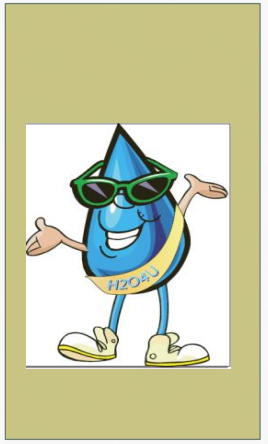
2014 Design Training Expo

Lake Buena Vista, Florida, June 11 2014

# BMPTRAINS MODEL: Version 7.1

## BACKGROUND, NAVIGATION AND EXAMPLES

BY: MARTY WANIELISTA



Credit and thanks to: Rick Renna, Mike Hardin, Dr. Harvey Harper, Dr. Ikiensinma Gogo-Abite and Chris Kuzlo

# PURPOSE OF PRESENTATION IS TO:

- Introduce **BMPTRAINS**… **B**est **M**anagement **P**ractices used for **T**reatment and calculations for **R**emoval on an **A**nnual basis **I**nvolving **N**utrients in **S**tormwater
- Describe the BMPTRAINS program to assist in the Design and Analysis of stormwater BMPs for nutrient removal.
- Show examples using BMPTRAINS.
- Understand BMPTRAINS as used for a basis of design and review for permits and mass reduction calculations.


BMPTRAINS Available from: www.stormwater.ucf.edu and www.SMADAONLINE.COM for legacy programs

# BMPTRAINS MODEL AND USERS MANUAL

Available from: www.stormwater.ucf.edu


What's New

**BMPTRAINS Stormwater Best Management Practices Analysis Model (Version 7.2)** Model, and User's Manual

FREE

Stormwater Management Academy

"Managed Stormwater is Good Water"

STATE OF FLORIDA • DEPARTMENT OF TRANSPORTATION

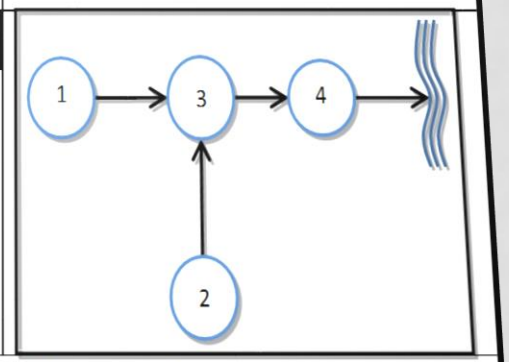
# User's Manual for the BMPTRAINS Model

Prepared By:
Marty Wanielista, Mike Hardin,
Przemyslaw Kuzlo, and Ikiensinma Gogo-Abite

| STORMWATER TREATMENT ANALYSIS: | V6.0 | GO TO GENERAL SITE INFORMATION PAGE | Blue Numbers = Input data<br>Red Numbers = Calculated |
|---|---|---|---|

STEP 1: Specify pre- and post-development watershed characteristics.

GO TO WATERSHED CHARACTERISTICS




Total Required Treatment Efficiency:

Required Treatment Eff (**Nitrogen**): %

Required Treatment Eff (**Phosphorus**): %

STEP 2: Select one of the systems below to analyze efficiency.

| | | | | | |
|---|---|---|---|---|---|
| RETENTION BASIN | WET DETENTION | EXFILTRATION TRENCH | RAIN (BIO) GARDEN | SWALE | USER DEFINED BMP |
| PERVIOUS PAVEMENT | STORMWATER HARVESTING | FILTRATION including BIOFILTRATION | LINED REUSE POND & UNDERDRAIN INPUT | NOTE !!!: All individual system must be sized prior to being analyzed in conjunction with other systems. Please read instructions in the MULTIPLE WATERSHEDS AND TREATMENT SYSTEMS ANALYSIS tab for more information. | |
| GREENROOF | RAINWATER HARVESTING | FLOATING ISLANDS WITH WET DETENTION | | | |
| VEGETATED NATURAL BUFFER | VEGETATED FILTER STRIP | VEGETATED AREA Example tree well | CATCHMENT AND TREATMENT SUMMARY RESULTS | | |

# NAVIGATING the BMP Nutrient Model BMPTRAINS

Enable Macros

EXCEL 2007 or Newer

Example NAVIGTION BUTTON

| Stormwater BMP Treatment Trains [BMPTRAINS©] | CLICK HERE TO START | HELP - INTRODUCTION<br>HELP AND BACKGROUND |
|---|---|---|
| FDOT / University of Central Florida | **INTRODUCTION PAGE**<br>Model requires the use of Excel 2007 or newer | 1) There is a users manual to help navigate this program and it is available at www.stormwater.ucf.edu |
| This program is compiled from stormwater management publications and deliberations during a two year review of the stormwater rule in the State of Florida.<br>Input from the members of the Florida Department of Environmental Protection Stormwater Review Technical Advisory Committee and the staff and consultants from the State Water Management Districts is appreciated.<br><br>The State Department of Transportation provided guidance and resources to compile this program. The Stormwater Management Academy is responsible for the content of this program. |  | 2) This spreadsheet is best viewed at 1280 BY 1080 PIXELS screen resolution. If the maximum resolution of your computer screen is lower than 1280 BY 1080 PIXELS you can adjust the view in the Excel VIEW menu by zooming out to value smaller than 100 PERCENT.<br><br>3) This spreadsheet has incorporated ERROR MESSAGE WINDOWS. Your analysis is not valid unless ALL ERROR MESSAGE WINDOWS are clear.<br><br>4) PRINTING INSTRUCTIONS: Print the page to MICROSOFT OFFICE DOCUMENT IMAGE WRITER (typically the default) or ADOBE PDF, save the page as an image document, then print the document you saved.<br><br>5) Click on the button located on the top of this window titled CLICK HERE TO START to begin the analysis. |

HELP VIDEOS

**Disclaimer: These workbooks were created to assist in the analysis of Best Management Practice calculations. All users are responsible for validating the accuracy of the internal calculations. If improvements are noted within this model, please e-mail Marty Wanielista, Ph.D., P.E. at martin.wanielista@ucf.edu with specific information so that revisions can be made.**

The authors of this program were Christopher Kuzlo, Marty Wanielista, Mike Hardin, and Ikiensinma Gogo-Abite.
This is version 7.2 of the program, updated on June 4, 2014. Comments are appreciated.

HELP - HYDROGRAPH AND LEGACY PROGRAMS

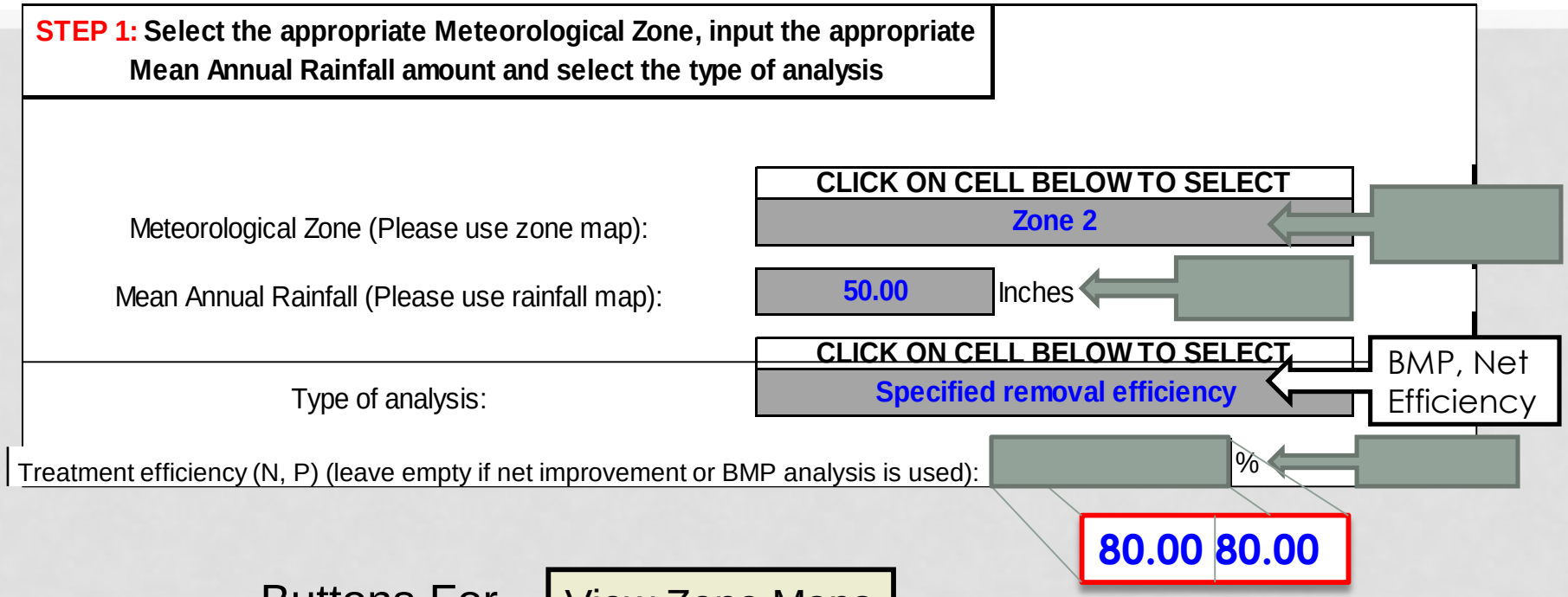
SMADA ONLINE

HELP VIDEOS

NOTE: the HELP button on a page will take you to information related to that page

