Engineering For New Concepts in Stormwater Management

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“NEW” CONCEPTS

LIKELY REQUIRES MULTIPLE PRONGED APPROACH TO TREATMENT

- Some examples of credit for “green” infrastructure
- A fresh look at DCIA, specific examples showing the effect of reducing DCIA on required retention volumes
- Step by step discussion of how to determine removal efficiencies for stormwater harvesting
- Demonstrate how the standards can be met by stacking components

TREATMENT STANDARDS

SECTION 8.3 APPLICANT'S HANDBOOK VOLUME I

Project Scenario	TP	TN	Additional Criteria
All Sites	80	55	or post=pre
OFW	90	80	or post=pre
Impaired Water	80	80	and post=pre plus net improvement
Impaired + OFW	95	95	and post=pre plus net improvement
Redevelopment	80	45	n/a
Redevelopment + OFW	95	60	n/a

TP = Total phosphorus.
TN = Total nitrogen.
OFW = Outstanding Florida Waters.

NEW CHALLENGE: DO HIGHER TREATMENT LEVELS MEAN BIGGER FACILITIES?

- Not necessarily…
- We will examine methods available for minimizing the effect on the size of both <u>dry retention</u> and <u>wet detention</u> BMPs

STRUCTURAL LOW IMPACT DESIGN (LID)

RETENTION SYSTEMS IN THE LANDSCAPE

- Primarily for small catchments
- Landscape-oriented micro-retention basins
- Curb cuts into rain gardens/biofiltration
- Pervious pavement and walkways

Cumulative storage may be credited to overall retention volume

RAIN GARDENS AND CURB CUTS

ALTERNATE RETENTION SYSTEM

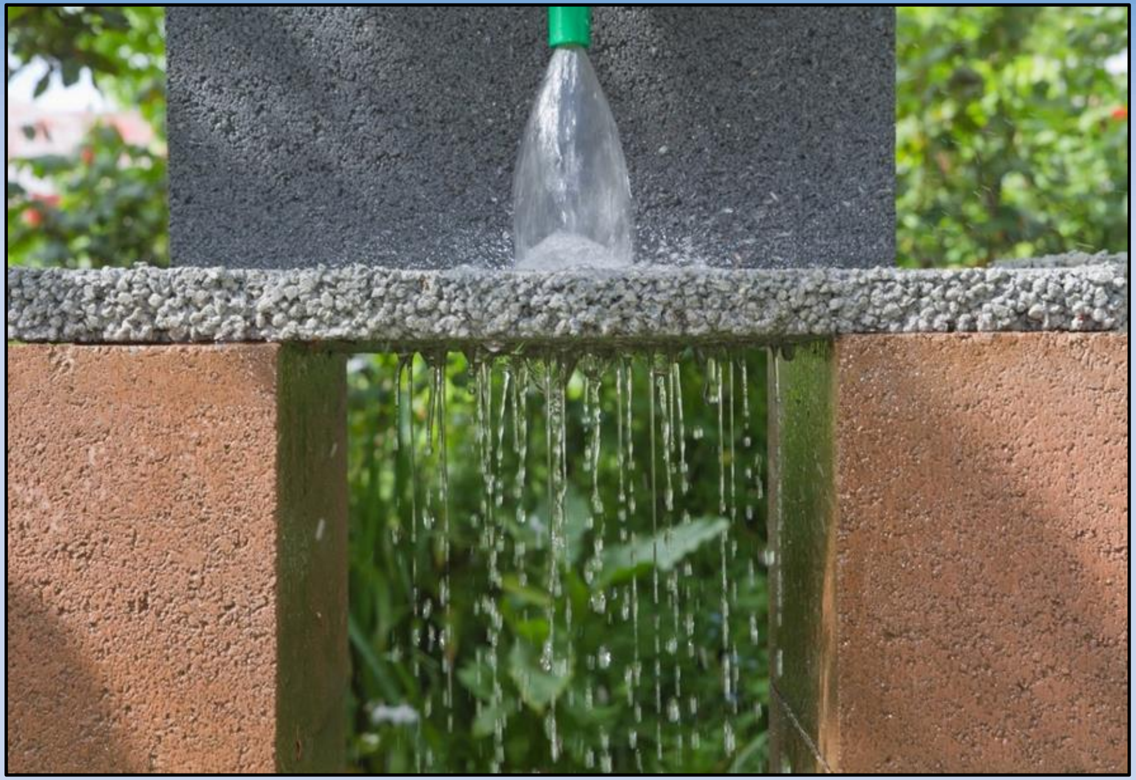
Microscale depressions in the landscape provide retention volume

BIOFILTRATION OR TREE BOXES

MICROSCALE INFILTRATION BASINS THROUGHOUT ROADWAY

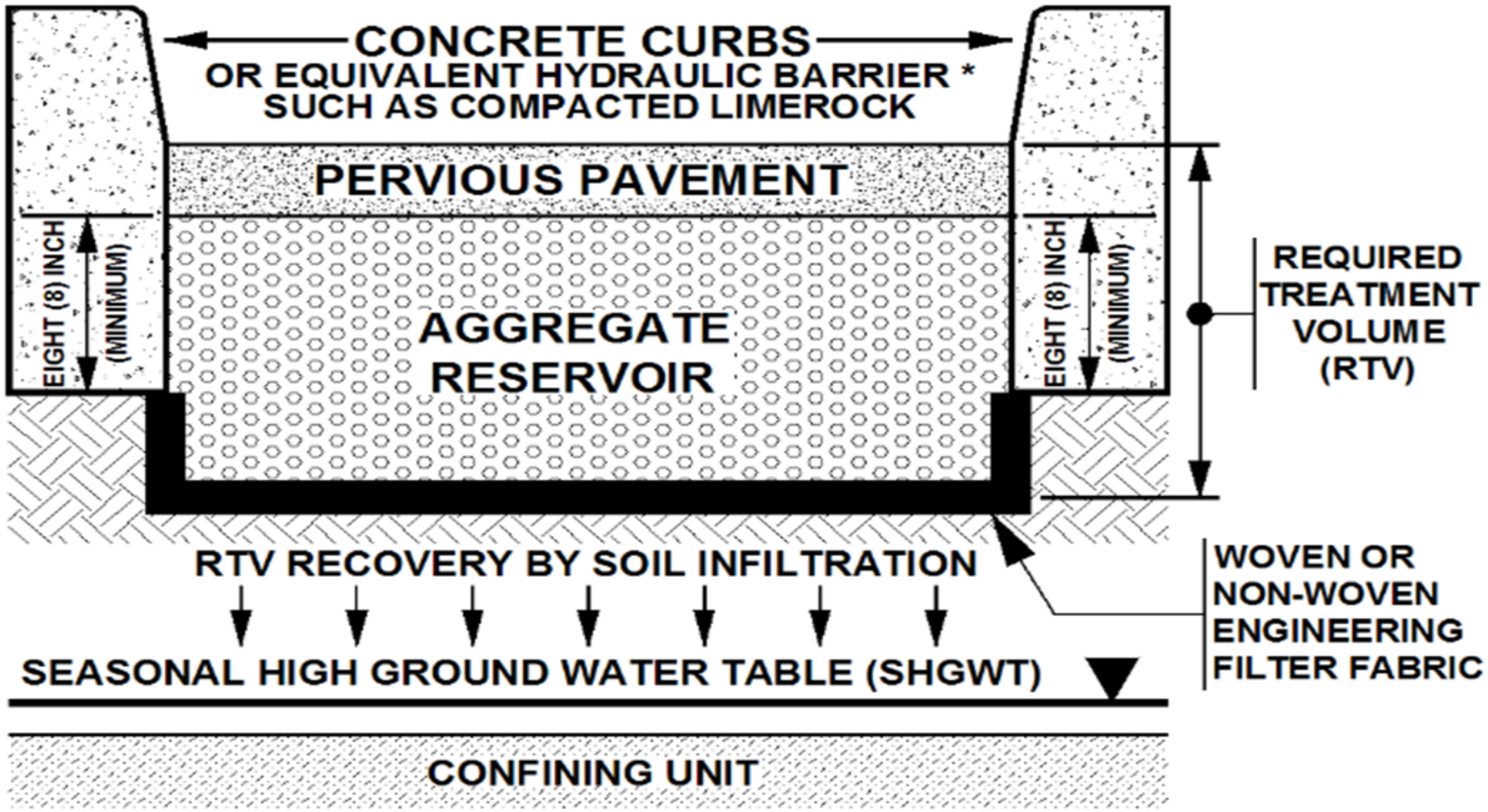
- Can be used without trees and/or provide “open bottom” inlets; act as small retention basins
- Cumulative volume may be significant (100 to 200 c.f. per box, etc.)

