FDEP Statewide Stormwater Rule Applications of the Handbook

PREPARED FOR

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New FDEP Stormwater Rule

for Stormwater Treatment

New stormwater regulations will mandate:

- An 85% reduction of post-development nutrient loading, or
- No net increase in post-development nutrient loading compared to predevelopment (natural vegetative community), i.e., Post <= Pre

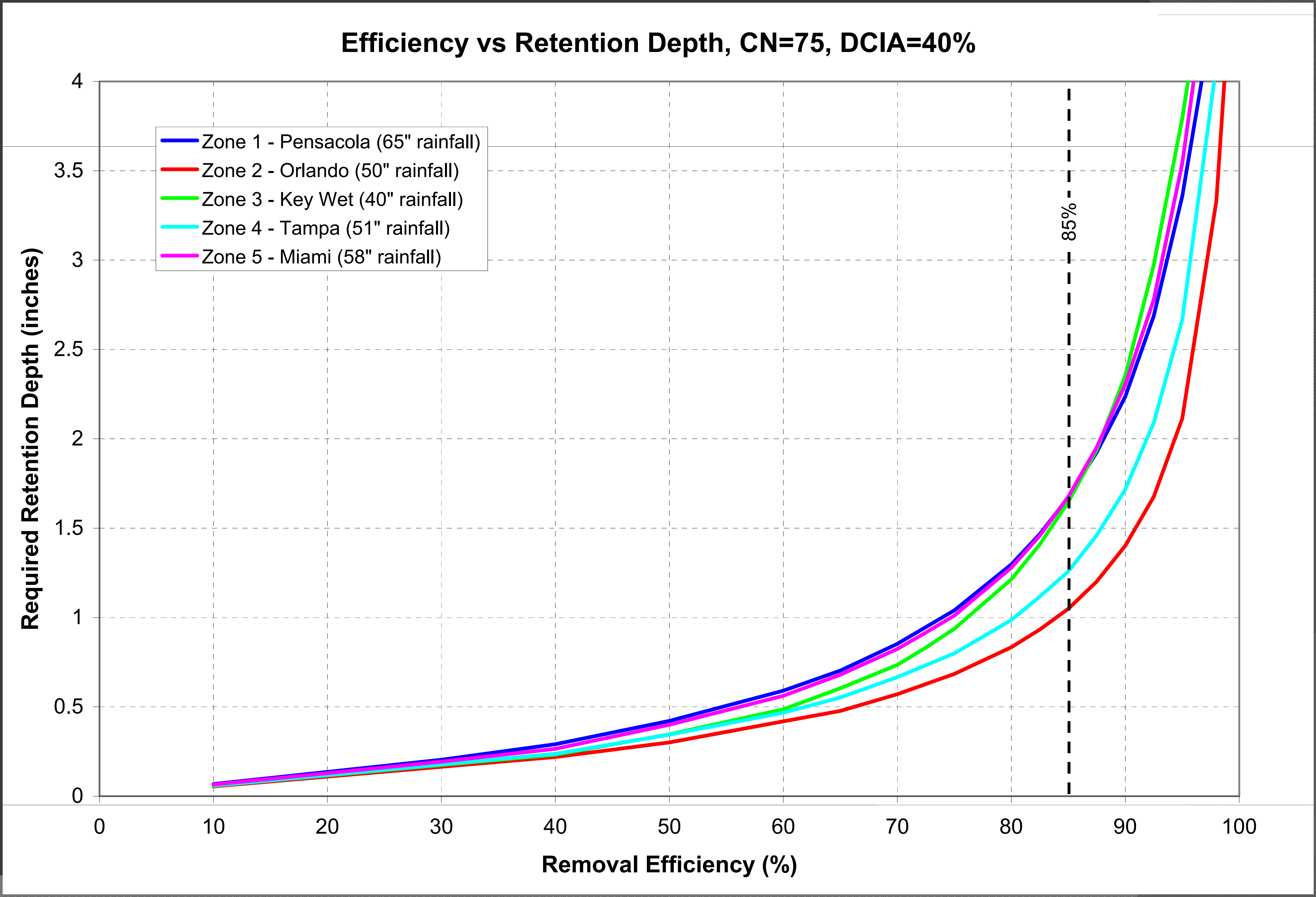
Calculations based on average annual nutrient loading (N & P), in kilograms per year.

Predevelopment is not the same as existing conditions. Visualize current site with a natural land cover condition, as if no clearing or earthwork had been done.

Stormwater Treatment Performance Standards

	REDEVELOPMENT SITES ≤ 2 ACRES	ALL OTHER ACTIVITIES
NON-OFWs	85% or Post = Pre, whichever is less, Unless feasibility analysis demonstrates lower level is appropriate	85% or Post = Pre, whichever is less
OFW	Post = Pre, Unless feasibility analysis demonstrates lower level is appropriate	Post = Pre
IMPAIRED WATERS	85% or Post = Pre, whichever is less, Unless feasibility analysis demonstrates lower level is appropriate AND Net Improvement for pollutant not meeting water quality standards	85% or Post = Pre, whichever is less, OR, if the water body is an OFW Post = Pre AND In either case net improvement for the pollutant not meeting water quality standards
IMPAIRED WATERS WITH ADOPTED TMDL OR BMAP	85% or Post = Pre, whichever is less, Unless feasibility analysis demonstrates lower level is appropriate AND Net improvement or TMDL/BMAP % reduction, whichever is greater, pollutant not meeting water quality standards	85% or Post = Pre, whichever is less, Or, if the water body is an OFW Post=Pre AND In either case net improvement or TMDL/BMAP % reduction, whichever is greater, for the pollutant not meeting water quality standards

The Problem With Achieving High Efficiencies (Dry Pond)



Dry Pond Example, Required Retention Depth

For Type A soils in Central Florida

Development Type	Curve Number	DCIA	Existing SJRWMD Rule, Retention Depth (in)	85% Reduction FDEP Rule, Retention Depth (in)	Post = Pre FDEP Rule, Retention Depth (in)
Low Density Residential	43.8	7.5	1	0.3	1.3
Single Family	48.4	22.8	1	0.5	3.1
Multi-Family	68.1	66.4	1.5	1.2	4+
High Intensity Commercial	66.9	81	1.6	1.4	4+

Notes:

1. Existing SJRWMD calculated for online treatment.
2. Post = Pre calculated using predevelopment Event Mean Concentration, for generic Undeveloped/Rangeland/Forrest.

Dry Pond Example, Required Retention Depth

For Type B soils in Central Florida

Development Type	Curve Number	DCIA	Existing SJRWMD Rule, Retention Depth (in)	85% Reduction FDEP Rule, Retention Depth (in)	Post = Pre FDEP Rule, Retention Depth (in)
Low Density Residential	64	7.5	1	0.7	1.1
Single Family	66.9	22.8	1	0.8	2.4
Multi-Family	79.3	66.4	1.5	1.4	4+
High Intensity Commercial	78.5	81	1.6	1.5	4+

Notes:

1. Existing SJRWMD calculated for online treatment.
2. Post = Pre calculated using predevelopment Event Mean Concentration, for generic Undeveloped/Rangeland/Forrest.

Dry Pond Example, Required Retention Depth

For Type C soils in Central Florida

Development Type	Curve Number	DCIA	Existing SJRWMD Rule, Retention Depth (in)	85% Reduction FDEP Rule, Retention Depth (in)	Post = Pre FDEP Rule, Retention Depth (in)
Low Density Residential	75.9	7.5	1	1.0	1.0
Single Family	77.8	22.8	1	1.1	1.4
Multi-Family	85.9	66.4	1.5	1.5	4+
High Intensity Commercial	85.4	81	1.6	1.6	4+

Notes:

1. Existing SJRWMD calculated for online treatment.
2. Post = Pre calculated using predevelopment Event Mean Concentration, for generic Undeveloped/Rangeland/Forrest.

Dry Pond Example, Required Retention Depth

For Type D soils in Central Florida

Development Type	Curve Number	DCIA	Existing SJRWMD Rule, Retention Depth (in)	85% Reduction FDEP Rule, Retention Depth (in)	Post = Pre FDEP Rule, Retention Depth (in)
Low Density Residential	81.5	7.5	1	1.2	1.0
Single Family	82.9	22.8	1	1.2	1.9
Multi-Family	88.9	66.4	1.5	1.5	3.6
High Intensity Commercial	88.5	81	1.6	1.6	3.4

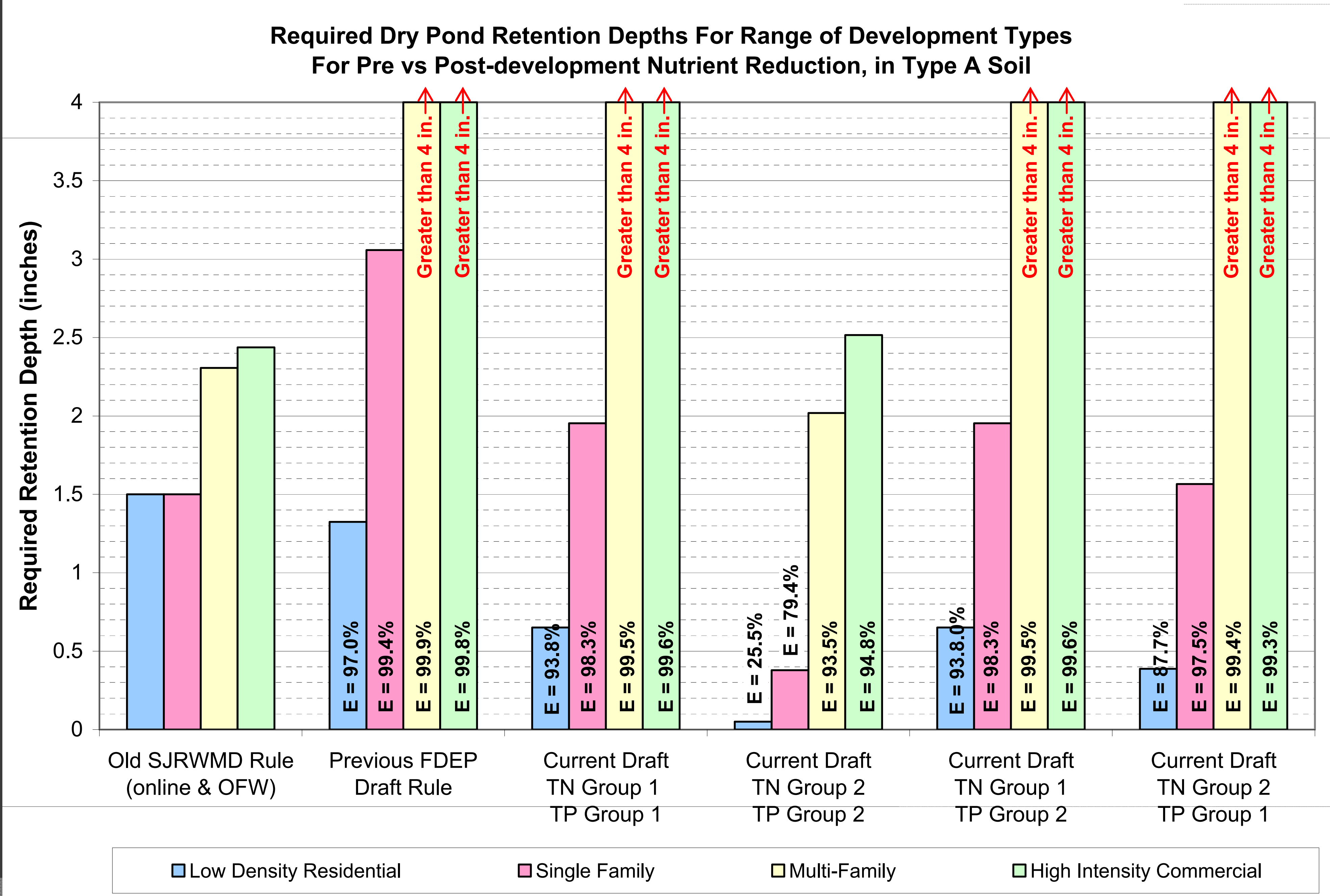
Notes:

1. Existing SJRWMD calculated for online treatment.
2. Post = Pre calculated using predevelopment Event Mean Concentration, for generic Undeveloped/Rangeland/Forrest.