# GENERAL SITE INFORMATION PAGE

## RAINFALL AND TYPE OF EFFECTIVENESS ANALYSIS



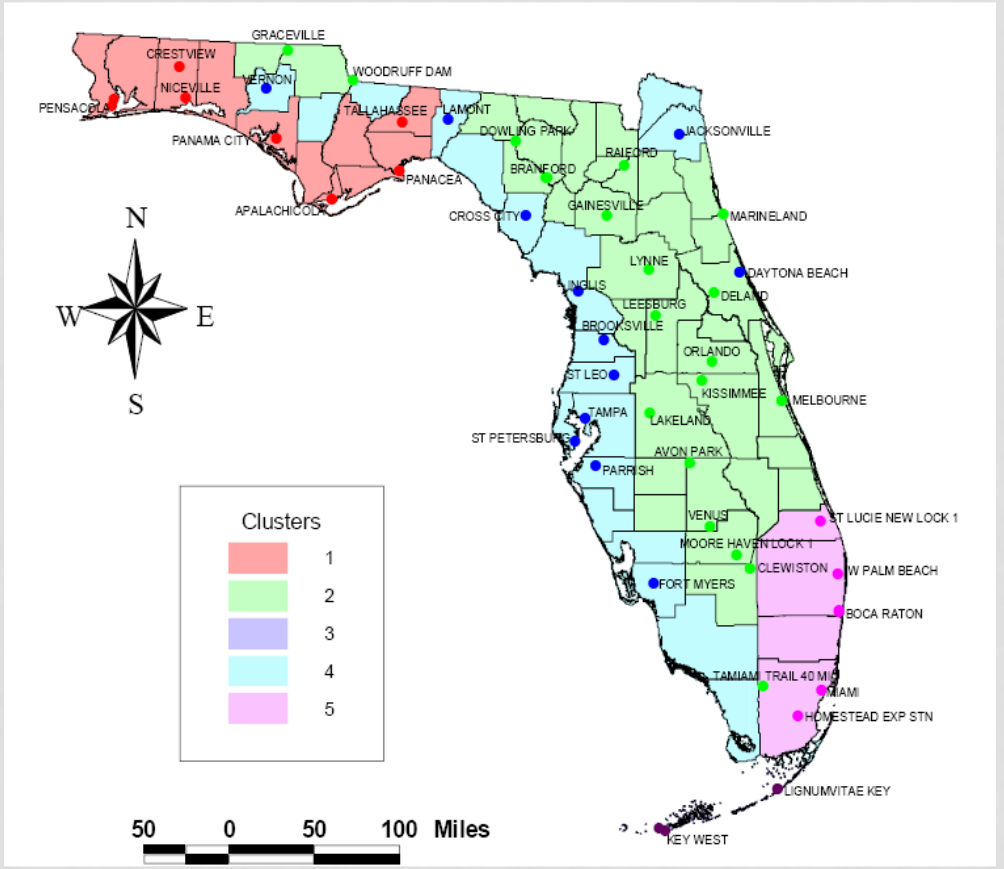

Buttons For

View Zone Maps

View Mean Annual Rainfall Map

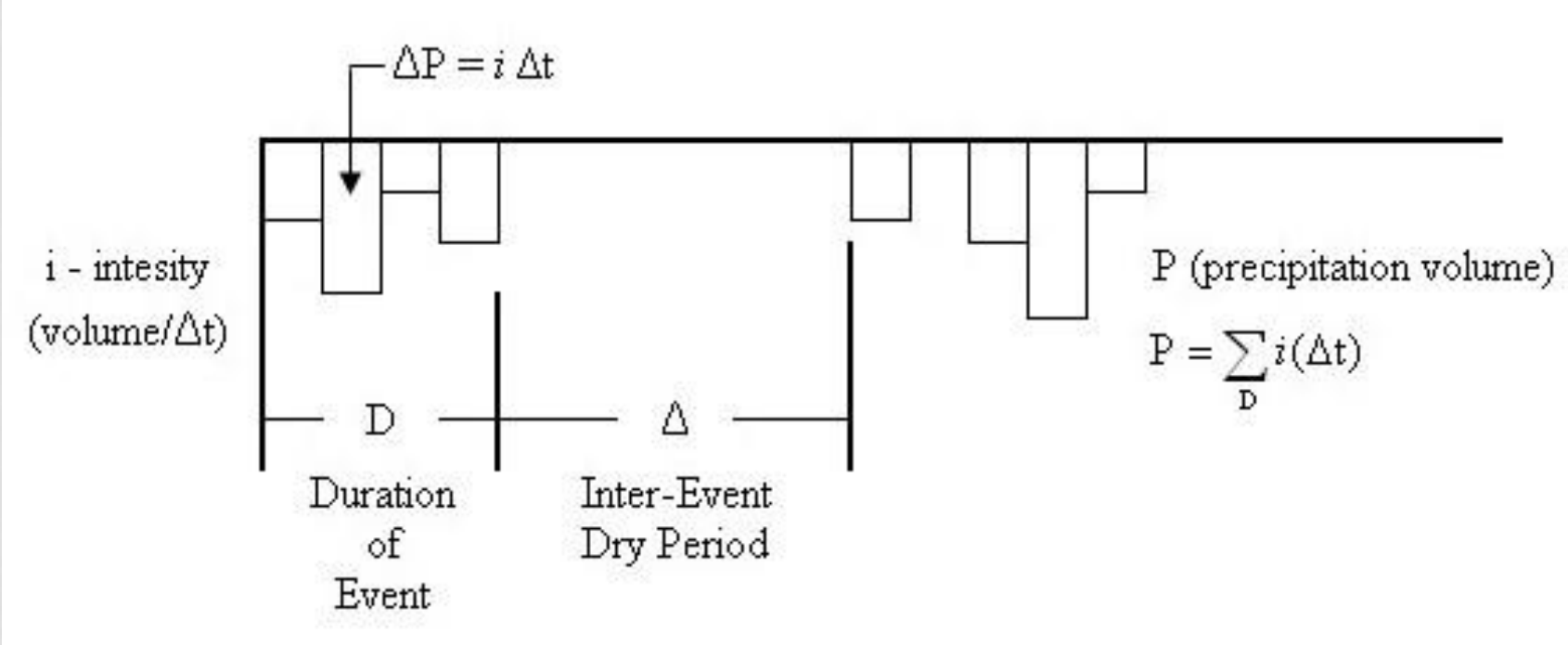
# RAINFALL DISTRIBUTIONS

- Rainfall distributions are regionally different.

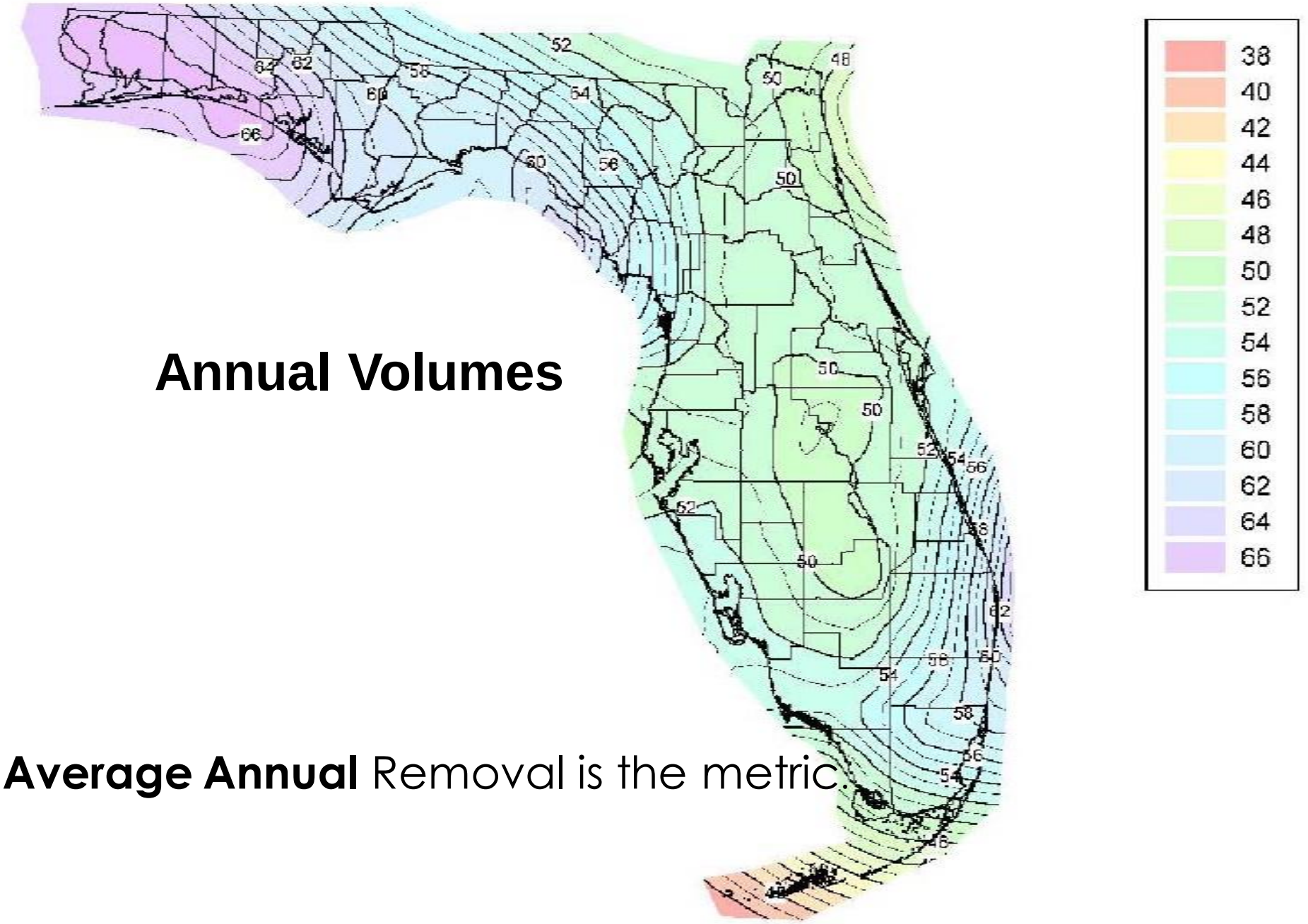


# BASIC PRINCIPLES

- Inter-Event Dry Period



# Annual Volumes




**Average Annual** Removal is the metric.

# WATERSHEDS
# CATCHMENT INPUTS

| WATERSHED CHARACTERISTICS | GO TO STORMWATER TREATEMENT ANALYSIS |
|---|---|
| SELECT CATCHMENT CONFIGURATION | CLICK ON CELL BELOW TO SELECT CONFIGURATION |

**CATCHMENT NO.1 CHARACTERISTICS:** \ **If mixed land uses (side calculation)**

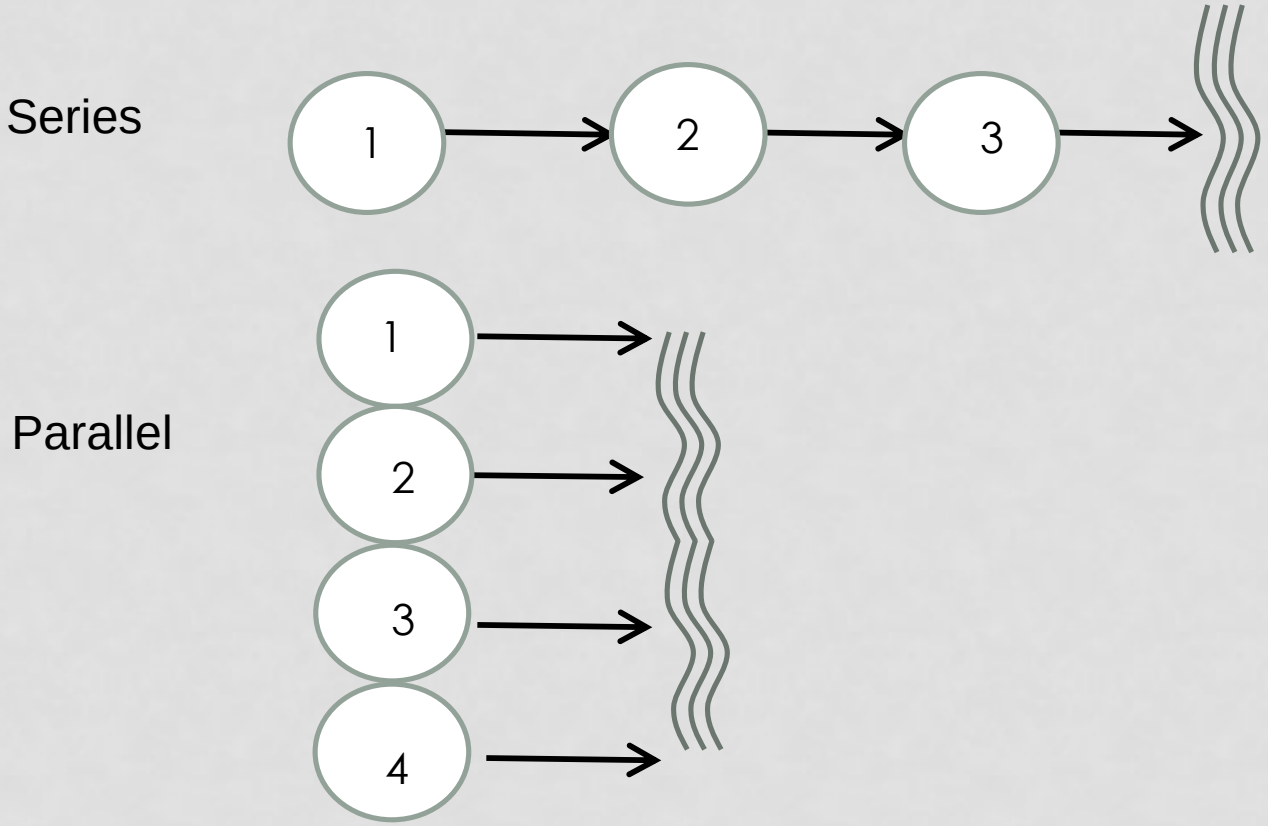
| | CLICK ON CELL BELOW TO SELECT | Land use | Area Acres | non DCIA CN | %DCIA |
|---|---|---|---|---|---|
| Pre-development land use: | Multi-Family: TN=2.230 TP=0.520 | | | | |
| with default EMCs | CLICK ON CELL BELOW TO SELECT | | | | |
| Post-development land use: | Highway: TN=1.640 TP=0.220 | | | | |
| with default EMCs | | Total | | | |

| | | |
|---|---|---|
| Total pre-development catchment area: | 0.55 | AC |
| Total post-development catchment or BMP analysis area: | 0.55 | AC |
| Pre-development Non DCIA CN: | 80.00 | |
| Pre-development DCIA percentage: | 0.00 | % |
| Post-development Non DCIA CN: | 80.00 | |
| Post-development DCIA percentage: | 100.00 | % |
| Estimated Area of BMP (used for rainfall excess not loadings) | 0.03 | AC |

# WATERSHEDS

## CATCHMENT CONFIGURATIONS

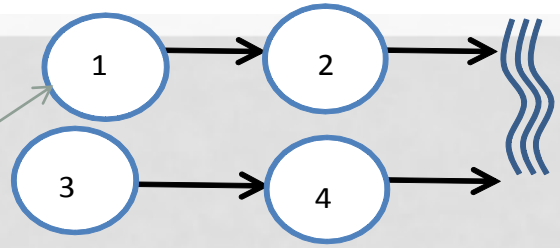
| WATERSHED CHARACTERISTICS | VIEW CATCHMENT CONFIGURATION |
| --- | --- |
| SELECT CATCHMENT CONFIGURATION | |



# UP TO 15 CONFIGURATIONS

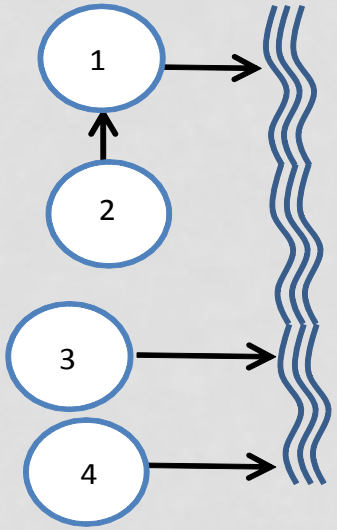
Up to 3 BMPs in Each catchment with no increase in catchment area between the BMPs