PERVIOUS PAVEMENT



"From an ERP perspective, pervious pavement is just a retention pond with cars on top."

PERVIOUS PAVEMENT AND CONCRETE



* THE PURPOSE OF THE PERIMETER CONCRETE CURBING (OR EQUIVALENT BARRIER) IS TWOFOLD. FIRST, CONCRETE CURBING (IF UTILIZED) CAN ALLOW NUISANCE PONDING ABOVE THE PERVIOUS PAVEMENT. SECOND, CONCRETE CURBING WILL REDUCE HORIZONTAL SCOUR EROSION SHOULD THE SYSTEM FAIL.

TYPICAL PERVIOUS PAVEMENT CROSS SECTION

NOT TO SCALE

TYPICAL PERVIOUS PAVEMENT CROSS SECTION - AS OF 02-23-10.DWG

PERVIOUS PAVERS

- Current products have excellent strength and permeabilities
- Modular so can easily be maintained and/or replaced

POROSITY OF PERVIOUS PAVEMENT AND PAVERS

- Pervious Concrete: 15-35%
- Pervious Asphalt: 20-30%
- Modular Pavers: 20-40%

Each inch of pervious material can store from 0.2 to 0.4 inches runoff

Excellent reference: https://www.devoeng.com/memos/pervious_pavement_systems.pdf

INSTALLATION OF PERVIOUS PAVEMENT AND PAVERS

<u>Where</u> to use:

Light duty drives and driveways

Angled parking

Edge parking

Pedestrian walks and bike trails

Where <u>Not</u> to use:

Heavy loads

Heavy traffic

High turning movements

Excellent reference: https://www.devoeng.com/memos/pervious_pavement_systems.pdf

PERVIOUS PAVEMENT AND PAVERS

- May provide credit as retention volume.
- Can be used with, **or without** storage underneath.
- Without storage provides its own retention and reduces Curve Number
- Additionally, areas with pervious materials can be removed from DCIA calculation, and strategic locations of pervious pavement/pavers may provide a disconnect from other impervious surfaces, reducing the site’s DCIA.

“LID” EXAMPLE CASE

PUTTING IT ALL TOGETHER

- Hypothetical 100-acre multi-use project
- Given: Site is 55% DCIA with a CN of 50.
- Required dry retention volume = 1.1 inches for 80% removal equals 400,00 c.f.
- Assume 1,500 l.f. of main boulevard

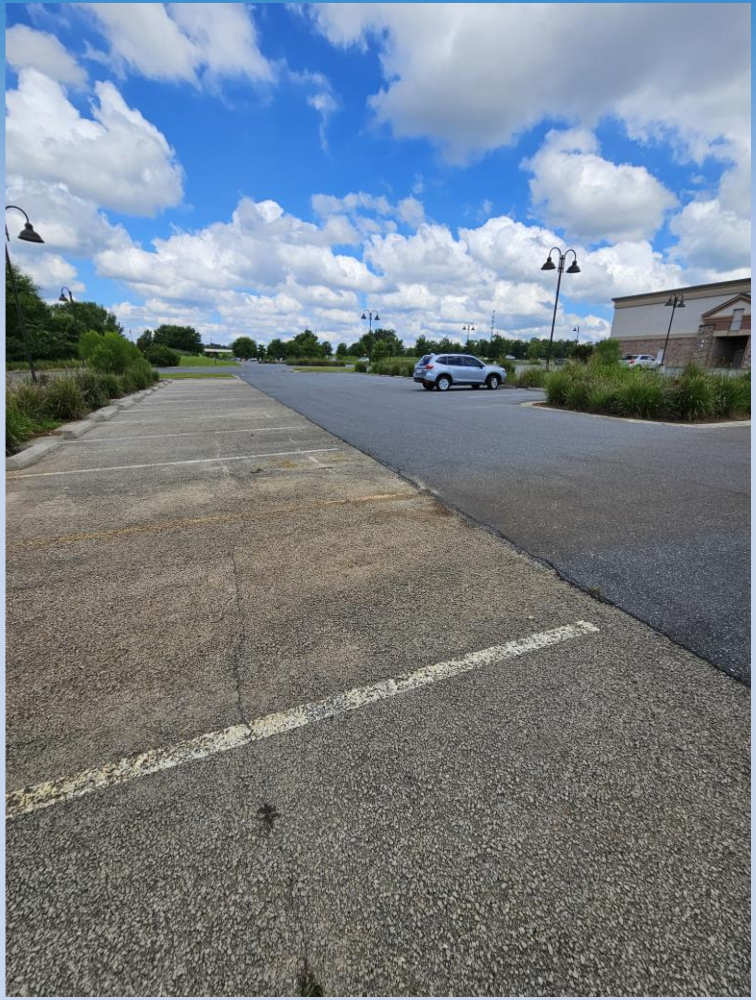
LID EXAMPLE FOR 100-ACRE MULTI-USE PROJECT

REQUIRED RETENTION VOLUME = 400,000 C.F.

- Use cumulative value of microscale retention say, 30 boxes at 200 c.f. each = 6,000 c.f.
- Use cumulative value of curb cut depressions, say 600 l.f. on both sides: 6 long x 3 wide x 2 feet deep each = 43,000 c.f.
- 2-acre parking area 25 % pervious pavement with 4 feet of storage and aggregate (stone) void space = 0.3
  Volume = 2 acres x 0.25 x 4 x 0.3 = 26,000 c.f.
- Cumulative Total = 75,000 c.f. equals 19% reduction in retention pond volume