Examples of Predevelopment Areal Loading Groups

TN 1 & TP 1	TN 2 & TP 2	TN 1 & TP 2	TN 2 & TP 1
Sand Pine Scrub in Astatula Soil (Type A)	Oak Hammock in Tavares Soil (Type A)	South Florida Flatwoods in Myakka Soil (Type B/D)	Turkey Oak in Candler Soil (Type A)
Long Leaf Pine in Candler Soil (Type A)	Cypress Swamp in Pomello Soil (Type C)	South Florida Flatwoods in Smyrna Soil (Type B/D)	Turkey Oak in Lake Soil (Type A)
Longleaf Pine in Lake Soil (Type A)	Swamp Hardwoods in Pomello Soil (Type C)	North Florida Coastal Strand in Canaveral Soil (Type C)	Turkey Oak in Tavares Soil (Type A)
Longleaf Pine in Tavares Soil (Type A)	Cypress Swamp in Bassinger, depr. Soil (Type D)	South Florida Flatwoods in Immokalee Soil (Type B/D)	Upland Hardwood Hammock in Archer Soil (Type A)
Sand Pine Scrub in Pomello Soil (Type C)	Upland Hardwood Hammock in Apopka Soil (Type A)	North Florida Flatwoods in Leon Soil (Type B/D)	Mixed Hardwood in Ardilla Soil (Type B)

Example, Pre vs. Post-Development, Type A Soil



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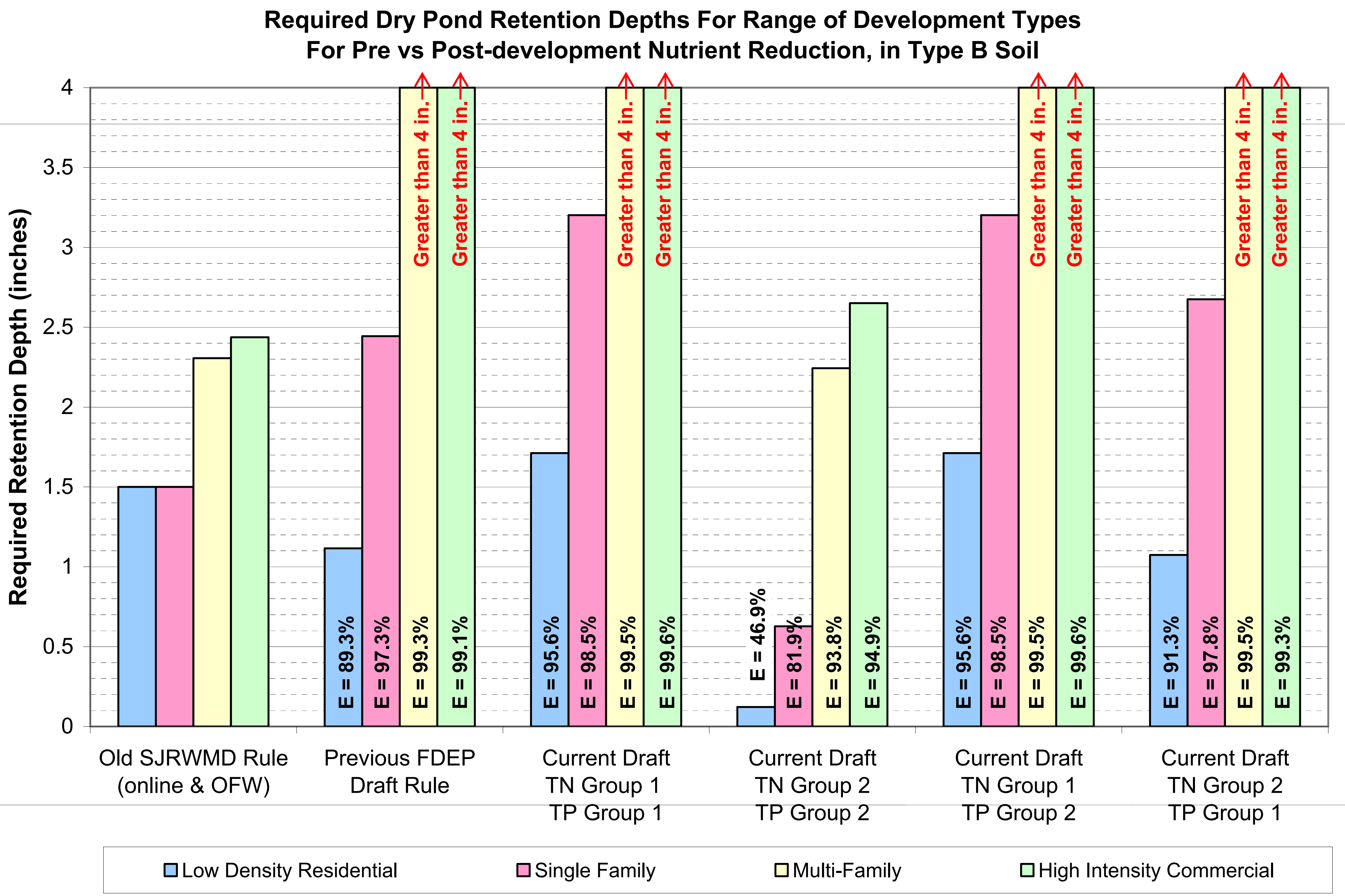
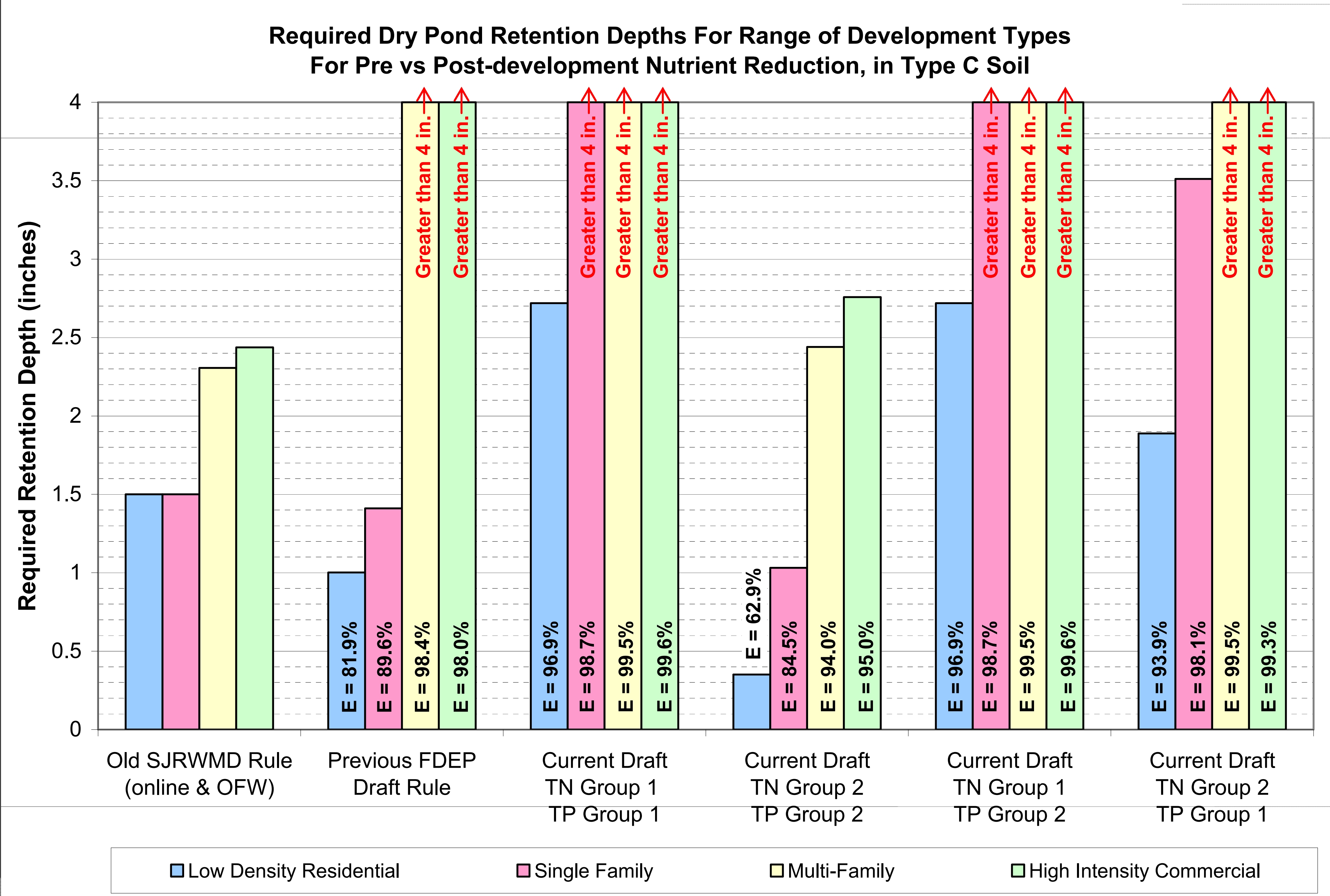
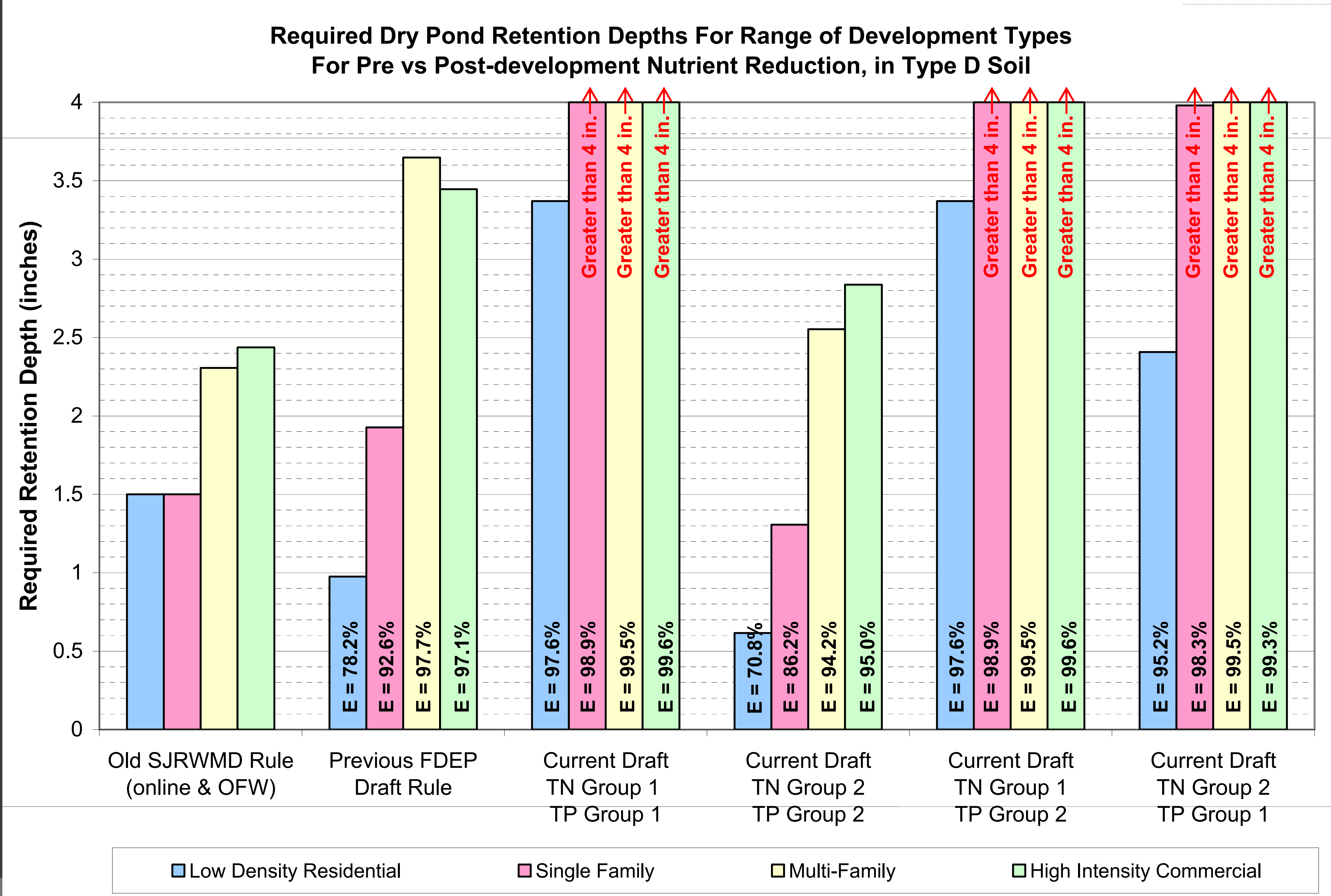
Example, Pre vs. Post-Development, Type B Soil



