2009 GMEC Conference

MODELING TECHNIQUES FOR STORMWATER POND

Sizing to Meet New Criteria in FDEP's State-wide Stormwater Rule

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 conditions (based on annual mass of nutrient in runoff).

Reference

Evaluation of Current Stormwater Design Criteria Within the State of Florida, Final Report

Prepared for
Florida Department of Environmental Protection,
FDEP Contract No. SO108, June 2007

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& David M. Baker, P.E.
Environmental Research & Design, Inc.

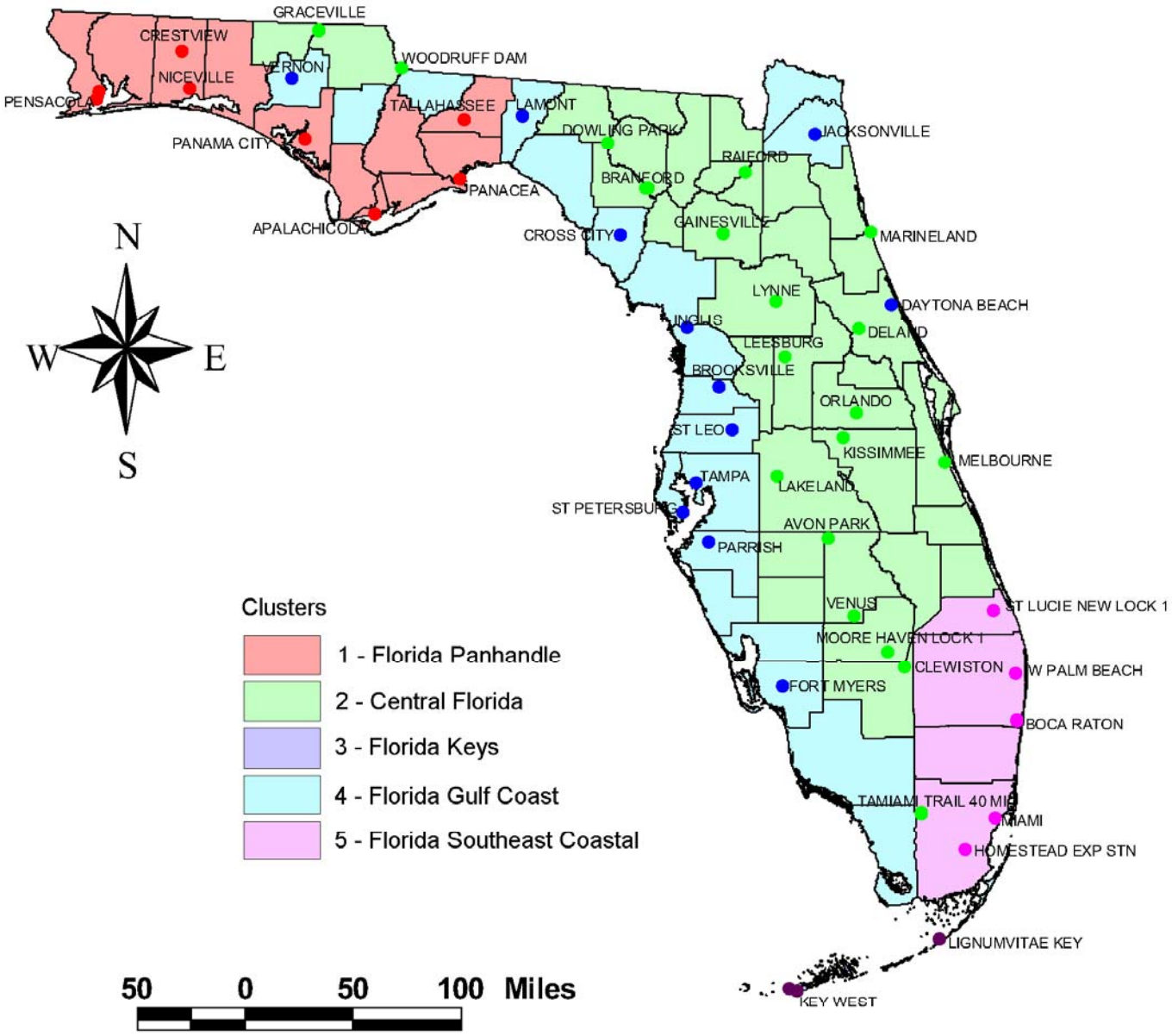
Proposed Methodology

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 Reuse Pond

Pond Efficiency

Dry Ponds

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.

Definition of Annual Residence Time

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

Example:

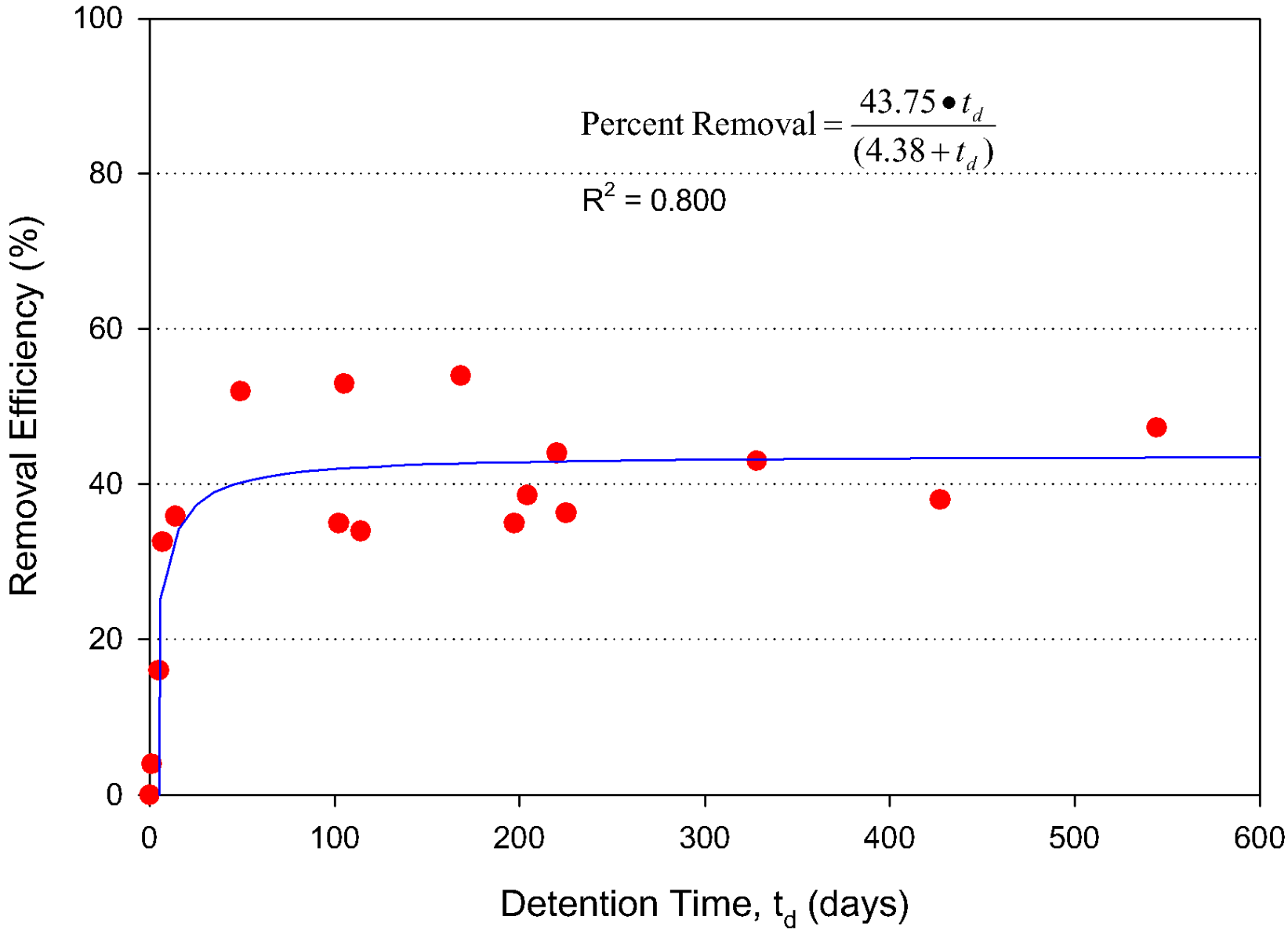
Pond Volume = 50 ac-ft

Yearly Runoff = 91.25 ac-ft/yr

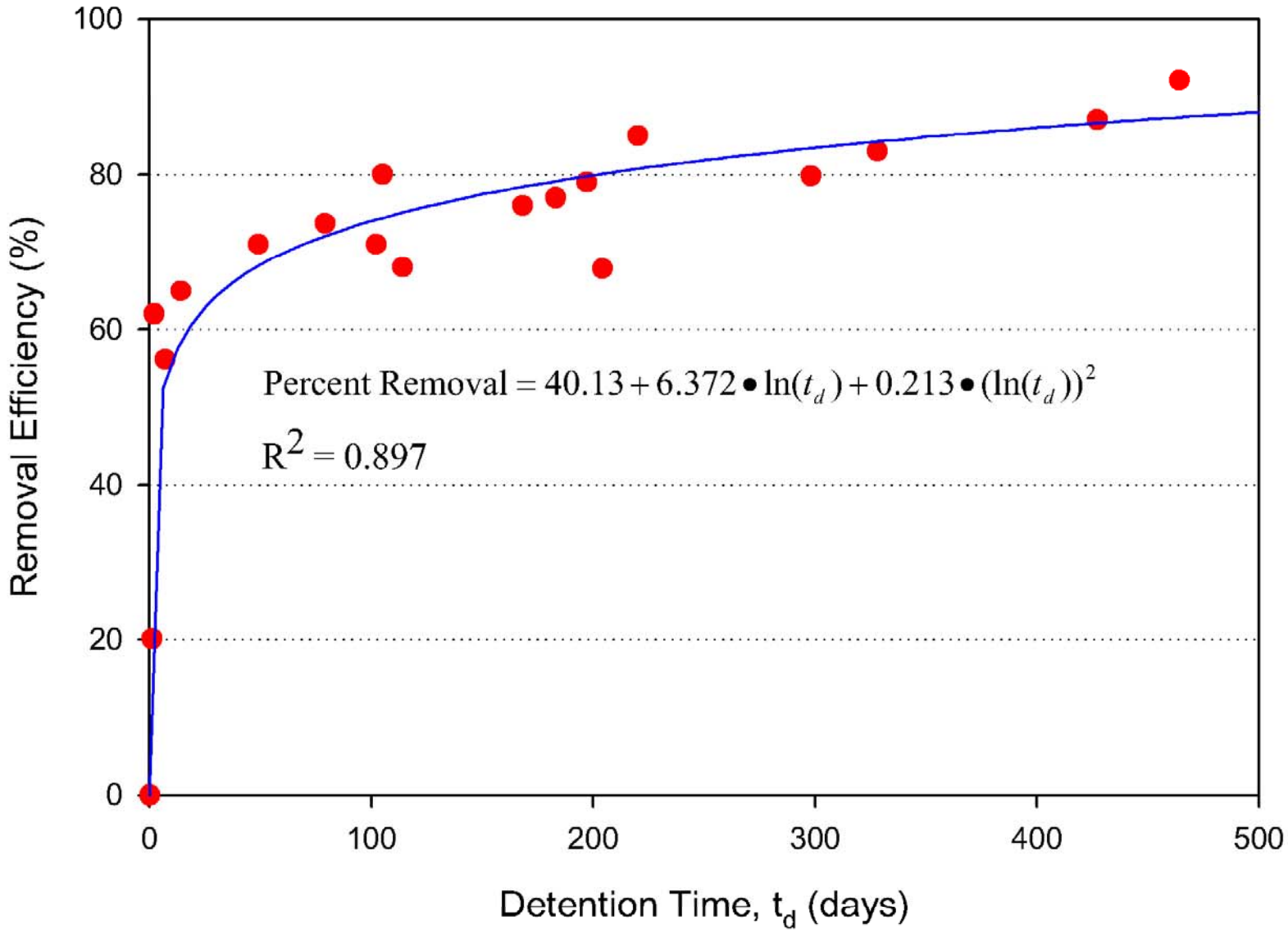
$$\text{Annual Residence Time} = \frac{50 \text{ ac-ft}}{91.25 \text{ ac-ft/yr}} = 200 \text{ days}$$

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

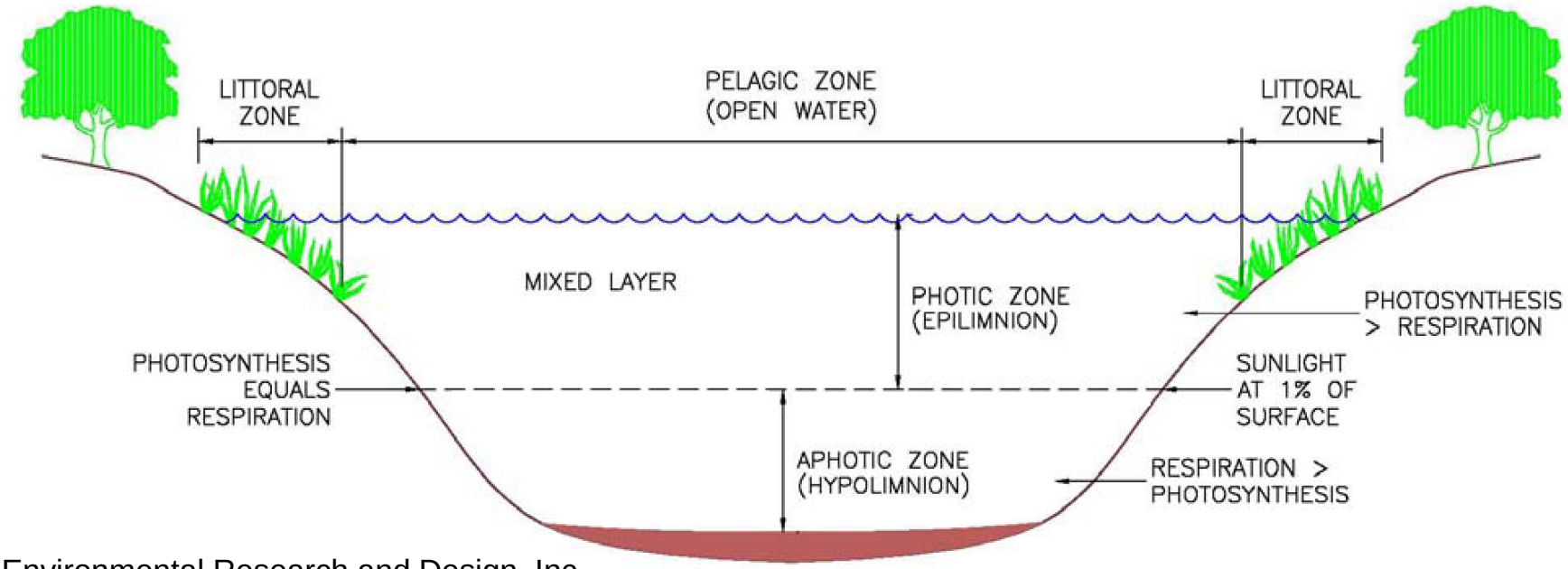
In SJRWMD, the current removal efficiency limit is 64.5% for a permanent pool volume that provides for a WET SEASON residence time of 21 days.