REAL-WORLD EXAMPLE

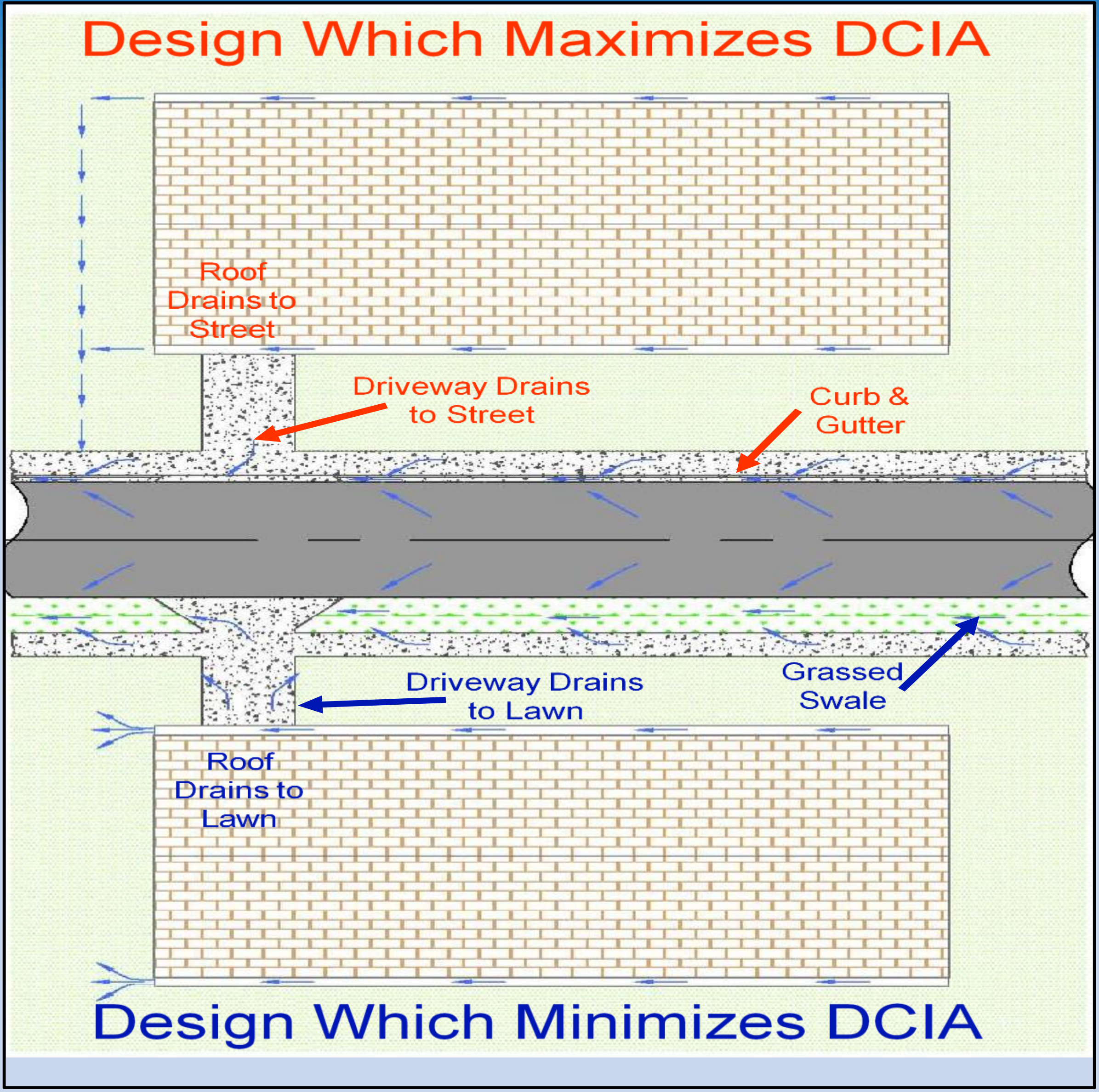
CMX THEATRE IN TALLAHASSEE



REDUCING DIRECTLY CONNECTED IMPERVIOUS AREA OR DCIA

- DCIA has direct effect on the annual runoff generated.
- Reducing DCIA results in less treatment volume required.
- Reduce DCIA by shunting runoff to natural areas, turf, or pervious pavement before entering storm sewer

DESIGN CHANGES TO REDUCE DCIA



Potential to significantly reduce annual runoff and therefore dry retention treatment volumes

REDUCING DCIA – RULE PROVISIONS

- Section 9.2.1(b) of A.H. Volume I defines non-DCIA as
  - All portions of pervious and impervious areas that flow over at least 10 feet of undisturbed pervious area for HSG A and B soils, and
  - At least 20 feet of undisturbed pervious area for other soil types
  - Narrower widths can be used if can demonstrate adequate infiltration (3-yr, 1-hour storm)
- Discussions with DEP indicate that the agency would likely accept a 20-foot buffer for cultivated areas such as turf grass

QUANTIFYING THE EFFECT OF REDUCING DCIA

- Primarily for dry retention systems
- The following data show the effect of DCIA reduction on retention volumes

RETENTION VOLUME REMOVAL TABLES – BASED ON CN AND DCIA

Mean Annual Mass Removal Efficiencies for 1.25-inches of Retention for Zone 1 by Percent DCIA

Non DCIA CN	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	96.1	97.3	97.2	96.3	94.9	93.4	91.6	89.7	87.8	85.8	83.8	81.8	79.9	77.9	76.0	74.2	72.4	70.6	68.9	67.3
35	94.5	96.1	96.2	95.4	94.1	92.7	91.0	89.2	87.4	85.5	83.5	81.6	79.7	77.8	75.9	74.1	72.3	70.6	68.9	67.3
40	92.5	94.5	94.8	94.2	93.2	91.9	90.3	88.6	86.9	85.0	83.2	81.3	79.5	77.6	75.8	74.0	72.3	70.6	68.9	67.3
45	90.4	92.7	93.2	92.8	92.0	90.9	89.4	87.9	86.3	84.5	82.8	81.0	79.2	77.4	75.6	73.9	72.2	70.5	68.9	67.3
50	88.0	90.6	91.3	91.2	90.6	89.7	88.4	87.0	85.5	83.9	82.2	80.5	78.8	77.1	75.4	73.7	72.1	70.4	68.9	67.3
55	85.4	88.2	89.2	89.3	88.9	88.2	87.2	86.0	84.6	83.1	81.6	80.0	78.4	76.7	75.1	73.5	71.9	70.3	68.8	67.3
60	82.7	85.7	86.9	87.2	87.0	86.5	85.7	84.7	83.5	82.2	80.8	79.3	77.8	76.3	74.8	73.2	71.7	70.2	68.8	67.3
65	80.1	83.1	84.4	84.9	84.9	84.5	83.9	83.1	82.1	81.0	79.8	78.5	77.1	75.7	74.3	72.9	71.5	70.1	68.7	67.3
70	77.6	80.3	81.7	82.4	82.5	82.4	81.9	81.3	80.6	79.7	78.6	77.5	76.3	75.1	73.8	72.5	71.2	69.9	68.6	67.3
75	75.2	77.6	79.0	79.7	80.0	79.9	79.7	79.3	78.7	78.0	77.2	76.3	75.3	74.2	73.1	72.0	70.9	69.7	68.5	67.3
80	73.0	74.9	76.1	76.8	77.2	77.3	77.3	77.0	76.6	76.1	75.5	74.8	74.0	73.2	72.3	71.4	70.4	69.4	68.4	67.3
85	70.9	72.3	73.3	73.9	74.3	74.5	74.6	74.5	74.3	73.9	73.5	73.1	72.5	71.9	71.2	70.5	69.8	69.0	68.2	67.3
90	69.2	70.0	70.6	71.1	71.4	71.6	71.7	71.7	71.7	71.5	71.3	71.1	70.7	70.4	70.0	69.5	69.0	68.5	67.9	67.3
95	67.8	68.1	68.4	68.6	68.7	68.9	68.9	69.0	69.0	69.0	68.9	68.9	68.7	68.6	68.5	68.3	68.1	67.8	67.6	67.3
98	67.7	67.7	67.7	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.7	67.7	67.6	67.6	67.5	67.5	67.4	67.3

