Florida Chamber's 28th Annual
Environmental Permitting Summer School

LOW IMPACT DEVELOPMENT
FOR ERP, TMDL, NPDES, NNC CREDITS

MARTY WANIELISTA
STORMWATER MANAGEMENT ACADEMY
JULY, 2014 MARCO ISLAND
WWW.STORMWATER.UCF.EDU
Florida Environmental Network, Inc

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, analysis, and review for ERP permits and BMAP and TMDL program estimates.

Best Management Practices Selection
BMPTRAINS

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

VALUE OF BMPTRAINS

- Quantification of information from many sources into one relatively easy to use computer program.
- Assists in the selection from among 15 BMPs. There is also a user defined BMP for those BMPs not always generally acceptable.
- Program inputs cover a wide range of Florida conditions, including both meteorological and land use.
- High acceptance by WMDs for ERPs. Also can have value in BMAP, TMDL and impaired water situations.
- Flexible program, some default values can be changed but only with agreement with regulatory agencies.

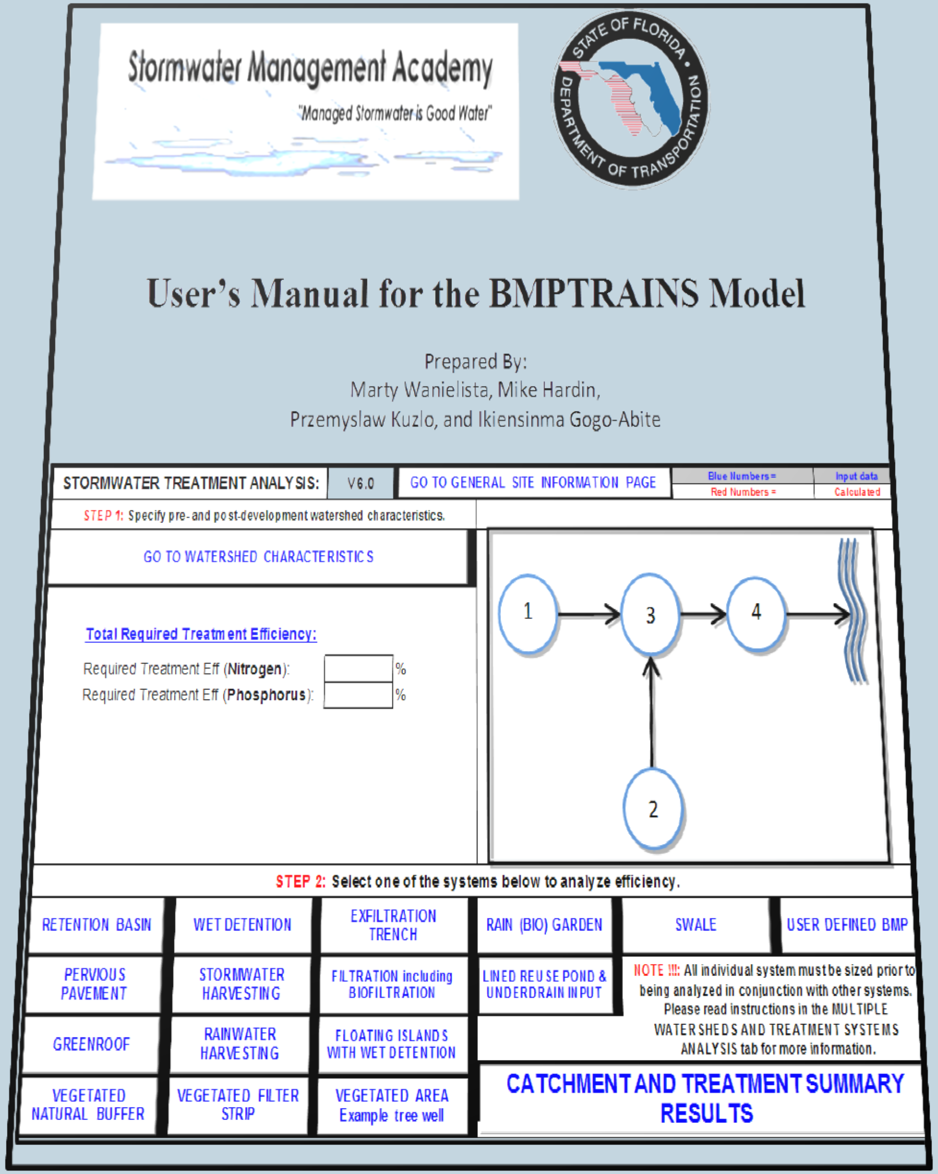
BMPTRAINS MODEL AND USERS MANUAL

Available from: www.stormwater.ucf.edu

What's New

BMPTRAINS Stormwater Best Management Practices Analysis Model (Version 7.3) 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
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):
%
1
3
4
2
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

LITERATURE REVIEW

FROM THE USER'S MANUAL

BMPTRAINS: Allows various sizes of treatment, more than 15 BMPs, and series/parallel configurations

COMPARISON OF MODELS BASED ON BMPS

Stormwater Model / BMPs	Retention inc. Bioretention	Dry Detention	Swale	Green Roof	Filter Strip inc. Grass Buffer	Permeable Pavement	Sand Filter	Water Harvesting	Wet Detention	Wetland	Rain Garden inc. Tree Wells	Exfiltration
Jordan/Falls Lake Model	x	x	x	x	x	x	x	x	x	x		
BMP SELECT Model	x	x	x		x	x	x		x	x		
Clinton River SET	x	x	x	x	x	x	x		x			
Virginia Runoff Reduction Method Worksheet	x	x	x	x		x			x			
DES Simple Method Pollutant Loading Spreadsheet Model[1]	x	x	x	x	x	x	x	x	x	x		
Colorado	x	x	x			x	x		x	x	x	
SMADA	x		x					x	x			
BMPTRAINS	**X**	**X**	**x**	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**

Most Models are
For a single BMP.

BMPTRAINS is used
For Series and
Parallel Configurations

However
USER INPUT to
BMPTRAINS

NAVIGATING and INFORMATION for the BMPTRAINS Model

Enable Macros

Example NAVIGATION BUTTON

EXCEL 2007 or Newer

Stormwater BMP Treatment Trains [BMPTRAINS©]

CLICK HERE TO START

HELP - INTRODUCTION

HELP AND BACKGROUND

HELP VIDEOS

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.

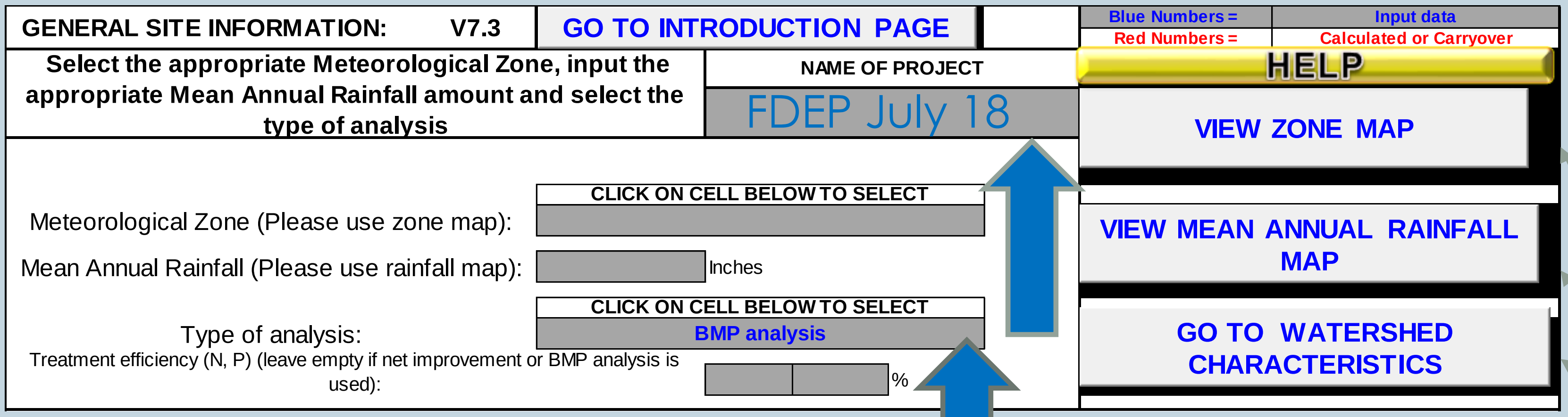
The authors of this program were Christopher Kuzlo, Marty Wanielista, Mike Hardin, and Ikiensinma Gogo-Abite.
This is version 7.3 of the program, updated on June 20, 2014. Comments are appreciated.

HELP - HYDROGRAPH AND LEGACY PROGRAMS

SMADA ONLINE

HELP VIDEOS

RAINFALL AND TYPE OF ANALYSIS WORKSHEET



NAVIGATION BUTTONS

NOTE: Blue Color Entries on grey are **input** data
For this case the name of the project
and the type of analysis (**drop down menu**)
activated by "clicking" twice.

BMP EFFECTIVENESS
(A PARTICULAR DESIGN, BMAP, LIMITING AREA, ETC.)