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.

Anoxic Depth of Pond or Lake

Anoxia is defined as dissolved oxygen concentrations less than1mg/l, for waterbodies in Central and South Florida.



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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, unless the required pre vs post-development nutrient removal efficiency is less than 43%.

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.

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.

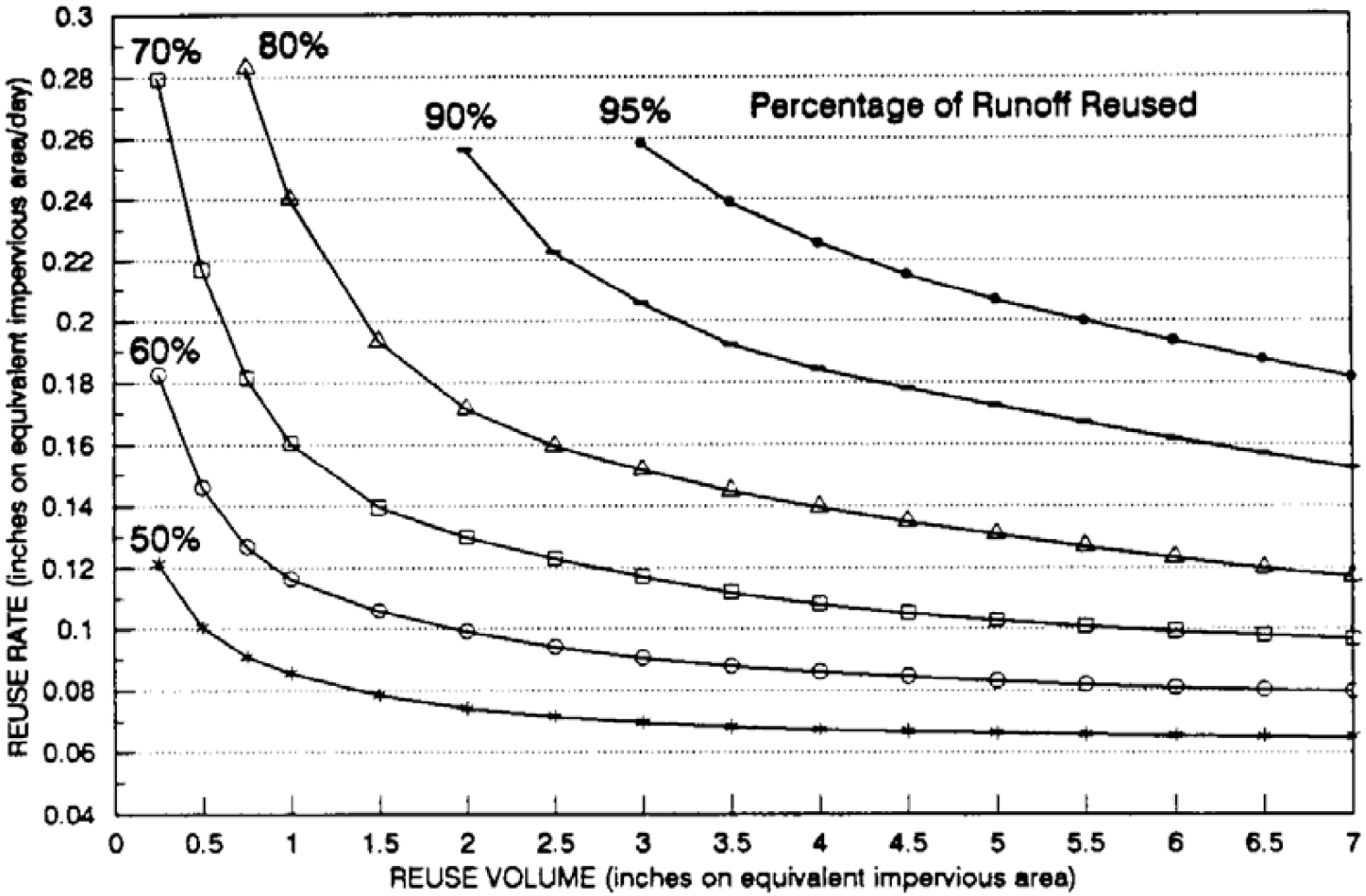
Stormwater Reuse Pond

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 reuse pond is a function of the volume of water which is consumed for irrigation which would otherwise have been discharged offsite.

Design curves for estimating the efficiency of a stormwater reuse pond are available based on the work of Dr. Marty Wanielista.