Tables found in Appendix O, Applicant's Handbook Volume I

INCHES OF RETENTION TO ATTAIN TREATMENT GOAL VARIED BY PERCENT DCIA AND CN

Inches of Retention to Achieve 80% Removal

	Directly Connected Impervious Area (DCIA)				
CN	35%	45%	55%	65%	75%
40	0.73	0.91	1.10	1.26	1.38
60	0.82	0.98	1.12	1.35	1.55
80	1.33	1.47	1.55	1.68	1.74

Inches of Retention to Achieve 90% Removal

	Directly Connected Impervious Area (DCIA)				
CN	35%	45%	55%	65%	75%
40	1.23	1.5	1.78	2.1	2.23
60	1.7	1.8	2	2.25	2.5
80	2.4	2.5	2.58	2.62	2.72

Values derived from Appendix O set of tables

EFFECT OF CHANGING DCIA ON RETENTION VOLUME

Percent Retention Volume Reduction for 80% Removal

DCIA Reduction

	65 to 55	55 to 45	45 to 35
CN=40	13%	17%	20%
CN=80	8%	9%	10%

Percent Retention Volume Reduction for 90% Removal

DCIA Reduction

	65 to 55	55 to 45	45 to 35
CN=40	12%	16%	18%
CN=80	2%	3%	4%

OBSERVATIONS ON DCIA ANALYSES

- DCIA can be significantly reduce of retention volumes
- More efficient at lower CNs
- Also more efficient for projects with lower values of DCIA
- Combined with LID strategies, may reduce retention pond volumes by 25 to 40% and higher

WET DETENTION REVISITED

METHODS FOR ENHANCING REMOVAL EFFICIENCIES

WET DETENTION REVISITED

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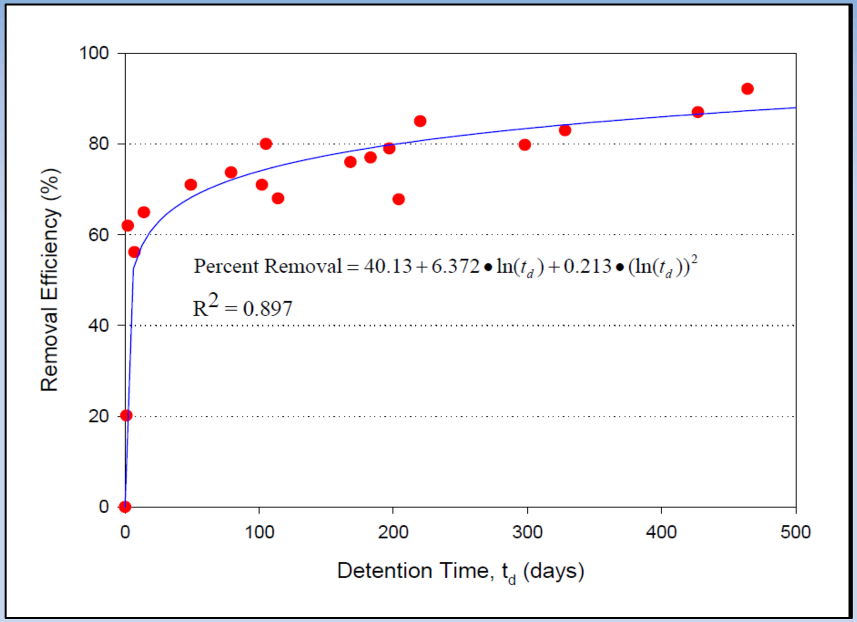
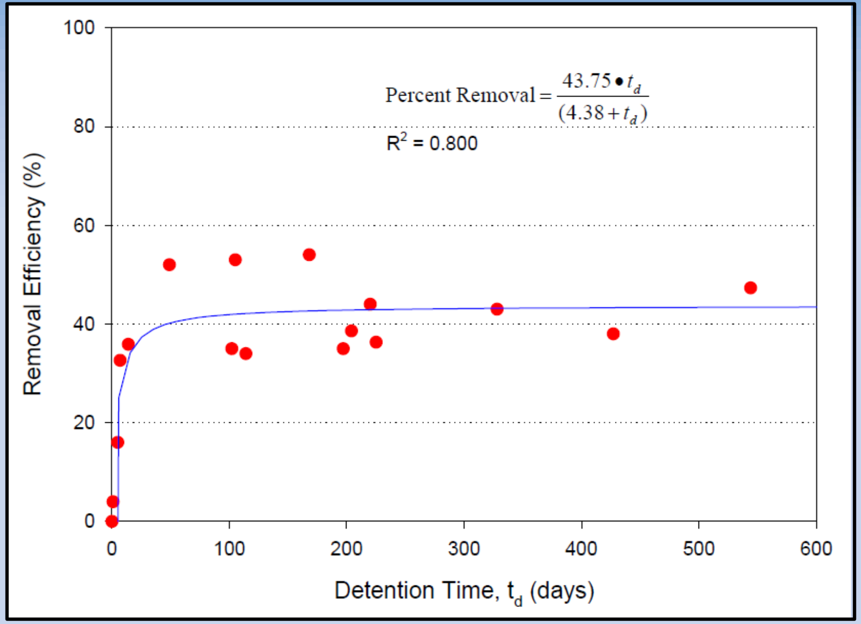


TOTAL PHOSPHORUS



TOTAL NITROGEN

WET DETENTION REVISITED

- Several best management practices (BMPs) can be used in conjunction with wet ponds to “super-charge” treatment efficiencies.
  - Adding littoral zones
  - Adding floating treatment wetlands
  - Employing stormwater harvesting for irrigation

WET POND ENHANCEMENT

REMOVAL CREDIT FROM APPENDIX O, A.H. VOLUME I

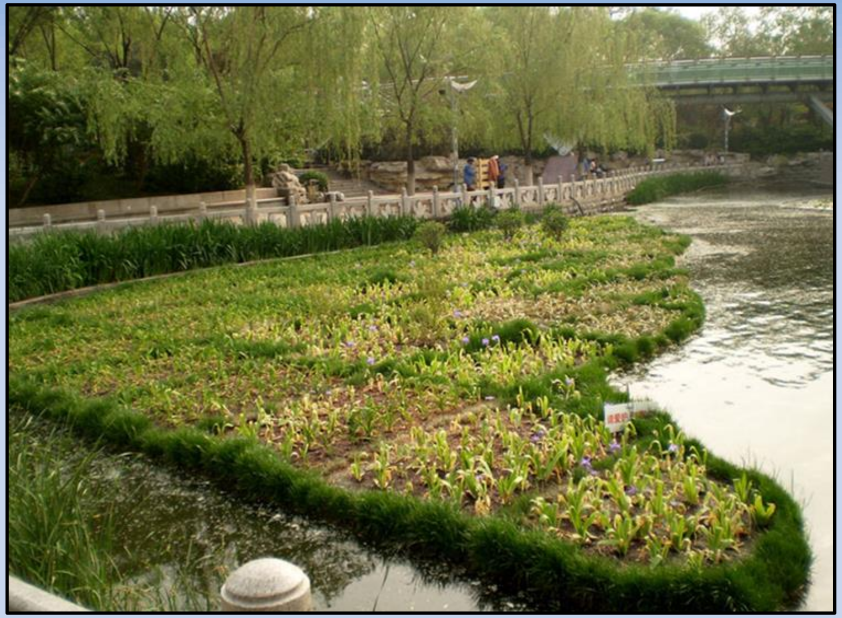
- Littoral zones TN & TP removals for minimum coverage per Water Management District Volume IIs).
- Floating treatment wetlands (FTWs) TN & TP removals for for 5% water surface coverage.
- Stormwater harvesting based on annual volume removed (credit based on site specific water balance).