	CLICK ON CELL BELOW TO SELECT	
Meteorological Zone (Please use zone map):		
Mean Annual Rainfall (Please use rainfall map):		Inches
	CLICK ON CELL BELOW TO SELECT	
Type of analysis:	**BMP analysis**	
Treatment efficiency (N, P) (leave empty if net improvement or BMP analysis is used):		%

SPECIFY A % REMOVAL
(TMDL OR COMPENSATORY PROGRAM TARGET)

	CLICK ON CELL BELOW TO SELECT		
Meteorological Zone (Please use zone map):			
Mean Annual Rainfall (Please use rainfall map):		Inches	
	CLICK ON CELL BELOW TO SELECT		
Type of analysis:	Specified removal efficiency		
Treatment efficiency (N, P) (leave empty if net improvement or BMP analysis is used):	40.00	67.00	%

POST = PRE (NET IMPROVEMENT)

	CLICK ON CELL BELOW TO SELECT	
Meteorological Zone (Please use zone map):		
Mean Annual Rainfall (Please use rainfall map):		Inches
	CLICK ON CELL BELOW TO SELECT	
Type of analysis:	Net improvement	
Treatment efficiency (N, P) (leave empty if net improvement or BMP analysis is used):		%

GENERAL SITE INFORMATION PAGE

RAINFALL AND TYPE OF EFFECTIVENESS ANALYSIS

STEP 1: Select the appropriate Meteorological Zone, input the appropriate Mean Annual Rainfall amount and select the type of analysis

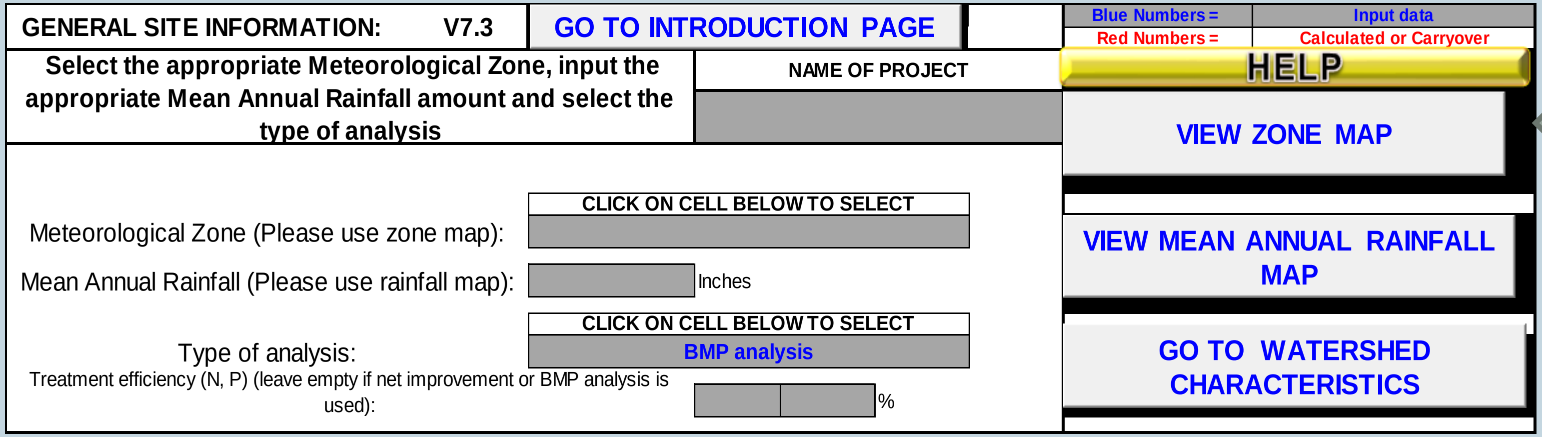
	CLICK ON CELL BELOW TO SELECT	
Meteorological Zone (Please use zone map):	Zone 2	Drop down menu
Mean Annual Rainfall (Please use rainfall map):	50.00 Inches	input
	CLICK ON CELL BELOW TO SELECT	
Type of analysis:	Specified removal efficiency	Drop down menu
Treatment efficiency (N, P) (leave empty if net improvement or BMP analysis is used):	%	80.00 80.00

Buttons For

View Zone Maps

View Mean Annual Rainfall Map

VIEW RAINFALL DATA



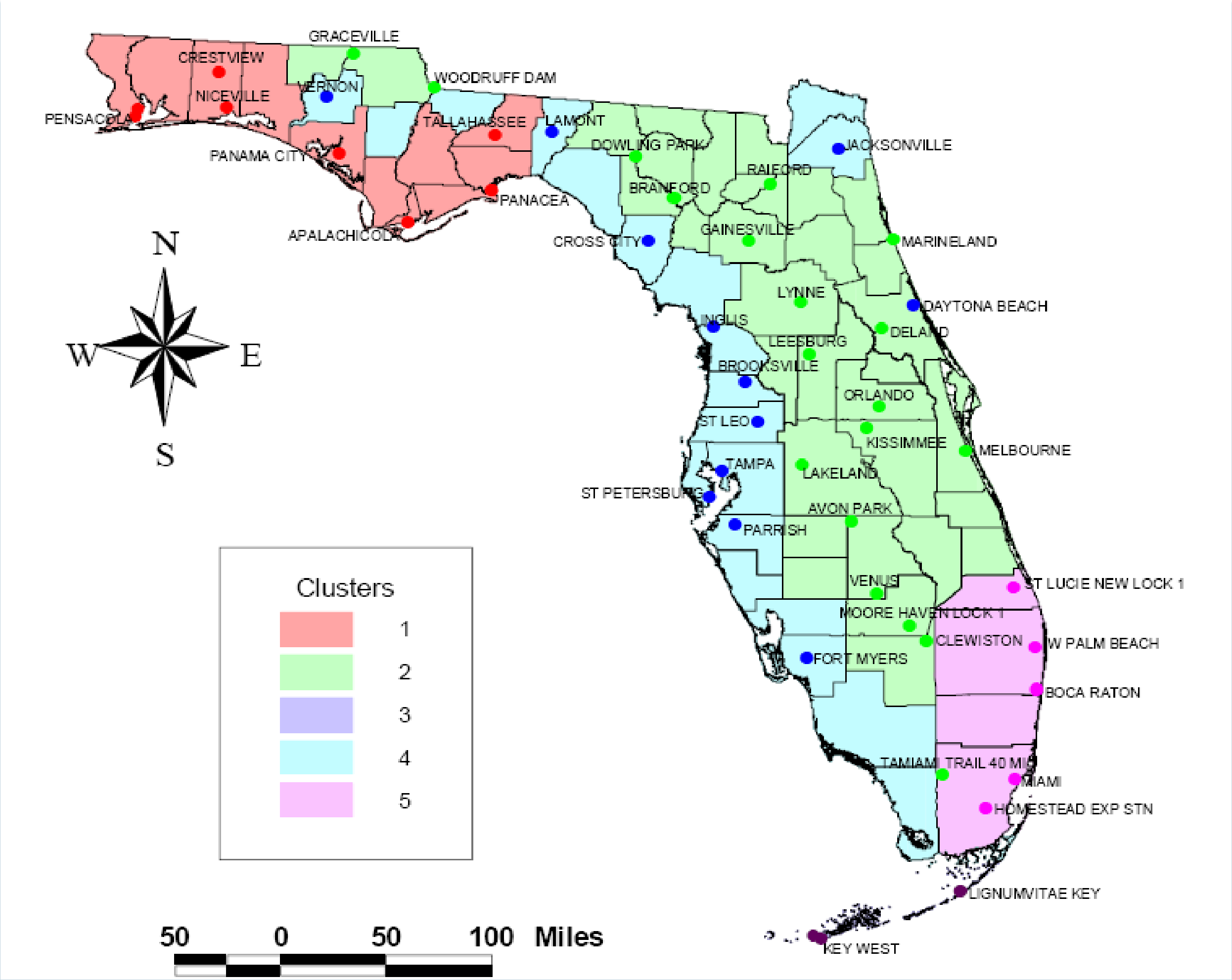
Navigation Buttons For

View Zone Maps

View Mean Annual Rainfall Map

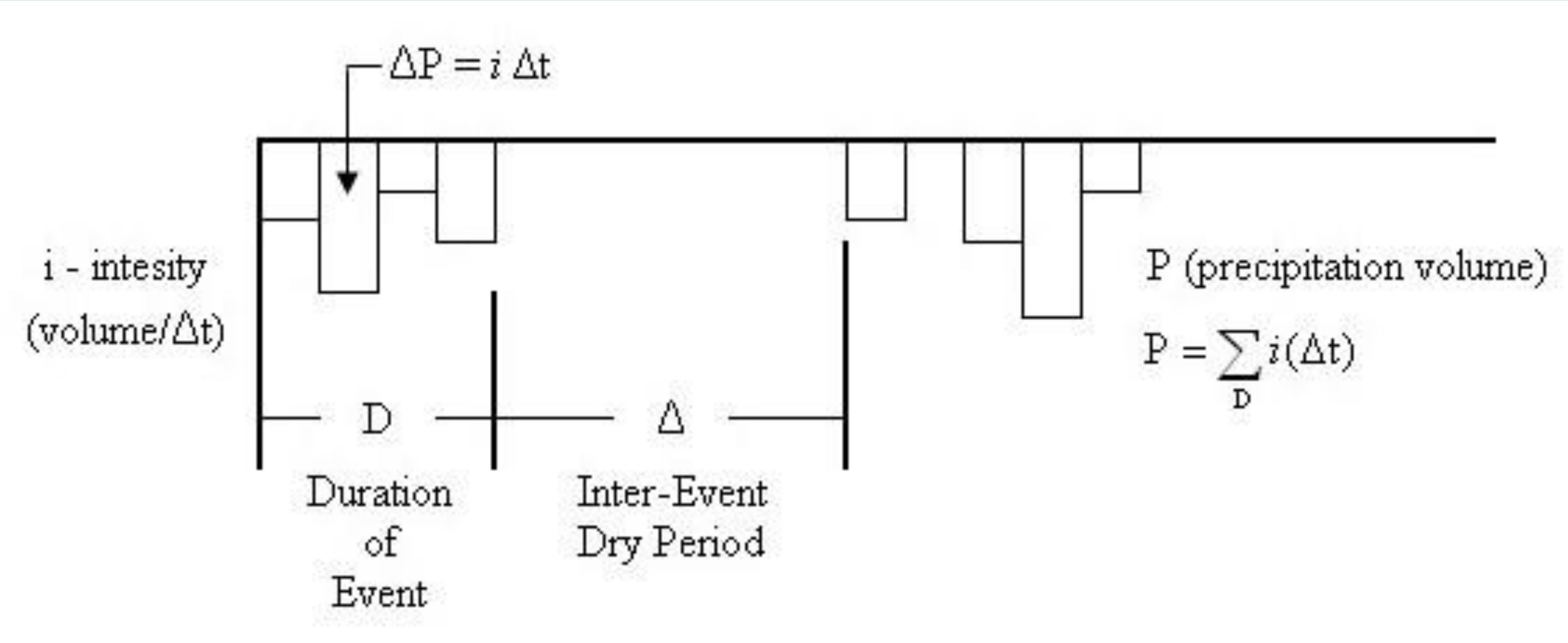
RAINFALL DISTRIBUTIONS

- Rainfall distributions are regionally different.