**M**

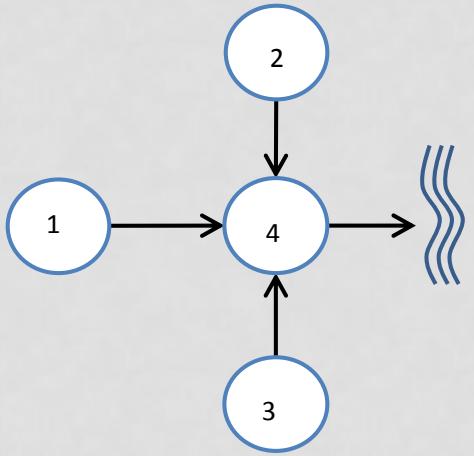



M - Mixed-4 Catchment-2 Series

**N**




N - Mixed-4 Catchment-2 Series-2 Parallel




O - Mixed-4 Catchment- Parallel- Series

# WATERSHEDS
# CATCHMENT INPUTS

NOTE: the latest version of the software, **V7.2 in this slide** will appear on pages normally printed

| WATERSHED CHARACTERISTICS V7.2 | | GO TO STORMWATER TREATEMENT ANALYSIS |
|---|---|---|
| SELECT CATCHMENT CONFIGURATION | | CLICK ON CELL BELOW TO SELECT CONFIGURATION |
| | | A - Single Catchment |

**CATCHMENT NO.1 CHARACTERISTICS:** \ If mixed land uses (side calculation)

| | CLICK ON CELL BELOW TO SELECT | Land use | Area Acres | non DCIA CN | %DCIA |
|---|---|---|---|---|---|
| Pre-development land use: | Multi-Family: TN=2.230 TP=0.520 | | | | |
| with default EMCs | CLICK ON CELL BELOW TO SELECT | | | | |
| Post-development land use: | Highway: TN=1.640 TP=0.220 | | | | |
| with default EMCs | | Total | | | |

| | | |
|---|---|---|
| Total pre-development catchment area: | 0.55 | AC |
| Total post-development catchment or BMP analysis area: | 0.55 | AC |
| Pre-development Non DCIA CN: | 80.00 | |
| Pre-development DCIA percentage: | 0.00 | % |
| Post-development Non DCIA CN: | 80.00 | |
| Post-development DCIA percentage: | 100.00 | % |
| Estimated Area of BMP (used for rainfall excess not loadings) | 0.03 | AC |

# LOADING RESULTS & CHANGE DATA

| Blue Numbers = | Input data |
|---|---|
| Red Numbers = | Answers |

| | | |
|---|---|---|
| Pre-development Annual Mass Loading - **Nitrogen:** | 0.886 | kg/year |
| Pre-development Annual Mass Loading - **Phosphorus:** | 0.199 | kg/year |
| Post-development Annual Mass Loading - **Nitrogen:** | 3.751 | kg/year |
| Post-development Annual Mass Loading - **Phosphorus:** | 0.503 | kg/year |

**OVERWRITE DEFAULT CONCENTRATIONS:**

| | PRE: | | POST: | |
|---|---|---|---|---|
| EMC(N): | | mg/L | | mg/L |
| EMC(P): | | mg/L | | mg/L |

NOTE: If any changes to the default values are made the numbers “carry” to the end

# EMC DEFAULT VALUES

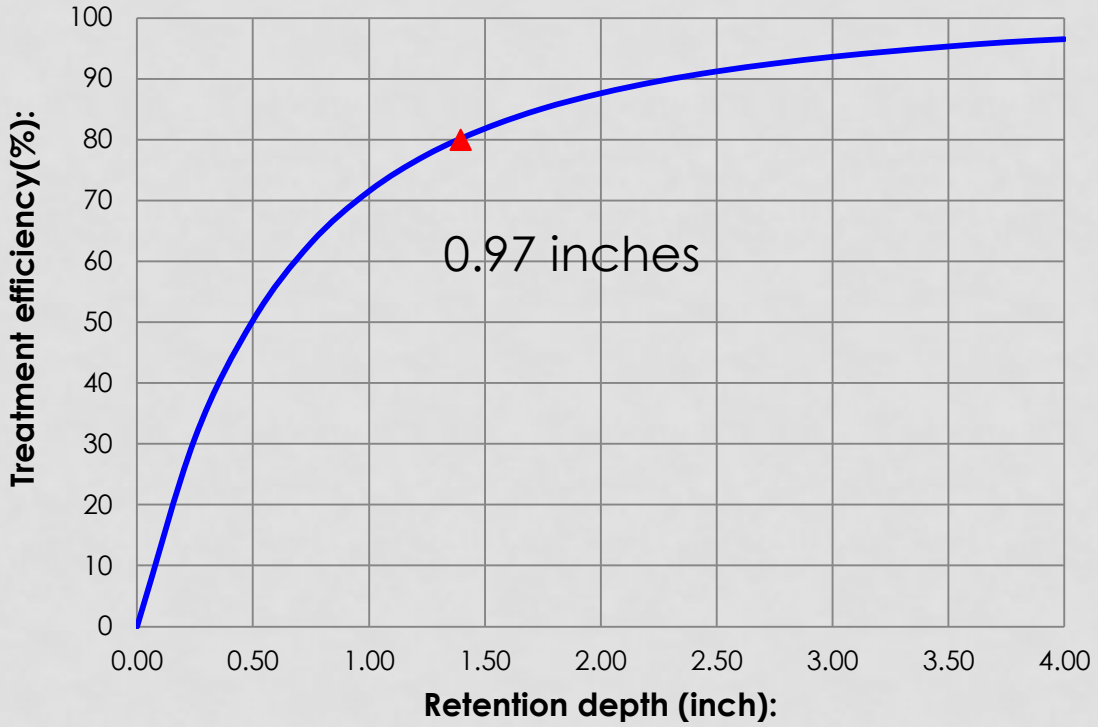
## AS OF JUNE 3, 2013

| LAND USE CATEGORY | Event Mean Concentration (mg/l) | |
|---|---|---|
| | TOTAL Nitrogen | TOTAL Phosphorus |
| Low-Density Residential[1] | 1.51 | 0.178 |
| Single-Family | 1.87 | 0.301 |
| Multi-Family | 2.1 | 0.497 |
| Low-Intensity Commercial | 1.07 | 0.179 |
| High-Intensity Commercial | 2.2 | 0.248 |
| Light Industrial | 1.19 | 0.213 |
| Highway | 1.37 | 0.167 |
| Agricultural - Pasture | 3.3 | 0.621 |
| Agricultural - Citrus | 2.07 | 0.152 |
| Agricultural - Row Crops | 2.46 | 0.489 |
| Agricultural - General Agriculture[2] | 2.79 | 0.431 |
| Undeveloped | 1.15 | 0.055 |
| Mining / Extractive | 1.18 | 0.15 |

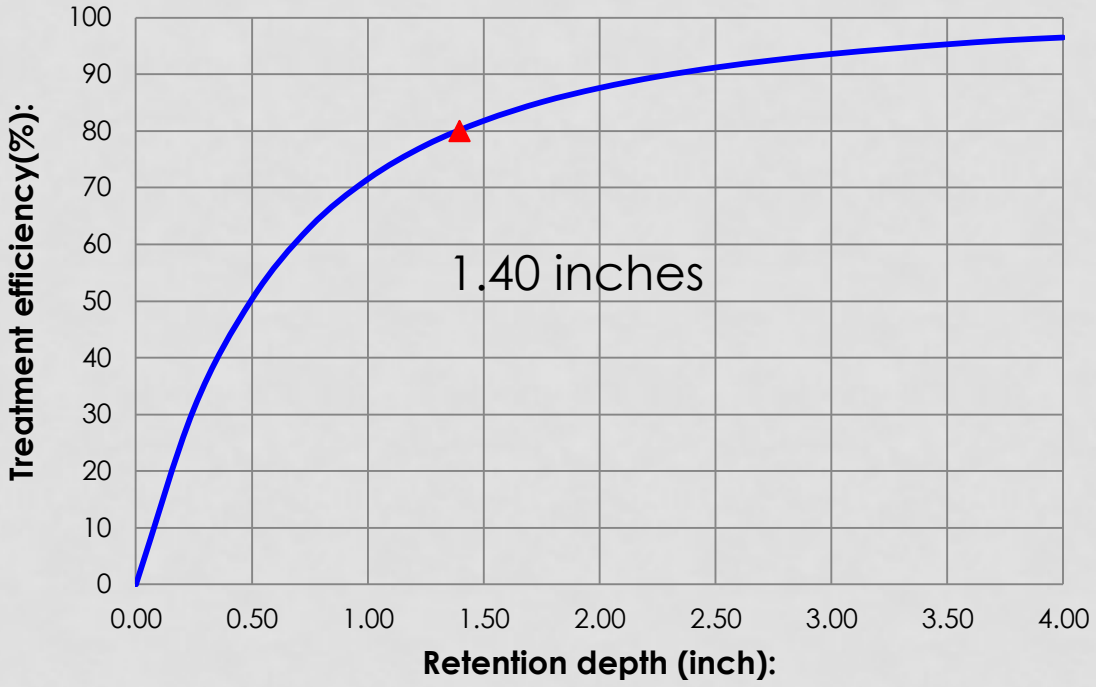
1. Average of single-family and undeveloped loading rates

2. Mean of pasture, citrus, and row crop land uses

# METHODOLOGY for RETENTION
# Example Output Retention Design



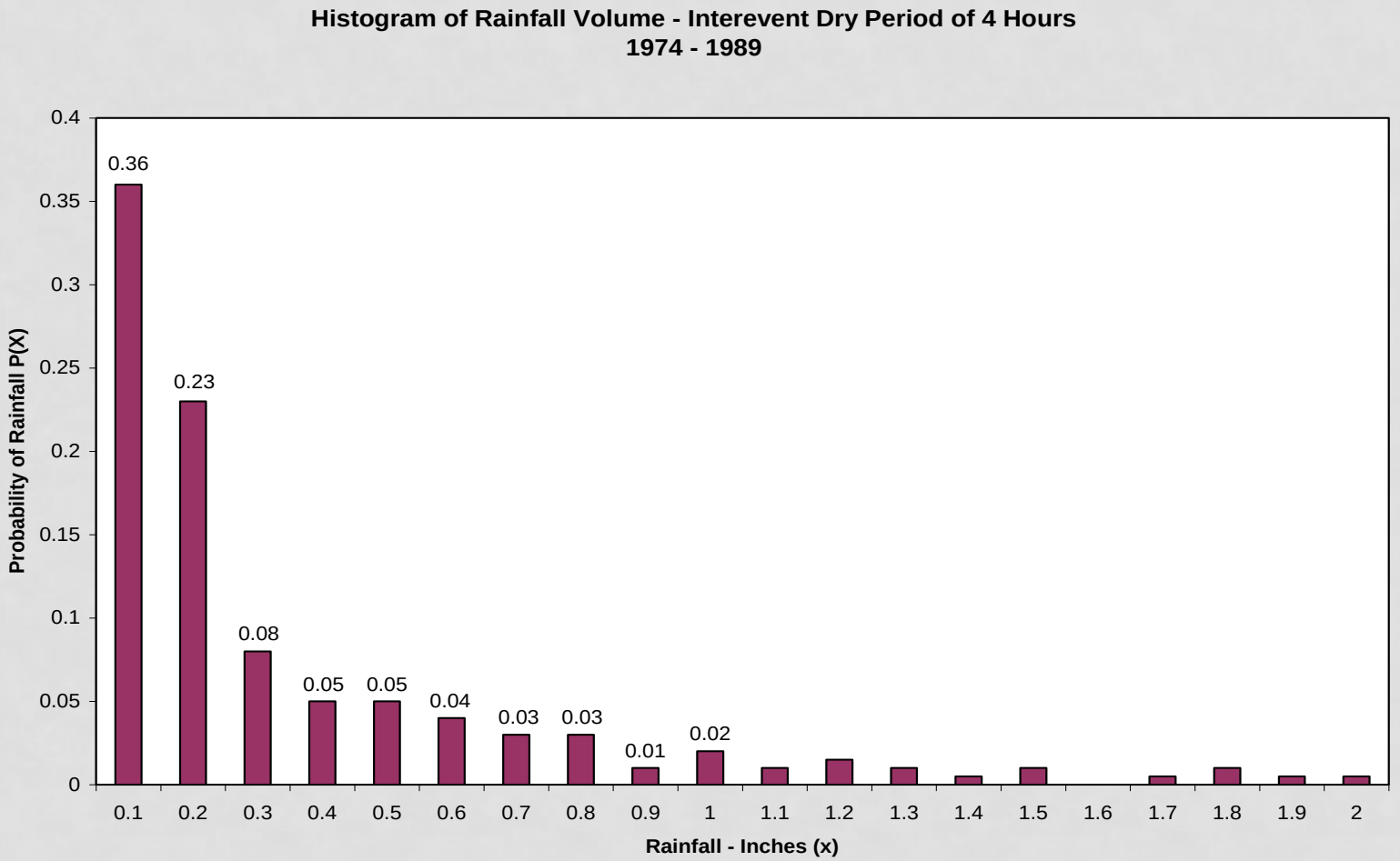

Central and east central Florida




Pan handle of Florida

Effectiveness over increases with the depth of retention over the area and rate of increase decreases with depth BUT varies within the STATE for a specific removal effectiveness