NO CHANGES TO FINAL GRADING OR POND GEOMETRY

LITTORAL ZONES AND FLOATING TREATMENT WETLANDS OR "FTWS"

REMOVAL Credit from Appendix O, A.H. Volume I

LITTORAL ZONE
10% TN & TP REMOVAL CREDIT



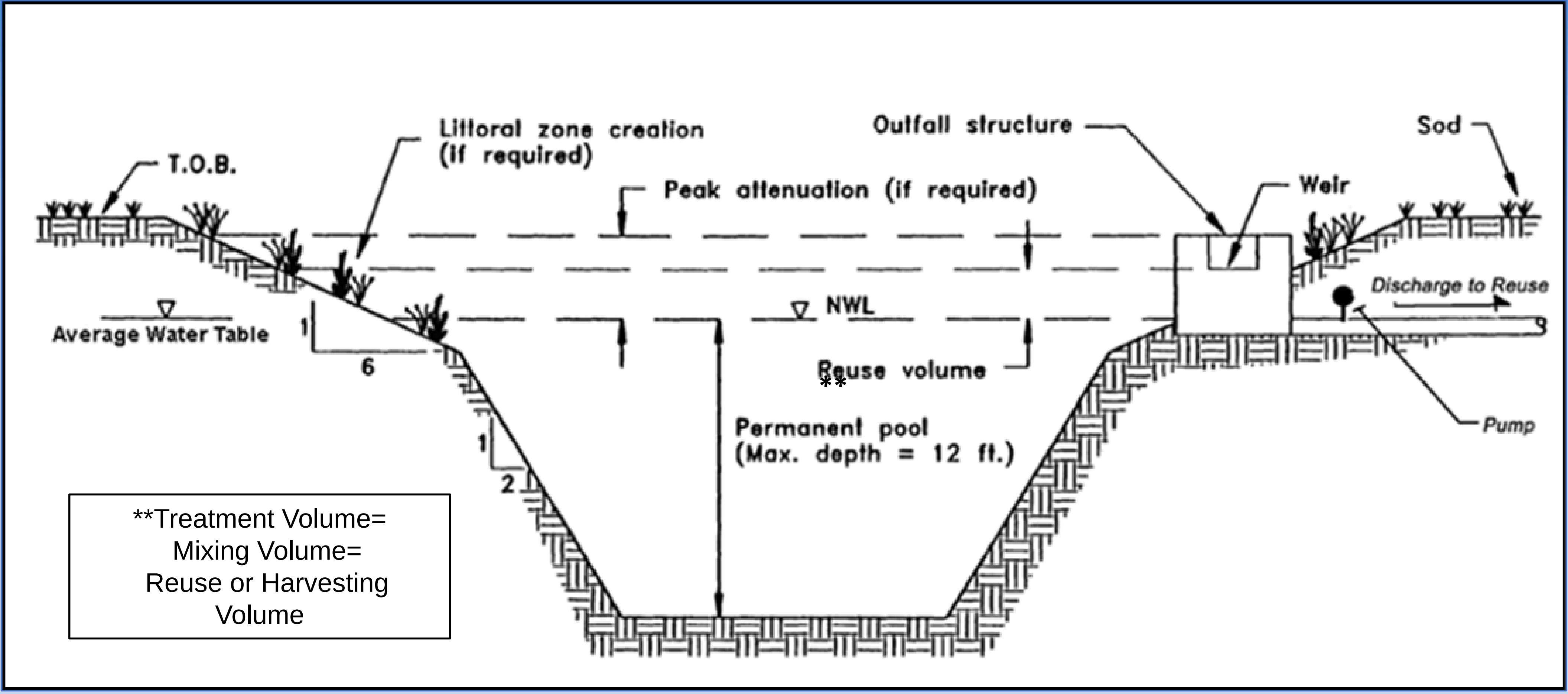
FLOATING TREATMENT WETLANDS
12% TN & TP REMOVAL CREDIT

STORMWATER HARVESTING

Developed years ago, but seldom used… until now

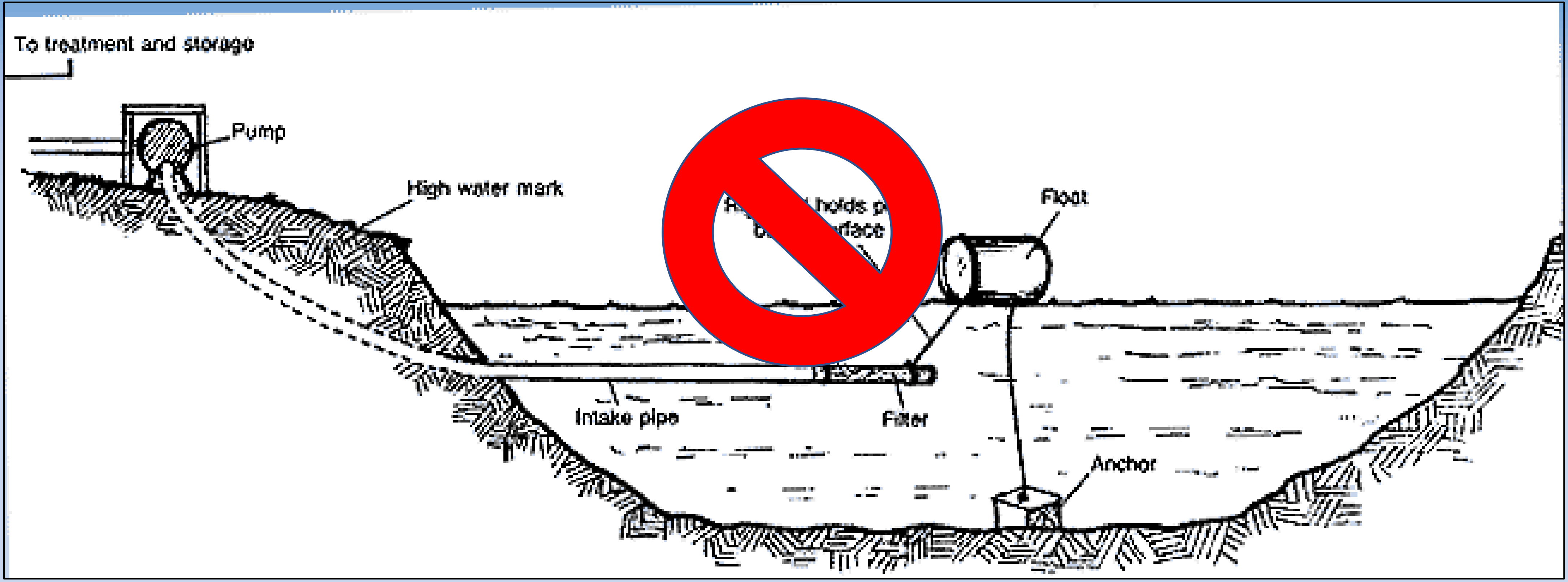
STORMWATER HARVESTING (REUSE)