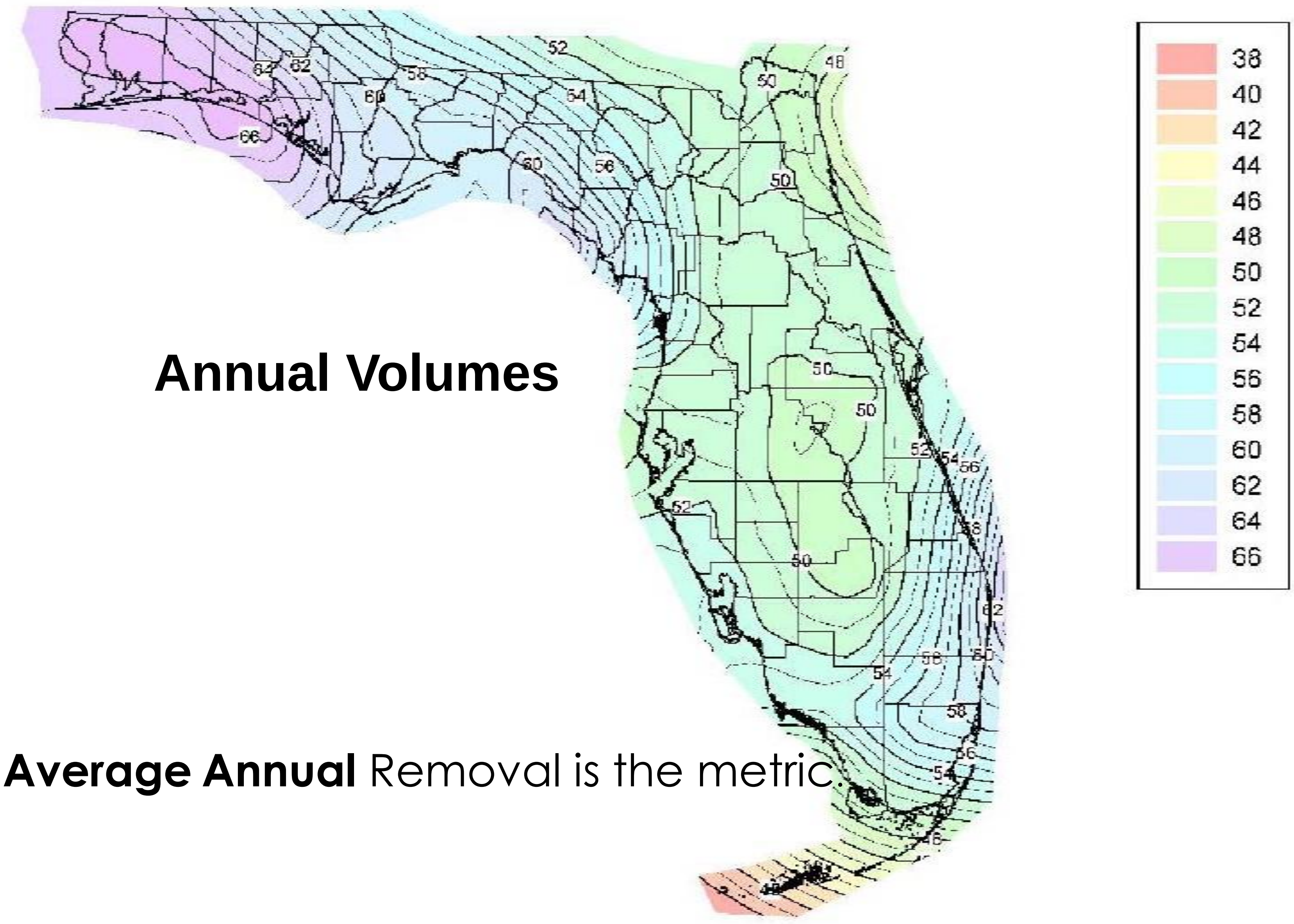


BASIC PRINCIPLES

- 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			

Drop Down Menu

Drop Down Menu

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

Pre and Post data inputs

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: Changes can be made to the default values and “carry” to the end

EMC DEFAULT VALUES

2010

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

New Data Available

UNDEVELOPED 2007 DATA

New Data Available

LAND	TOTAL		TOTAL
Agricultural - Citrus: TN=2.240 TP=0.183	2.240		0.183
Agricultural - General: TN=2.790 TP=0.431	2.790		0.431
Agricultural - Pasture: TN=3.470 TP=0.616	3.470		0.616
Agricultural - Row Crops: TN=2.650 TP=0.593	2.650		0.593
Conventional Roofs: TN=1.050 TP=0.120	1.050		0.120
High-Intensity Commercial: TN=2.40 TP=0.345	2.400		0.345
Highway: TN=1.640 TP=0.220	1.640		0.220
Light Industrial: TN=1.200 TP=0.260	1.200		0.260
Low-Density Residential: TN=1.610 TP= 0.191	1.610		0.191
Low-Intensity Commercial: TN=1.180 TP=0.179	1.180		0.179
Mining / Extractive: TN=1.180 TP=0.150	1.180		0.150
Multi-Family: TN=2.230 TP=0.520	2.320		0.520
Single-Family: TN=2.070 TP=0.327	2.070		0.327
Undeveloped - Dry Prairie: TN=1.950 TP=0.107	1.950		0.107
Undeveloped - Hydric Hammock: TN=1.072 TP=0.0	1.072		0.026
Undeveloped - Marl Prairie: TN=0.603 TP=0.010	0.603		0.010
Undeveloped - Mesic Flatwoods: TN=1.000 TP=0.0	1.000		0.034
Undeveloped - Mixed Hardwood: TN=0.288 TP=0.50	0.288		0.501
Undeveloped - Ruderal/Upland Pine: TN=1.318 TP=	1.318		0.347
Undeveloped - Scrubby Flatwoods: TN=1.023 TP=0.	1.023		0.027
Undeveloped - Upland Hardwood: TN=0.891 TP=0.2	0.891		0.269
Undeveloped - Upland Mixed: TN=0.676 TP=2.291	0.676		2.291
Undeveloped - Wet Flatwoods: TN=1.175 TP=0.015	1.175		0.015
Undeveloped - Wet Prairie: TN=0.776 TP=0.009	0.776		0.009
Undeveloped - Xeric Hammock: TN=1.318 TP=2.816	1.318		2.816
Undeveloped - Xeric Scrub: TN=1.158 TP=0.096	1.158		0.096
Apopka Open Space/Recreation/Fallow Crop: TN=1	1.100		0.050
Apopka Forests/Abandoned Tree Crops: TN=1.250	1.250		0.080
Undeveloped / Rangeland / Forest: TN=1.150 TP=0.	1.150		0.055

WATERSHEDS

CATCHMENT CONFIGURATIONS

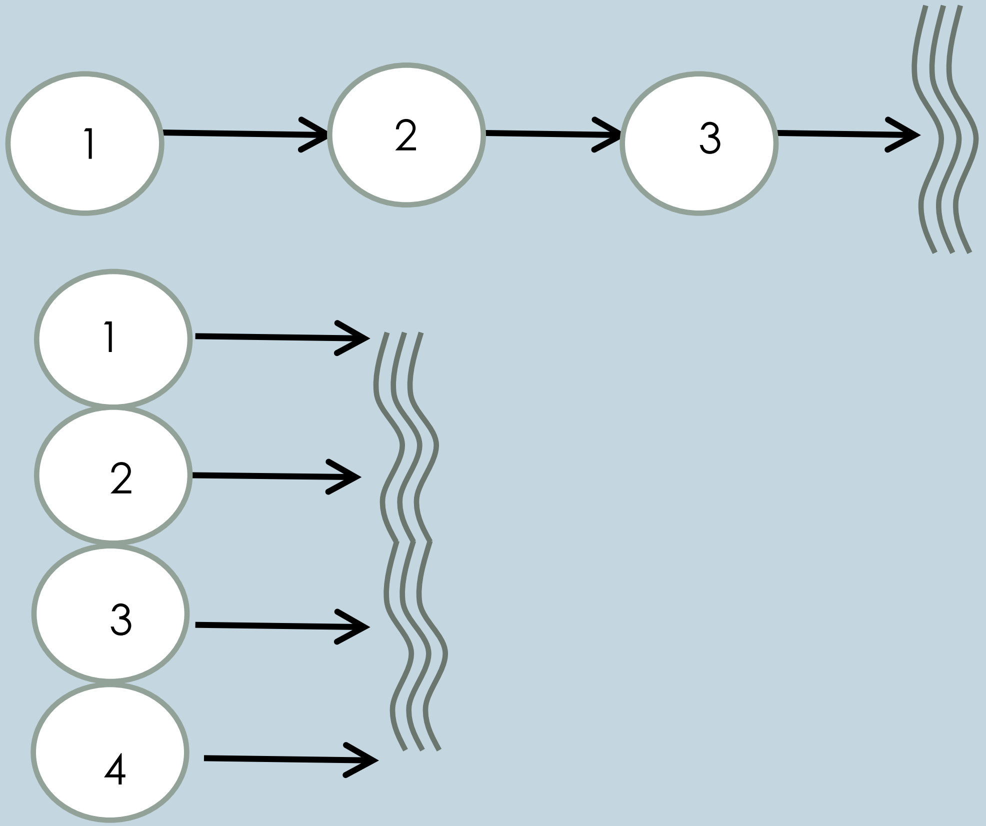
WATERSHED CHARACTERISTICS

SELECT CATCHMENT CONFIGURATION

VIEW CATCHMENT CONFIGURATION

Series

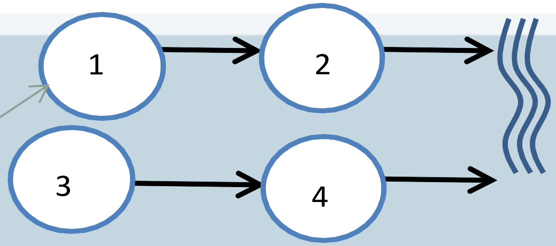
Parallel



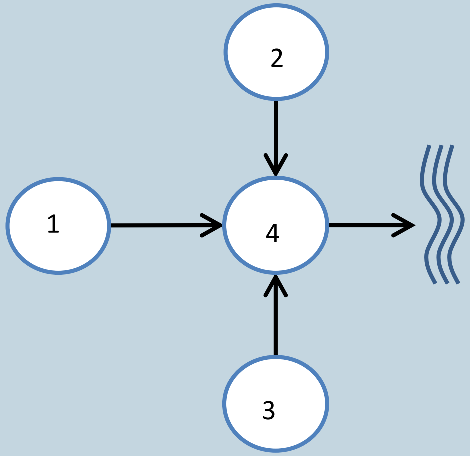
UP TO 15 CONFIGURATIONS

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

M

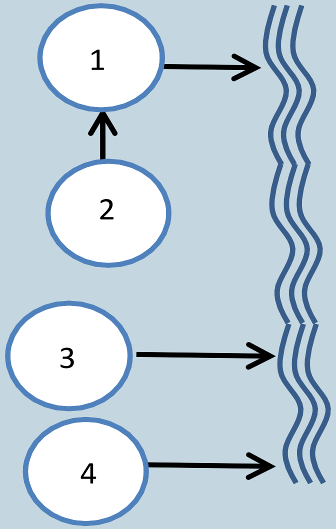


M - Mixed-4 Catchment-2 Series



O - Mixed-4 Catchment- Parallel- Series

N



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

GENERAL SITE INFORMATION:	GO TO INTRODUCTION PAGE	Blue Numbers =	Input data
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STEP 1: Select the appropriate Meteorological Zone, input the appropriate Mean Annual Rainfall amount and select the type of analysis

CLICK ON CELL BELOW TO SELECT

METHODOLOGIES
Descriptions with the HELP buttons and
In the model itself
See below for access using the model.