# HISTOGRAM OF RAINFALL VOLUMES



# METHODOLOGY FOR WET DETENTION SYSTEMS

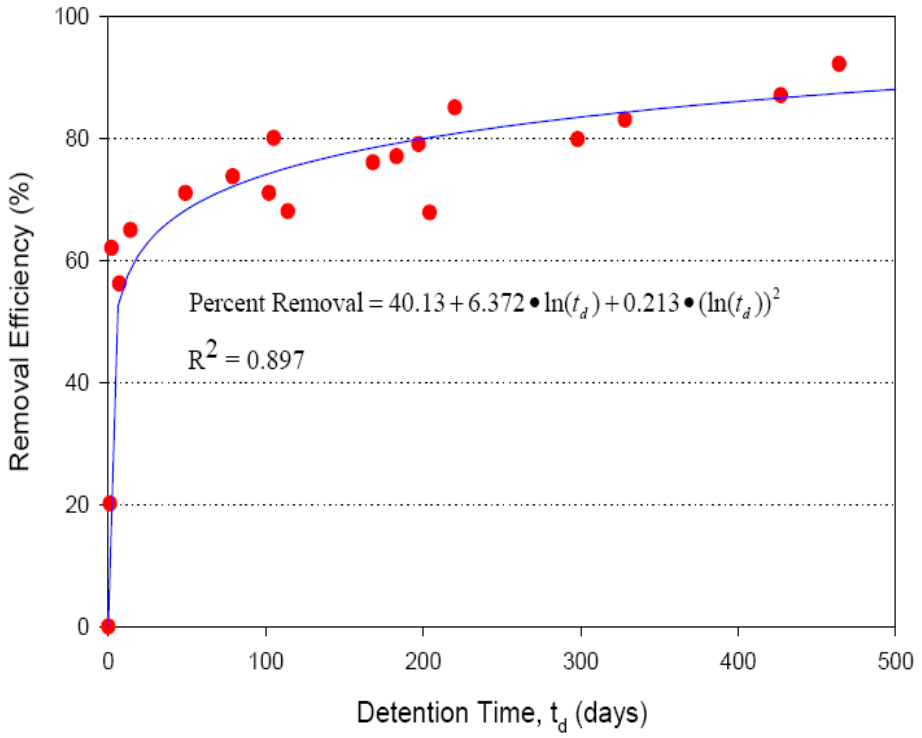



**Figure 7.5-1** Removal Efficiency of Total Phosphorus in Wet Detention Ponds as a Function of Residence Time.

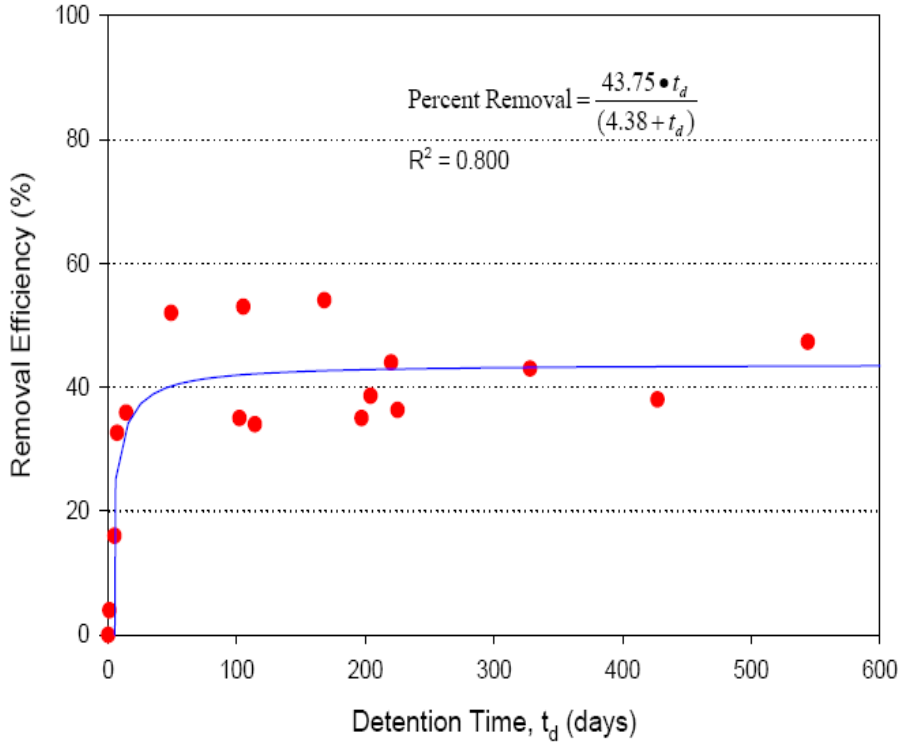


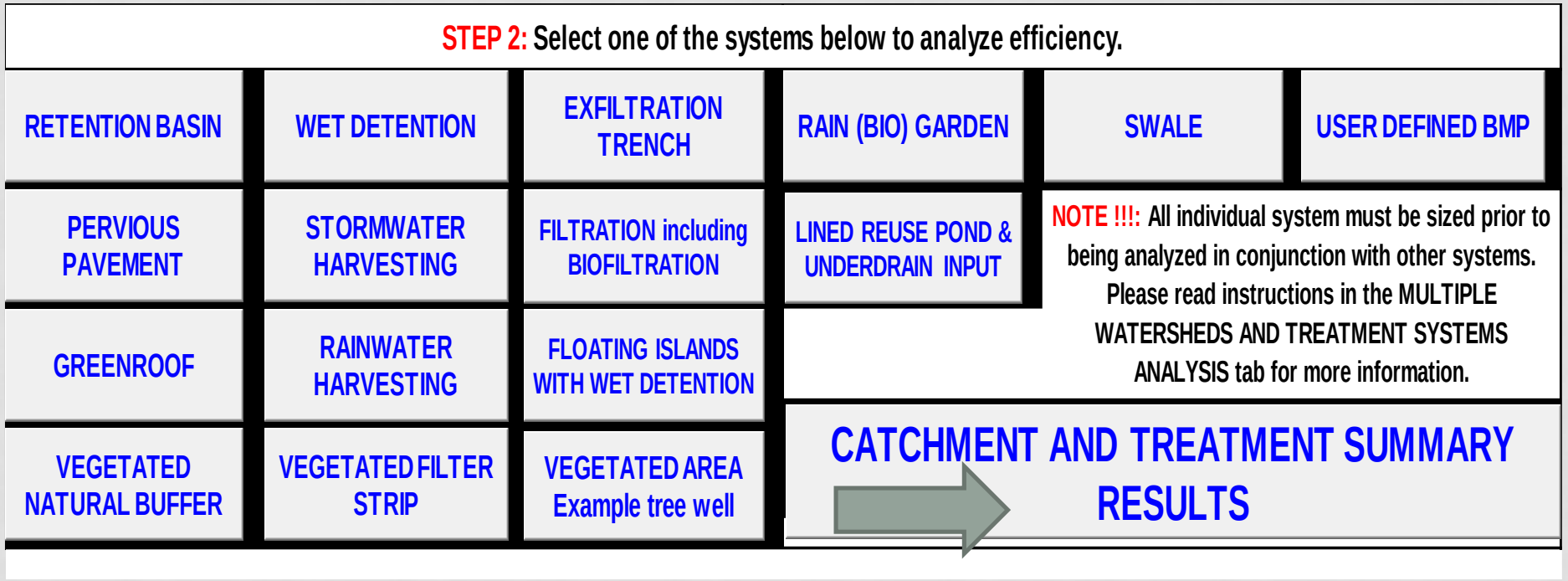

**Figure 7.5-2** Removal Efficiency of Total Nitrogen in Wet Detention Ponds as a Function of Residence Time.

# 15 BMPS AND ONE USER DEFINED

**STEP 2:** Select one of the systems below to analyze efficiency.

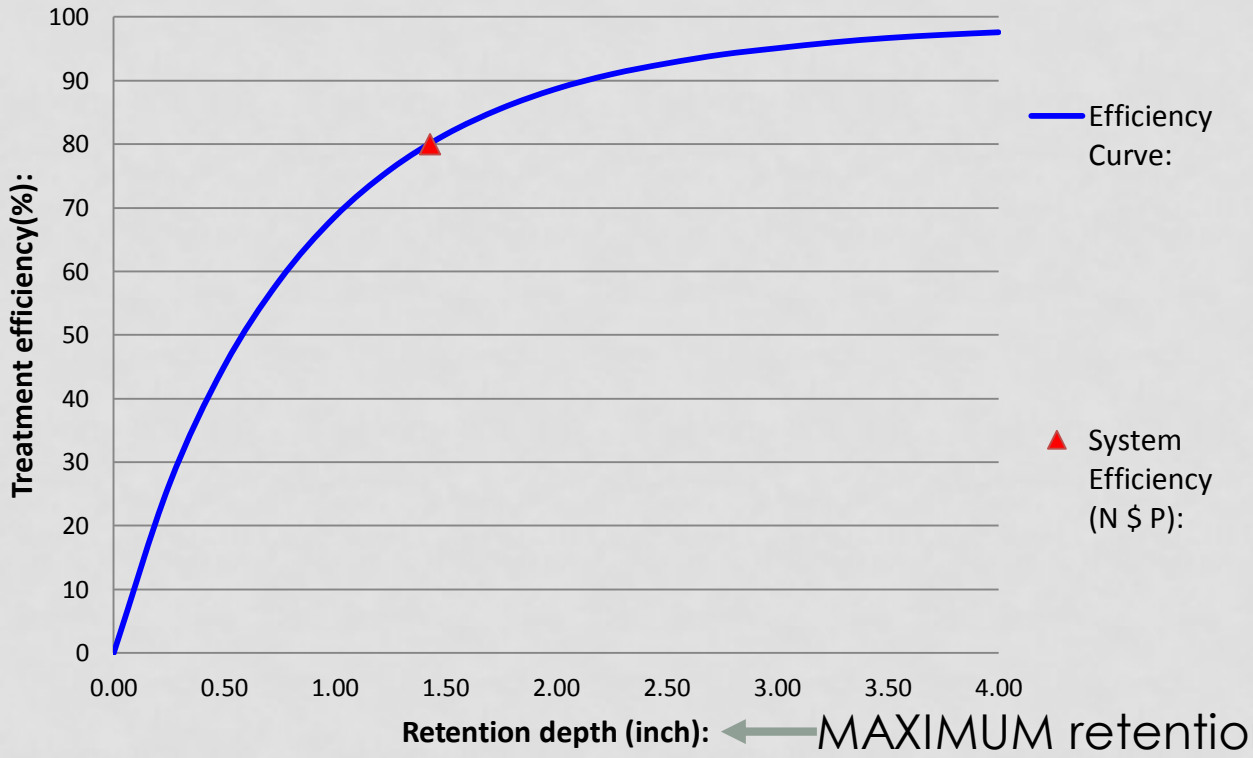
| | | | | | |
|---|---|---|---|---|---|
| RETENTION BASIN | WET DETENTION | EXFILTRATION TRENCH | RAIN (BIO) GARDEN | SWALE | USER DEFINED BMP |
| PERVIOUS PAVEMENT | STORMWATER HARVESTING | FILTRATION including BIOFILTRATION | LINED REUSE POND & UNDERDRAIN INPUT | NOTE !!!: All individual system must be sized prior to being analyzed in conjunction with other systems. Please read instructions in the MULTIPLE WATERSHEDS AND TREATMENT SYSTEMS ANALYSIS tab for more information. | |
| GREENROOF | RAINWATER HARVESTING | FLOATING ISLANDS WITH WET DETENTION | | | |
| VEGETATED NATURAL BUFFER | VEGETATED FILTER STRIP | VEGETATED AREA Example tree well | CATCHMENT AND TREATMENT SUMMARY RESULTS | | |

# 15 BMPS AND ONE USER DEFINED




Note: For watersheds in series the first one must have a removal or a BMP size.