R-E-V Design Curves for Reuse Pond

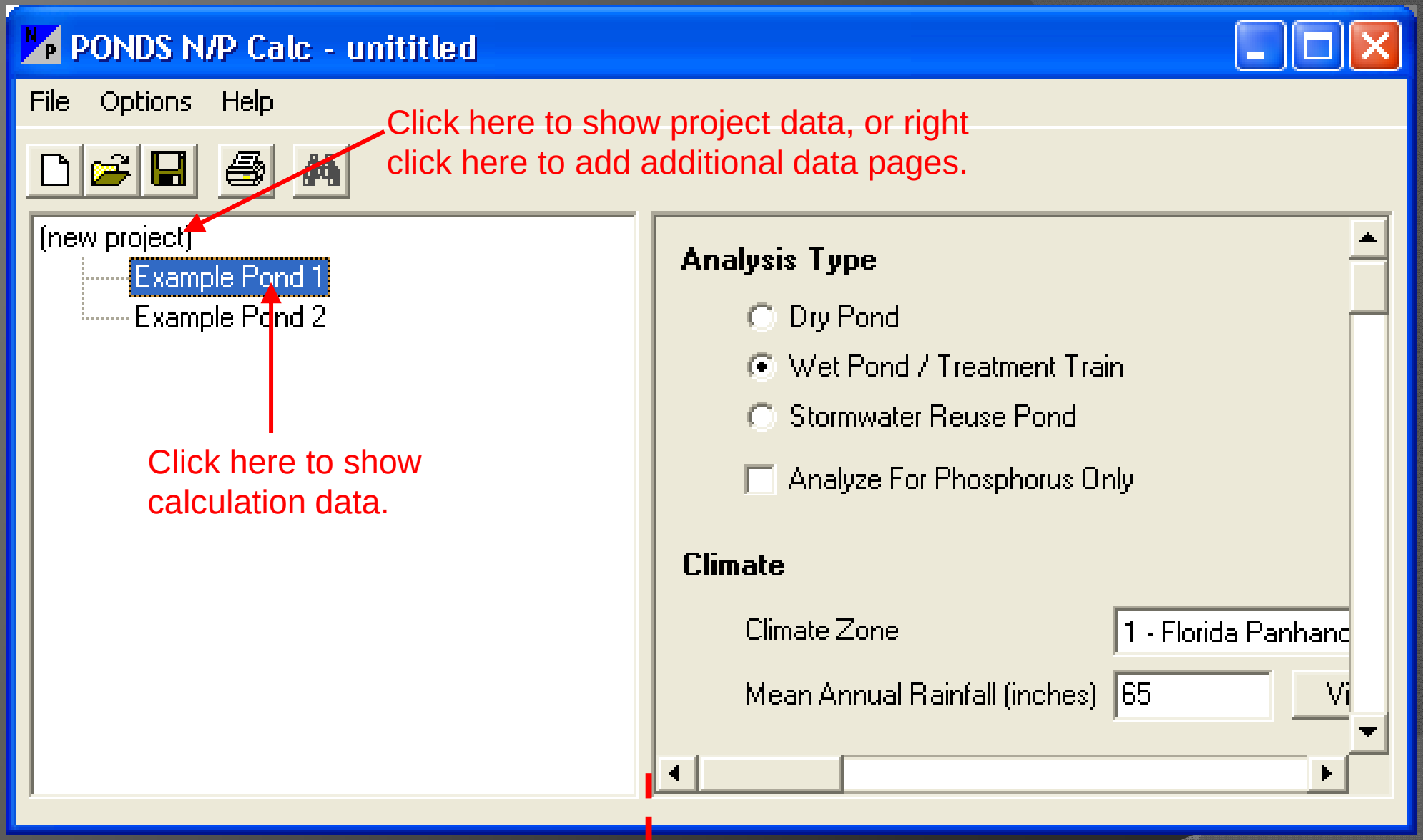


ORLANDO RAINFALL STATION

Using the PONDS 3.3 Nitrogen and Phosphorous Loading Module

First Look

Early adopters of the PONDS N-P module will notice a big change in the data layout of the current program version. The data input has been simplified and made more intuitive.



Left pane shows list of current data pages, for example project data or calculation data pages.

Right pane shows data entry page, for project data or calculations.

A Quick Look at the Calculations Data

Analysis Type

- ○ Dry Pond
- ◉ Wet Pond / Treatment Train
- ○ Stormwater Reuse Pond
- ☐ Analyze For Phosphorus Only

Climate

Climate Zone: 1 - Florida Panhandle [View Map]

Mean Annual Rainfall (inches): 65 [View Map]

Predevelopment Basins ☐ Show Details

Number Of Runoff Basins: 2

	Area (acres)	CN	DCIA (%)	Land Use
1	100	65	0	Undeveloped / Rangeland / Forest
2	2	98	100	Highway
	102	65.64706	1.960784	

Non-Runoff Producing Areas (acres): 0

Total Predevelopment Area (acres): 102

Postdevelopment Basins ☐ Show Details

Number Of Runoff Basins: 2

	Area (acres)	CN	DCIA (%)	Land Use
1	90	65	25	Single-Family
2	2	98	100	Highway
	92	65.71739	26.63043	

Non-Runoff Producing Areas (acres): 10 (Includes pond area.)

Total Postdevelopment Area (acres): 102

Wet Pond Input

Residence Time (days) 200

Anoxic Depth Reduction Factor 1.0 (0.75 is current recommendation from FDEP)

☐ Limit Maximum Phosphorous Removal Efficiency to Agency Specified Maximum: %

Treatment Train Summary Results

	Req. Total	Avail. Wet	Pre-treatment
Nitrogen Removal Efficiency (%)	79.37243	42.81241	63.92999
Phosphorous Removal Efficiency (%)	90.75214	79.87025	54.05876

Required Permanent Pool Volume of Wet Pond (ac-ft) 27.2546

Estimated Anoxic Depth of Wet Pond (ft) 12.25032

Dry Pond Pretreatment

Required Design Efficiency of Dry Pond (%)	63.92999
Required Retention Depth of Dry Pond (inches)	0.480123

Wet Pond Properties

Annual Runoff Reaching Wet Pond (ac-ft)	49.73965
Required Permanent Pool Volume (ac-ft)	27.2546
Yearly Phosphorous Load (kg/yr)	19.62456
Wet Pond Phorphorous Removal Efficiency (%)	79.87025
Annual Mass of Unremoved Phosphorous (kg/yr)	3.950375
Mean Phosphorous Concentration in Pond (µg/l)	41.59559
Estimated Chlorophyll-a Concentration (mg/m³)	20.29182
Estimated Sechi Disk Depth (ft)	3.785547
Estimated Anoxic Depth (ft)	12.25032

Stormwater Reuse Pond Option

Analysis Type

- ○ Dry Pond
- ○ Wet Pond / Treatment Train
- ◉ Stormwater Reuse Pond
- ☐ Analyze For Phosphorus Only

Stormwater Reuse

Click here to launch PONDS R-E-V module.

Solve Using REV

Reuse Rate (gpd)	163612.8
Efficiency (%)	90.75883
Stormwater Reuse Volume (ac-ft)	10.867

Note: If pretreatment requirement is zero, then no pretreatment (dry pond, etc.) is required.

Treatment Train Summary Results

	Req. Total	Avail. Wet	Pre-treatment
Nitrogen Removal Efficiency (%)	79.37243	90.75883	0
Phosphorous Removal Efficiency (%)	90.75214	90.75883	0

PONDS 3.3 Stormwater Reuse - [untitled]

