$$E_T = E_R + (1-E_R)(E_N)$$
$$E_T = (0.7) + (1-0.7)(0.425) = 0.83 \text{ or } 83\%$$

This example calculation illustrates that if 70% of the runoff water is reused, and the nitrogen reduction in the pond is 42.5%, the mass reduction of nitrogen in the runoff is 83%.

R-E-V Design Curves for Stormwater Harvesting Pond

The stormwater reuse efficiency can be determined from design charts in the FDEP Stormwater Quality Applicant's Handbook



R-E-V Design Curves for Stormwater Harvesting Pond

EIA = Equivalent Impervious Area

EIA = Total Basin Area * Weighted Average Runoff Coefficient

Reuse Rate (R) is calculated as inches over the equivalent impervious area (EIA). Convert to actual application rate as follows:

R_{app} = R x EIA / Irrigated Area

Reuse Volume (V) is calculated as inches over the equivalent impervious area (EIA). Convert to storage volume as follows:

$V_{storage}$ = V x EIA

Note: The design curves for stormwater reuse assume that the pond area is included in the calculation of the weighted average runoff coefficient.

FILTRATION AND DISINFECTION

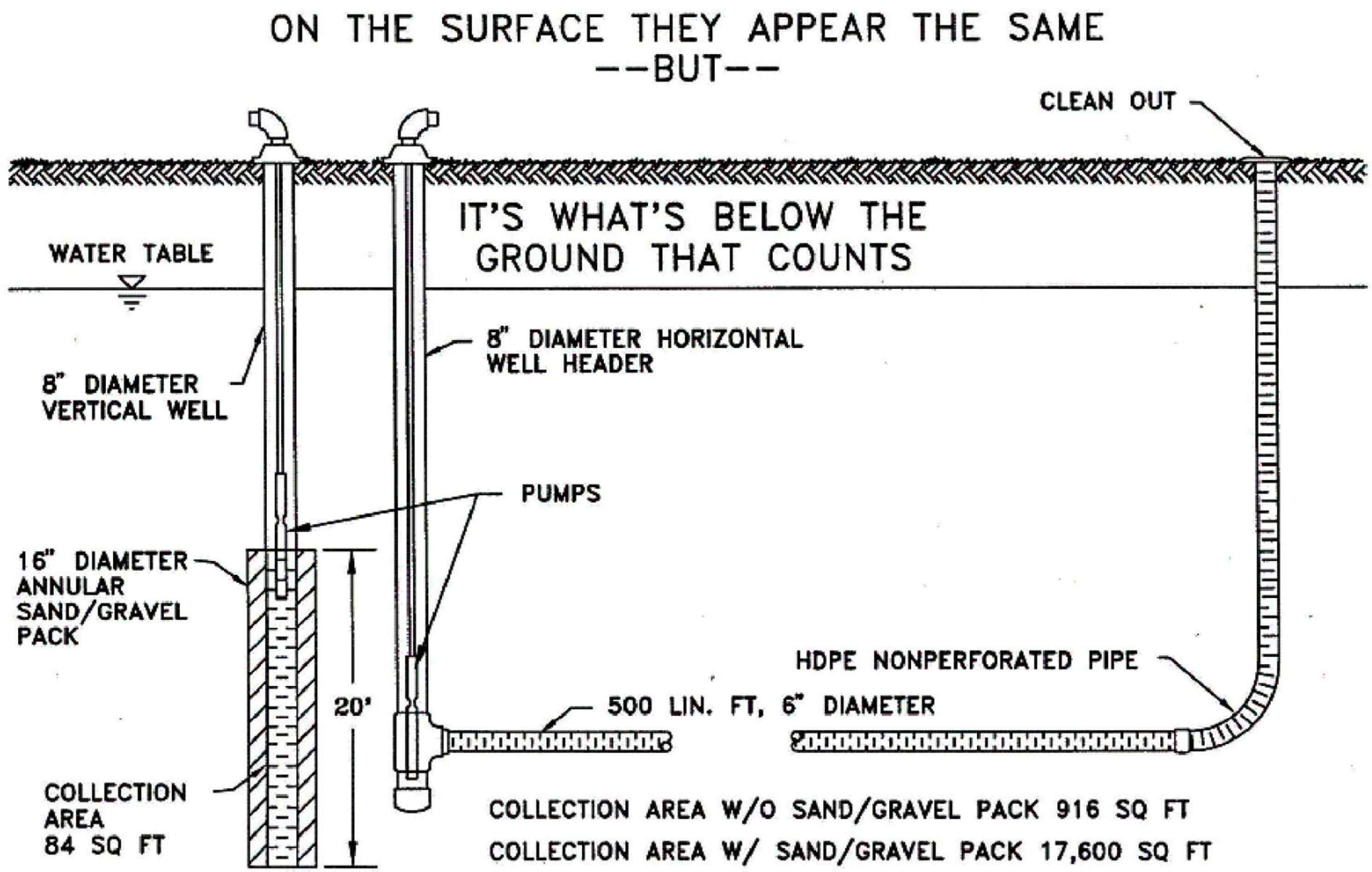
Filtration and Disinfection

Reuse water that is used for irrigation must be withdrawn from a structure that allows for seepage of the reuse volume through a minimum of 4 feet of native soils or clean sands. This is best accomplished by withdrawing water through a horizontal well configuration located directly
adjacent or under the reuse pond.