Example, Pre vs. Post-Development, Type C Soil

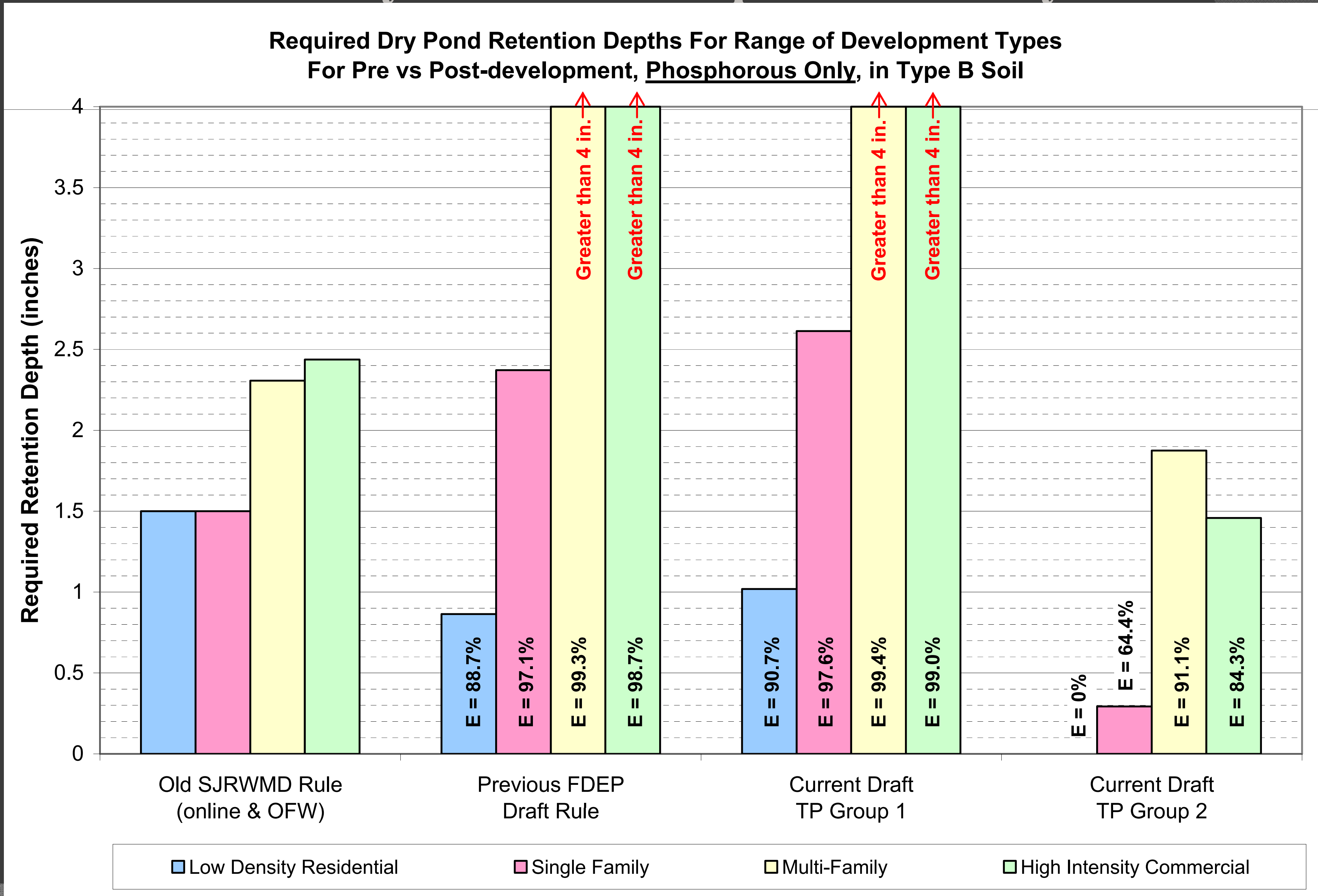


Example, Pre vs. Post-Development, Type D Soil



Example, Pre vs. Post-Development, Type D Soil

Analyzed For Phosphorous Only



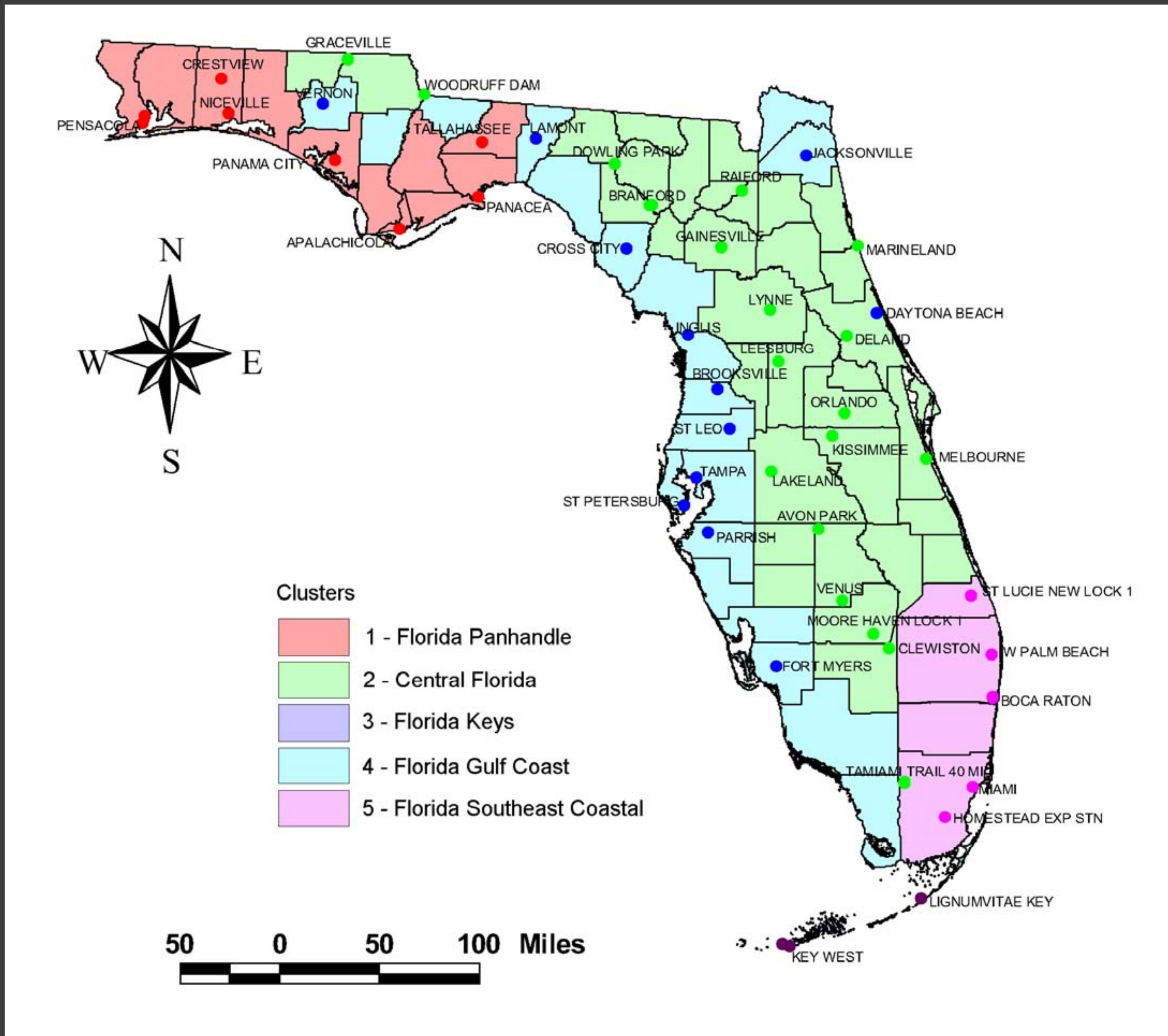
New Stormwater Rule Methodology

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

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

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

Climate Zones



Types of Pond Configurations

- Dry Pond
- Wet Pond
- Treatment Train
- Stormwater Harvesting
- Alternative BMPs:
    - Pervious Pavement
    - Underground storage and retention
    - Swales
    - Etc.

BMPs

Primary "Bread and Butter" BMPs
Dry Retention
Wet Detention
Wet Detention, wet detention with MAP/littoral credit
Underdrains
Stormwater Harvesting

Moderately Used, Passive BMPs
Swales (with & without blocks)
Vegetative Natural Buffers
Exfiltration Trenches
Underground Storage and Retention Systems
Underground Retention Vault/Chamber
Pervious Pavement
Low Impact Development

BMPs

Limited Use BMPs
Green Roofs Chemical Treatment Wetland Stormwater Treatment

Dead BMPS (no longer allowed)
Dry Detention Filtration

Differences Between Underground Systems

- Exfiltration trenches: a subsurface retention system consisting of perforated pipe surrounded by aggregate.
- Underground storage & retention: an underground storage system and “drainfield” which generally consist of lightweight, high strength modular units with “open” bottoms not intended to have human access for maintenance.
- Underground retention vault/chamber: a “closed” underground hard structure with an “open” bottom; access port to allow for inspection and maintenance of the infiltrative surface.