Return Project Data Help

Project | Data | Save and Exit | Discard and Exit

Climate Station: Apalachicola | Map

Solve For: Interactive

Contributing Basin Area (acres): 92

Runoff Coefficient: 0.2767174

Equivalent Impervious Area, EIA (acres): 25.458

Irrigation Area (acres): 40

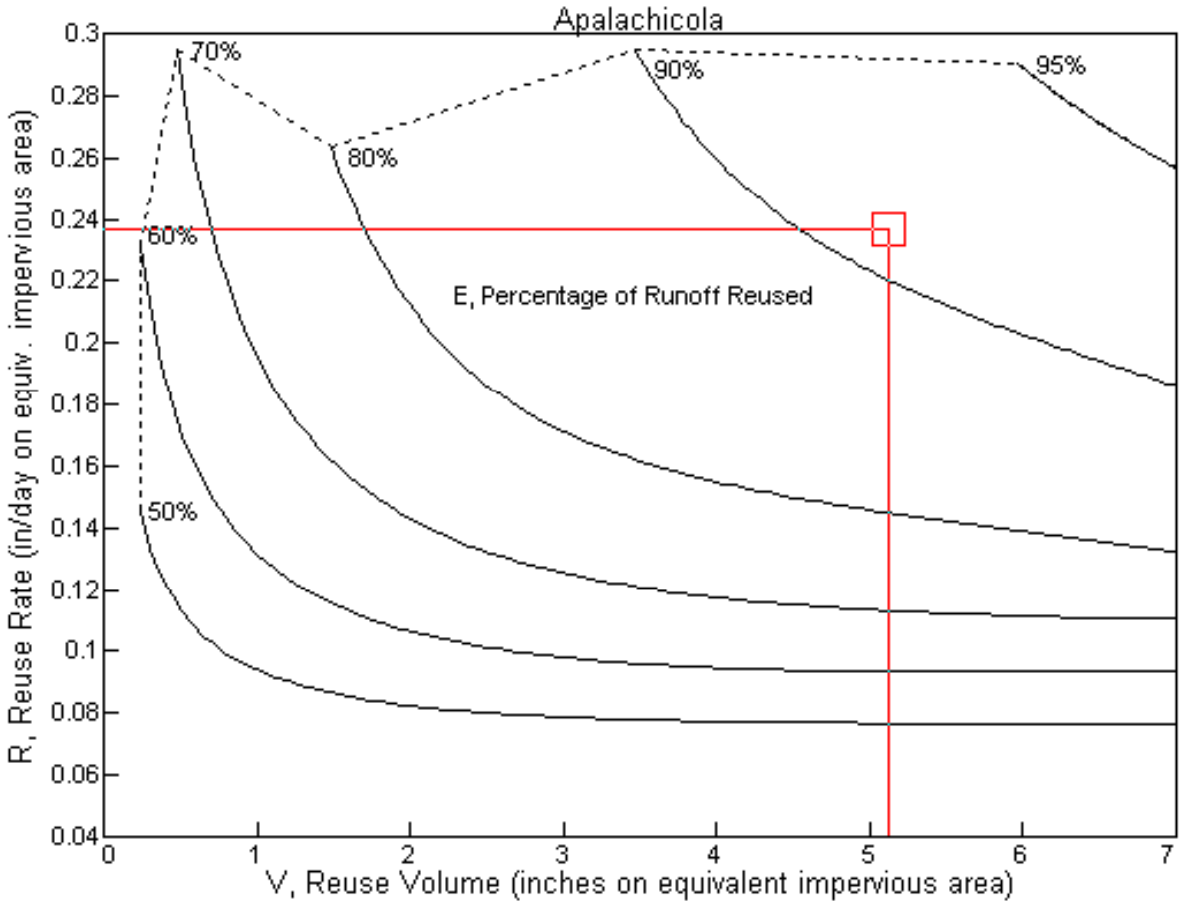
Reuse Rate (in/week): 1.054428

Efficiency (%): 90.75883

Storage Volume (ac-ft): 10.867

R	0.2366762	Lock
E	90.75883	Lock
V	5.122318	Lock

Recalculate



Example 1: Single Basin Dry Pond

100 acres of undeveloped land will be converted into a single family housing development.

Determine the size of dry pond needed to provide the required stormwater nutrient removal.

The site is located in Central Florida (SJRWMD) with an average rainfall of 50 inches per year.

Example 1: Predevelopment Conditions

Basin Area = 100 acres

Land Use = Undeveloped / Rangeland / Forest *

Non-DCIA Curve Number = 65

DCIA = 0%

Note: At present, the intent of the stormwater regulations is to consider the predevelopment condition to be undeveloped land, i.e., natural conditions, regardless of the past land use (for example, pasture, agricultural land, etc.). This condition may or may not become part of the final regulations, so consult the final regulations when available.

Example 1: Postdevelopment Conditions

Basin Area = 90 acres *

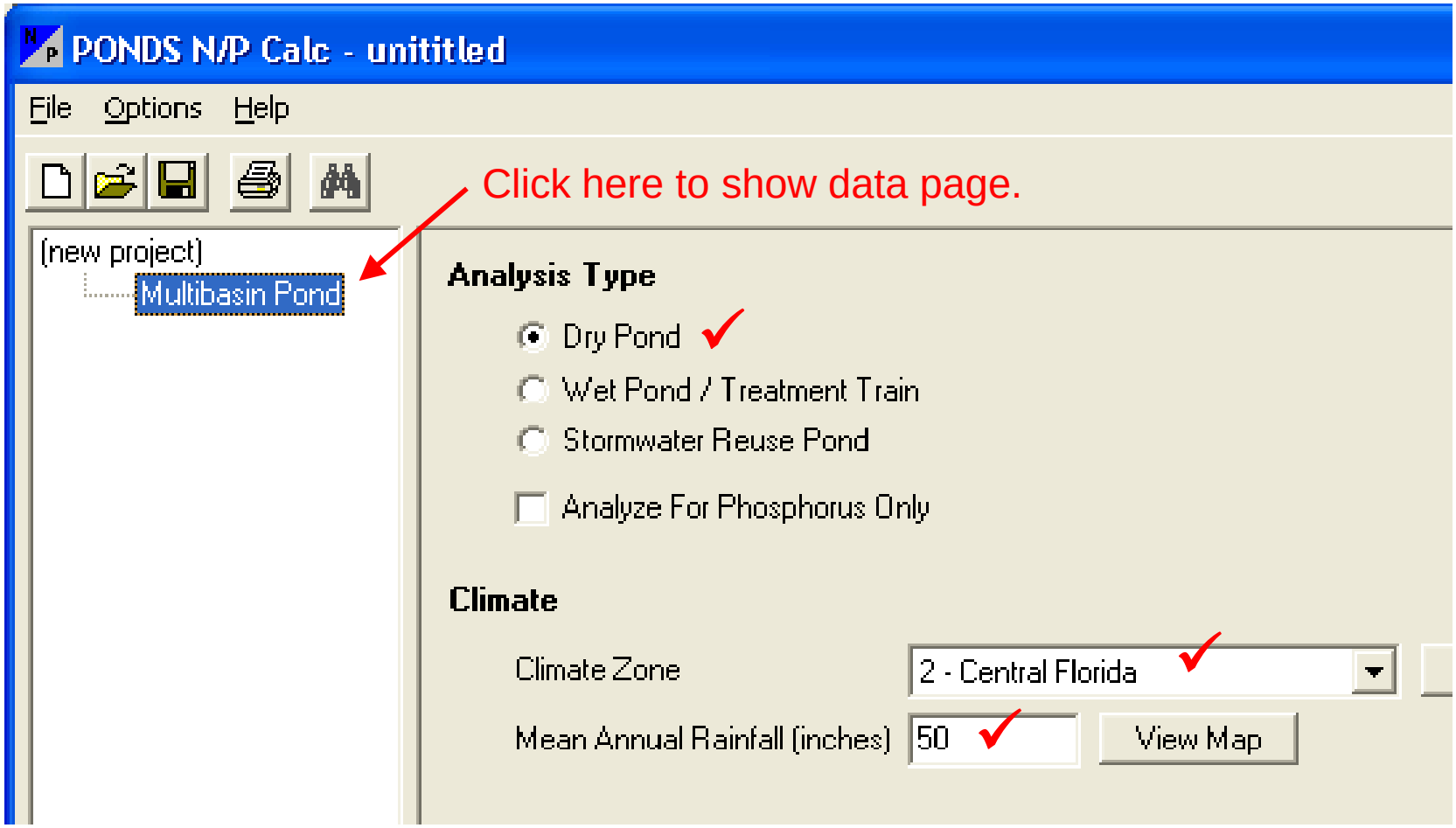
Land Use = Single Family

Non-DCIA Curve Number = 65

DCIA = 35%

Note that the postdevelopment basin area is less than the predevelopment basin area in this example. This is because the stormwater pond itself is not counted in the runoff-producing area. As a starting point, we have assumed a 10 acre pond.

Example 1: Single Basin Dry Pond, Step 1



Example 1: Single Basin Dry Pond, Step 2

Predevelopment Basins ☐ Show Details

✓ Number Of Runoff Basins: 1

	Area (acres)	CN	DCIA (%)	Land Use
✓ 1	100	65	0	Undeveloped / Rangeland / Forest

✓ Non-Runoff Producing Areas (acres): 0

Total Predevelopment Area (acres): 100

Postdevelopment Basins ☐ Show Details

✓ Number Of Runoff Basins: 1

	Area (acres)	CN	DCIA (%)	Land Use
✓ 1	90	65	35	Single-Family

✓ Non-Runoff Producing Areas (acres): 10 (Includes pond area.)

Total Postdevelopment Area (acres): 100

Example 1A: Single Basin Dry Pond, Results

Results

Required Nitrogen Removal Efficiency (%)	91.66369
Required Phosphorous Removal Efficiency (%)	97.47617
Design Efficiency (%)	97.47617
Required Retention Depth (inches)	2.488087

In an average year, the pond must retain and infiltrate 97.5% of the total runoff from the site.