Withdrawal of irrigation water from the reuse pond in this manner effectively removes algae, turbidity, and other materials that might be considered adverse to human health when converted to an aerosol condition.

Acceptable alternatives include in-pipe treatment filtration that is used to remove detained water from ponds. Options other than horizontal wells must demonstrate removal of turbidity and algae toxins.

Filtration and Disinfection



Types of Filtration Systems

There are generally four-types of filters used for filtration of surface waters for irrigation purposes. The type of filtration system that is selected will depend on the water quality.

- Screen
- Centrifugal
- Disk
- Sand Media

Screen and centrifugal filters are best suited for removing sand and large inorganic particles. Screen and centrifugal filters are best suited for removing sand and large inorganic particles. If there are organic solids, then disk filters will work for light concentrations, but heavy concentrations require sand media filters. Thus, if the water quality is poor (high organic solids), then sand media filters will probably be the best choice. Screen filters are typically installed downstream of the sand media filter to capture sand that may escape the media filters during backwashing.

Types of Filtration Systems (cont'd)

- Screen and centrifugal filters are best suited for removing sand and large inorganic particles.
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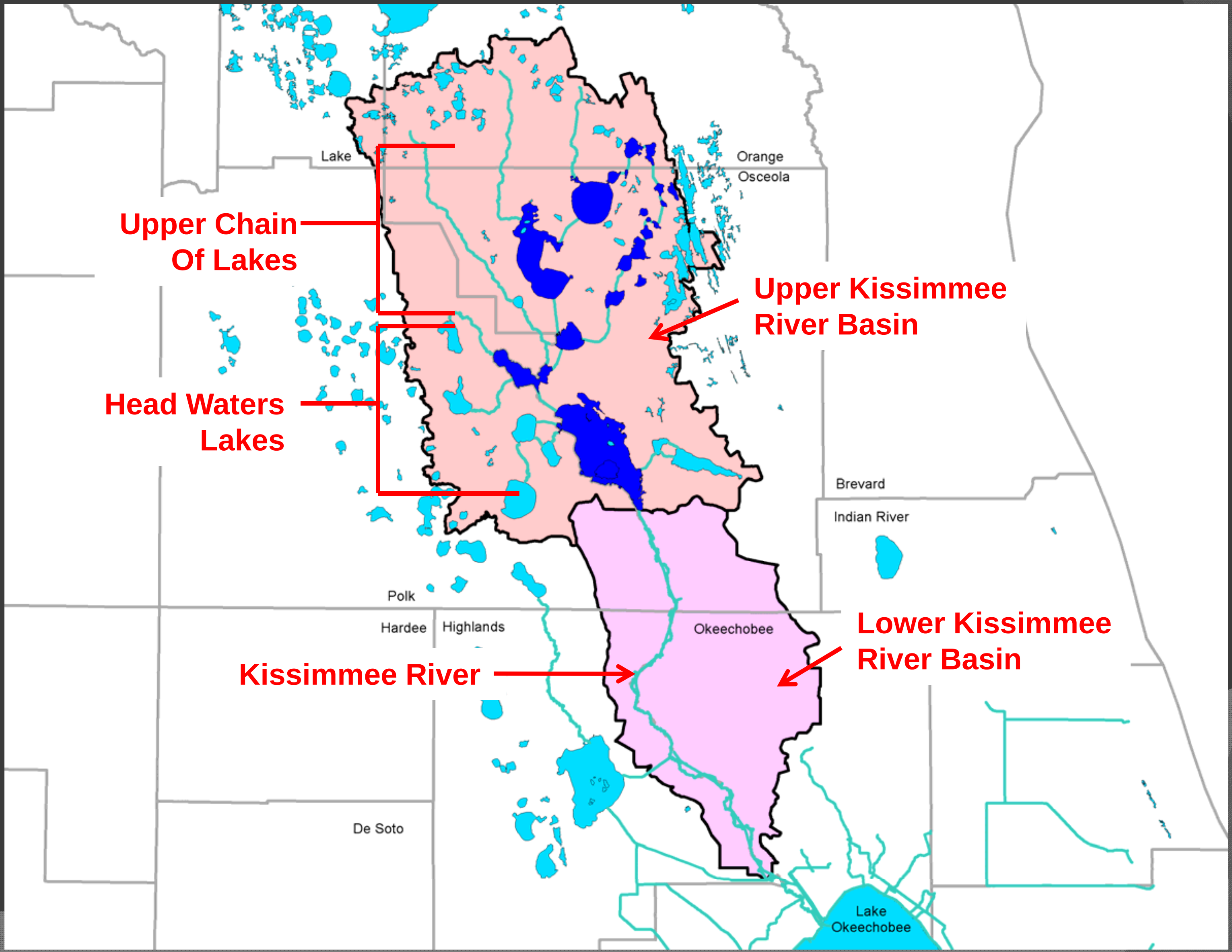
KISSIMMEE RIVER RESERVATION