Don't Be Intimated by the New Calculations - Software Demonstration

Video file must be downloaded separately from our website www.devoeng.com

Calculating Predevelopment Nutrient Loading

Step 1

Determine soil type and native vegetative community type, from which the stormwater rule vegetative group is determined. For example:

Soil Series	Vegetative Community	Stormwater Rule Vegetative Group TP	Stormwater Rule Vegetative Group TN
Adamsville	6 - South Florida Flatwoods	1	2
	11- Upland Hardwood Hammock	2	2
	15 - Oak Hammock	2	2
Alaga	5 - Mixed Hardwood / Pine	2/1	2/1
Alapaha	11 - Wetland Hardwood Hammock	2	2
etc.			

Calculating Predevelopment Nutrient Loading (cont'd.)

Step 2

Annual loading rates for natural vegetative communities are defined, by group, for each of the five climate zones.

Meteorological Zone	TP Load (kg/ac-inch-yr)		TN Load (kg/ac-inch-yr)	
	Group 1	Group 2	Group 1	Group 2
1	0.00025	0.00372	0.00131	0.01199
2	0.00015	0.00226	0.00064	0.00769
3	0.00023	0.00333	0.00141	0.00978
4	0.00016	0.00236	0.0008	0.00752
5	0.00027	0.00396	0.00157	0.01217

Annual pre-development loading rate is calculated by multiplying the areal loading rate (table above) times the area times the mean annual rainfall.

Note that the procedure for calculating pre-development nutrient loading has changed from what is presented in earlier drafts of the stormwater rule.

Note on Predevelopment Loading

In previous draft versions of the proposed FDEP stormwater rule, the predevelopment nutrient loading was calculated in the same manner as the postdevelopment nutrient loading.

Note that the procedure proposed for calculating predevelopment nutrient loading in the March 2010 Stormwater Applicant's handbook is under review, and may be subject to change in the final stormwater rule.

Calculating Postdevelopment Nutrient Loading

Postdevelopment nutrient loading is based on Event Mean Concentration (EMC) of runoff volume:

Land Use Category	Event Mean Concentration (mg/l) Total Nitrogen	Event Mean Concentration (mg/l) Total Phosphorous
Low-Density Residential	1.5	0.18
Single Family	1.85	0.31
Multi-Family	1.91	0.48
Low-Intensity Commercial	0.93	0.16
High-Intensity Commercial	2.48	0.23
Light Industrial	1.14	0.23
Highway	1.37	0.17
Agricultural		
Pasture	2.48	0.70
Citrus	2.31	0.16
Row Crops	2.47	0.51
General Agriculture	2.42	0.46
Mining/Extractive	1.18	0.15

Calculating Postdevelopment Nutrient Loading (cont'd.)

Annual mass loading is calculated as:

Annual Mass Loading = EMC x Annual Runoff Volume

Mean annual runoff coefficients are provided in design tables in Appendix E of the FDEP stormwater handbook, based on climate zone, curve number and DCIA.

Annual runoff volume is calculated as:

$$Q = C\ I\ A$$

Where:

Q = Annual Runoff Volume
C = Mean Annual Runoff Coefficient
I = Annual Rainfall
A = Contributing Basin Area

Design Table For Annual Runoff Coefficient (Example)

From Appendix E of FDEP stormwater handbook (March 2010 draft)

Zone 1

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

NDCIA	Percent DCIA																				
CN	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

DRY PONDS

Dry Ponds - Efficiency

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

For a dry pond, the phosphorous removal efficiency is the same as the nitrogen removal efficiency, since it is based solely on the percentage of the runoff volume which is infiltrated.

Dry Pond Example 1

Calculate the required treatment volume for a dry pond to achieve 85% post-development removal efficiency, given the following:

- Climate Zone 2 (Central Florida)
- Runoff producing area = 90 acres
- DCIA = 20
- CN = 45

The required retention depth for 85% removal can be determined from design tables in Appendix D of the FDEP stormwater applicant's handbook (March 2010 draft). For Climate Zone 2, CN = 45 and DCIA=20%, the required retention depth is 0.44 inches. This retention depth is multiplied by the runoff producing area to calculate the required treatment volume:

Treatment Volume = 0.44 inches x 90 acres / 12 = 3.3 ac-ft

Note that this calculation does not require the mean event concentration, or runoff volume to be specified.

Design Table For Required Dry Detention Depth for 85% Removal Efficiency (Example)

From Appendix D of the FDEP stormwater applicant's handbook (March 2010 draft).

Calculated Dry Retention Depth
For an Annual Mass Removal Efficiency of 85 Percent
Central (Zone 2)

NDCIA	Percent DCIA																		
CN	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	0.24	0.29	0.40	0.46	0.54	0.63	0.71	0.79	0.88	0.96	1.04	1.13	1.21	1.29	1.38	1.46	1.55	1.63	1.72
35	0.24	0.31	0.41	0.47	0.55	0.64	0.72	0.80	0.89	0.96	1.05	1.13	1.21	1.30	1.38	1.46	1.55	1.63	1.72
40	0.26	0.34	0.43	0.48	0.57	0.66	0.72	0.81	0.90	0.97	1.06	1.14	1.22	1.30	1.39	1.47	1.55	1.64	1.72
45	0.30	0.38	0.44	0.50	0.59	0.67	0.74	0.83	0.91	0.98	1.07	1.15	1.23	1.31	1.39	1.47	1.55	1.64	1.72
50	0.38	0.42	0.47	0.54	0.62	0.69	0.76	0.85	0.92	1.00	1.08	1.16	1.24	1.32	1.40	1.48	1.56	1.64	1.72
55	0.49	0.48	0.52	0.59	0.66	0.72	0.79	0.87	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.48	1.56	1.64	1.72
60	0.62	0.58	0.60	0.65	0.70	0.76	0.84	0.91	0.97	1.05	1.12	1.19	1.27	1.34	1.42	1.49	1.57	1.64	1.72
65	0.78	0.72	0.71	0.73	0.77	0.83	0.89	0.95	1.01	1.08	1.15	1.22	1.29	1.36	1.43	1.50	1.57	1.65	1.72
70	0.94	0.86	0.84	0.85	0.87	0.91	0.96	1.01	1.07	1.13	1.19	1.25	1.32	1.38	1.45	1.51	1.58	1.65	1.72
75	1.10	1.03	0.99	0.98	0.99	1.02	1.05	1.09	1.14	1.19	1.24	1.30	1.36	1.41	1.47	1.53	1.59	1.66	1.72
80	1.26	1.19	1.15	1.14	1.14	1.15	1.17	1.20	1.23	1.27	1.31	1.36	1.41	1.45	1.50	1.56	1.61	1.66	1.72
85	1.41	1.35	1.32	1.30	1.29	1.30	1.31	1.32	1.35	1.37	1.40	1.43	1.47	1.51	1.55	1.59	1.63	1.67	1.72
90	1.54	1.51	1.48	1.47	1.46	1.46	1.46	1.47	1.48	1.49	1.51	1.53	1.55	1.57	1.60	1.63	1.66	1.69	1.72
95	1.65	1.64	1.63	1.62	1.62	1.62	1.62	1.62	1.62	1.63	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.72
98	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.69	1.69	1.69	1.69	1.69	1.70	1.70	1.70	1.71	1.71	1.72

Dry Pond Example 2

Calculate the efficiency of a dry pond with a known storage volume, given:

- Climate Zone 2 (Central Florida)
- Runoff producing area = 100 acres
- DCIA = 40%
- CN = 75
- Pond Volume = 4.1667 ac-ft

Appendix F of the FDEP stormwater applicants handbook contains efficiency tables for dry ponds, for a range of retention depths, based on climate zone, curve number and DCIA. (Interpolate between tables as necessary.)

Retention Depth = 4.1667 ac-ft / 100 acres / 12 = 0.5 inches

From the design tables in Appendix F, for a retention depth of 0.5 inches, CN=75 and DCIA = 40%, the **removal efficiency for the dry pond is 66.9%**

Design Table For Efficiency of Dry Pond of Known Retention Depth

Mean Annual Mass Removal Efficiencies (%) for 0.50-inches of Retention for Zone 2

NDCIA	Percent DCIA																	
CN	0-15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	94.8	91.7	87.9	83.8	79.7	75.7	71.9	68.4	65.2	62.1	59.4	56.9	54.5	52.3	50.3	48.4	46.7	45.1
35	93.8	90.9	87.3	83.4	79.3	75.4	71.7	68.3	65.0	62.1	59.3	56.8	54.4	52.3	50.3	48.4	46.7	45.1
40	92.5	89.9	86.5	82.7	78.9	75.1	71.4	68.0	64.9	61.9	59.2	56.7	54.4	52.2	50.2	48.4	46.7	45.1
45	90.9	88.6	85.5	81.9	78.2	74.6	71.1	67.7	64.6	61.7	59.1	56.6	54.3	52.2	50.2	48.4	46.7	45.1
50	88.9	87.0	84.2	80.9	77.4	73.9	70.5	67.3	64.3	61.5	58.9	56.5	54.2	52.1	50.2	48.3	46.6	45.1
55	86.4	84.9	82.6	79.6	76.4	73.1	69.9	66.8	63.9	61.2	58.6	56.3	54.1	52.0	50.1	48.3	46.6	45.1
60	83.4	82.5	80.6	78.0	75.1	72.1	69.1	66.1	63.4	60.8	58.3	56.0	53.9	51.9	50.0	48.2	46.6	45.1
65	79.8	79.5	78.1	76.0	73.5	70.7	68.0	65.3	62.7	60.2	57.9	55.7	53.6	51.7	49.9	48.2	46.6	45.1
70	76.0	76.0	75.2	73.5	71.4	69.1	66.6	64.2	61.8	59.5	57.3	55.3	53.3	51.4	49.7	48.1	46.5	45.1
75	71.9	71.9	71.5	70.4	68.8	66.9	64.9	62.7	60.6	58.6	56.6	54.7	52.8	51.1	49.5	47.9	46.5	45.1
80	67.3	67.3	67.2	66.5	65.5	64.1	62.5	60.8	59.0	57.3	55.5	53.9	52.2	50.7	49.2	47.7	46.4	45.1
85	62.3	62.3	62.3	62.0	61.3	60.4	59.3	58.1	56.8	55.4	54.0	52.7	51.3	50.0	48.7	47.4	46.2	45.1
90	56.8	56.8	56.8	56.7	56.4	55.9	55.2	54.5	53.6	52.8	51.8	50.9	49.9	48.9	47.9	46.9	46.0	45.1
95	50.8	50.8	50.8	50.8	50.6	50.4	50.2	49.9	49.5	49.1	48.7	48.2	47.7	47.2	46.7	46.1	45.6	45.1
98	47.7	47.6	47.6	47.5	47.4	47.2	47.1	46.9	46.8	46.6	46.5	46.3	46.1	45.9	45.7	45.5	45.3	45.1

Dry Pond Example 3

Calculate the required dry pond treatment volume to meet Post = Pre, for the following:

- Climate Zone = 2 (Central Florida)
- Annual Rainfall = 50 inches/yr

Predevelopment

- Runoff Producing Area = 100 acres (undeveloped)
- Soil Type = Candler (HSG A)
- Vegetative Community = Turkey Oak
- Stormwater Rule Vegetation Group

  Total Nitrogen, Group 1 = 0.00064 kg/ac-in-yr
  Total Phosphorous, Group 2 = 0.00226 kg/ac-in-yr

Annual TN Load = 0.00064 kg/ac-in-yr x 100 acres x 50 inches = 3.2 kg

Annual TP Load = 0.00226 kg/ac-in-yr x 100 acres x 50 inches = 11.3 kg

Dry Pond Example 3 (cont'd.)