Required Pond Storage Volume = 2.49 in x 90 acres = 18.7 ac-ft

Example 2: Single Basin Wet Pond

Given the same conditions as in Example 1, what is the required configuration for a wet/dry treatment train pond system.

Example 2: Basin Parameters

Predevelopment

Basin Area = 100 acres

Land Use = Undeveloped / Rangeland / Forest *

Non-DCIA Curve Number = 65

DCIA = 0%

Postdevelopment

Basin Area = 90 acres

Land Use = Single Family

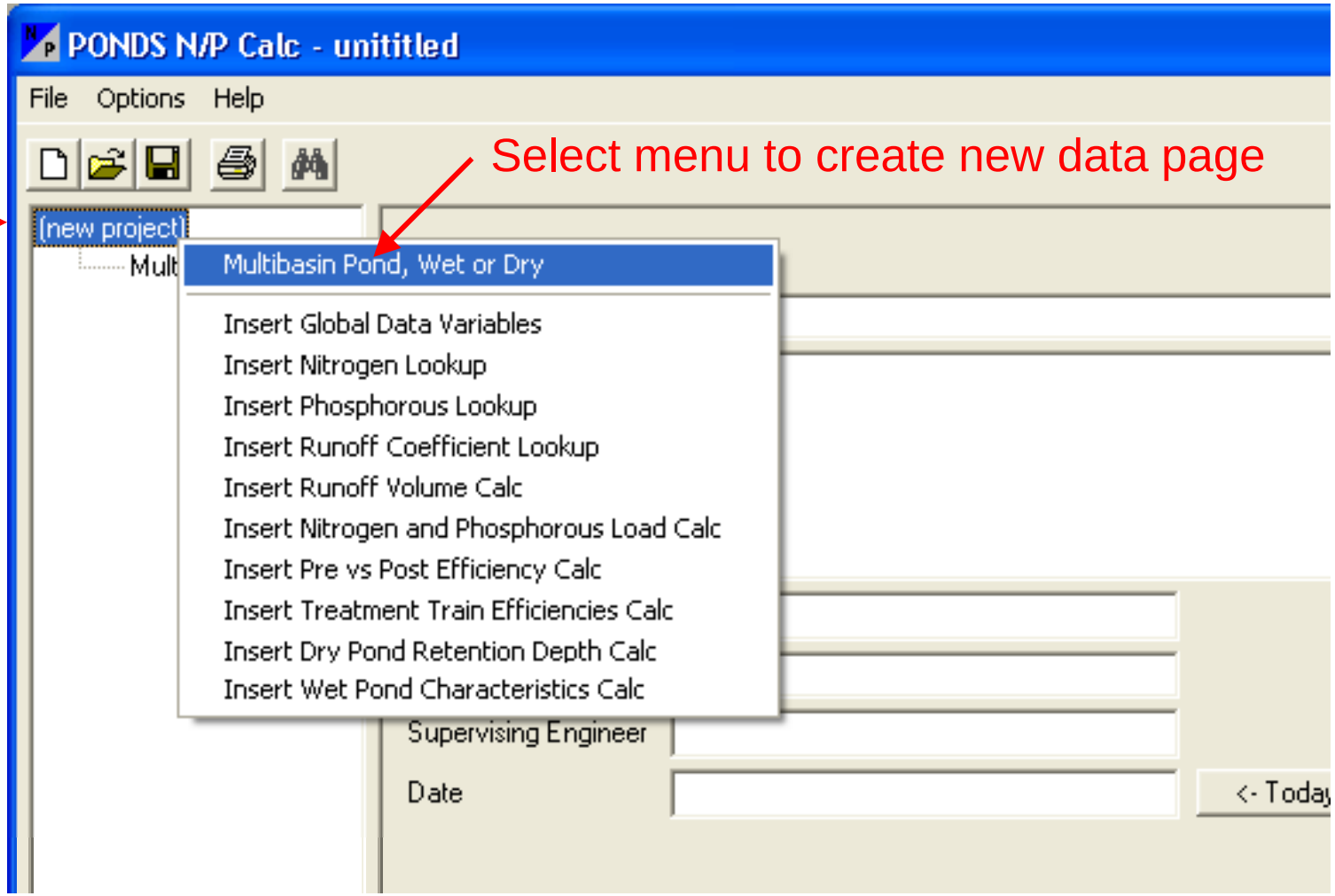
Non-DCIA Curve Number = 65

DCIA = 35%

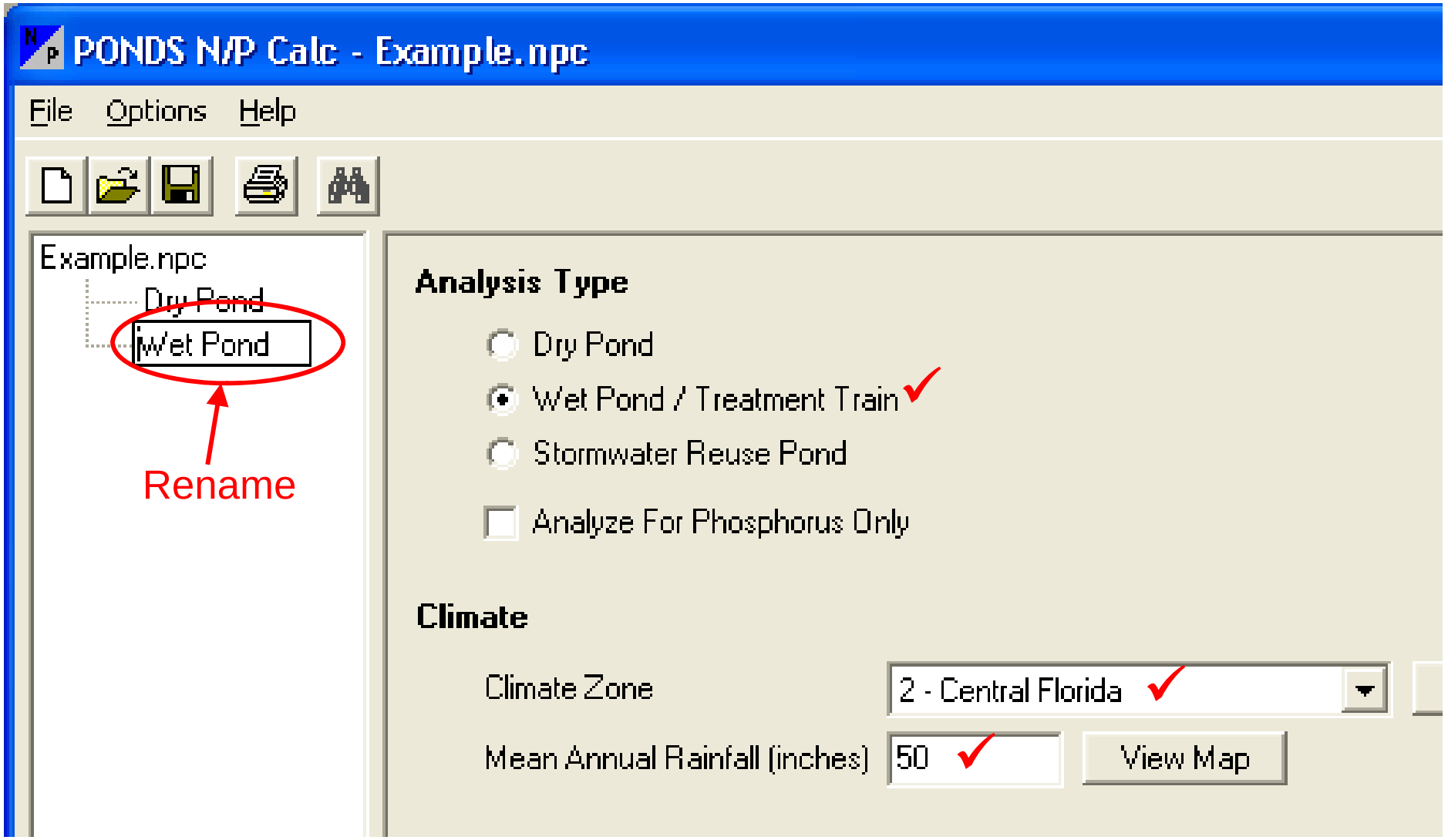
Wet Pond Residence Time = 200 days

Example 2: Single Basin Wet Pond, Step 1

Right click here for menu



Example 2: Single Basin Wet/Train, Step 2



Example 2: Single Basin Wet/Train, Step 3

Predevelopment Basins ☐ Show Details

✓ Number Of Runoff Basins: 1

	Area (acres)	CN	DCIA (%)	Land Use
✓ 1	100	65	0	Undeveloped / Rangeland / Forest

✓ Non-Runoff Producing Areas (acres): 0

Total Predevelopment Area (acres): 100

Postdevelopment Basins ☐ Show Details

✓ Number Of Runoff Basins: 1

	Area (acres)	CN	DCIA (%)	Land Use
✓ 1	90	65	35	Single-Family

✓ Non-Runoff Producing Areas (acres): 10 (Includes pond area.)

Total Postdevelopment Area (acres): 100

Example 2: Single Basin Wet/Train, Step 4

Wet Pond Input

Residence Time (days) 200 ✓

Anoxic Depth Reduction Factor 0.75 ✓ (0.75 is current recommendation from FDEP)

☑ Limit Maximum Phosphorous Removal Efficiency to Agency Specified Maximum: 64.5 ✓ %

For SJRWMD

Treatment Train Summary Results

	Req. Total	Avail. Wet	Pre-treatment
Nitrogen Removal Efficiency (%)	91.66369	42.81241	85.42287
Phosphorous Removal Efficiency (%)	97.47617	64.5	92.89063

Required Permanent Pool Volume of Wet Pond (ac-ft)	4.543178