VIEW ZONE MAP

VIEW MEAN ANNUAL RAINFALL MAP

STEP 2: Select the STORMWATER TREATMENT ANALYSIS to begin analyzing Best Management Practices.

STORMWATER TREATMENT ANALYSIS

METHODOLOGY FOR CALCULATING REQUIRED TREATMENT EFFICIENCY

METHODOLOGY FOR RETENTION SYSTEMS

METHODOLOGY FOR WET DETENTION SYSTEMS

METHODOLOGY FOR STORMWATER AND RAINWATER HARVESTING

METHODOLOGY FOR GREENROOF SYSTEMS

NAVIGATION BUTTONS

Systems available for analysis:
Retention Basin
Wet Detention
Exfiltration Trench
Pervious Pavement
Stormwater Harvesting
Underdrain Biofiltration
Greenroof
Rainwater Harvesting
Floating Island with Wet Detention
Vegetated Natural Buffer
Vegetated Filter Strip
Swale
Rain Garden

RESET INPUT FOR SINGLE SYSTEM TABS

Harper and Baker, FDEP 2007

MEAN ANNUAL RUNOFF

(RESULTS USING 116 RAINFALL STATIONS IN THE STATE, MANY YEARS OF DATA)

Zone 1
Mean Annual Runoff Coefficients (C Values) as a Function of DCIA Percentage and Non-DCIA Curve Number (CN)

NDCIA CN	Percent DCIA																				
	0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
30	0.006	0.048	0.090	0.132	0.175	0.217	0.259	0.301	0.343	0.386	0.428	0.470	0.512	0.554	0.596	0.639	0.681	0.723	0.765	0.807	0.849
35	0.009	0.051	0.093	0.135	0.177	0.219	0.261	0.303	0.345	0.387	0.429	0.471	0.513	0.555	0.597	0.639	0.681	0.723	0.765	0.807	0.849
40	0.014	0.056	0.098	0.139	0.181	0.223	0.265	0.307	0.348	0.390	0.432	0.474	0.515	0.557	0.599	0.641	0.682	0.724	0.766	0.808	0.849
45	0.020	0.062	0.103	0.145	0.186	0.228	0.269	0.311	0.352	0.394	0.435	0.476	0.518	0.559	0.601	0.642	0.684	0.725	0.767	0.808	0.849
50	0.029	0.070	0.111	0.152	0.193	0.234	0.275	0.316	0.357	0.398	0.439	0.480	0.521	0.562	0.603	0.644	0.685	0.726	0.767	0.808	0.849
55	0.039	0.079	0.120	0.161	0.201	0.242	0.282	0.323	0.363	0.404	0.444	0.485	0.525	0.566	0.606	0.647	0.687	0.728	0.768	0.809	0.849
60	0.052	0.092	0.132	0.172	0.212	0.252	0.291	0.331	0.371	0.411	0.451	0.491	0.531	0.570	0.610	0.650	0.690	0.730	0.770	0.810	0.849
65	0.069	0.108	0.147	0.186	0.225	0.264	0.303	0.342	0.381	0.420	0.459	0.498	0.537	0.576	0.615	0.654	0.693	0.732	0.771	0.810	0.849
70	0.092	0.130	0.167	0.205	0.243	0.281	0.319	0.357	0.395	0.433	0.471	0.508	0.546	0.584	0.622	0.660	0.698	0.736	0.774	0.812	0.849
75	0.121	0.158	0.194	0.230	0.267	0.303	0.340	0.376	0.412	0.449	0.485	0.522	0.558	0.595	0.631	0.667	0.704	0.740	0.777	0.813	0.849
80	0.162	0.196	0.230	0.265	0.299	0.334	0.368	0.402	0.437	0.471	0.506	0.540	0.574	0.609	0.643	0.678	0.712	0.746	0.781	0.815	0.849
85	0.220	0.252	0.283	0.315	0.346	0.378	0.409	0.441	0.472	0.503	0.535	0.566	0.598	0.629	0.661	0.692	0.724	0.755	0.787	0.818	0.849
90	0.312	0.339	0.366	0.393	0.419	0.446	0.473	0.500	0.527	0.554	0.581	0.608	0.634	0.661	0.688	0.715	0.742	0.769	0.796	0.823	0.849
95	0.478	0.496	0.515	0.533	0.552	0.571	0.589	0.608	0.626	0.645	0.664	0.682	0.701	0.719	0.738	0.757	0.775	0.794	0.812	0.831	0.849
98	0.656	0.666	0.676	0.685	0.695	0.705	0.714	0.724	0.734	0.743	0.753	0.763	0.772	0.782	0.792	0.801	0.811	0.821	0.830	0.840	0.849

Harper and Baker, FDEP 2007

INTERPOLATING NIGHTMARE

NDCIA CN	Percent DCIA											
	0	5	10	15	20	25	30	35	40	45	50	55
30	0.006	0.048	0.090	0.132	0.175	0.217	0.259	0.301	0.343	0.386	0.428	0.470
35	0.009	0.051	0.093	0.135	0.177	0.219	0.261	0.303	0.345	0.387	0.429	0.471
40	0.014	0.056	0.098	0.139	0.181	0.223	0.265	0.307	0.348	0.390	0.432	0.474
45	0.020	0.062	0.103	0.145	0.186	0.228	0.269	0.311	0.352	0.394	0.435	0.476
50	0.029	0.070	0.111	0.152	0.193	0.234	0.275	0.316	0.357	0.398	0.439	0.480
55	0.039	0.079	0.120	0.161	0.201	0.242	0.282	0.323	0.363	0.404	0.444	0.485

Harper and Baker, FDEP 2007

GENERAL SITE INFORMATION: | GO TO INTRODUCTION PAGE | Blue Numbers = Input data | Red Numbers = Answers

NAVIGATION BUTTONS

STEP 1: Select the appropriate Meteorological Zone, input the appropriate Mean Annual Rainfall amount and select the type of analysis

CLICK ON CELL BELOW TO SELECT

Met

Mean

Treatm

METHODOLOGIES
Descriptions with the HELP buttons and
In the model itself
See below for access using the model.

VIEW ZONE MAP

VIEW MEAN ANNUAL RAINFALL MAP

STEP 2: Select the STORMWATER TREATMENT ANALYSIS to begin analyzing Best Management Practices.

STORMWATER TREATMENT ANALYSIS

Systems available for analysis:
Retention Basin
Wet Detention
Exfiltration Trench
Pervious Pavement
Stormwater Harvesting
Underdrain Biofiltration
Greenroof
Rainwater Harvesting
Floating Island with Wet Detention
Vegetated Natural Buffer
Vegetated Filter Strip
Swale
Rain Garden