Postdevelopment

- Runoff Producing Area = 90
- Stormwater Treatment Area = 10 acres
- CN = 45
- DCIA = 20%
- Single Family Residence

EMC for TN = 1.85 mg/l
EMC for TP = 0.31 mg/l

Calculate the annual postdevelopment runoff volume (Appendix E)

For Climate Zone 2, CN=45 and DCIA = 20%, the annual runoff coefficient is 0.170. Therefore, annual runoff is:

50 in/yr x 90 acres x 0.170 / 12 = 63.75 ac-ft/yr

Dry Pond Example 3 (cont'd.)

Calculate the annual postdevelopment nutrient loading

TN = 1.85 mg/l x 63.75 ac-ft/yr = 145.47 kg/yr
TP = 0.31 mg/l x 63.75 ac-ft/yr = 24.38 kg/yr

Calculate the required removal efficiency

TN = (145.47 kg/yr – 3.2 kg/yr) / 145.47 kg/yr = 97.8%
TP = (24.38 kg/yr - 11.3 kg/yr) / 24.38 kg/yr = 53.7 %

Required dry pond efficiency is 97.8%

Calculate the required retention depth

From Appendix F, for Climate Zone 2, CN =45 and DCIA = 20%, the required retention depth is 3.5 inches. The required treatment volume is therefore:

Treatment Volume = 3.5 inches x 90 acres / 12 = 25.25 ac-ft

Dry Pond Example 3 (cont'd.)

Check Assumptions

In this example, we have initially assumed that the stormwater ponds will occupy 10 acres of the developed site. Check to see whether this assumption is valid, given the required treatment volume and recovery requirements. Iterate as necessary.

Note:

Comparing Example 3 to Example 1 demonstrates the difficulty in achieving treatment levels greater than 85%:

Example	Treatment Level	Required Efficiency	Required Treatment Depth
Example 1	85%	85%	0.44 inches
Example 3	Post = Pre	97.8%	3.5 inches

Wet Ponds

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

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

Definition of Annual Residence Time

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

Example:

Pond Volume = 50 ac-ft

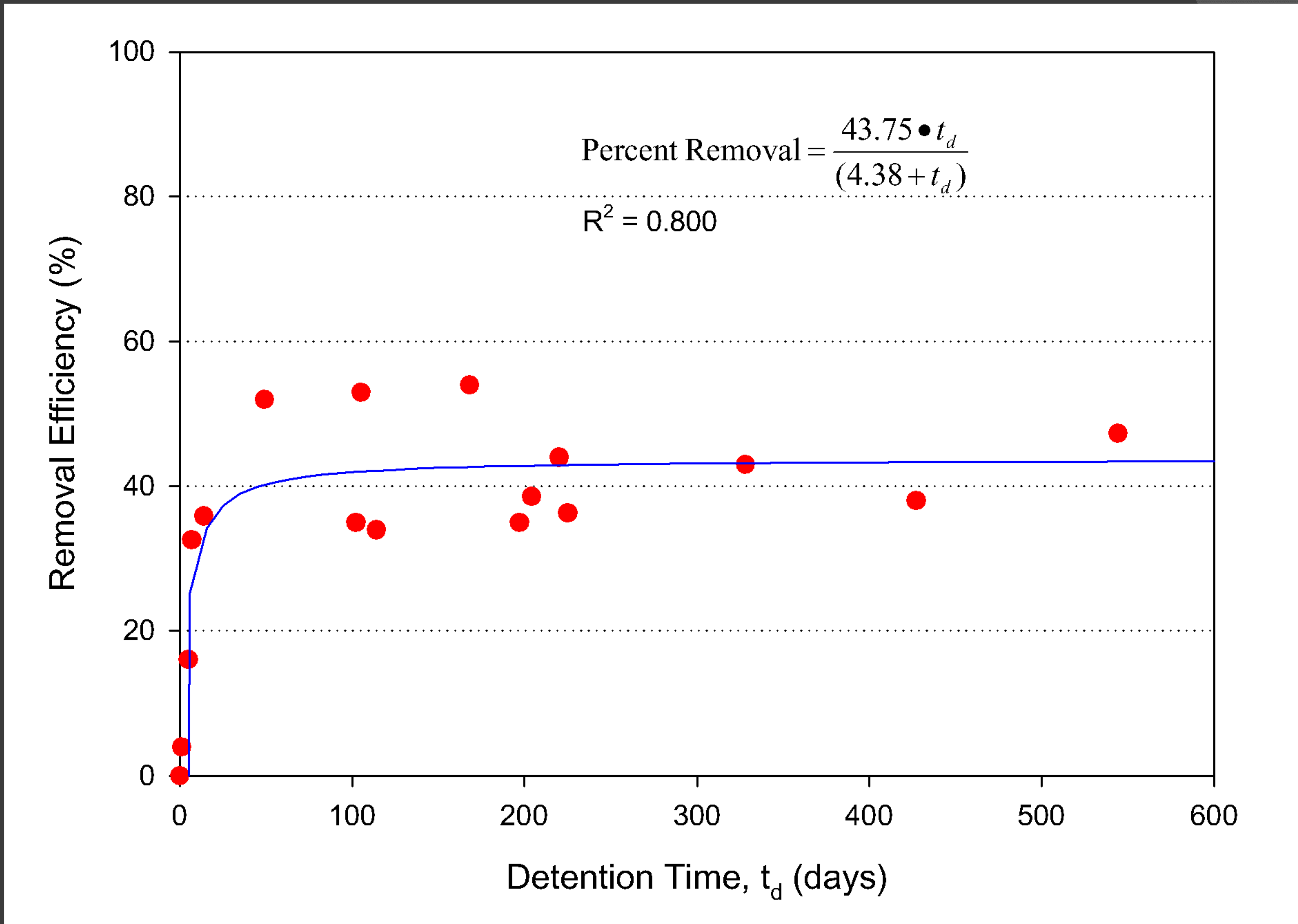
Yearly Runoff = 91.25 ac-ft/yr

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

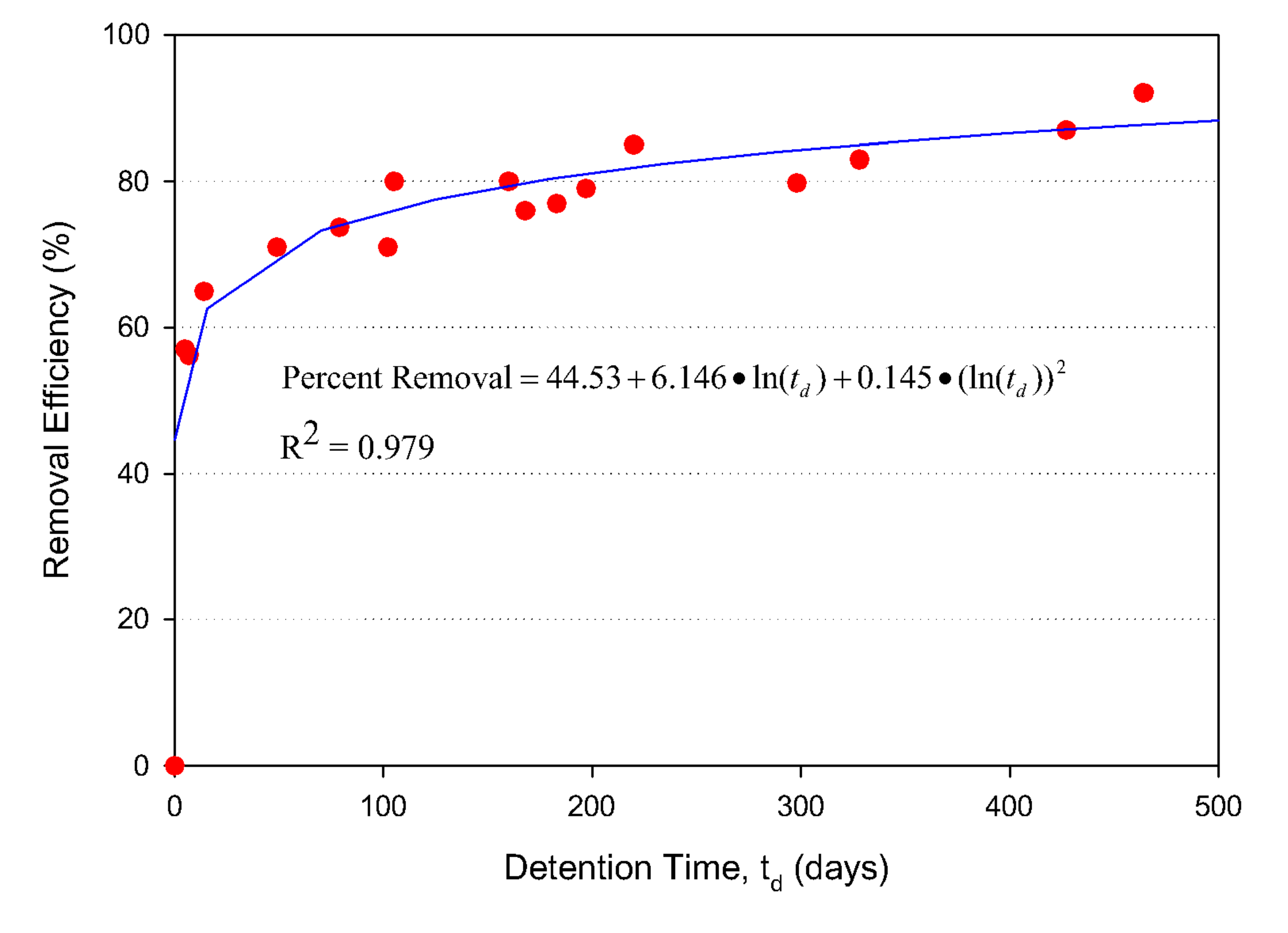
Annual Residence Time (continued)