Estimated Anoxic Depth of Wet Pond (ft)	7.175991

Wet pond alone is not sufficient. Requires pre-treatment, such as a dry pond in series before the wet pond.

Example 2: Single Basin Wet/Train, Results

Dry Pond Pretreatment

Required Design Efficiency of Dry Pond (%)	92.89063
Required Retention Depth of Dry Pond (inches)	1.379837

1.38 in x 90 acre = 10.35 ac-ft

Wet Pond Properties

Annual Runoff Reaching Wet Pond (ac-ft)	8.2913
Required Permanent Pool Volume (ac-ft)	4.543178
Yearly Phosphorous Load (kg/yr)	3.344284
Wet Pond Phorphorous Removal Efficiency (%)	64.5
Annual Mass of Unremoved Phosphorous (kg/yr)	1.187221
Mean Phosphorous Concentration in Pond (µg/l)	74.99297
Estimated Chlorophyll-a Concentration (mg/m²)	37.85652
Estimated Sechi Disk Depth (ft)	2.670612
Estimated Anoxic Depth (ft)	7.175991

Example 2: Single Basin Wet/Train, Results

The wet pond is capable of removing 42.8 % of the nitrogen and 64.5% (capped for SJRWMD) of the phosphorous. Since this is less than the total efficiency required, pretreatment must be provided.

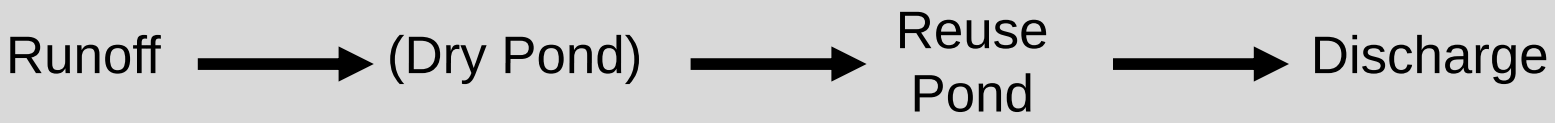
The pre-treatment must be capable of removing 85.4% of the nitrogen, and 92.9% of the phosphorous from the stormwater before it enters the wet pond.

If the pretreatment is provided by a dry pond (the usual case) then the dry pond must be sized to retain and infiltrate 1.38 inches multiplied by the contributing runoff basin area (90 acres).

The wet pond must provide at least 4.54 ac-ft of volume at a depth of 7.2 ft or less.

Example 3: Single Basin Stormwater Reuse Pond

Given the same conditions as in Example 1, what is the required configuration for a stormwater reuse pond.