USED IN CONJUNCTION WITH WET DETENTION



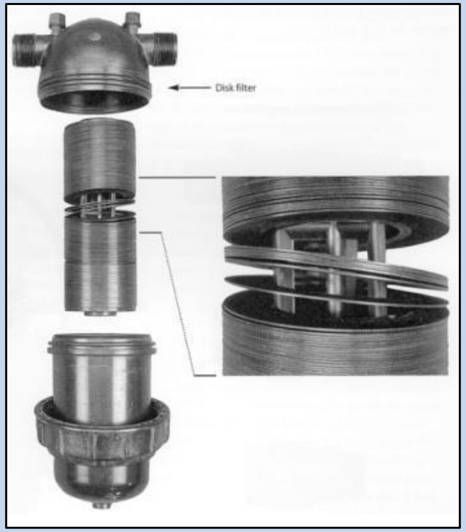
HARVESTING VOLUME = TREATMENT VOLUME
NOW MIXING VOLUME

HARVESTING WATER WITHDRAWAL METHOD

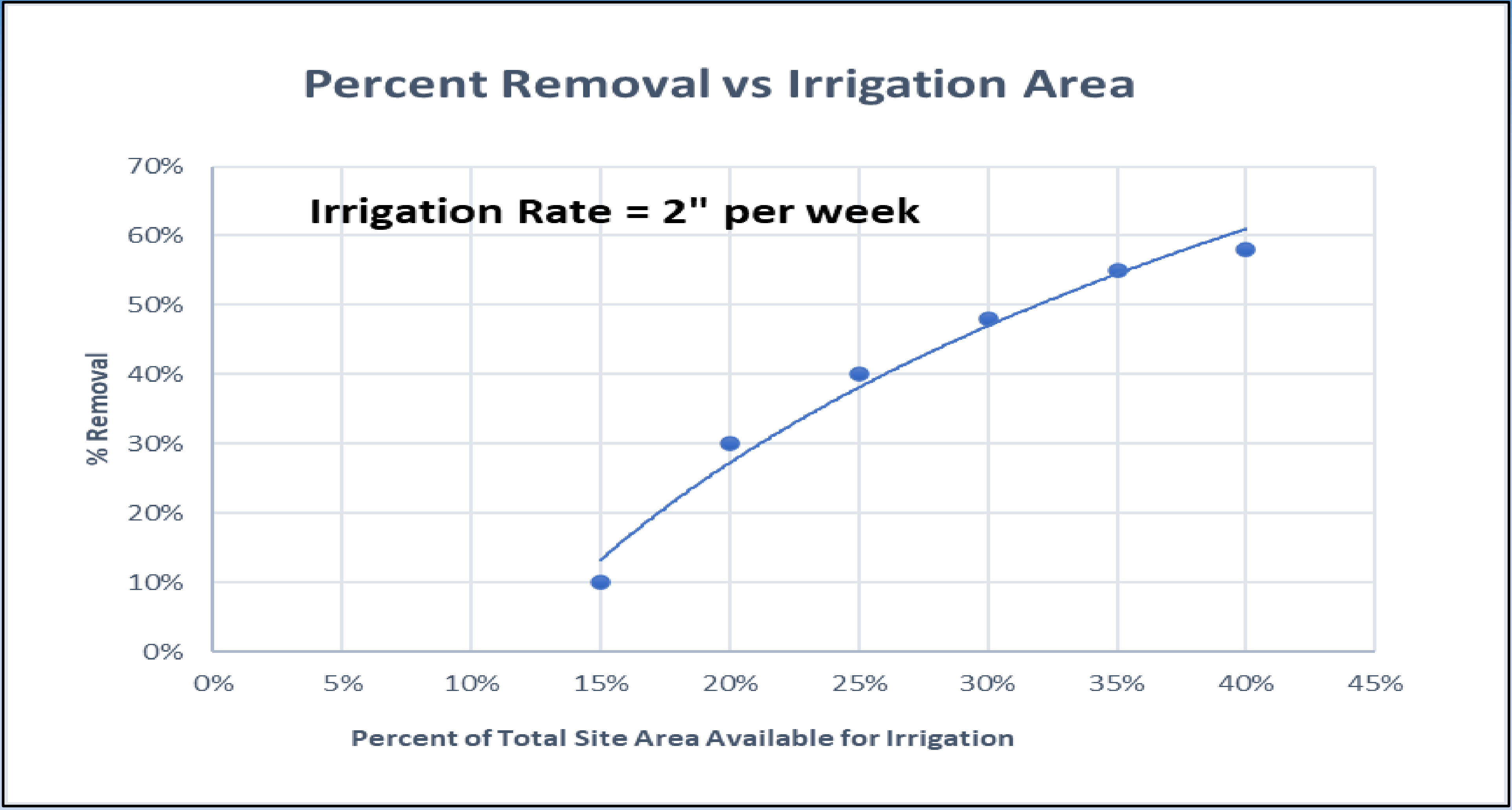


HARVESTING WITHDRAWAL METHODS – DISK FILTERS

- Technology performs reasonably well for small particulates including unicellular algae. Consists of plastic discs stacked like a pile of poker chips
- Each disc is covered with small grooves or bumps and water is withdrawn from the center. Clean by taking the discs apart and rinsing.



EXAMPLE OF STORMWATER HARVESTING EFFICIENCY
60% IMPERVIOUS SITE



STORMWATER HARVESTING DESIGN

- Design of a stormwater harvesting system requires development of a water budget
- Budgets must include all inputs, storage, and outputs from the system
- Elements necessary for water budgets include:
  - Watershed characteristics
  - Irrigation area
  - Percentage of runoff to be harvested
  - Harvesting volume and irrigation rate
  - Rainfall and evaporation data

HARVESTING ASSUMPTIONS

- Net groundwater contribution (in or out) is zero
- Harvesting rate is consistent over time
- Mean annual evaporation from the pond equals mean annual rainfall on the pond
- Can perform individual water budget analyses, or can use UCFs model

STORMWATER HARVESTING
UCF MODEL

- The University of Central Florida performed a series of mass balance measurements and simulations resulting in plotted-curve solutions (R-E-V curves) relating the following:
  - Irrigation rate (R).
  - Efficiency (E) is the mean annual percentage of runoff pumped for irrigation and/or other uses.
  - Harvestable volume (V).
  - Equivalent Impervious Area (EIA)

SEE SECTION 5.5, NWFWMD APPLICANT'S HANDBOOK II, DESIGN AIDS

EQUIVALENT IMPERVIOUS AREA OR EIA

- UCF’s harvesting curves are based around the term Equivalent Impervious Area or EIA
- EIA represents an equivalent impervious area that would produce the same volume of runoff as the actual watershed
- R-E-V curves allow for use on any site since data is based on **relative percentages** and is **fully scalable**.

HARVESTING VOLUME

- Harvesting volume (V) is former "bleed-down" volume, or what formerly was called the treatment volume, now termed mixing volume
- The harvesting volume is used for irrigation and can include grey water purposes
- Harvesting volume is expressed as "inches over the EIA" and represents available watershed runoff for irrigation