# Example Demonstration Retention in Series

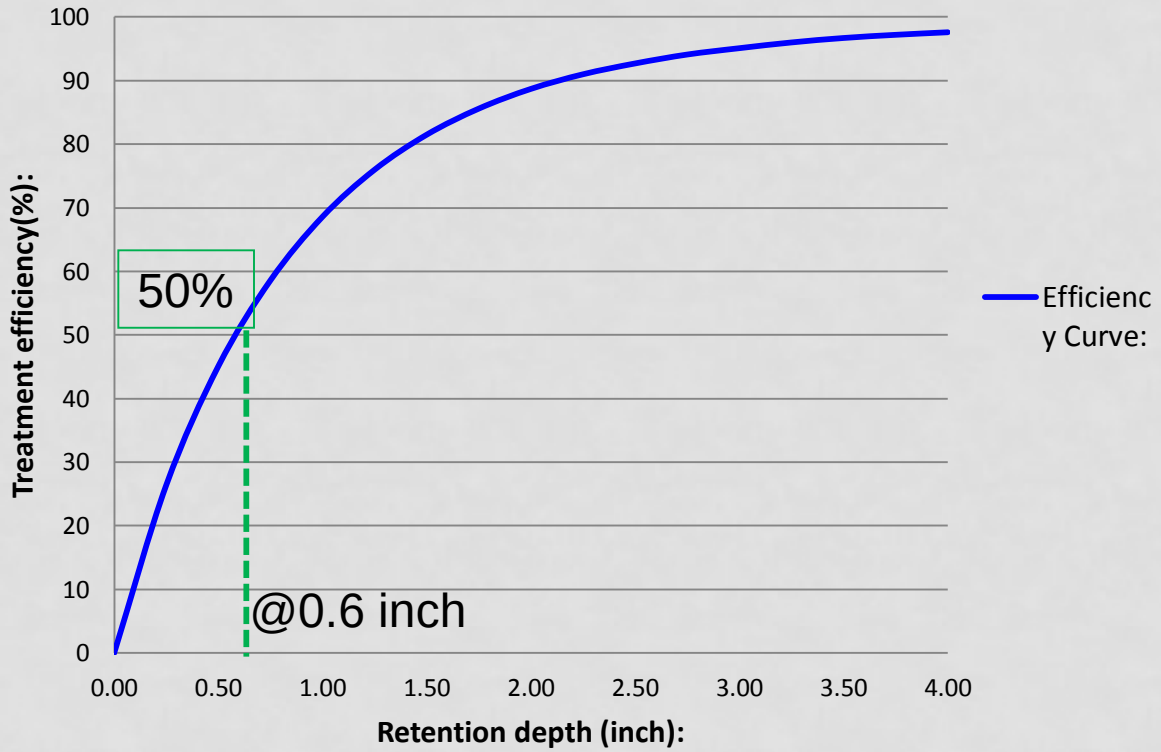



MAXIMUM retention for all events in a year

Retention depth over the equivalent impervious area is 1.43 inches
for the watershed conditions and rainfall zone.

# BUT not sufficient area for one retention basin
# But may use 3 BMPs for each catchment in Series in one Watershed

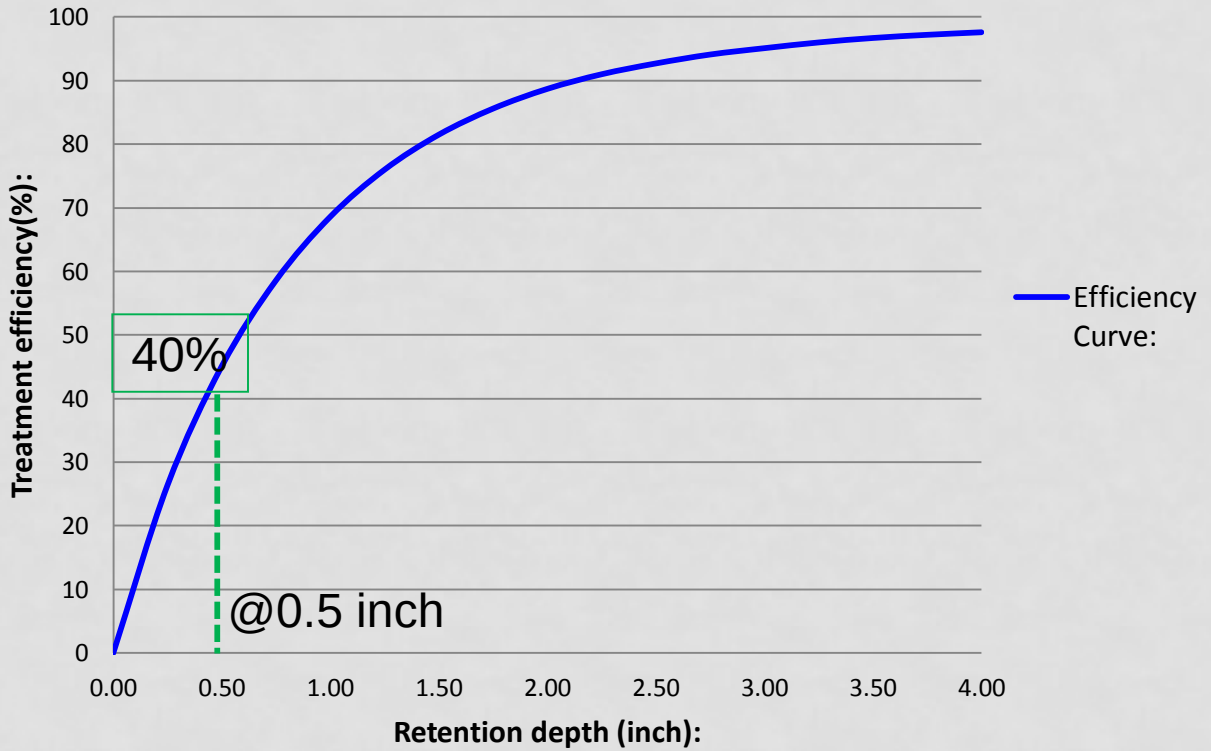
1st BMP is pervious pavement @ 0.6 inch treatment




NOTE: This is the effectiveness curve if pervious pave is only used. Retention depth over the equivalent impervious area is 0.60 inches for a pervious pavement with reservoir.

# Example 3 BMPs in Series in one Watershed

2nd BMP in series is exfiltration @ 0.5 inch treatment

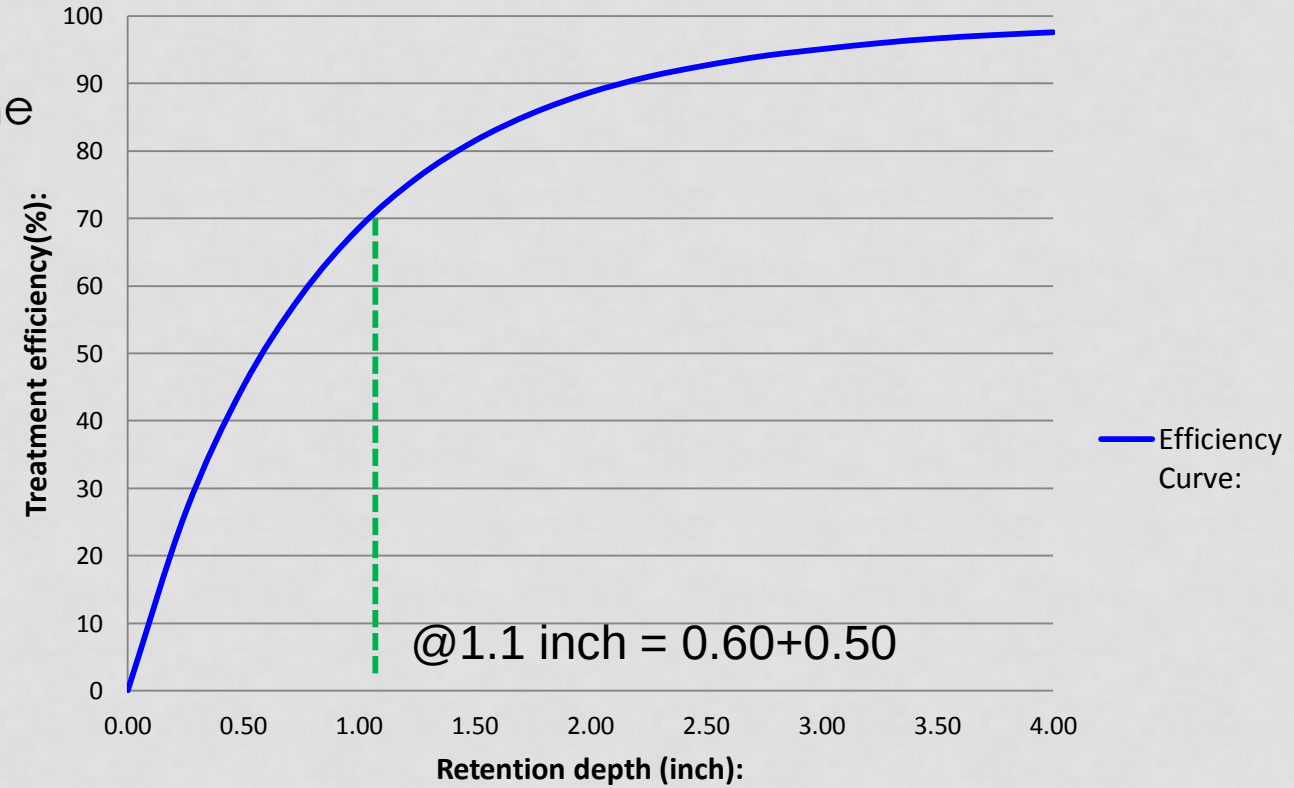



NOTE: This is the effectiveness curve if exfiltration is only used. Retention depth over the equivalent impervious area is 0.50 inches for an exfiltration system.

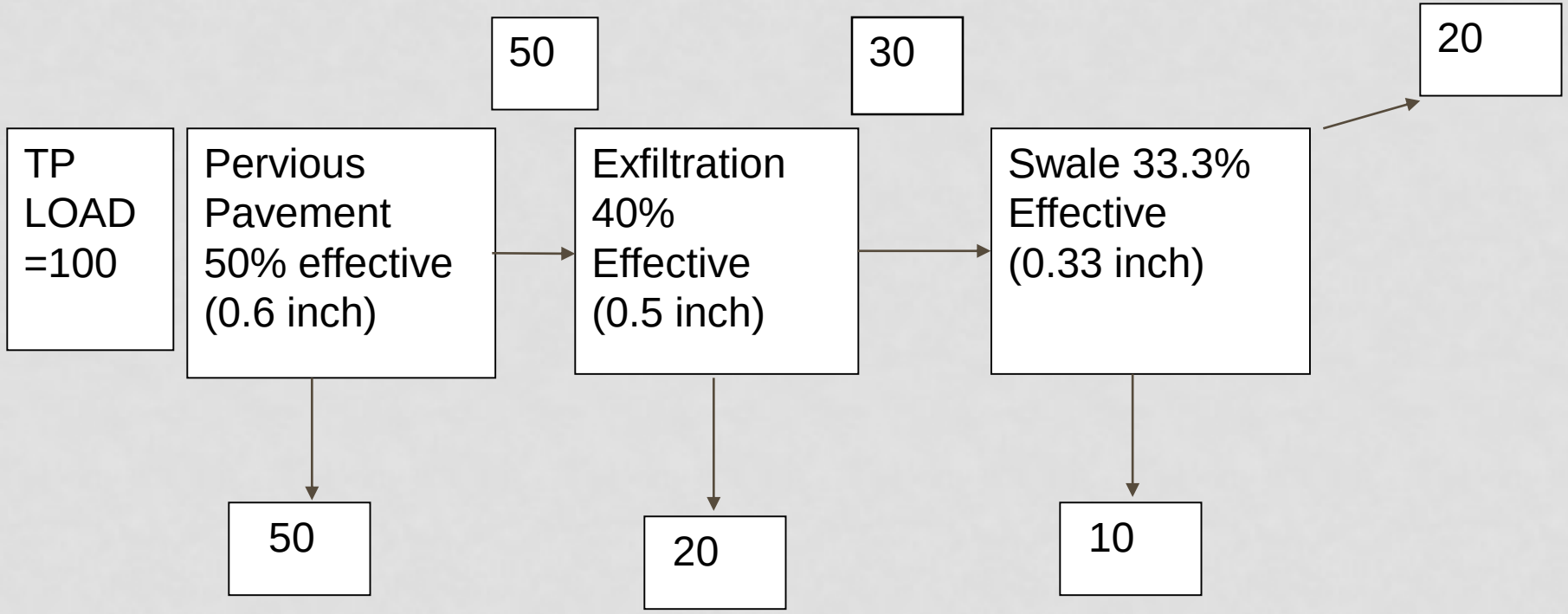
# FOR RETENTION
# STAY TRUE TO THE UNDERLYING PRINCIPLES

Annual effectiveness is **not** the sum of the two efficiencies (50+40= 90%)
It is however the annual effectiveness at 1.1 inch retention or 70%.

NOTE: order of retention BMPs has no affect on the removal.