Example 3: Basin Parameters

Predevelopment

Basin Area = 100 acres

Land Use = Undeveloped / Rangeland / Forest *

Non-DCIA Curve Number = 65

DCIA = 0%

Postdevelopment

Basin Area = 90 acres

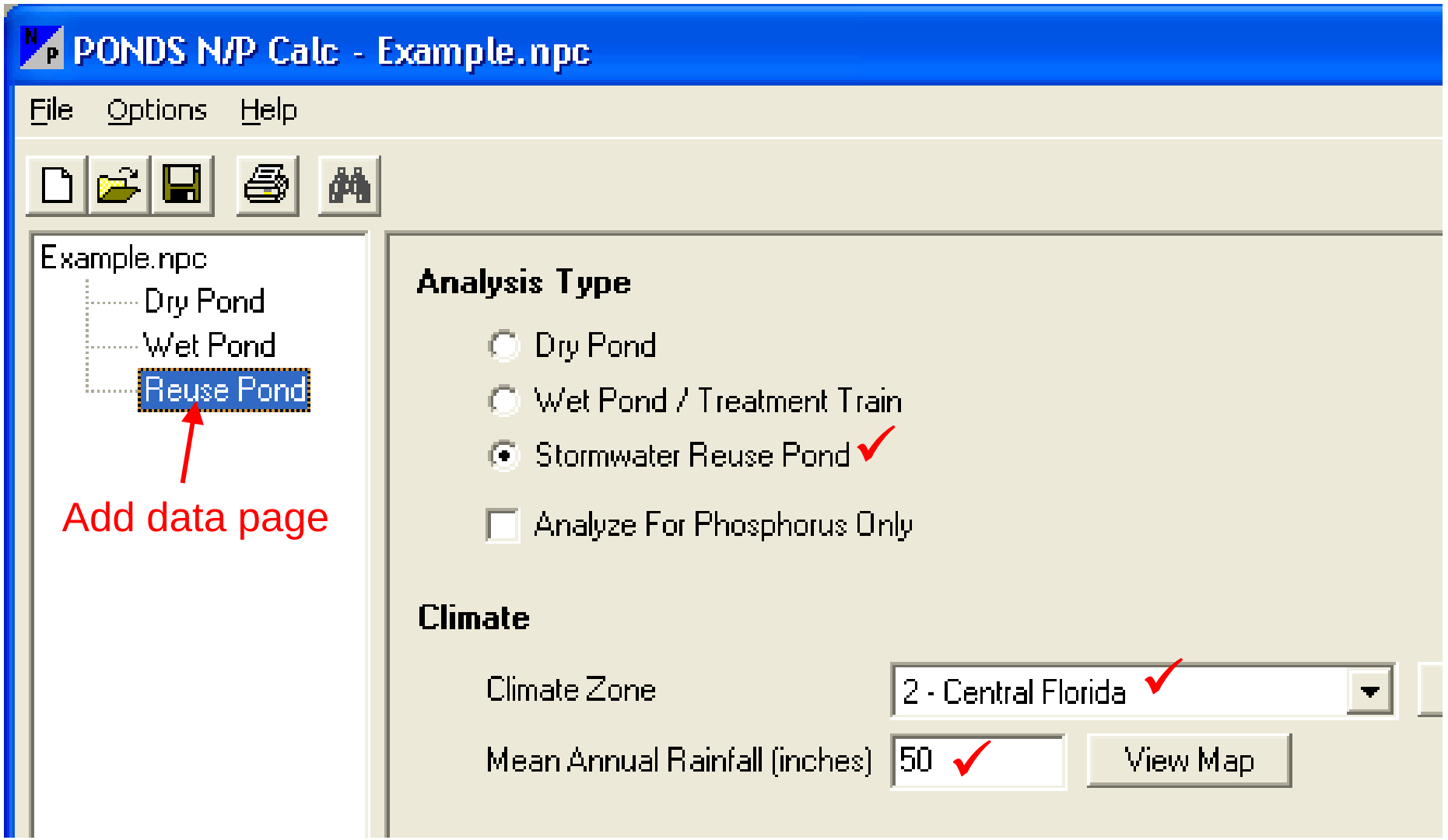
Land Use = Single Family

Non-DCIA Curve Number = 65

DCIA = 35%

Irrigated Area = 30 acres

Example 3: Stormwater Reuse Pond, Step 1



Example 3: Stormwater Reuse Pond, Step 2

Predevelopment Basins ☐ Show Details

✓ Number Of Runoff Basins: 1

	Area (acres)	CN	DCIA (%)	Land Use
✓ 1	100	65	0	Undeveloped / Rangeland / Forest

✓ Non-Runoff Producing Areas (acres): 0

Total Predevelopment Area (acres): 100

Postdevelopment Basins ☐ Show Details

✓ Number Of Runoff Basins: 1

	Area (acres)	CN	DCIA (%)	Land Use
✓ 1	90	65	35	Single-Family

✓ Non-Runoff Producing Areas (acres): 10 (Includes pond area.)

Total Postdevelopment Area (acres): 100

Example 3: Stormwater Reuse Pond, Step 3

Stormwater Reuse

Click here.

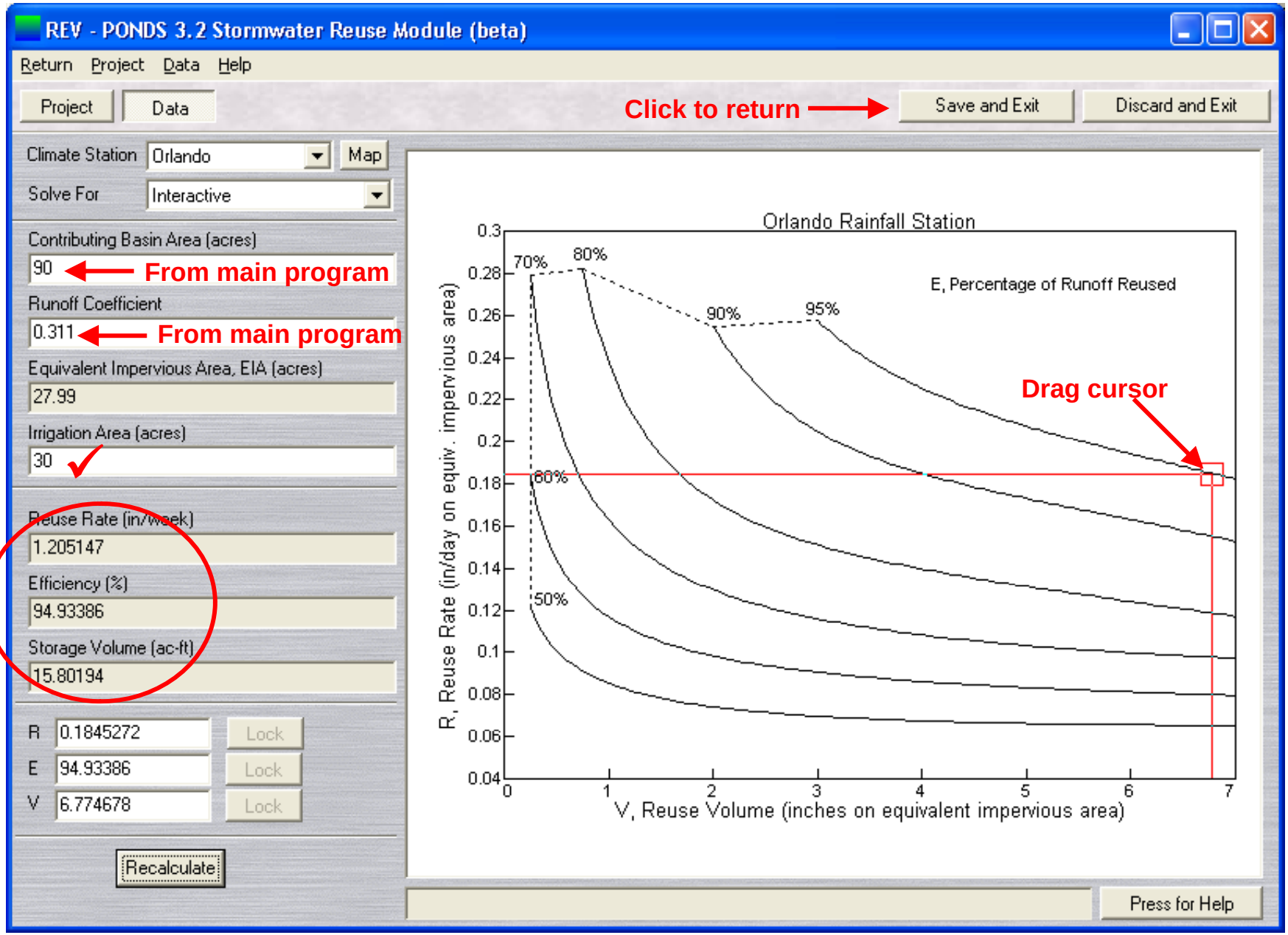
Solve Using REV

Reuse Rate (gpd)	
Efficiency (%)	
Stormwater Reuse Volume (ac-ft)	

Treatment Train Summary Results

	Req. Total	Avail. Wet	Pre-treatment
Nitrogen Removal Efficiency (%)	91.66369		
Phosphorous Removal Efficiency (%)	97.47617		

Example 3: Stormwater Reuse Pond, Step 4



Example 3: Stormwater Reuse Pond, Step 5

Stormwater Reuse

Solve Using REV

Reuse Rate (gpd)	140249.6
Efficiency (%)	94.93386
Stormwater Reuse Volume (ac-ft)	15.80194

From R-E-V module

Treatment Train Summary Results

	Req. Total	Avail. Wet	Pre-treatment
Nitrogen Removal Efficiency (%)	91.66369	94.93386	0
Phosphorous Removal Efficiency (%)	97.47617	94.93386	50.18242

Requires pretreatment

Dry Pond Pretreatment

Required Design Efficiency of Dry Pond (%)	50.18242
Required Retention Depth of Dry Pond (inches)	0.2417265

Required Dry Pond Volume = 0.24 in x 90 acres = 1.81 ac-ft