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

Nitrogen Removal Efficiency for Wet Pond

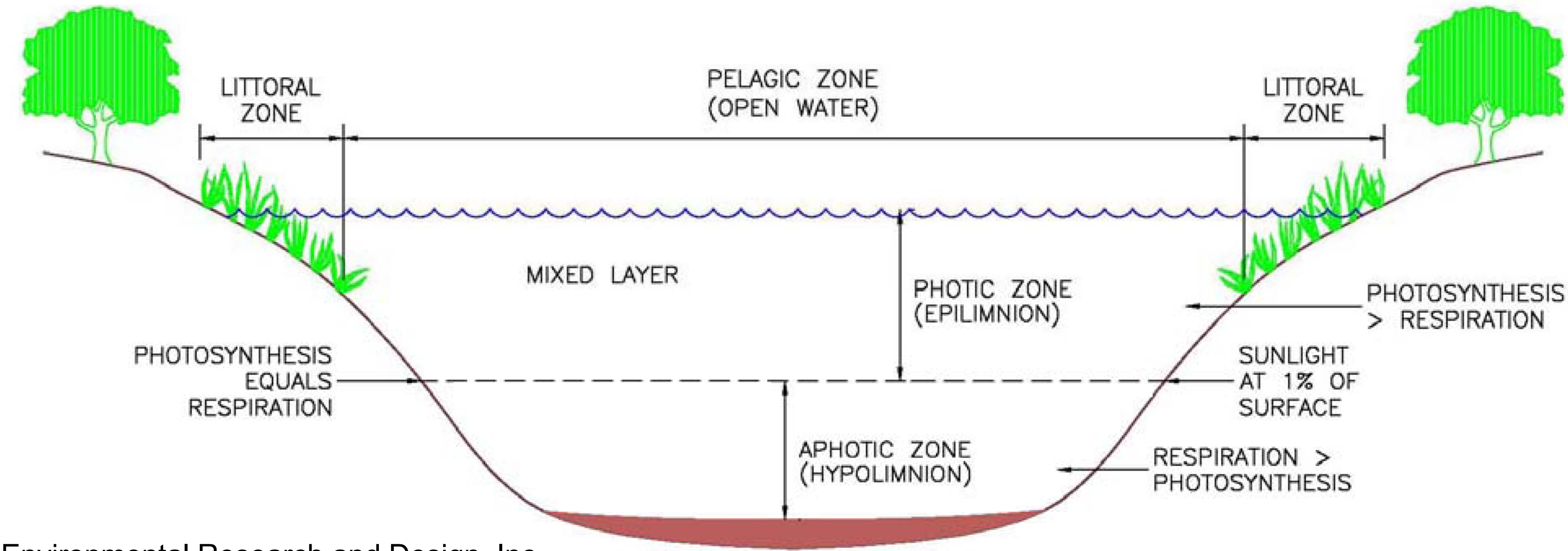


Phosphorous Removal Efficiency for Wet Pond



Anoxic Depth of Pond or Lake

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



Environmental Research and Design, Inc.

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

Wet Pond Limitations

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

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

Notes:

- IF the control elevation is located more than six inches below the SHGWT, nutrient loads from baseflows must be accounted for.
- If reclaimed water is discharged into a wet detention system, the nutrient loads from the reclaimed water must be accounted for.

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 must be provided. Pretreatment can consist of a dry pond, or other BMP, in series with a wet pond.

→ Dry Pond Or Other BMP → Wet Pond →

The pretreatment must provide for removal of 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:

$$E_{Total} = E_{dry} + (1 - E_{dry}) \times E_{wet}$$

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

Wet Pond Example

Calculate the required wet pond treatment train configuration to provide 85% removal efficiency for the following:

- Climate Zone 2 (Central Florida)
- Runoff producing area = 100 acres
- DCIA = 40%
- CN = 75
- Annual Wet Pond Residence Time = 200 days

Wet Pond Example (cont'd.)

Nitrogen removal efficiency of wet pond with residence time of 200 days:

$$E_N = \frac{43.75 \times t_d}{(4.38 + t_d)} = \frac{43.75 \times 200}{(4.38 + 200)} = 42.8\%$$

Phosphorous removal efficiency of wet pond with residence time of 200 days:

$$E_P = 44.53 + 6.146 \times \ln(t_d) + 0.145 \times (\ \ln(t_d)\ )^2$$

$$= 44.53 + 6.146 \times \ln(200) + 0.145 \times (\ \ln(200)\ )^2 = 81.2\%$$

The wet pond does not provide 85% removal efficiency. Therefore, pretreatment (such as a dry pond) will be required.

Wet Pond Example (cont'd.)

The limiting efficiency of the wet pond is 42.8%, for nitrogen removal. Therefore, pretreatment (such as a dry pond) will be required.

$$E_{Total} = E_{dry} + (1 - E_{dry}) \times E_{wet}$$

$$E_{dry} = \frac{E_{Total} - E_{wet}}{1 - E_{wet}} = \frac{0.85 - 0.428}{1 - 0.428} = 0.738 = 73.8\%$$

Size dry pond for 73.8% removal efficiency, from design tables in Appendix F of FDEP stormwater handbook, based on Climate Zone, curve number and DCIA:

For a retention depth of 0.6 inches, $E_{dry} = 72.1\%$
For a retention depth of 0.7 inches, $E_{dry} = 76.2\%$
By interpolation, for E_{dry}=73.8%, the required retention depth is 0.64 inches

Wet Pond Example (cont'd.)

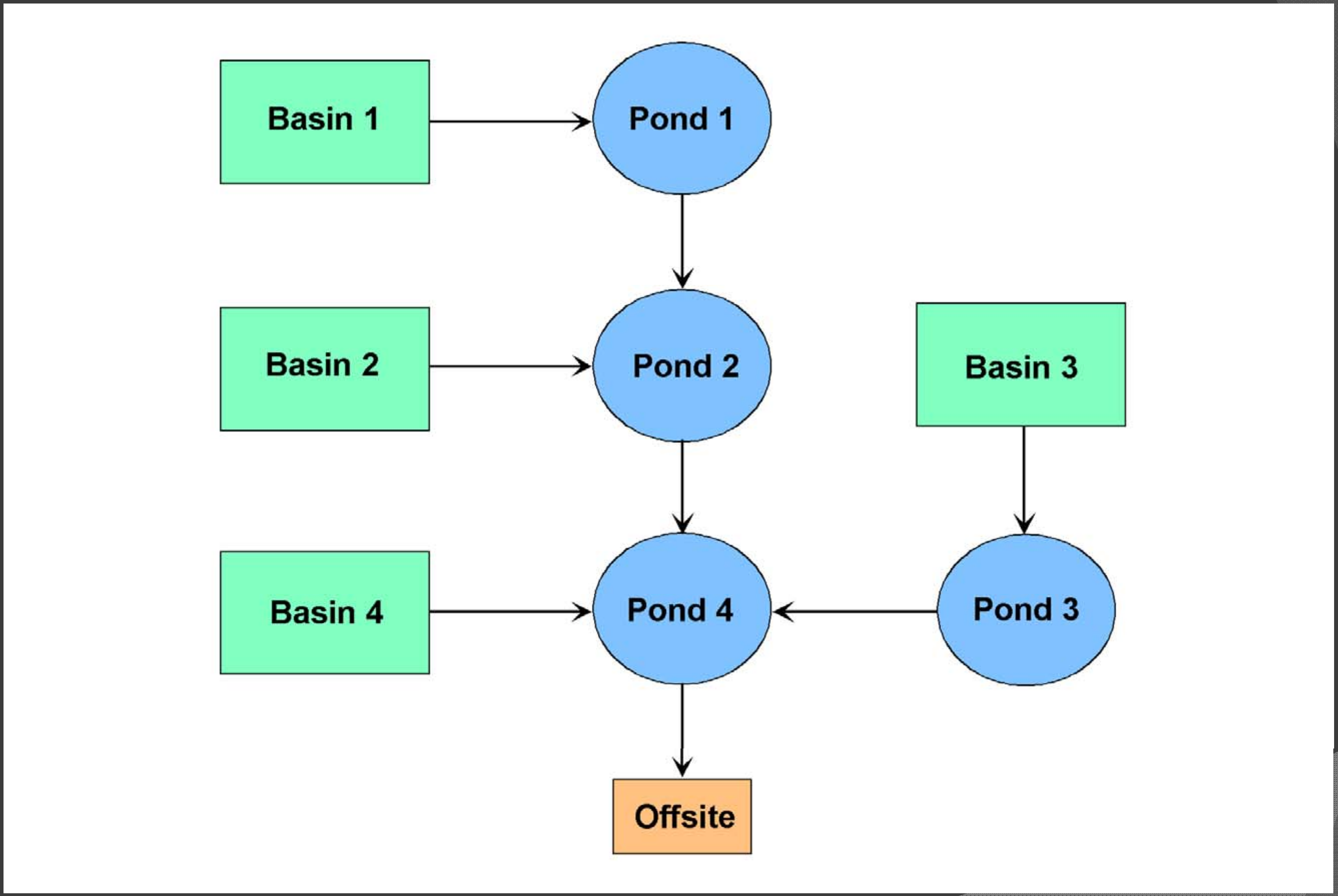
Finally, size the wet pond to ensure that the permanent pool volume is provided, above the anoxic depth.

The anoxic depth can be calculated on a monthly basis to determine the limiting anoxic depth, or can assume 75% of the anoxic depth calculated from annual runoff and loading conditions.

Required Permanent Pool Volume = 22.2 ac-ft
Estimated Anoxic Depth = 12.9 ft x 0.75 = 9.6 ft

Refer to FDEP stormwater handbook for details of these calculations.

Chained Wet Ponds



Efficiency of Chained Wet Ponds

The removal efficiency for a series of chained wet ponds is based on total residence time

$$T = T1 + T2 + T3... \rightarrow \text{Efficiency}$$

Nutrient removal in a wet pond is primarily a function of sedimentation, which depends on the total amount of time that runoff (from a particular basin) is resident within the pond system. Each runoff basin will therefore have a different total residence time.

Efficiency of Chained Wet Ponds (cont'd)

The efficiency of wet ponds in series is NOT calculated by compounding the efficiencies of individual ponds in series, for example

$$E = E1 + (1 - E1) \times E2$$ (Wrong!)

Stormwater Harvesting

What Is Stormwater Harvesting ?

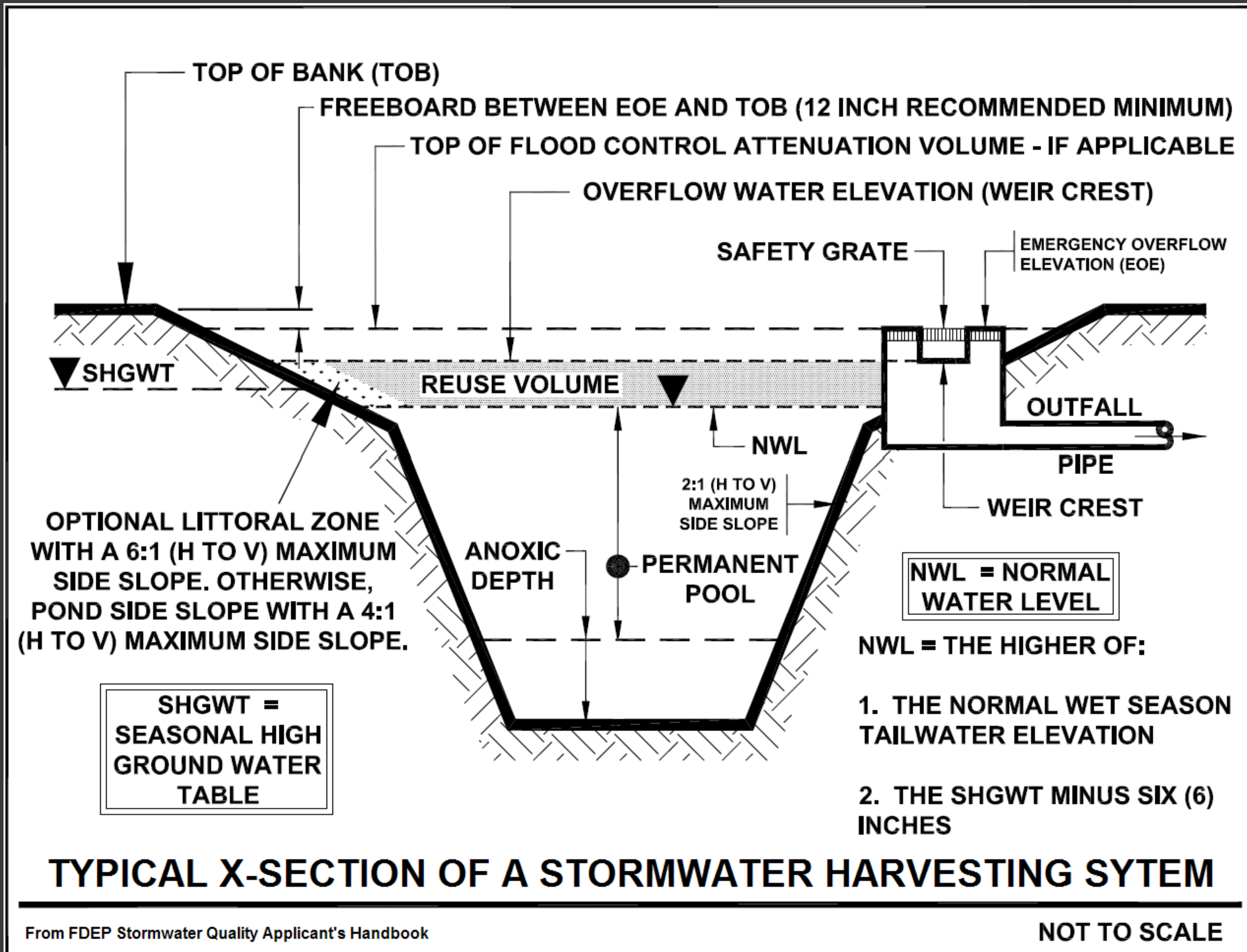
A stormwater harvesting pond is a retention pond which is also used as a source for irrigation water (or other non-potable use).