Kissimmee River Reservation



Issues Within the Kissimmee River Reservation

In order to further the goals of the Kissimmee River restoration project, SFWMD is proposing rule changes within the Kissimmee River Reservation to preserve the volume of water which recharges the Kissimmee River system. This means that development can not result in a decrease in runoff discharge volume , compared to predevelopment conditions.

This goal is somewhat at odds with the FDEP rules for nutrient reduction in stormwater runoff which generally require a reduction in annual runoff volume to achieve required treatment levels (i.e., dry ponds and stormwater harvesting ponds), since wet ponds alone will not generally provide the desired treatment levels.

POTENTIAL ISSUES WITH HORIZONTAL WELLS

Potential Issues With Horizontal Wells

- They are high maintenance and can result in pump burnout during droughty periods when the water table is low.
- Horizontal wells are not easy to maintain systems and their startup requires a lot of tuning as their production is not known ahead of time and there is a tendency to burn out pumps and cavitate/crush the well bores during this start up process.
- The wells will draw some groundwater in addition to surface water which could result in high iron levels.

Potential Issues With Horizontal Wells

- To minimize mixing of groundwater, the collection system should be installed at the bottom of the pond, sized as typical for underdrains. Create a sand blanket to accommodate the effective aquifer required for the underdrain system, since wet ponds are typically located in low permeable soils. The underdrain system would then be manifolded into an appropriate wet well structure with pump(s).

- It is be best to make the vertical header pipe (wet well) 12" in diameter instead of 8". This will allow for more storage and minimizes drawdown somewhat, and that becomes critical during low water table conditions typical of dry season and especially during droughts.

Potential Issues with Horizontal Wells (cont'd.)

- It is a good idea to install a drawdown seal above the pump - this forces more of the pump withdrawal volume to come from the horizontal well rather than the vertical header pipe. At Reunion, the horizontal wells were creating a vortex (even with a 15 ft water column above the pump) which caused air to be entrained. The air in the line rendered the flow meter inaccurate and caused it to read artificially high.

- Pumping for stormwater reuse directly from a pond has been practiced for many years. The rule should allow this without the need for the horizontal wells, unless there is definite indication of toxic algae. Also, it will be difficult to install horizontal wells in some formations. Does this need a water use permit?

POTENTIAL IMPLEMENTATION ISSUES

Potential Implementation Issues

- Phased development where greenspace is not in place when the stormwater management system is constructed

Potential Implementation Issues

- Is this not a “pumped” discharge that is frowned upon by the regulatory agencies for homeowner association (HOA) controlled facilities? Are the agencies going to change their policy on allowing pumped systems to be maintained by HOAs? Typically some treatment is required if iron content is too high - major staining?