# BMP TREATMENT TRAIN CREDITS WHEN THREE EFFICIENCIES ARE IN SERIES




M = 100 [ 1- {(1-0.5)(1-0.4)(1-.33)}] = 100[ 1-.20] = 80 % removed

NOT 50+40+33.3=123.3%

NOTES 1. Example flow diagram for this problem only.
2. There was no input or additional catchment flow between BMPs

# THE QUESTIONS OF MEETING LOADING REDUCTIONS AND OFF-SITE VS. ON-SITE CO-MINGLING

- Can one BMP meet loading reduction? Not always….
  - Wet ponds do not achieve 80% reduction of N, or must occupy large areas to meet only the P reduction (about 200 days residence time).
  - Thus use a treatment train of swales within the R/W before the wet pond.
  - Convert a wet pond to a reuse pond (stormwater harvesting).
  - There may not be sufficient area for a swale or need for reuse water. Thus use an up flow filter within a drainage pipe that you can provide storage and use a sorption media and in a treatment train.

- Should off-site flows by-pass on-site (in R/W) stormwater facilities?
  - Build a by-pass system for off-site flows, or incorporate some or all of the off-site stormwater into an existing DOT R/W stormwater facility?

# WET POND & SWALES OR WET POND & REUSE
# WET POND & UP FLOW FILTER

- In zone 1, pan handle area, 60 inches of annual rain.
- 10 acre upland hardwood watershed going to a highway with 40% DCIA, CN=75.
- Use a "big" wet pond, annual residence time of 80 days.
- Wet pond does not get 80% removal percentages, 47% TN and 75% TP
- Thus use a treatment train approach.
- Consider a swale as pre treatment, infiltration rate of 3 in/hr, 4 foot bottom, running slope is 0.015, swale blocks 6 inches high.
- No additional input to wet pond, swale discharge is only input (one catchment configuration).
- Resulting removal is 80% TN and 90% TP.

# GO TO SWALES + WET DETENTION EXAMPLE IN BMPTRAINS MODEL

Stormwater BMP Treatment Trains [BMPTRAINS©]

CLICK HERE TO START

HELP - INTRODUCTION

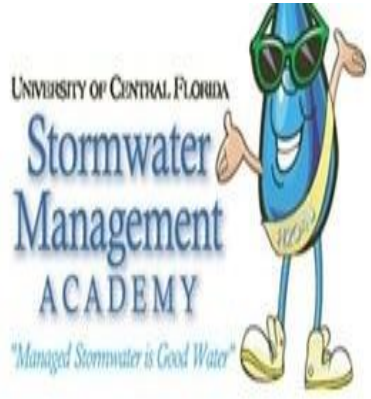
HELP AND BACKGROUND

## INTRODUCTION PAGE

Model requires the use of Excel 2007 or newer

This program is compiled from stormwater management publications and deliberations during a two year review of the stormwater rule in the State of Florida.
Input from the members of the Florida Department of Environmental Protection Stormwater Review Technical Advisory Committee and the staff and consultants from the State Water Management Districts is appreciated.

The State Department of Transportation provided guidance and resources to compile this program. The Stormwater Management Academy is responsible for the content of this program.




1) There is a users manual to help navigate this program and it is available at www.stormwater.ucf.edu

2) This spreadsheet is best viewed at 1280 BY 1080 PIXELS screen resolution. If the maximum resolution of your computer screen is lower than 1280 BY 1080 PIXELS you can adjust the view in the Excel VIEW menu by zooming out to value smaller than 100 PERCENT.

3) This spreadsheet has incorporated ERROR MESSAGE WINDOWS. Your analysis is not valid unless ALL ERROR MESSAGE WINDOWS are clear.

4) PRINTING INSTRUCTIONS: Print the page to MICROSOFT OFFICE DOCUMENT IMAGE WRITER (typically the default) or ADOBE PDF, save the page as an image document, then print the document you saved.

5) Click on the button located on the top of this window titled CLICK HERE TO START to begin the analysis.

**Disclaimer: These workbooks were created to assist in the analysis of Best Management Practice calculations. All users are responsible for validating the accuracy of the internal calculations. If improvements are noted within this model, please e-mail Marty Wanielista, Ph.D., P.E. at martin.wanielista@ucf.edu with specific information so that revisions can be made.**

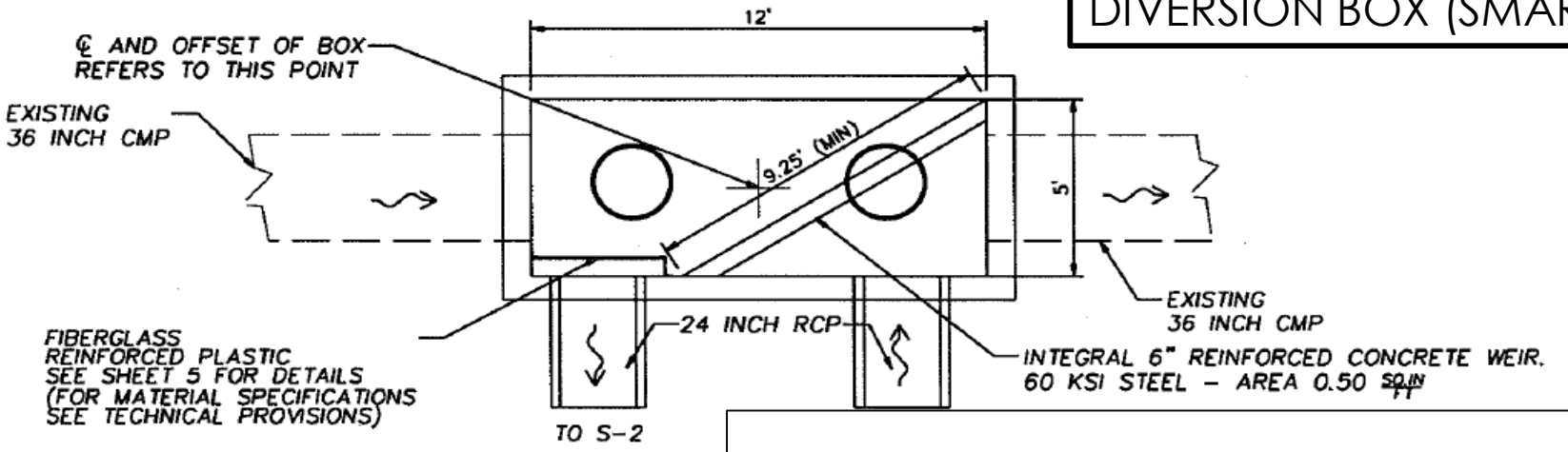
The authors of this program were Christopher Kuzlo, Marty Wanielista, Mike Hardin, and Ikiensinma Gogo-Abite.
This is version 7.1 of the program, updated on April 28 2014. Comments are appreciated.

HELP - HYDROGRAPH AND LEGACY PROGRAMS

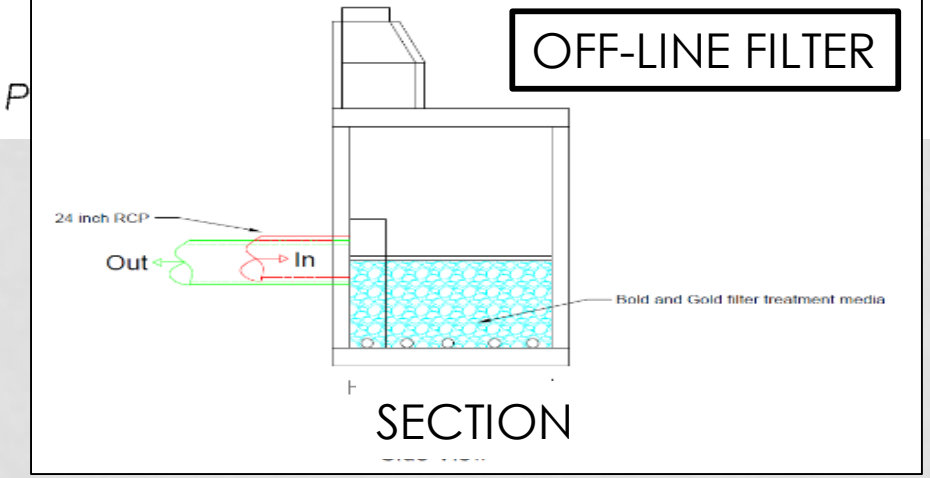
SMADA ONLINE

# DESIGN BY FDOT DELAND AND CH2M HILL

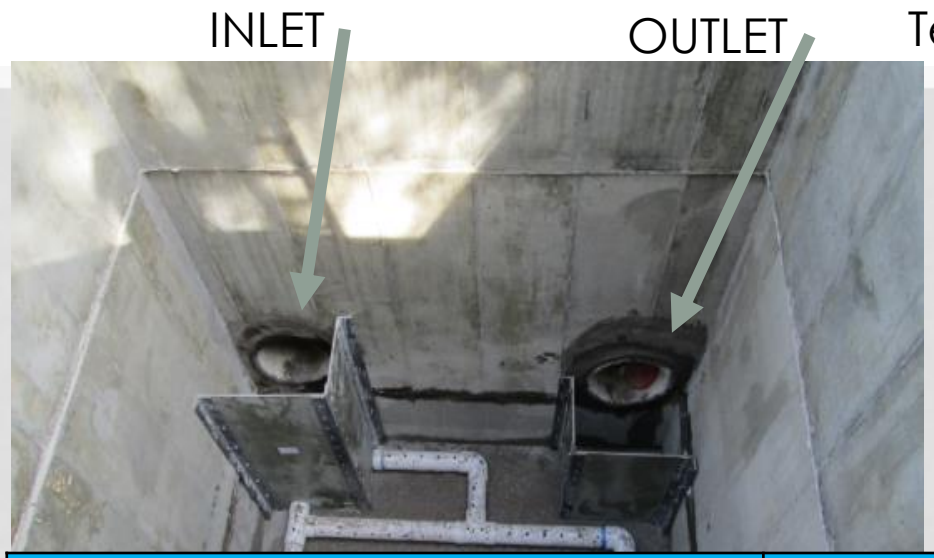
DIVERSION BOX (SMART)

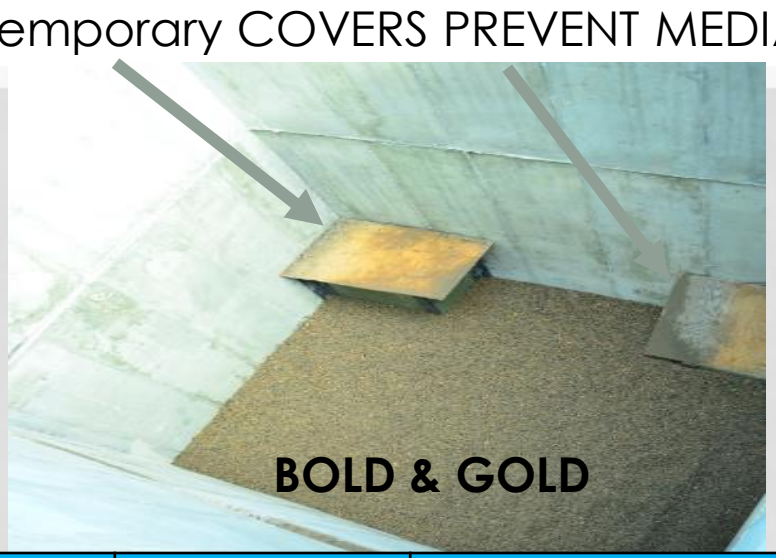



OFF-LINE FILTER



# SAMPLING RESULTS AND INSTALLATION PHOTOS
## 70% OF FLOW THROUGH FILTER (PHOTO CREDIT: FDOT OCALA)




| Average Concentration and % Removal | TN | TP | TSS |
|---|---|---|---|
| Concentration from the Street (mg/L) | 2.10 | 0.360 | 100 |
| Concentration to the Filter (mg/L) | 1.27 | 0.180 | 35 |
| Concentration from the Filter (mg/L) | 0.502 | 0.098 | 17 |
| Average Filter Removal (%) | 60 | 46 | 51 |
| Overall Average Removal (%) | 76 | 73 | 83 |
| Annual Average Removal (%) | 59 | 63 | 73 |

NOTE: Not cleaned during sampling period

# CO-MINGLING OF OFF-SITE STORMWATER FROM A CITRUS LAND USE OPERATION IN ZONE 2 (CENTRAL FLORIDA)

This is a citrus land use that can either by-pass or be treated within a FDOT **retention** basin

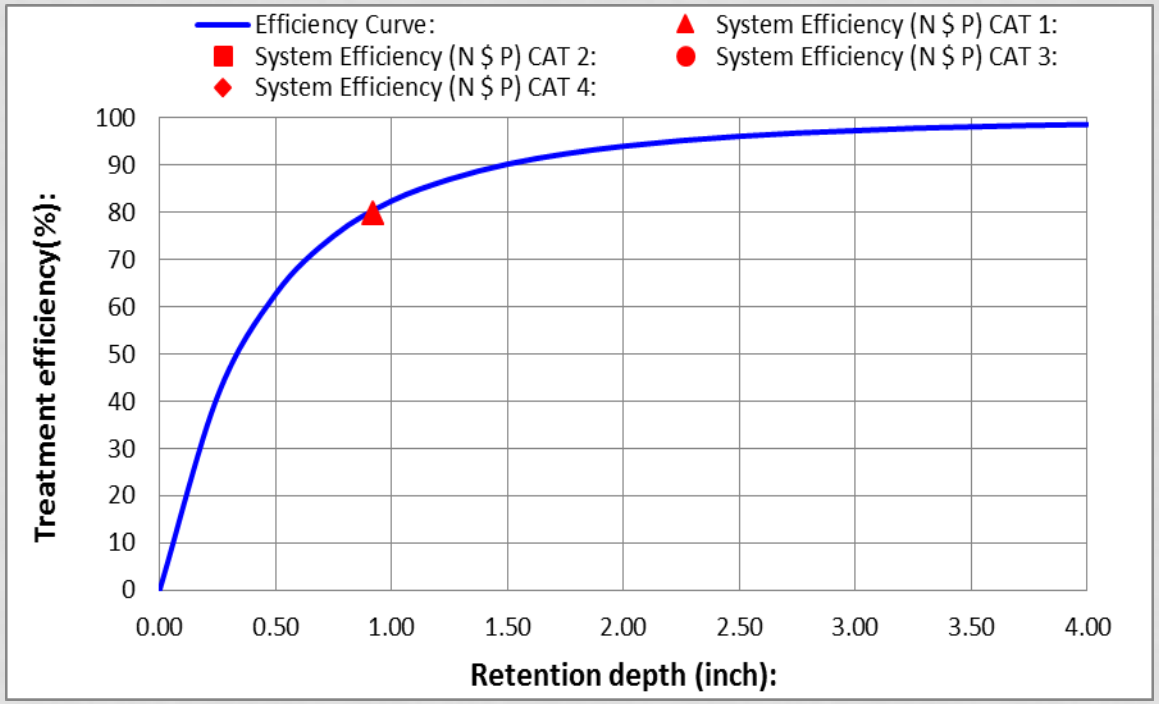
Citrus agricultural
Land use, no DICA

Treatment ?