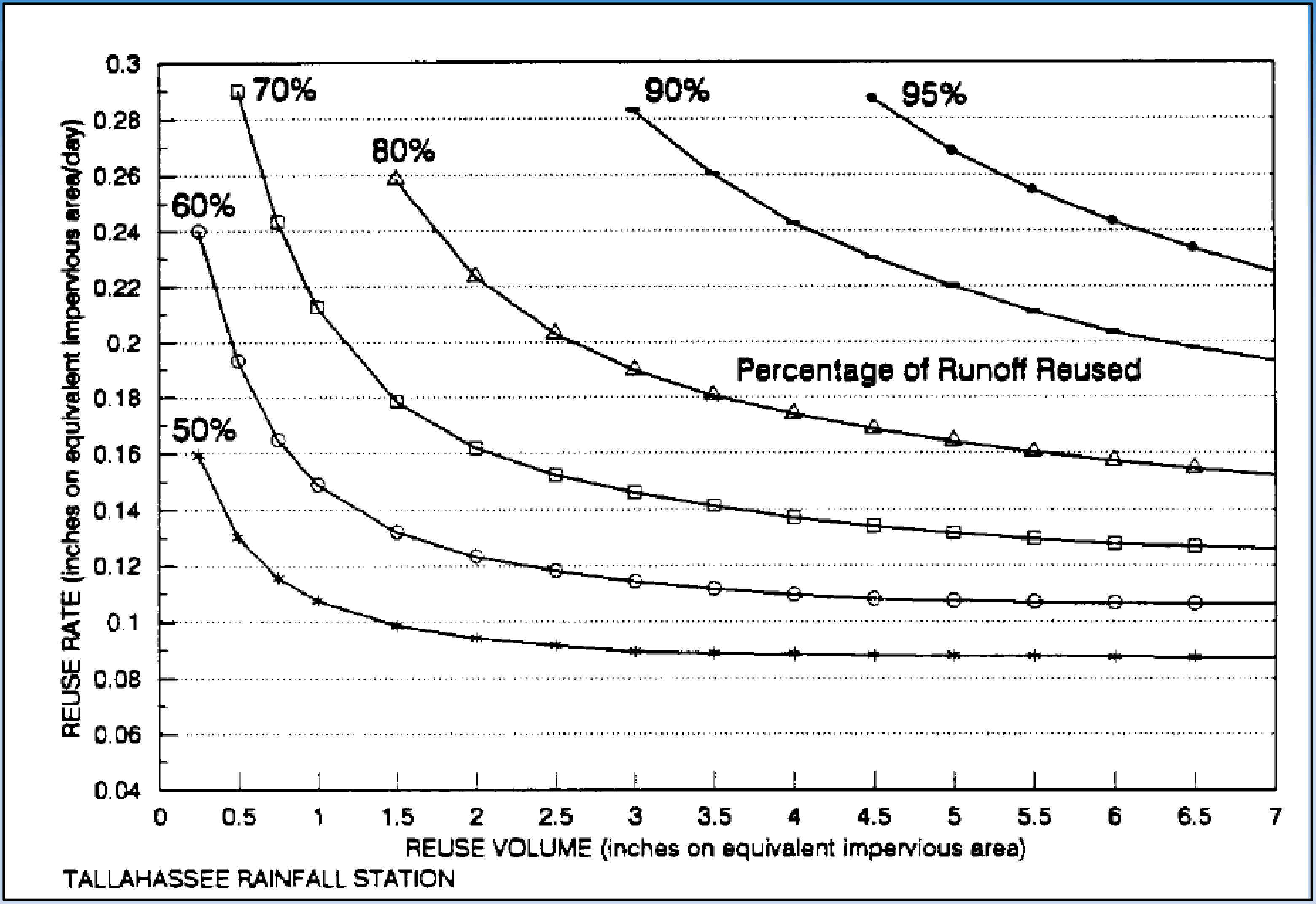
HARVESTING RATE

- Harvesting Rate (R) is the rate at which stored stormwater is used.
- Units for R: “inches per day over the EIA”
- Landscape irrigation specialists should be consulted for the design of the irrigation system and recommended irrigation rates

HARVESTING EFFICIENCY

- Efficiency value (E) represents the annual average volume of water withdrawn from the pond for use within the watershed for irrigation or grey water, expressed as a percentage
- Mass of water removed represents the annual mass of pollutants removed from the pond system
- Therefore, E values are equivalent to annual mass pollutant removals expressed as annual percentages

RATE-EFFICIENCY-VOLUME (REV) CURVES



TALLAHASSEE EXAMPLE

LOW DENSITY RESIDENTIAL SUBDIVISION

- Given: 100-acre watershed that is 45% impervious; weighted C = 0.45
- Wet detention system for the site requires 363,000 c.f. (8.33 acre-feet) for mixing volume, this then is the harvesting volume (V)
- Area available for irrigation = 25 acres
- Allowable irrigation rate is 1.5 inches per week
- Determine the efficiency (E) of the system

TALLAHASSEE EXAMPLE

LOW DENSITY RESIDENTIAL SUBDIVISION

- Step 1: Determine the Equivalent Impervious Surface or EIA

  EIA = Weighted C x Watershed Area

  EIA = 0.45 x 100 acres

  EIA = 45

TALLAHASSEE EXAMPLE CALCULATIONS

Step 2: Convert the harvesting volume (V) to “Inches over the EIA”