METHODOLOGY FOR CALCULATING REQUIRED TREATMENT EFFICIENCY

METHODOLOGY FOR RETENTION SYSTEMS

METHODOLOGY FOR WET DETENTION SYSTEMS

METHODOLOGY FOR STORMWATER AND RAINWATER HARVESTING

METHODOLOGY FOR GREENROOF SYSTEMS

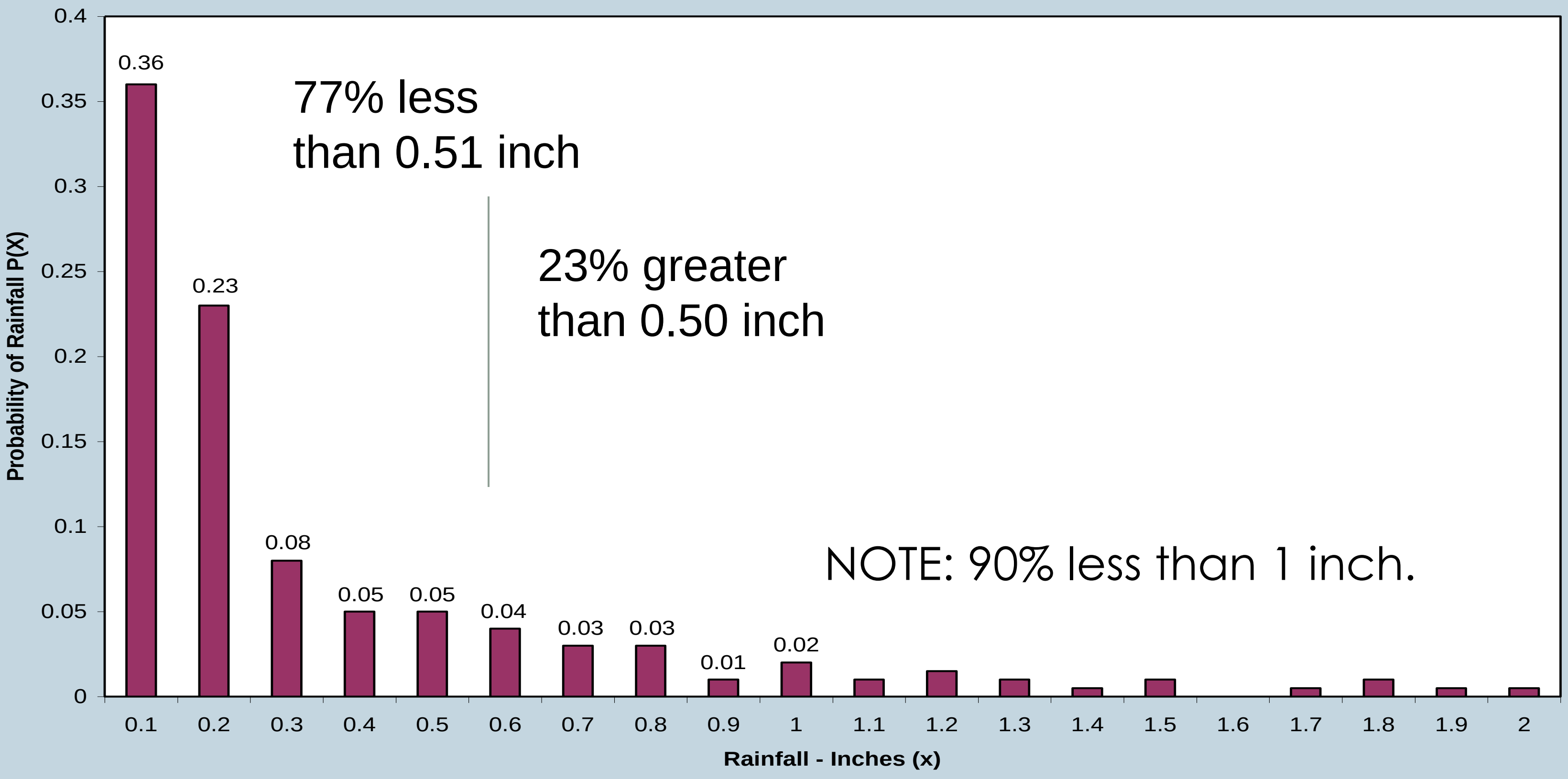
RESET INPUT FOR SINGLE SYSTEM TABS

Harper and Baker, FDEP 2007

HISTORY : HISTOGRAM (PROBABILITY DISTRIBUTION) Wanielista, Stormwater Management, Ann Arbor Science, 1978.

- N=130 events per year

Hourly Data Used for Central Florida sites over at least 15 years



VOLUME CAPTURED
USING LIMITED NUMBER OF STATIONS = 80% CAPTURE

- Using probability basic principles

$$\text{Volume Abstracted} = \sum_{i}^{\text{Abstraction Vol.}} \mathrm{P}(i)_i \,\bar{\mathrm{x}}_i \mathrm{n} + \sum_{i=\text{Abstraction Vol.}}^{\infty} \mathrm{P(i)}_i (\text{Abstraction Vol.})(\mathrm{n})$$

Where the first term is the Expected Value of the abstraction volume up to the abstraction (retention) depth,
and the second term the abstraction volume for all storm events greater than or equal to the retention depth.

National publication of this principle in 1978, Stormwater Management, Ann Arbor Science, Wanielista
Recently, simulations showed that the capacity of the BMP may not be available for all storms and long term simulations were done to refine the capture effectiveness (Harper and Baker, FDEP, 2007)

METHODOLOGY FOR RETENTION SYSTEMS

Mean Annual Mass Removal Efficiency table from Appendix D of the evaluation report (1 of 80):

Mean Annual Mass Removal Efficiencies for 0.25-inches of Retention for Zone 1

NDCIA	Percent DCIA																			
CN	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	86.2	81.3	73.3	65.5	58.7	53.0	48.3	44.2	40.8	37.9	35.3	33.1	31.1	29.4	27.8	26.4	25.1	24.0	22.9	21.9
35	81.6	78.7	71.7	64.5	58.0	52.5	47.9	44.0	40.6	37.7	35.2	33.0	31.0	29.3	27.8	26.4	25.1	23.9	22.9	21.9
40	76.4	75.5	69.6	63.1	57.1	51.9	47.4	43.6	40.3	37.5	35.0	32.9	30.9	29.2	27.7	26.3	25.1	23.9	22.9	21.9
45	70.7	71.7	67.2	61.4	55.9	51.0	46.8	43.1	40.0	37.2	34.8	32.7	30.8	29.1	27.6	26.3	25.0	23.9	22.9	21.9
50	64.7	67.5	64.2	59.4	54.5	50.0	46.0	42.6	39.5	36.9	34.6	32.5	30.7	29.0	27.5	26.2	25.0	23.9	22.9	21.9
55	58.6	62.8	60.9	57.0	52.7	48.7	45.1	41.8	39.0	36.5	34.2	32.3	30.5	28.9	27.4	26.1	24.9	23.9	22.9	21.9
60	52.8	57.8	57.1	54.2	50.7	47.1	43.9	40.9	38.3	35.9	33.8	31.9	30.2	28.7	27.3	26.0	24.9	23.8	22.8	21.9
65	47.3	52.6	53.0	51.1	48.3	45.3	42.5	39.8	37.4	35.3	33.3	31.5	29.9	28.4	27.1	25.9	24.8	23.8	22.8	21.9
70	42.2	47.3	48.6	47.6	45.6	43.2	40.8	38.5	36.4	34.4	32.6	31.0	29.5	28.1	26.9	25.7	24.7	23.7	22.8	21.9
75	37.8	42.2	43.9	43.7	42.4	40.7	38.8	36.9	35.1	33.4	31.8	30.4	29.0	27.8	26.6	25.5	24.5	23.6	22.7	21.9
80	34.0	37.5	39.1	39.4	38.8	37.7	36.4	34.9	33.5	32.1	30.8	29.5	28.3	27.2	26.2	25.2	24.3	23.5	22.7	21.9
85	30.8	33.1	34.3	34.8	34.7	34.2	33.4	32.5	31.4	30.4	29.4	28.4	27.4	26.5	25.7	24.8	24.1	23.3	22.6	21.9
90	27.9	29.2	29.9	30.3	30.3	30.2	29.8	29.3	28.8	28.2	27.5	26.8	26.2	25.5	24.9	24.2	23.6	23.0	22.5	21.9
95	25.3	25.6	25.8	25.9	26.0	25.9	25.8	25.6	25.4	25.2	24.9	24.6	24.3	24.0	23.6	23.3	23.0	22.6	22.3	21.9
98	23.8	23.8	23.8	23.7	23.7	23.6	23.5	23.4	23.3	23.2	23.1	23.0	22.9	22.8	22.6	22.5	22.4	22.2	22.1	21.9

Harper and Baker, FDEP 2007

INTERPOLATING DIFFICULTIES
(NOT LINEAR BETWEEN RETENTION DEPTHS)

Harper and Baker, FDEP 2007

Mean Annual Mass Removal Efficiencies for 0.25-inches of Retention for Zone 1

NDCIA CN	Percent DCIA 5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
30	86.2	81.3	73.3	65.5	58.7	53.0	48.3	44.2	40.8	37.9	35.3	33.1	31.1	29.4	27.8	26.4
35	81.6	78.7	71.7	64.5	58.0	52.5	47.9	44.0	40.6	37.7	35.2	33.0	31.0	29.3	27.8	26.4
40	76.4	75.5	69.6	63.1	57.1	51.9	47.4	43.6	40.3	37.5	35.0	32.9	30.9	29.2	27.7	26.3
45	70.7	71.7	67.2	61.4	55.9	51.0	46.8	43.1	40.0	37.2	34.8	32.7	30.8	29.1	27.6	26.3
50	64.7	67.5	64.2	59.4	54.5	50.0	46.0	42.6	39.5	36.9	34.6	32.5	30.7	29.0	27.5	26.2
55	58.6	62.8	60.9	57.0	52.7	48.7	45.1	41.8	39.0	36.5	34.2	32.3	30.5	28.9	27.4	26.1
60	52.8	57.8	57.1	54.2	50.7	47.1	43.9	40.9	38.3	35.9	33.8	31.9	30.2	28.7	27.3	26.0
65	47.3	52.6	53.0	51.1	48.3	45.3	42.5	39.8	37.4	35.3	33.3	31.5	29.9	28.4	27.1	25.9
70	42.2	47.3	48.6	47.6	45.6	43.2	40.8	38.5	36.4	34.4	32.6	31.0	29.5	28.1	26.9	25.7
75	37.8	42.2	43.9	43.7	42.4	40.7	38.8	36.9	35.1	33.4	31.8	30.4	29.0	27.8	26.6	25.5
80	34.0	37.5	39.1	39.4	38.8	37.7	36.4	34.9	33.5	32.1	30.8	29.5	28.3	27.2	26.2	25.2
85	30.8	33.1	34.3	34.8	34.7	34.2	33.4	32.5	31.4	30.4	29.4	28.4	27.4	26.5	25.7	24.8
90	27.9	29.2	29.9	30.3	30.3	30.2	29.8	29.3	28.8	28.2	27.5	26.8	26.2	25.5	24.9	24.2
95	25.3	25.6	25.8	25.9	26.0	25.9	25.8	25.6	25.4	25.2	24.9	24.6	24.3	24.0	23.6	23.3
98	23.8	23.8	23.8	23.7	23.7	23.6	23.5	23.4	23.3	23.2	23.1	23.0	22.9	22.8	22.6	22.5

Mean Annual Mass Removal Efficiencies for 0.50-inches of Retention for Zone 1

NDCIA CN	Percent DCIA 5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
30	91.8	91.5	88.3	84.0	79.5	75.0	70.7	66.6	62.9	59.6	56.5	53.6	51.1	48.7	46.6	44.6
35	88.2	89.1	86.6	82.8	78.6	74.3	70.1	66.2	62.6	59.3	56.3	53.5	51.0	48.7	46.5	44.6
40	84.0	86.3	84.4	81.2	77.4	73.4	69.4	65.7	62.2	59.0	56.0	53.3	50.8	48.5	46.4	44.5
45	79.6	82.9	81.9	79.3	75.9	72.2	68.5	65.0	61.7	58.6	55.7	53.0	50.6	48.4	46.3	44.4
50	74.8	79.1	79.0	77.0	74.1	70.8	67.4	64.1	61.0	58.0	55.3	52.7	50.4	48.2	46.2	44.3
55	70.1	74.9	75.6	74.2	71.9	69.1	66.1	63.0	60.1	57.3	54.7	52.3	50.0	47.9	46.0	44.2
60	65.5	70.4	71.7	71.1	69.4	67.0	64.4	61.7	59.1	56.5	54.1	51.8	49.6	47.6	45.8	44.0
65	61.0	65.8	67.5	67.6	66.4	64.7	62.5	60.2	57.8	55.5	53.3	51.1	49.1	47.2	45.5	43.8
70	56.7	61.1	63.1	63.6	63.1	61.9	60.2	58.3	56.3	54.3	52.3	50.3	48.5	46.8	45.1	43.5
75	52.7	56.6	58.6	59.3	59.3	58.6	57.5	56.0	54.4	52.7	51.0	49.3	47.7	46.1	44.6	43.2
80	49.1	52.2	54.1	55.0	55.2	54.9	54.2	53.2	52.1	50.8	49.4	48.0	46.6	45.3	44.0	42.7