By-pass ?

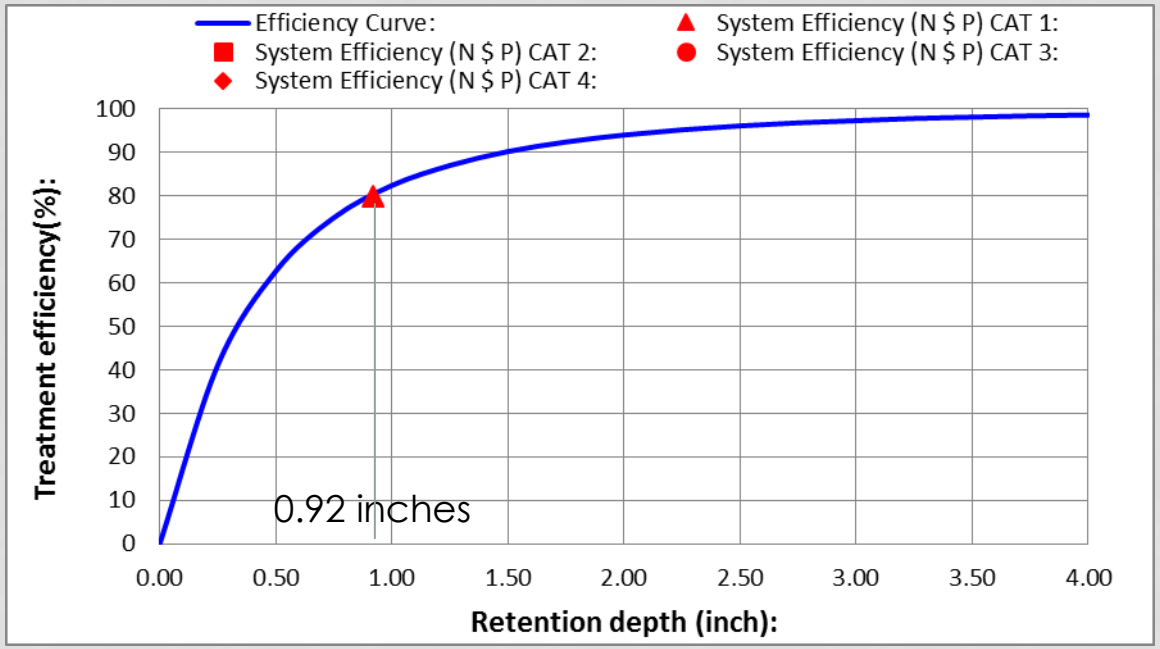
4 lane highway
1 acre of land
50% DCIA

NOTE: keep size of BMP retention basin equal to what is needed for on-site Treatment of 80%



# MASS REMOVAL BY RETENTION (VARIES BY CLIMATE ZONE AND WATERSHED CONDITIONS)

As annual flow into fixed size retention basin increases, % removal decreases but mass of pollution into the basin increases. There is a trade off between the rate of increase of pollution in and the rate of decrease of effectiveness as the volume of flow into the system increases.

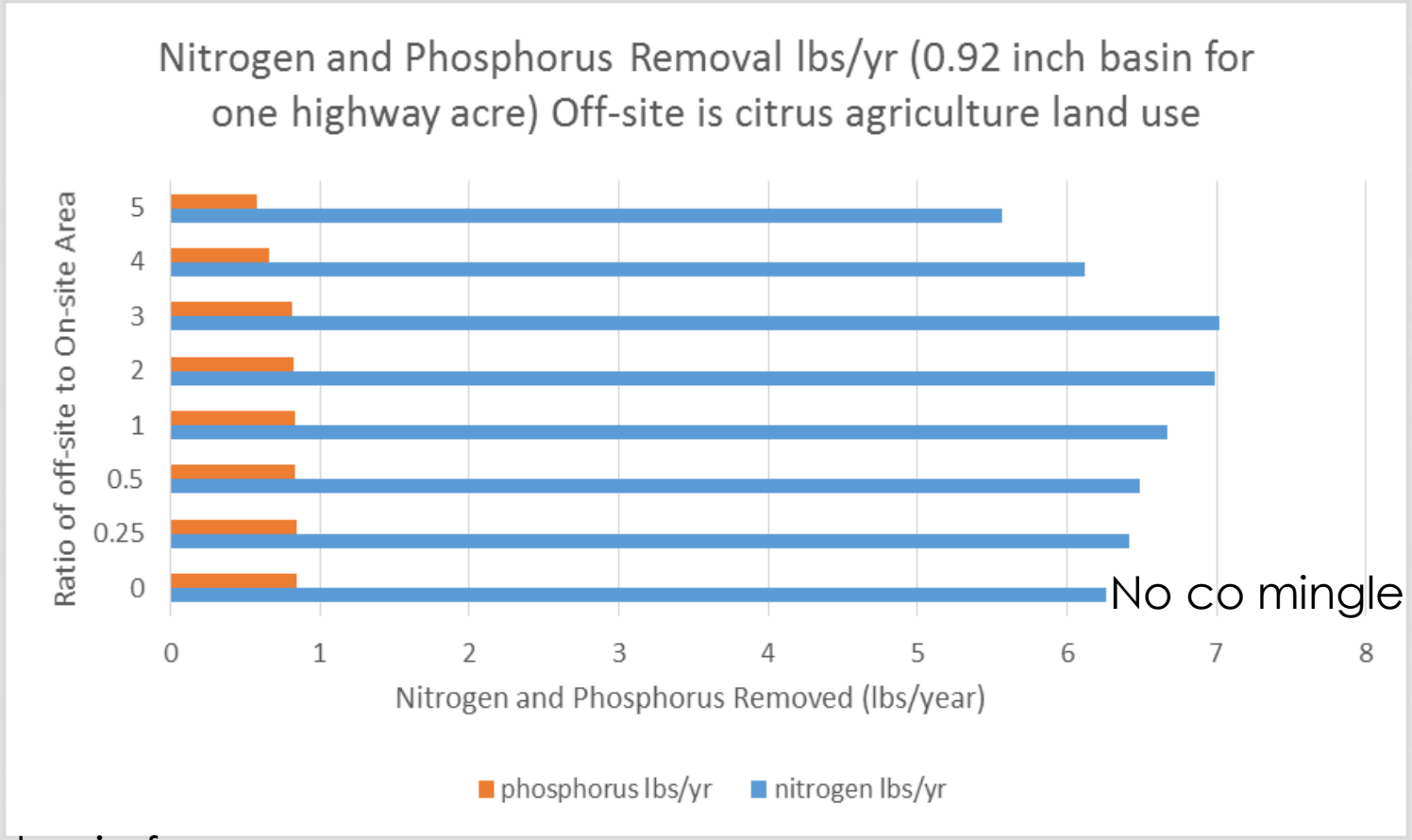


# CONTINUATION OF OFF-SITE CITRUS AGRICULTURAL CO-MINGLING EXAMPLE

Evaluation Based on TN & TP:

One possible evaluation:
From a TN mass removal basis, co-mingle treatment using a FDOT retention basin for these land uses & climate Zone up to a ratio of 3.0. Thus no by-pass cost if the ratio of off-site to on-site area is <= 3.

For TP, marginal changes




Point of View:
The regulatory agency may permit the use of the retention basin for off-site flow without increase in basin size, because of more mass removal.

# CO-MINGLING OF OFF-SITE STORMWATER FROM A GENERAL AGRICULTURE LAND USE OPERATION IN ZONE 5 (SE FLORIDA)

General agricultural that can either by-pass or be treated within a FDOT retention basin

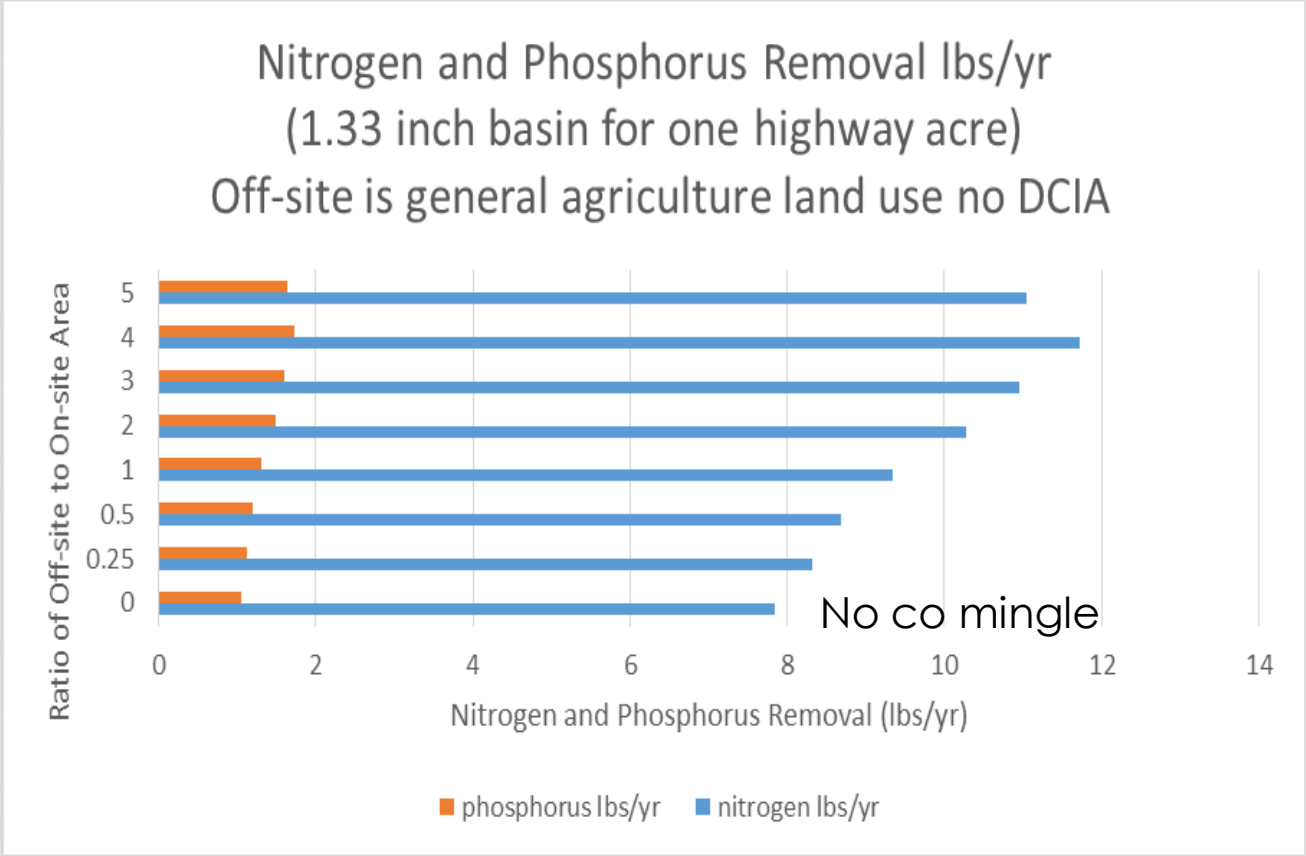
General agricultural
Land use, no DICA

Treatment ?

By-pass ?