- Most water management districts currently do not allow HOAs to control these systems since many HOA’s tend to be derelict in their duty and financial obligations. If a system is permitted as a stormwater reuse system and then not pumped due to system malfunction or lack of funds, how is the responsible entity asked to comply?

Potential Implementation Issues

- Where possible should the bleed down discharge not be sent to reclaimed facility through sanitary sewer (for example, APRICOT)? This should be considered when tie-in to irrigation system not feasible.

- If the stormwater is introduced into a reclaimed water line with treated wastewater, it falls under the jurisdiction of the FDEP with their own requirements. If the mixed stormwater and reclaimed water is sold to residents, it must be treated by filtration and disinfection prior to introduction into the reclaimed line, unless it is a pure end user under one ownership such as a golf course or commercial facility.

Potential Implementation Issues

- Is the system going to be regulated by the water use/consumptive use permit review staff or the ERP staff at each district?

- SFWMD currently restricts pumping from stormwater ponds to 55% of permitted allocation during droughts when the destination for the irrigation water is a golf course. This constraint needs to be lifted where stormwater treatment is part of the process.

Potential Implementation Issues

- There will need to be a criteria for analysis of safe yield from stormwater ponds. The critical time for these systems is during the dry season when there is little or no stormwater runoff and high demand. This is the period when the demand is highest and the supply is lowest. SFWMD has recognized this and requires a 90 day, no rainfall analysis to check the drawdown for this critical scenario.

- If a minimum lake level is set for a cutoff, there must be a backup supply as this is the time when demand is greatest. Drawdown impact needs to be assessed carefully as a permanent drawdown in the water table to adjacent property can cause house settlement (if there are buried layers of muck), kill mature trees, etc.

Potential Implementation Issues

- Will horizontal wells be allowed under dry retention ponds? This will be a good option for getting some dry pretreatment credit. It will be akin to a pumped “biofiltration” pond. Dehydration impacts will have to be assessed, of course

Potential Implementation Issues

- The demand of 0.74 inches per week (as stated) is not applicable to all golf courses. It is based on the soil type, depth to water table, and use of soil amendments. There should be no onerous restriction on allocation if the stormwater water is available for reuse/treatment. The landscape vegetation and grasses soil/root zone should be considered an organic biofiltration system. This is the zone where nitrogen uptake is a maximum. Additional sprinkling over the predicted demand can be allowed in these applications.

Potential Implementation Issues

- There are times when the pump system will not work, either due to downtime for repairs and maintenance or lack of power during storms. In such cases, there will not be an opportunity to bring the water level in the pond back to its control level by mechanical pumping. This elevated water level in the pond can lead to flooding since there will be no attenuation volume in case of another storm. It is recommended that emergency bleed-down devices be installed so they can be opened during such events, usually for a maximum period of 30 days operation.

- In light of the above, a 30 day backup supply should also be permitted to keep the vegetation alive during such a potential downtime. The source water for backup is usually Floridan aquifer water or other deep aquifer well.

Potential Implementation Issues

- There are some areas where horizontal wells are going to be problematic from an installation and operation standpoint – take for example the Miccosukee clays in Tallahassee which have low permeability but support wet detention ponds. In addition, in the shallow limerock area of Broward County – horizontal wells may not be practical. Dense coquina zones on the west side of St. Lucie County will also be problematic and the FDEP may have to waive the filtration requirement and allow direct pumpage to end users as is practiced now.

Potential Implementation Issues

- Interconnected, equalized wet detention ponds are more desirable for stormwater reuse since they tend to distribute the withdrawal load across the ponds, taking advantage of the hydro-geotechnical localities which may be more productive within a site. In other words, one pond may safely produce 15,000 gpd while another similarly sized pond may produce 30,000 gpd, so it is best to equalize and interconnect them to get the weighted average withdrawal and minimize impacts.