INTERPOLATING DIFFICULTIES
(**NOT LINEAR** BETWEEN RETENTION DEPTHS)

Harper and Baker, FDEP 2007

.25 inch

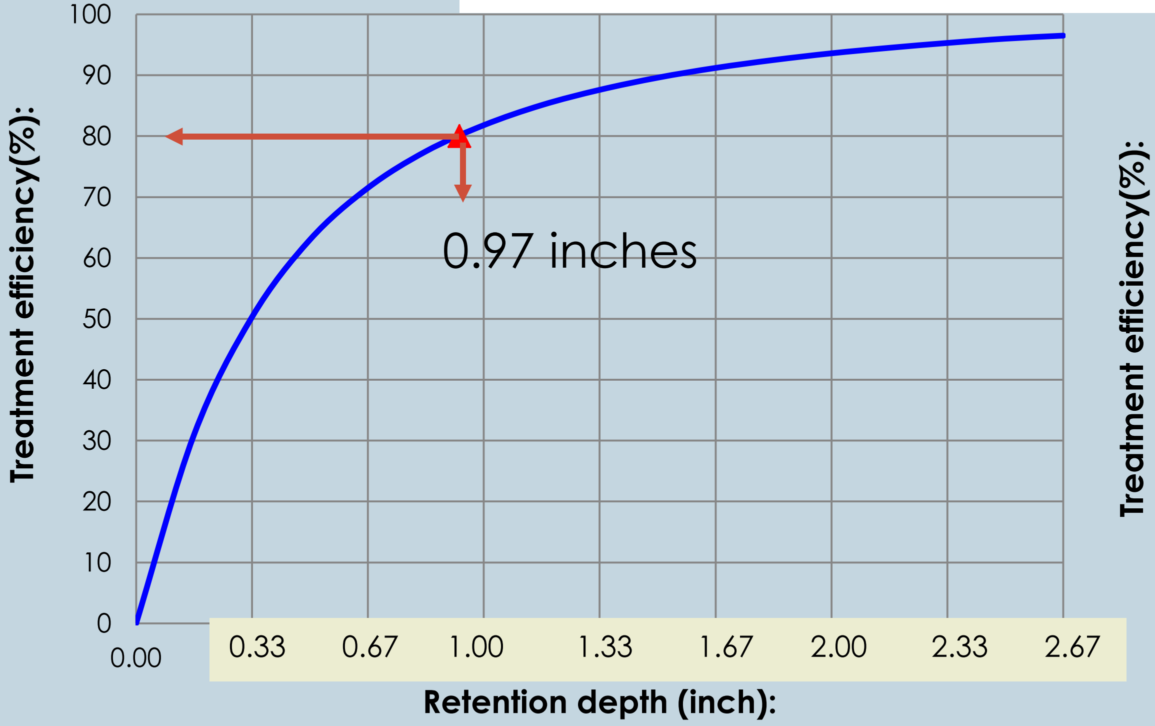
Percen
50
37.9
37.7
37.5
37.2

0.50 inch

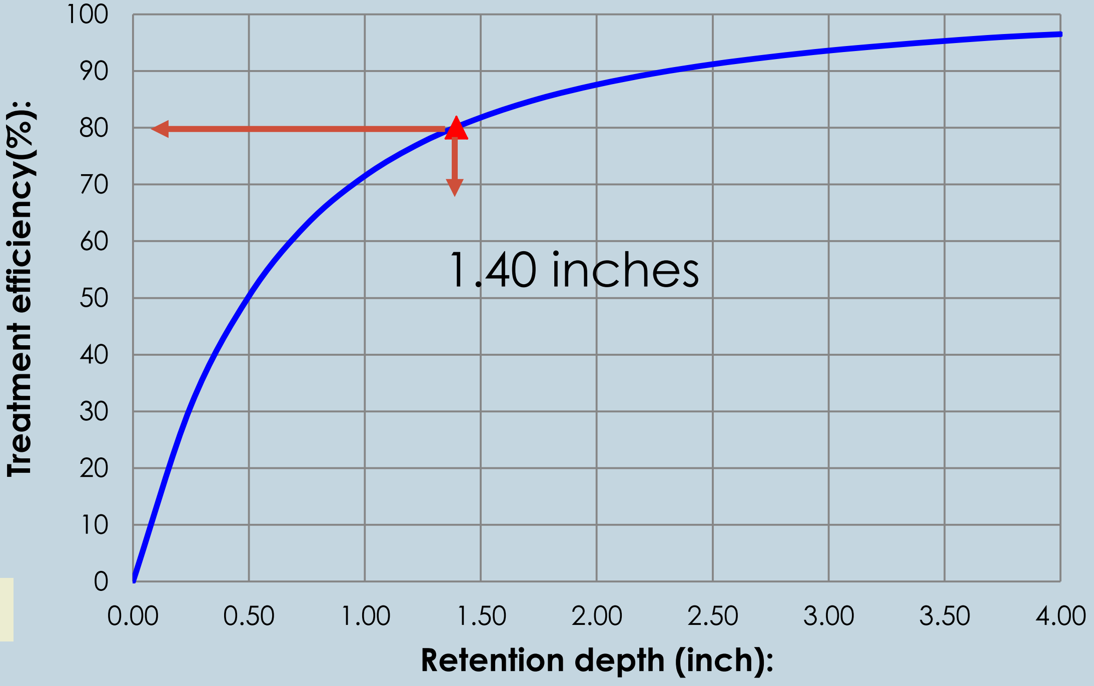
Percent
50
59.6
59.3
59.0
58.6

METHODOLOGY for RETENTION DESIGN
Examples Showing Climatological Differences in Design

RESULTS from BMPTRAINS modeling analysis at 80% capture



Central and east central Florida



Pan handle of Florida

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

WHAT TO DO ABOUT SENSITIVE AREAS? LIKE ESTUARIES AND SPRINGS

- The BMPTRAINS allows for options to improve water quality before it enters into the groundwater that discharges to springs or estuaries.
- Remove pollutants from surface flows using treatment trains, reactive media, chemical treatment, and stormwater reuse.
- For infiltration BMPs including Retention Basins.
  - Removed the pollutant before it enters the ground
  - Bottom of basins (Marion County)
  - Swales with reactive media

NAVIGATION BUTTONS

METHODOLOGIES
Descriptions with the HELP buttons and
In the model itself
See below for access using the model.

GENERAL SITE INFORMATION:

GO TO INTRODUCTION PAGE

Blue Numbers =	Input data
Red Numbers =	Answers

STEP 1: Select the appropriate Meteorological Zone, input the appropriate Mean Annual Rainfall amount and select the type of analysis

CLICK ON CELL BELOW TO SELECT

Met

Mean

Treatm

VIEW ZONE MAP

VIEW MEAN ANNUAL RAINFALL MAP

STEP 2: Select the STORMWATER TREATMENT ANALYSIS to begin analyzing Best Management Practices.

STORMWATER TREATMENT ANALYSIS

Systems available for analysis:
Retention Basin
Wet Detention
Exfiltration Trench
Pervious Pavement
Stormwater Harvesting
Underdrain Biofiltration
Greenroof
Rainwater Harvesting
Floating Island with Wet Detention
Vegetated Natural Buffer
Vegetated Filter Strip
Swale
Rain Garden

RESET INPUT FOR SINGLE SYSTEM TABS

METHODOLOGY FOR CALCULATING REQUIRED TREATMENT EFFICIENCY

METHODOLOGY FOR RETENTION SYSTEMS

METHODOLOGY FOR WET DETENTION SYSTEMS

METHODOLOGY FOR STORMWATER AND RAINWATER HARVESTING

METHODOLOGY FOR GREENROOF SYSTEMS

METHODOLOGY FOR WET DETENTION SYSTEMS

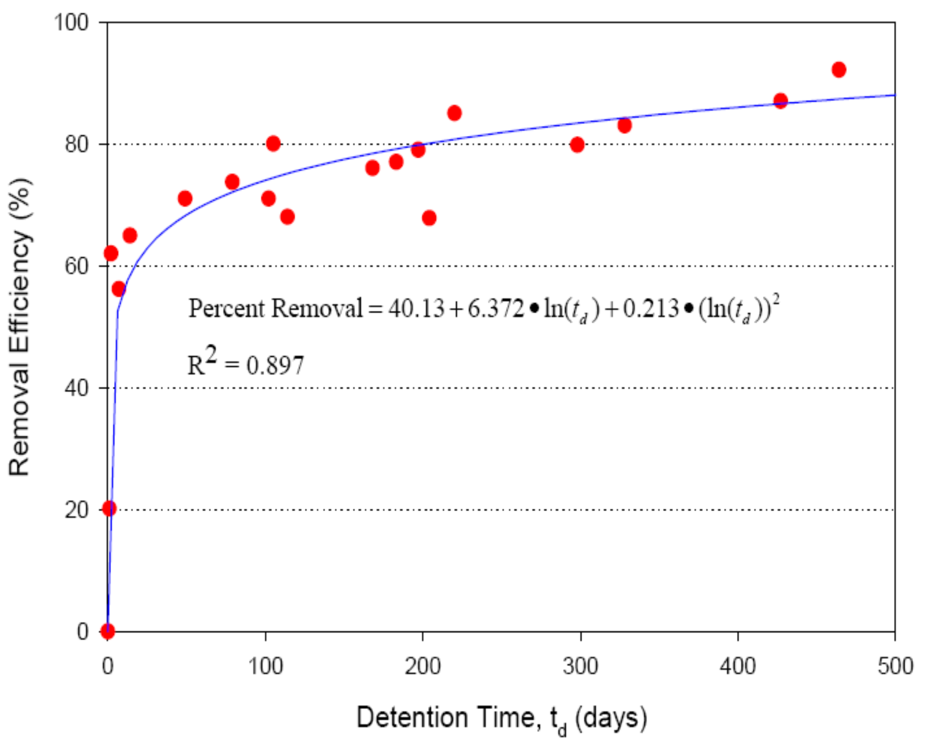


Figure 7.5-1 Removal Efficiency of Total Phosphorus in Wet Detention Ponds as a Function of Residence Time.