4 lane highway
1 acre of land
50% DCIA

NOTE: keep size of BMP retention basin equal to what is needed for on-site Treatment of 80% with no off-site flow.



# CO-MINGLING OF OFF-SITE STORMWATER FROM A GENERAL AGRICULTURE LAND USE OPERATION IN ZONE 1 (NW FLORIDA)

Same annual average rainfall of 60 inches used in NWF as in the previous SEF example .

General agricultural that can either by-pass or be treated within a FDOT retention basin

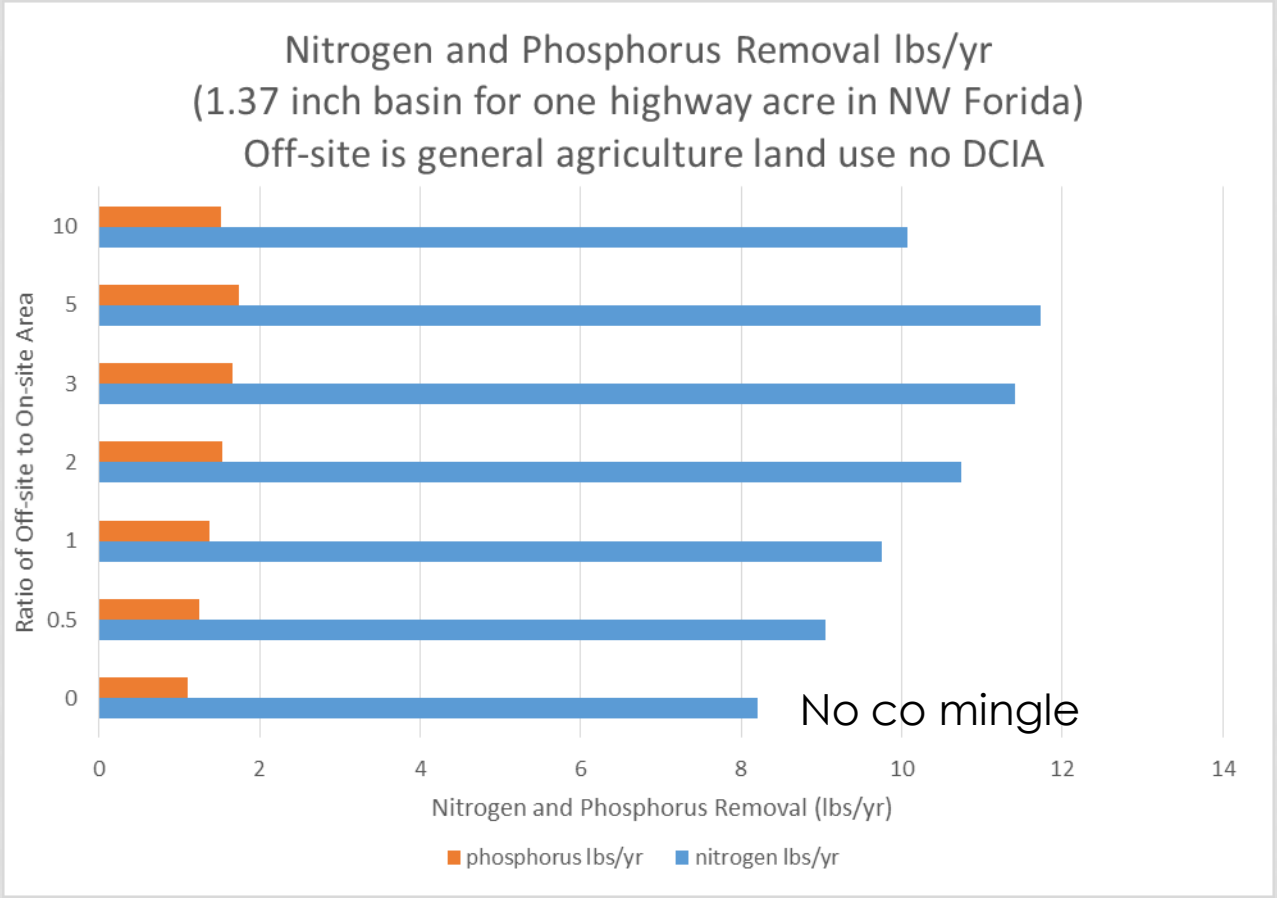
General agricultural
Land use, no DICA

Treatment ?

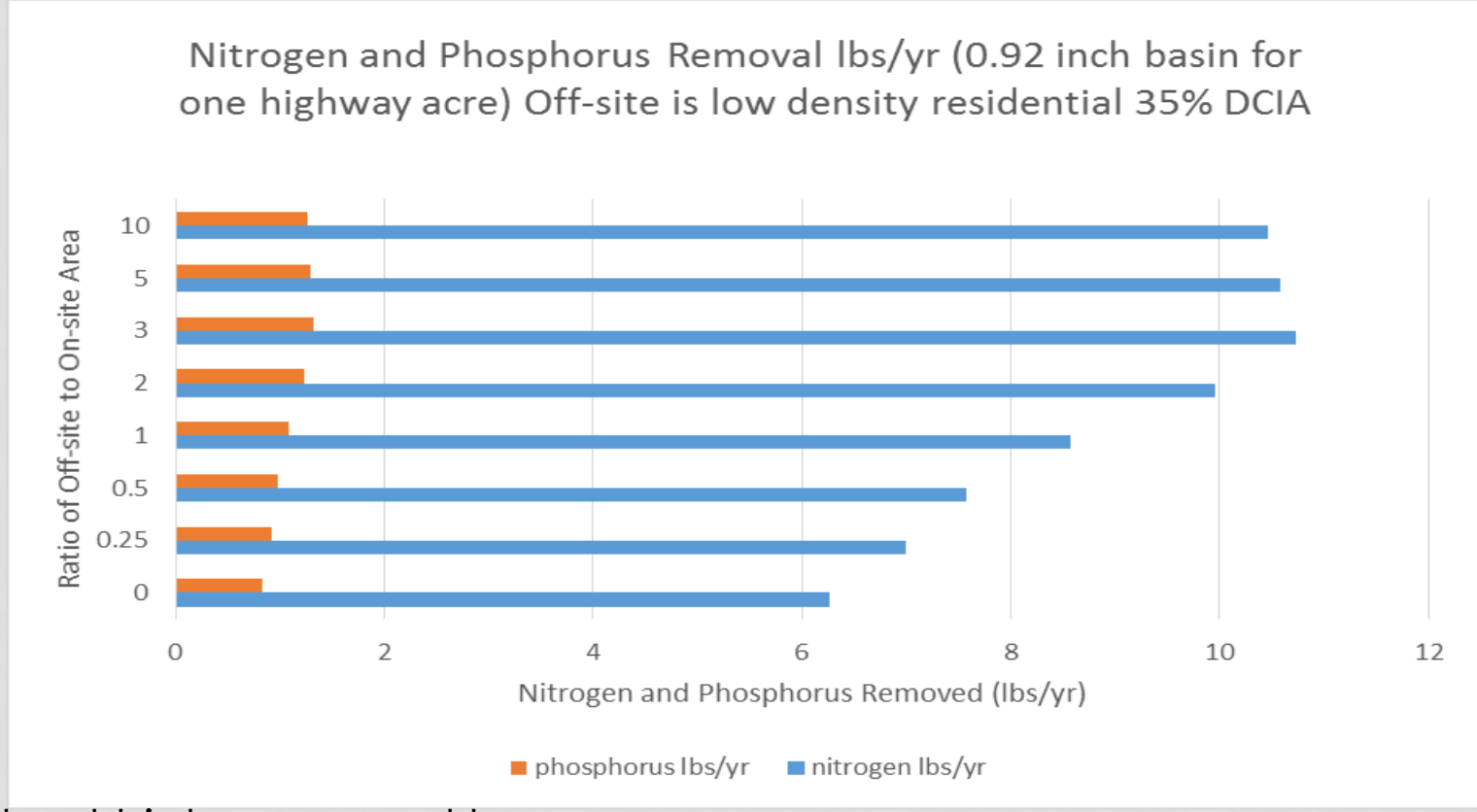
By-pass ?

4 lane highway
1 acre of land
50% DCIA

NOTE: keep size of BMP retention basin equal to what is needed for on-site Treatment of 80% with no off-site flow.

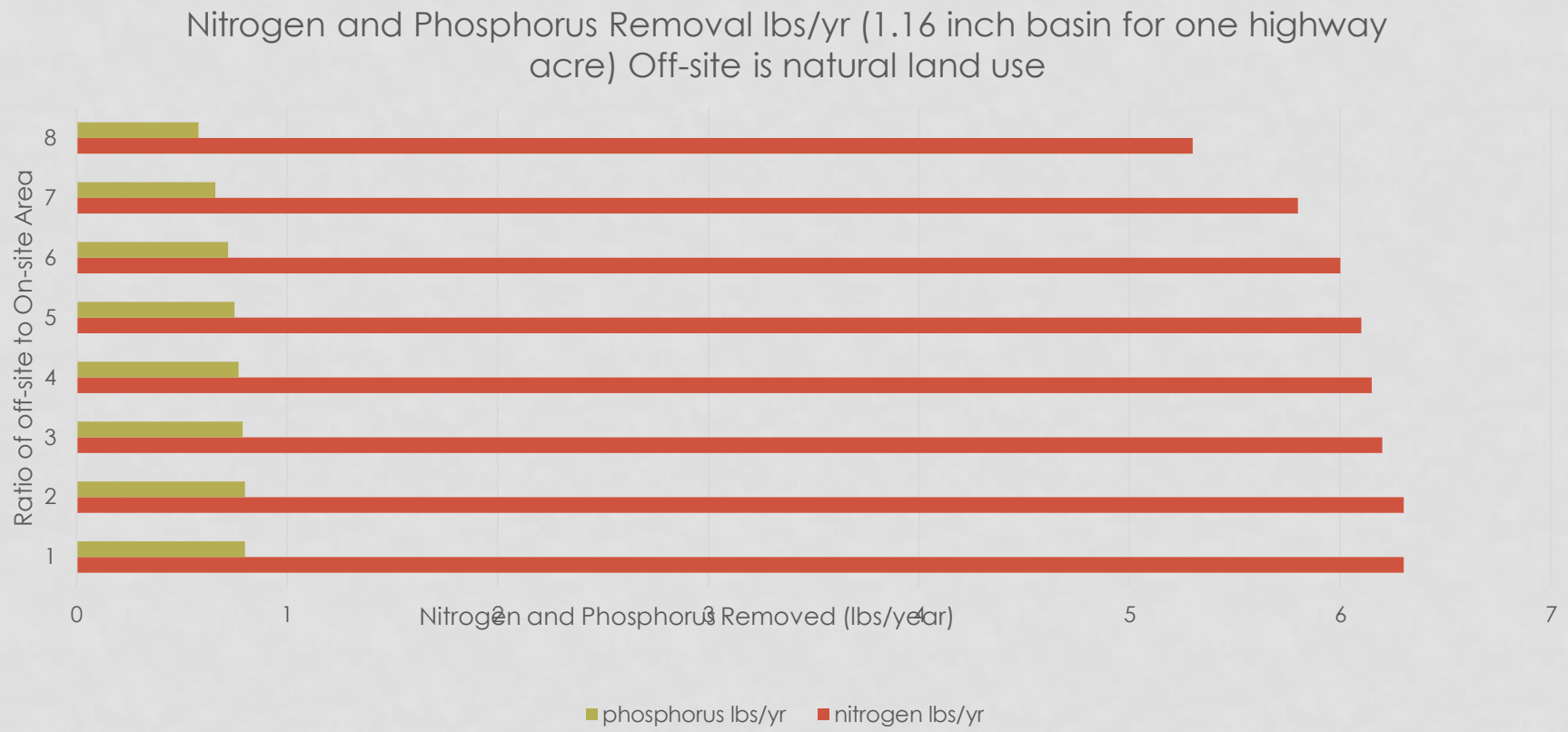


# CO-MINGLING OF OFF-SITE STORMWATER FROM A LOW DENSITY RESIDENTIAL LAND USE OPERATION ZONE 2




Remark
Most likely would get higher removal because
Off-site flow time of concentration not considered

# CO-MINGLING OF OFF-SITE STORMWATER FROM A NATURAL AREA WITH LOW EMCS AND RUNOFF VOLUME ZONE 4




Remark
Most likely would get higher removal because
Off-site flow time of concentration not considered

# Conclusions

1. BMPTRAINS model is used to estimate annual nutrient removal effectiveness and size BMPs in treatment systems.
2. It is available at no cost to the users.
3. The average annual effectiveness is site specific incorporating rainfall conditions of the area and combinations of BMPs.
4. BMPs can be analyzed in either series or parallel structure. The estimates stay “true” to the underlying rainfall conditions.
5. BMP “train” options for additional removal and co-mingling of off-site flows can be evaluated.

Seal of Approval

2014 Design Training Expo

# QUESTIONS, REMARKS AND DISCUSSION

THANK YOU!

FDOT

University of Central Florida