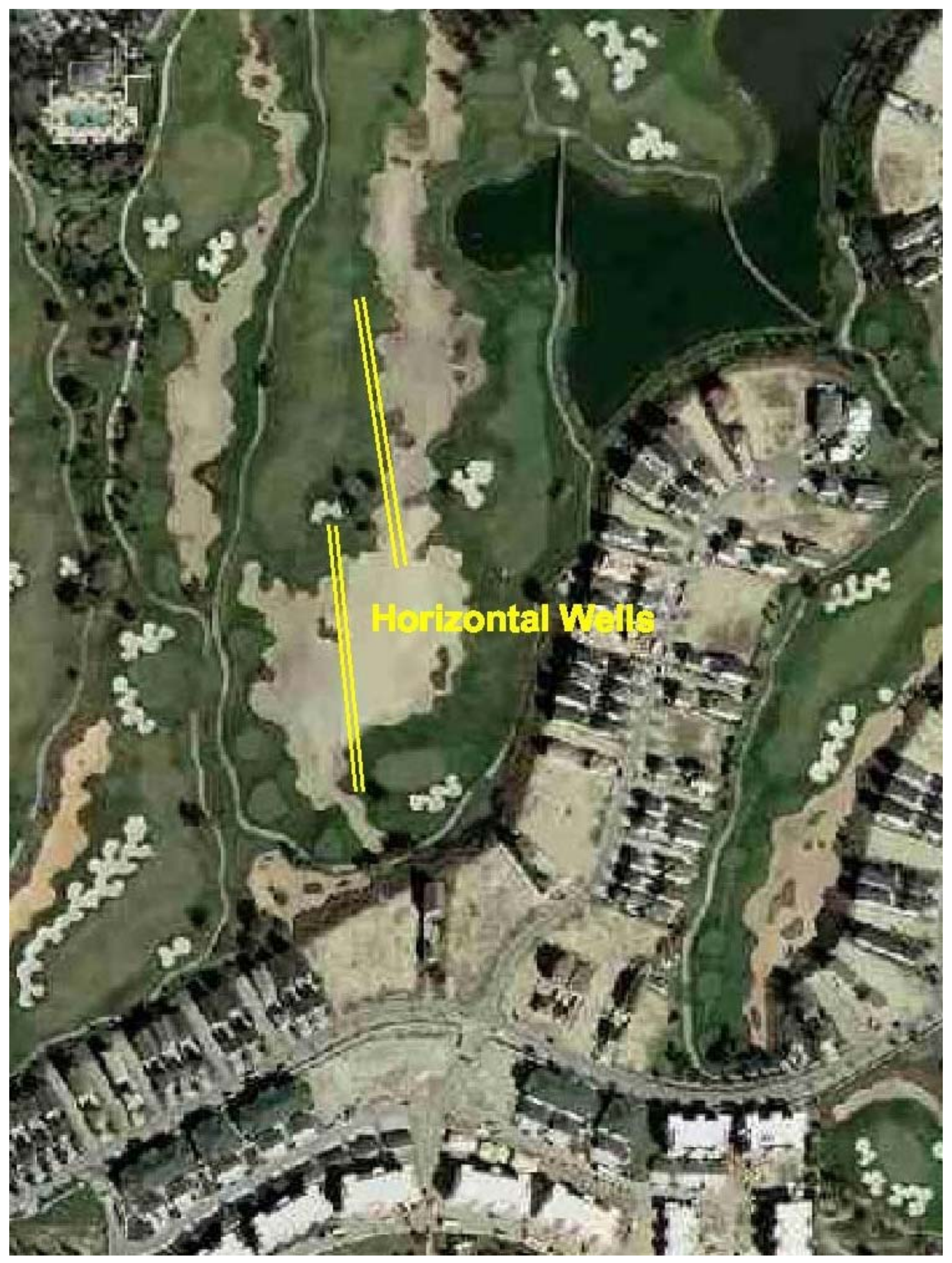
- For flood routing in such systems, what initial stage can be used in computer modeling? Must it be the top of the reuse volume which is very conservative? Or can it be the control level similar to a wet detention pond?

Potential Implementation Issues

- In addition to the REV curves, applicants should be given the opportunity to run their own continuous simulation models to estimate yield and demonstrate compliance with water quality criteria via reuse. The technology exists now and the applicant should not have to rely strictly on the published charts.

EXAMPLES OF STORMWATER HARVESTING SYSTEMS

Reunion Resort



Horizontal wells in the surficial aquifer to provide landscape irrigation water (although not a stormwater harvesting pond, per se)

Examples - Bellagio