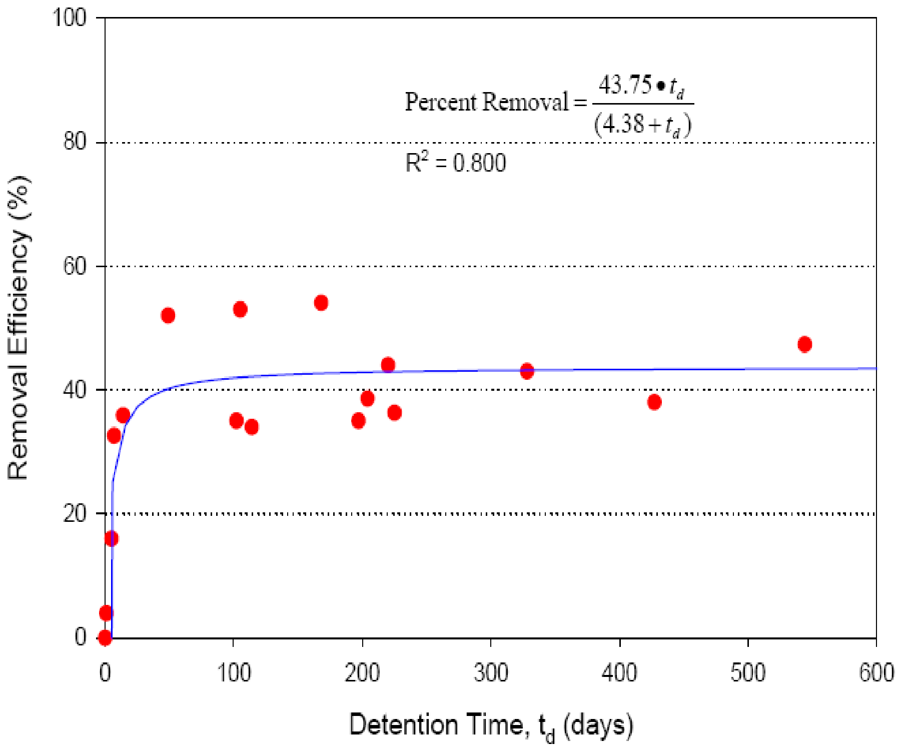


Figure 7.5-2 Removal Efficiency of Total Nitrogen in Wet Detention Ponds as a Function of Residence Time.

15 BMPS AND ONE USER DEFINED

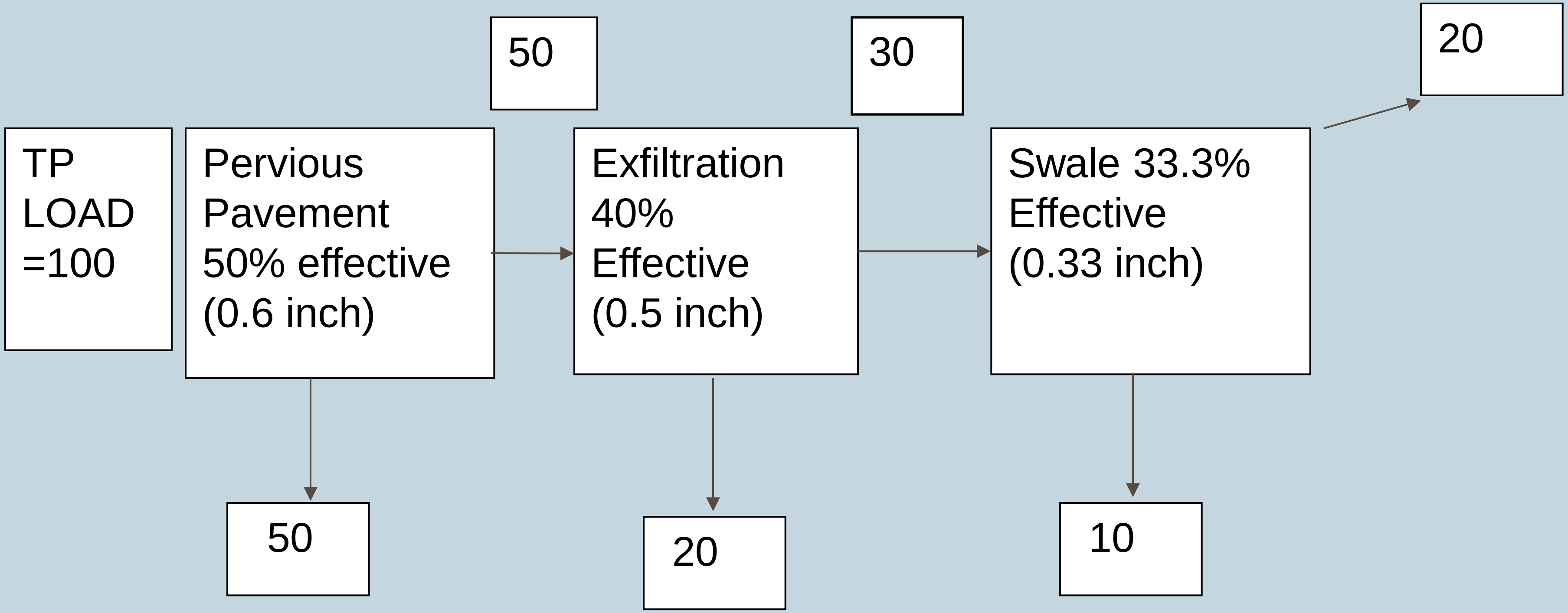
Select one of the BMPs below to analyze efficiency or review the summary data.

RETENTION BASIN	WET DETENTION	EXFILTRATION TRENCH	RAIN (BIO) GARDEN	SWALE	USER DEFINED BMP
PERVIOUS PAVEMENT	STORMWATER HARVESTING	FILTRATION including Up-Flow Filters	LINED REUSE POND & UNDERDRAIN INPUT		
GREENROOF	RAINWATER HARVESTING	FLOATING ISLANDS WITH WET DETENTION			
VEGETATED NATURAL BUFFER	VEGETATED FILTER STRIP	VEGETATED AREA Example tree well	CATCHMENT AND TREATMENT SUMMARY RESULTS		

NOTE !!!: All individual system must be sized prior to being analyzed in conjunction with other systems. Please read instructions in the CATCHMENT AND TREATMENT SUMMARY RESULTS tab for more information.

15 BMPs and17 NAVIGATION BUTTONS

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

- Can one BMP meet loading reduction target? 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.

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 EXAMPLES 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 7.3 of the program, updated on June 20, 2014. Comments are appreciated.