V = Harvesting Volume / EIA x Conversion Factors

V = (8.33 ac-ft) x (1/45 ac) x (12 inches/1 ft) = 2.2 inches

V= 2.2 inches over the EIA

TALLAHASSEE EXAMPLE CALCULATIONS

Step 3: Covert the harvesting rate units to inches over the EIA per day

R = Irrigation area x inches per week x conversion / EIA

R = (25 ac) x (1.5 inches/1 week) x (1 week/7 days) x (1/45 acres) =

R = 0.12 inches per day over the EIA

V = 2.2 inches over the EIA

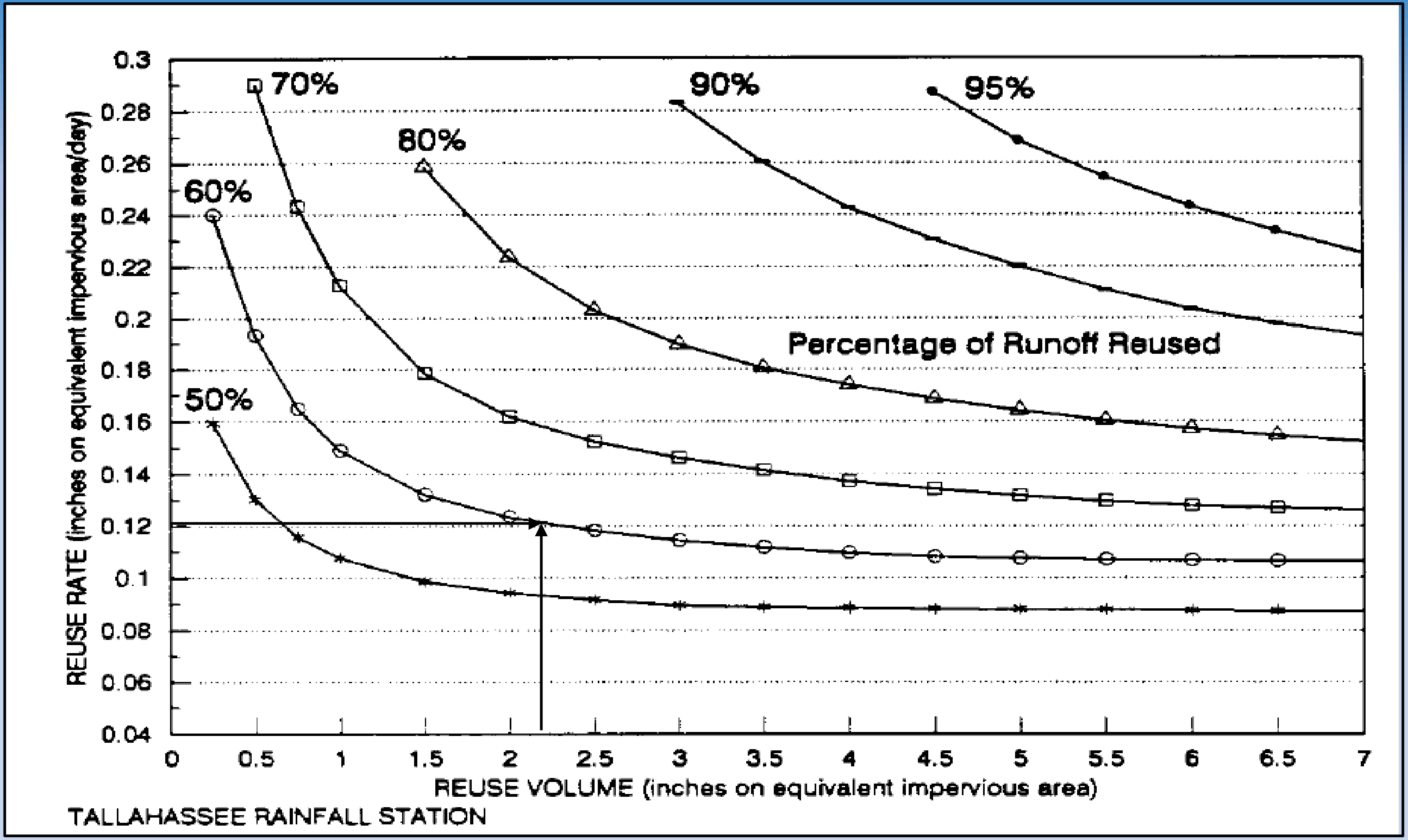
R = 0.12 inches per day over the EIA

R-E-V CURVES FOR TALLAHASSEE

- Find “E” harvesting efficiency

V = 2.2
R = 0.12

Efficiency Just Under 60%



HARVESTING CONCLUSIONS

- Potential to provide needed “lift” to meet new standards for wet detention systems
- The efficiency determined for harvesting *is in addition* to the treatment that occurs in the permanent pool
- Little to no effect on development footprint

MEETING NUTRIENT REMOVAL TARGETS

WET DETENTION EXAMPLE

- The following examples are for the new minimum treatment standards by water classification.
- The example site is a generic development.
  - 60% impervious.
  - Non-DCIA CN of 40.
  - Wet detention primary driver with a complementary suite of practices.
  - Uses current rule for permanent pool detention time (14 days/21 days).
  - Irrigable area 25% of site; Maximum irrigation rate = 2.0” per week.

EXAMPLE FOR "ALL SITES"

Rule Target for "All Sites"					
TN=55 TP=80					
	Wet Pond				
Wet Detention	**Removal**	**Littoral**		**Stormwater**	**Total**
Detention = 14 days	**Efficiency**	**Zone**	**FTWs**	**Harvesting**	**Reduction**
Percent TN Removal	0.33	0	0	0	**0.33**
Percent TP Removal	0.58	0	0	0	**0.58**

EXAMPLE FOR "ALL SITES" ADDING LITTORAL ZONES

Rule Target for "All Sites"					
TN=55 TP=80					
Wet Detention Detention = 14 days	**Wet Pond Removal Efficiency**	**Littoral Zone**	**FTWs**	**Stormwater Harvesting**	**Total Reduction**
Percent TN Removal	0.33	0.1	0	0	**0.40**
Percent TP Removal	0.58	0.1	0	0	**0.62**

Overall Treatment Efficiency =

E1 + (1-((1-E1)*(1-E2)*(1-E3))) + Harvesting Value

BMPTrains program can calculate the reduced efficiency for BMPs in series

EXAMPLE FOR "ALL SITES" ADDING TREATMENT WETLANDS

Rule Target for "All Sites"					
TN=55 TP=80					
	Wet Pond				
Wet Detention	**Removal**	**Littoral**		**Stormwater**	**Total**
Detention = 14 days	**Efficiency**	**Zone**	**FTWs**	**Harvesting**	**Reduction**
Percent TN Removal	0.33	0.1	0.12	0	**0.47**
Percent TP Removal	0.58	0.1	0.12	0	**0.67**

EXAMPLE FOR "ALL SITES" ADDING HARVESTING

Rule Target for "All Sites"					
TN=55 TP=80					
	Wet Pond			**0.75" per week**	
Wet Detention	**Removal**	**Littoral**		**Stormwater**	**Total**
Detention = 14 days	**Efficiency**	**Zone**	**FTWs**	**Harvesting**	**Reduction**
Percent TN Removal	0.33	0.1	0.12	0.15	**0.62**
Percent TP Removal	0.58	0.1	0.12	0.15	**0.82**

EXAMPLE FOR IMPAIRED WATERS

Rule Target for Impaired Waters					
TN=80 TP=80					
	Wet Pond			**2" per week**	
Wet Detention	**Removal**	**Littoral**		**Stormwater**	**Total**
Detention = 14 days	**Efficiency**	**Zone**	**FTWs**	**Harvesting**	**Reduction**
Percent TN Removal	0.33	0.1	0	0.4	**0.80**
Percent TP Removal	0.58	0.1	0	0.4	**0.95+**

EXAMPLE FOR OFWS

Rule Target for OFWs					
TN=80 TP=90					
	Wet Pond			**1.7" per week**	
Wet Detention	**Removal**	**Littoral**		**Stormwater**	**Total**
Detention = 21 days	**Efficiency**	**Zone**	**FTWs**	**Harvesting**	**Reduction**
Percent TN Removal	0.36	0.1	0.12	0.32	**0.81**
Percent TP Removal	0.62	0.1	0.12	0.32	**0.95+**

EXAMPLE IMPAIRED AND OFWS

Rule Target for Impaired & OFW					
TN=95 TP=95					
	Wet Pond			**2" per week**	
Wet Detention	**Removal**	**Littoral**		**Stormwater**	**Total**
Detention = 21 days	**Efficiency**	**Zone**	**FTWs**	**Harvesting**	**Reduction**
Percent TN Removal	0.36	0.1	0.12	0.4	**0.89**
Percent TP Removal	0.62	0.1	0.12	0.4	**0.95+**

EXAMPLE IMPAIRED AND OFWS

EXPANDING TO 60 DAYS DETENTION TIME

Rule Target for Impaired & OFW					
TN=95 TP=95					
	Wet Pond			**2" per week**	
Wet Detention	**Removal**	**Littoral**		**Stormwater**	**Total**
Detention = 60 days	**Efficiency**	**Zone**	**FTWs**	**Harvesting**	**Reduction**
Percent TN Removal	0.41	0.1	0.12	0.4	**0.93**
Percent TP Removal	0.7	0.1	0.12	0.4	**0.95+**

NOTES ON PREVIOUS CALCULATIONS

- Note that the bulk of removals result from pond detention time and mass removals by harvesting.
- Littoral zone and FTW removals act as final polishing.
- Harvesting rate is somewhat adjustable to meet need.
- Did not account for potential retention opportunities for LID-type microscale storage or pervious pavement/pavers.
- These practices do not require any change to the overall site plan footprint.

OPTIMIZING WET POND GEOMETRY: DEEP-XTORM COMPUTER PROGRAM

- Computational fluid dynamics (CFD) and machine learning can optimize the design of a wet detention basin
- Developed by Dr. John Sansalone at the University of Florida
- By manipulating flow-paths, treatment efficiencies can be dramatically increased
- Demonstration project in Naples, Florida, measured increases in nutrient removal by 40 to 50%

NEW CONCEPTS SUMMARY

- Numerous options are available for the design professional.
- Stacking components for wet detention provides a reasonable means for meeting nutrient removal goals.
- LID concepts form a similar suite of options for dry retention.
- These practices used together will likely form the next-generation “toolbox.”
- Engineers will likely regularly use tools such as BMPtrains and DeepXtorm and others

Why This Matters

Questions?

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