HELP - HYDROGRAPH AND LEGACY PROGRAMS

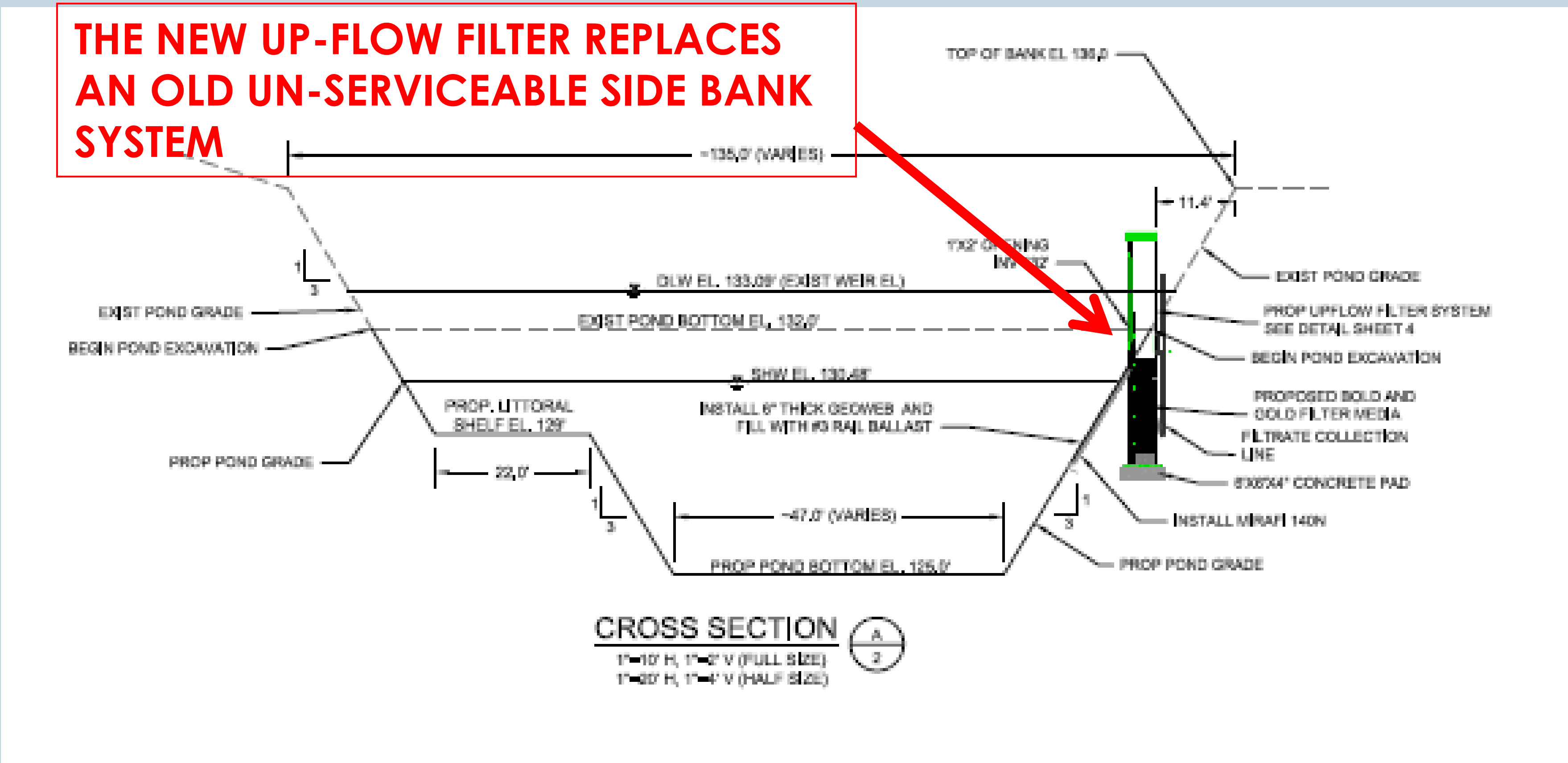
SMADA ONLINE

TYPICAL FAILURE PROBLEMS ASSOCIATED WITH SIDE BANK FILTERS

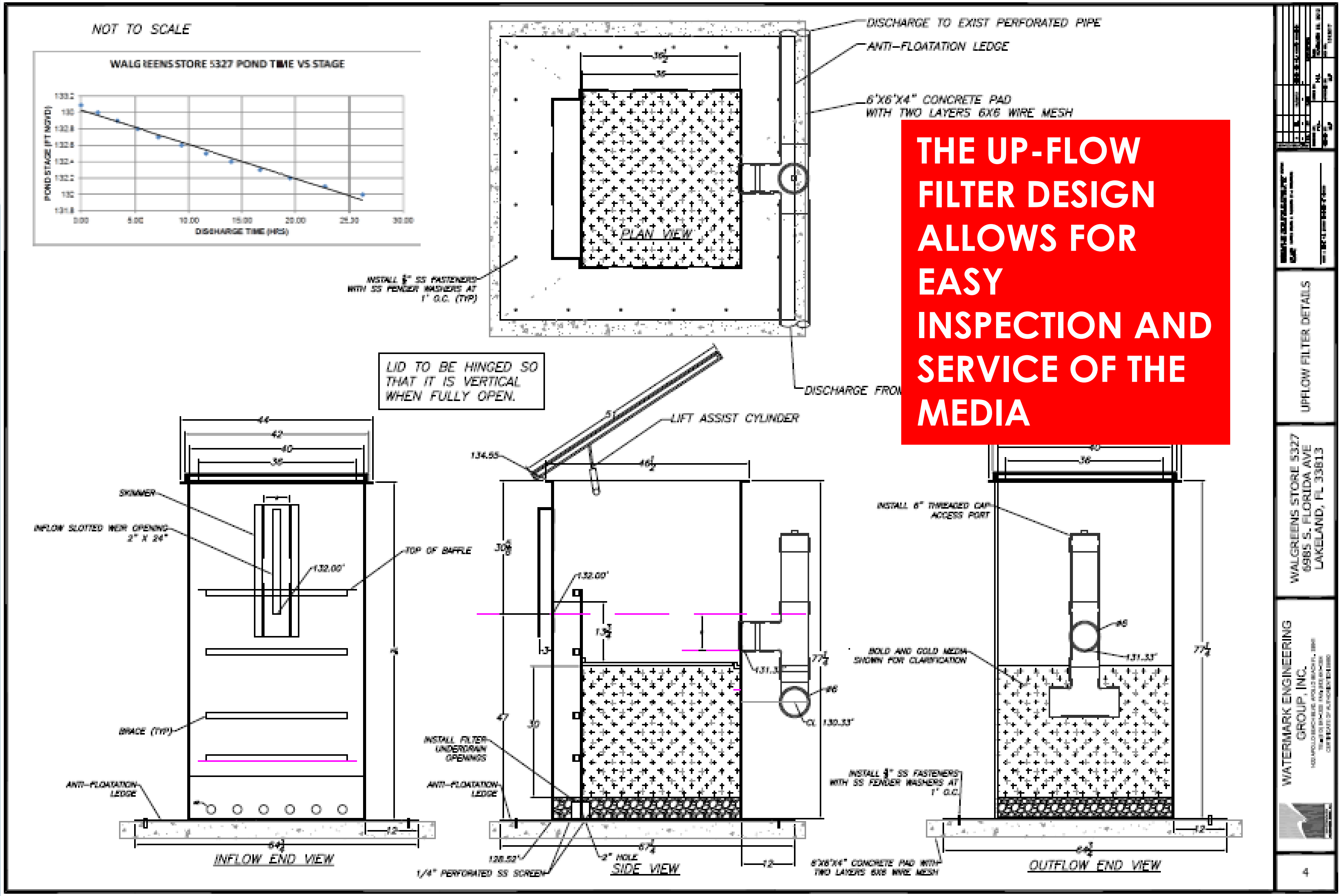
Some Failure Problems

- Filters are difficult to access to properly clean
- Because of slow filtration or no filtration, exotics take over
- Often difficult or very costly to replace

Example Pond Retrofit Design for Upflow Filter



WATERMARK ENGINEERING GROUP, INC.



THE UP-FLOW FILTER DESIGN ALLOWS FOR EASY INSPECTION AND SERVICE OF THE MEDIA

DESIGN by Watermark Engineering Group

UP-FLOW FILTER INSTALLATION BY SUNTREE TECHNOLOGIES

Suntree Technologies Inc.

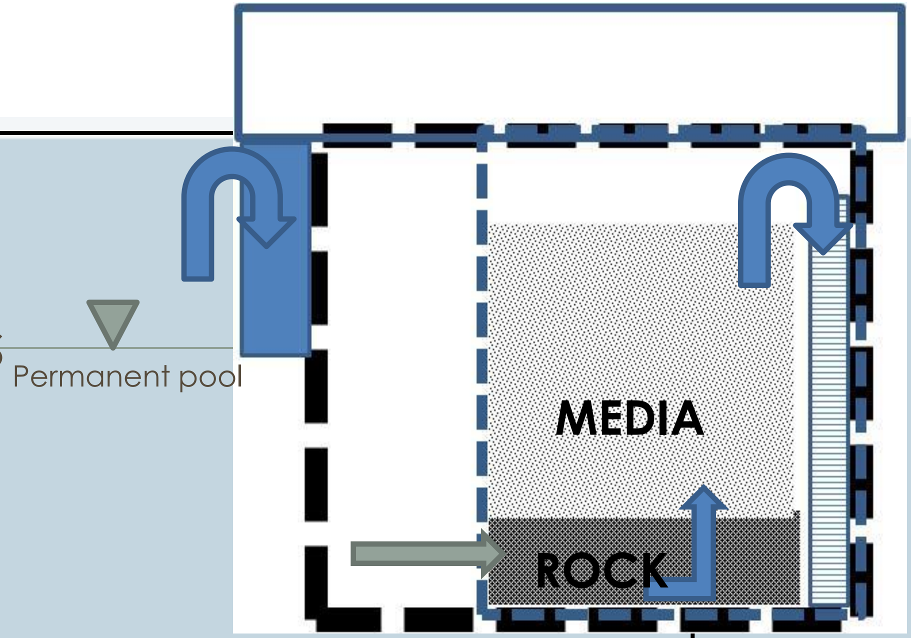
IMPROVED TREATMENT USING AN UP-FLOW FILTER WITH WET POND

Observations

- Filters can be designed to remove nitrogen without media replacement
- For phosphorus, media replacement time is specified
- Can be easily cleaned
- Can be used in BMP Treatment Train

UP-FLOW WITH WET DETENTION PERFORMANCE DATA

- **Summary Data**
  - Concentration data based
  - Averages based on 6 events
  - Construction cost less
    than under drains
  - Average yearly based
    1.0 inch design for filter



Parameter	TN	TP	TSS
Average Influent Concentration (mg/L)	1.83	0.73	42.7
Average Filter Removal (%)	**22**	**25**	**60**
Average Pond Removal (%)	**62**	**63**	**79**
Average Pond + Filter Removal (%)	**70**	**72**	**91**
Average Annual System Performance	**67**	**70**	**89**

USE THE BMPTRAINS MODEL TO CHECK FIELD DATA

Stormwater BMP Treatment Trains [BMPTRAINS©]

CLICK HERE TO START

HELP - INTRODUCTION

HELP AND BACKGROUND

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University of Central Florida Stormwater Management Academy
"Managed Stormwater is Good Water"

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HELP - HYDROGRAPH AND LEGACY PROGRAMS

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Stormwater Management Academy
"Managed Stormwater is Good Water"

BMPTRAINS MODEL COMPARISON TO FIELD COLLECTED DATA
NOTE: average annual removal

Percent Removal				
	TN (Field)	TN (Model)	TP (Field)	TP (Model)
Pond + Filter	67	66	70	78

Notes: 1. Pond input measured TP of 0.73 mg/L is high and 81% of TP is dissolved. Thus, can change or alter the effectiveness of the pond

2. A wet pond effectiveness for TN removal has been increased by about 30% (66-35%). If more pond water is treated by the filter before discharge the effectiveness can increase by about 40-45%.

SPRINGS AND ESTUARIES PROTECTION

FIELD DATA

FIELD DATA

Date:	pH Pond In SU	pH Filter In SU	pH Filter Out SU	Turbidity Pond In NTU	Turbidity Filter In NTU	Turbidity Filter Out NTU	DO Pond In mg/L	DO Filter In mg/L	DO Filter Out mg/L	Temp °C
3/25	7.14	7.25	7.05	10.5	2.50	2.25	7.20	6.09	0.61	22.5
4/8	7.20	7.40	7.30	39.0	5.47	4.52	7.08	4.09	1.14	24.0
4/14	7.15	7.20	7.05	4.40	1.19	1.12	7.13	7.54	0.27	25.2
4/15	6.90	6.85	6.8				6.23	7.10	0.59	27.0
4/28	6.76	6.67	6.45	32.5	2.85	1.96	5.29	5.80	0.36	29.1
AVG	7.03	7.07	6.93	21.6	3.00	2.46	6.59	6.10	0.74	25.6
% Change based on pond influent					86%	89%		7%	89%	
% Change due to filter						18%			88%	

USING 5 SAMPLES: NOx (mg/L) IN=0.77 OUT=0.025 97% removal

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 an 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. BMPTRAINS can be used to assess protection of Springs and Estuaries.

Seal of Approval

QUESTIONS, REMARKS AND DISCUSSION

THANK YOU!