The reuse efficiency of a stormwater harvesting pond is a function of the volume of water which is consumed for irrigation which would otherwise have been discharged offsite, i.e., the harvesting efficiency

There is an additional nutrient removal efficiency from wet retention.

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

Typical Stormwater Harvesting Pond



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Example Uses For Stormwater Harvesting

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

Important Assumptions

- Net groundwater movement into or out of the pond is assumed to be zero of the period of simulation.
- The use rate is kept constant for each month in a year.
- Effectiveness results are long term averages based on historical rainfall.
- The effective runoff coefficient includes all areas within the basin, including the pond area.
- If water is taken from the permanent pool of the wet detention system, must demonstrate that drawdown will not adversely affect surface waters or wetlands.
- Water may not be available during dry periods. A backup supply may be needed.

Operational and Design Water Levels

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

Efficiency of Stormwater Harvesting Pond

Definitions:

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

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

Efficiency of Stormwater Harvesting Pond

Example:

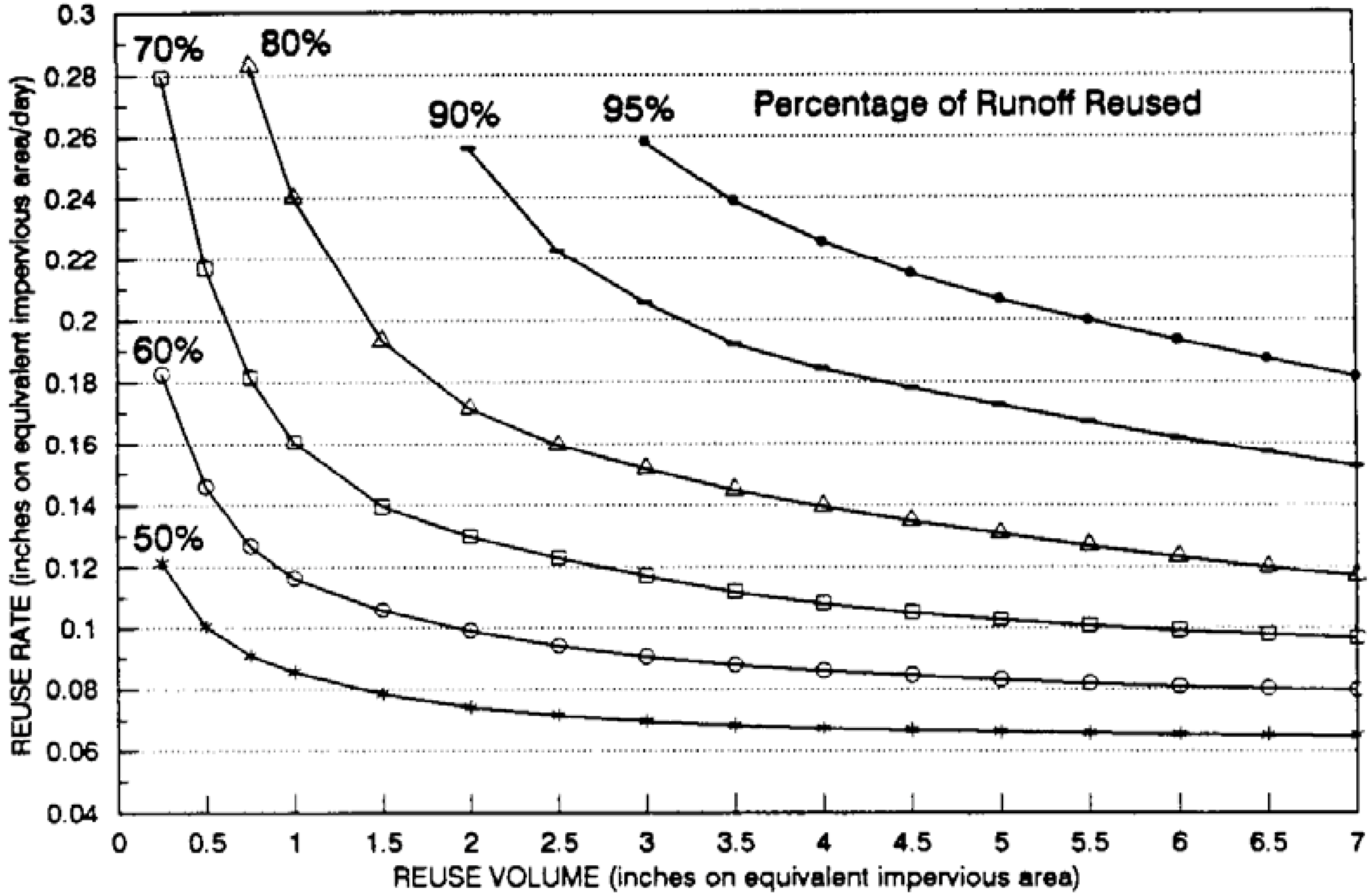
- For a pond water reuse efficiency (E_R) of 70%
- And a wet pond nitrogen removal efficiency (E_N) of 42.5%
- The total nitrogen removal efficiency (E_T) is:

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

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

R-E-V Design Curves for Stormwater Harvesting Pond

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



ORLANDO RAINFALL STATION

R-E-V Design Curves for Stormwater Harvesting Pond

EIA = Equivalent Impervious Area

EIA = Total Basin Area * Weighted Average Runoff Coefficient

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

R_{app} = R x EIA / Irrigated Area

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

$V_{storage}$ = V x EIA

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

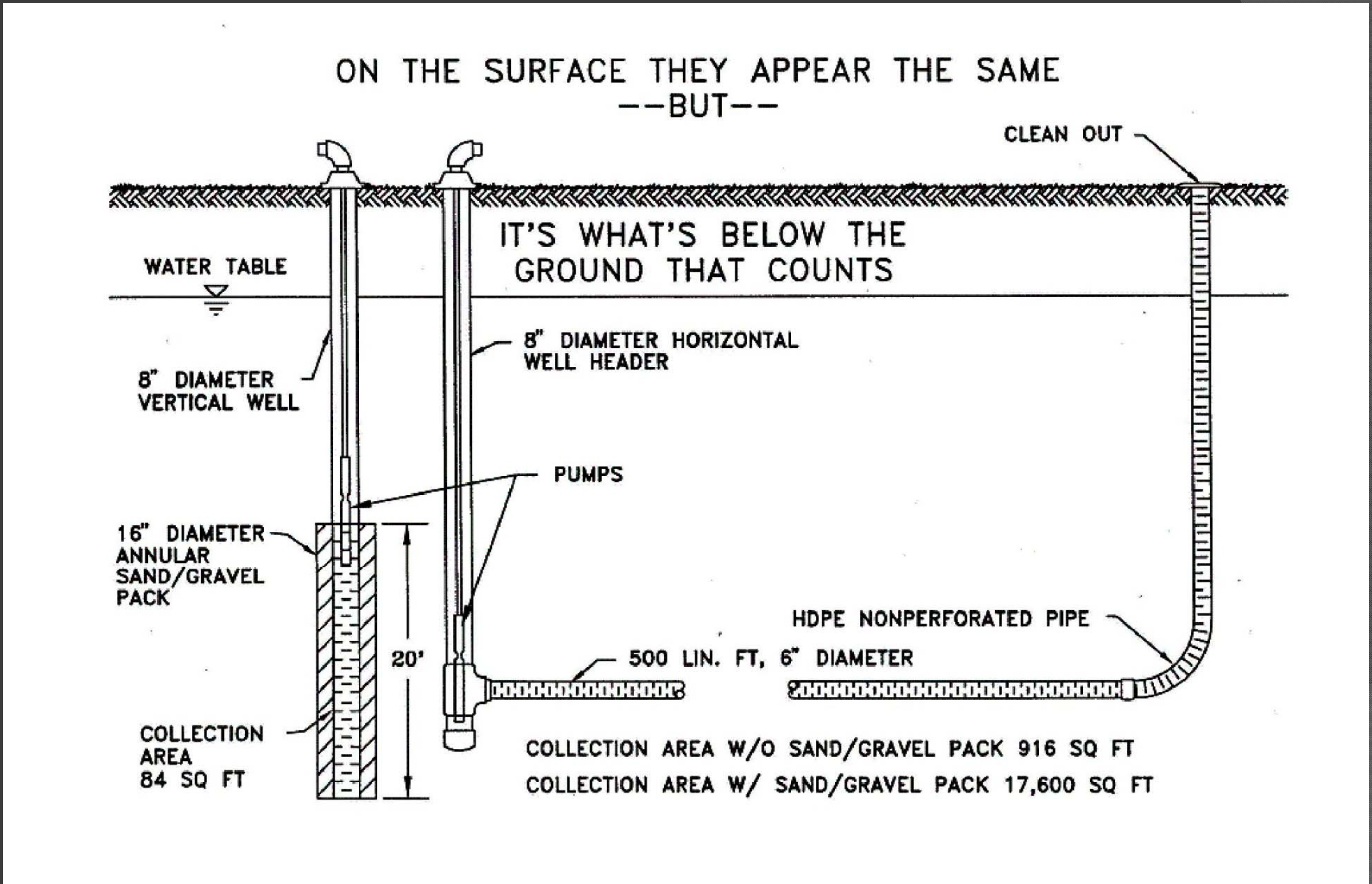
Filtration and Disinfection

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

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

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

Filtration and Disinfection



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Types of Filtration Systems

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

- Screen
- Centrifugal
- Disk
- Sand Media

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

Additional BMPs:

Underground Storage and Retention

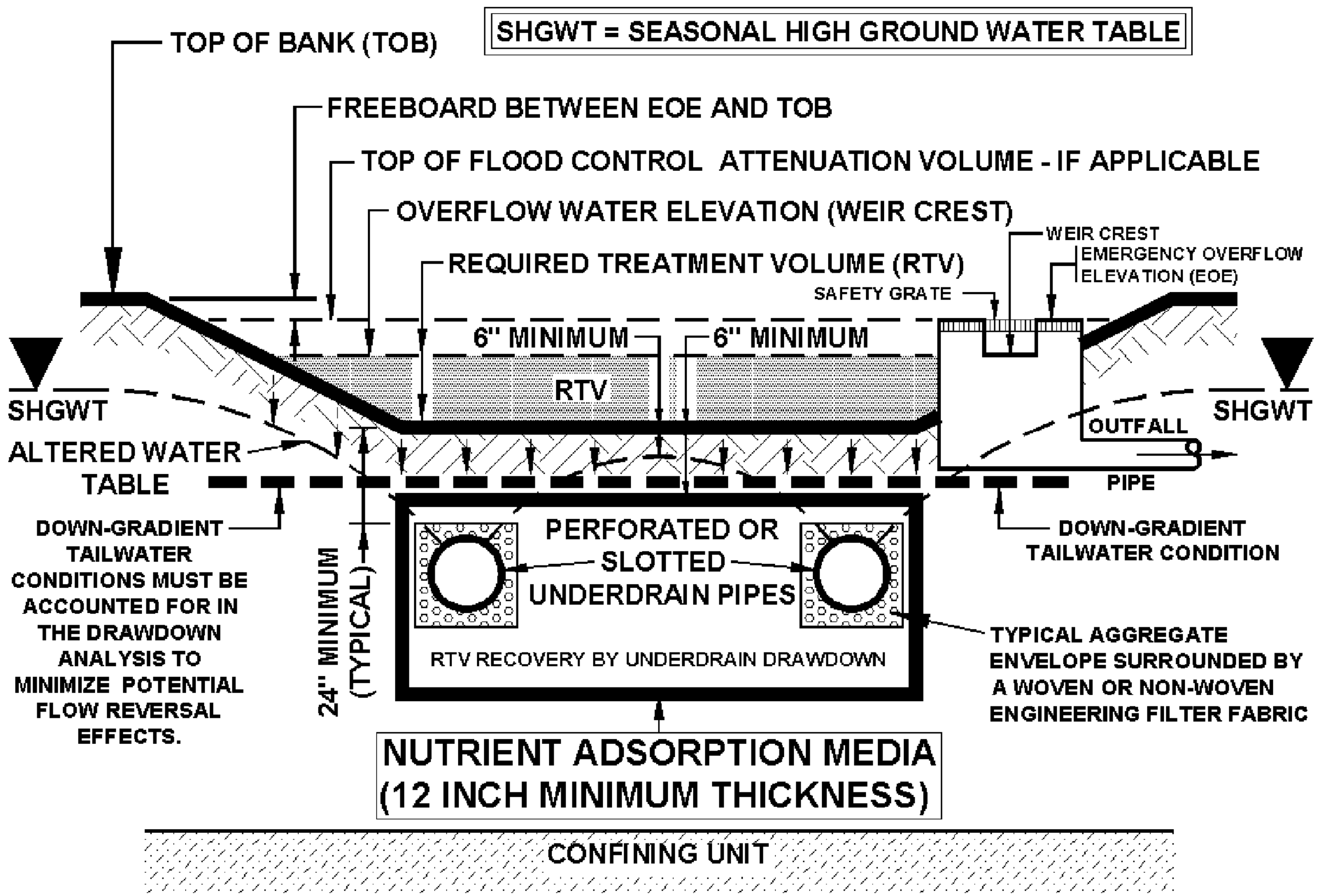
Underground Storage and Retention Systems

- Generally consist of lightweight, high strength modular units with open bottoms, for example, infiltration chambers.
- Sometimes used where land values are high, to minimize the potential loss of usable land.
- Not intended to have human access for maintenance.
- Analyze similar to a dry pond, either alone or as part of a treatment train.
- Must recover in 72 hours, with a safety factor of two.
- Seasonal high groundwater table shall be at least two feet beneath the bottom of the system, unless system performance can be demonstrated, by modeling, etc.

Additional BMPs:

Underdrain Filtration System

Underdrain Filtration System



TYPICAL X-SECTION OF AN EFFLUENT DETENTION UNDERDRAIN SYSTEM

NOT TO SCALE

TYPICAL X-SECTION OF AN EFFLUENT DETENTION UNDERDRAIN SYSTEM - AS OF 12-04-09.DWG

Underdrain Filtration System

- This is an interim BMP, since no data currently is available on the nutrient removal effectiveness of this BMP.
- The DEP-WMD is currently in the process of identifying suitable monitoring sites to develop nutrient removal data for these systems.
- If the invert of the underdrain system is located more than two feet below the SHGWT, nutrient loads from baseflows must be accounted for in the loading calculation.

Additional BMPs:

Managed Aquatic Plant Systems (MAPS)

Managed Aquatic Plant Systems (MAPS)

- Managed aquatic plant systems (MAPS) are aquatic plant-based BMPs which remove nutrients through a variety of processes related to nutrient uptake, transformation, and microbial activities.
- Examples include planted littoral zones and floating wetlands.
- Can be incorporated into a wet detention BMP treatment train to provide additional treatment and nutrient removal after the wet pond has provided reduction of pollutants through settling and other mechanisms.

Example of Floating Wetland Mat

www.devoeng.com

Managed Aquatic Plant Systems (MAPS)

Estimated removal efficiencies (to be updated as additional data becomes available):

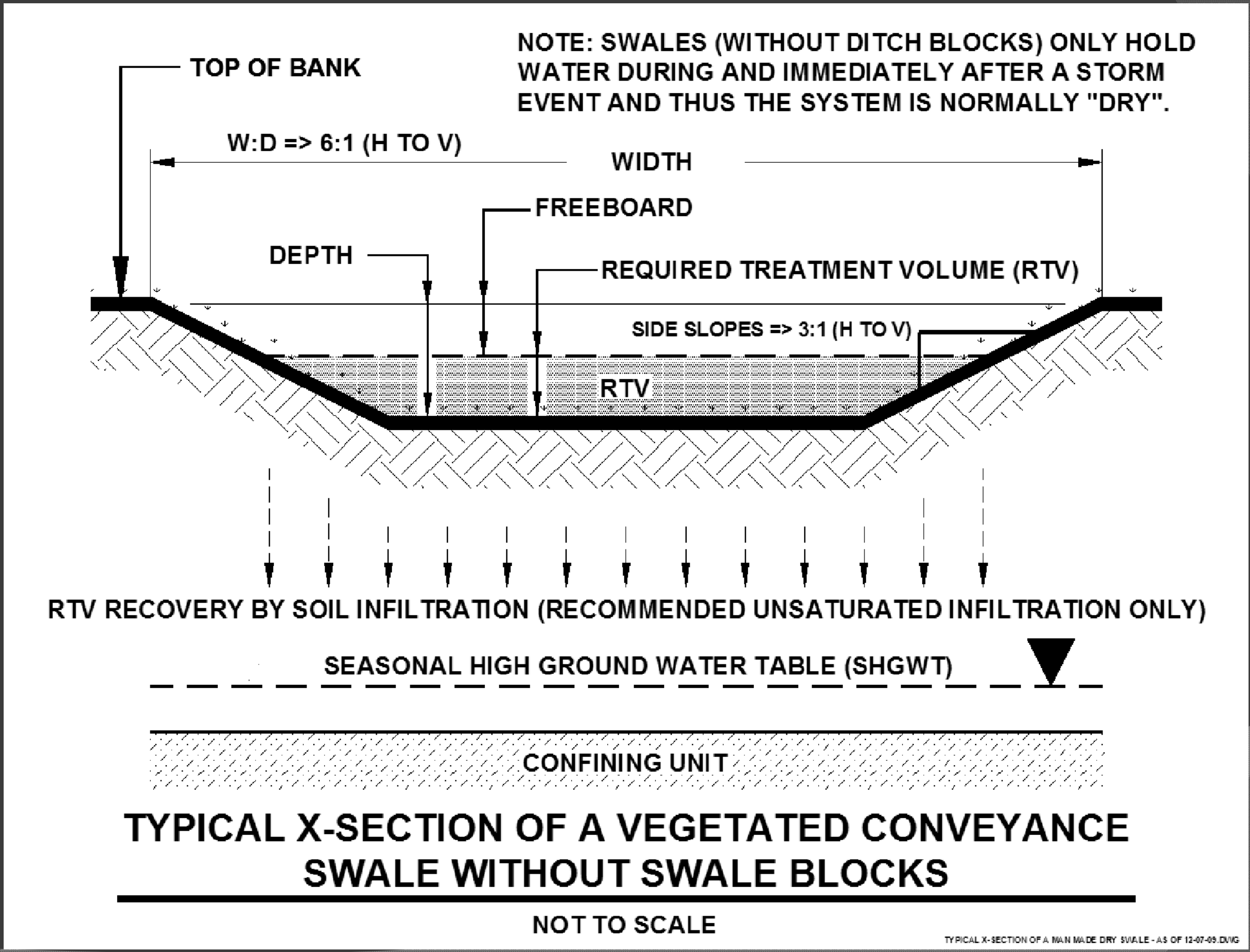
Type of MAPS	TN Removal	TP Removal
Littoral zone	10%	10%
Floating Wetland Mats or Islands	20% to 40%	20% to 40%

Note: harvesting of the biomass is an essential process for floating wetland mats/islands.

Additional BMPs:

Swales

Swales


NOTE: SWALES (WITHOUT DITCH BLOCKS) ONLY HOLD WATER DURING AND IMMEDIATELY AFTER A STORM EVENT AND THUS THE SYSTEM IS NORMALLY "DRY".
TOP OF BANK
W:D => 6:1 (H TO V)
WIDTH
FREEBOARD
DEPTH
REQUIRED TREATMENT VOLUME (RTV)
SIDE SLOPES => 3:1 (H TO V)
RTV
RTV RECOVERY BY SOIL INFILTRATION (RECOMMENDED UNSATURATED INFILTRATION ONLY)
SEASONAL HIGH GROUND WATER TABLE (SHGWT)
CONFINING UNIT
TYPICAL X-SECTION OF A VEGETATED CONVEYANCE SWALE WITHOUT SWALE BLOCKS
NOT TO SCALE
TYPICAL X-SECTION OF A MAN MADE DRY SWALE - AS OF 12-07-09.DWG

Swales

- The treatment efficiency of a swale, as part of a BMP Treatment Train, is directly related to the amount of annual stormwater volume that is infiltrated.
- Swales with swale blocks or raised driveway culverts are treated as linear retention ponds.
- Swales without swale blocks or raised driveway culverts are treated as conveyance swales.

Swales

Average flow rate is calculated assuming a triangular hydrograph:

$$Q = 0.5\ CIA$$

Where:

Q = average flow rate
C = runoff coefficient
I = rainfall intensity (in/hour) for the time of concentration
A = contributing basin area

Swales

Swale length for trapezoidal swales:

$$L = \frac{43,200\,Q}{\left\{ B + 2\left[\dfrac{1.068\,n\,Q\,(1+Z^2)^{1/3}}{S^{1/2}\,Z^{2/3}\,2[(1+Z^2)^{1/2} - Z]}\right]^{3/8} (1+Z^2)^{1/2} \right\} i}$$

Where:

- L = Length of swale (ft)
- B = Bottom Width (ft)
- Q = average low rate
- n = Manning's roughness coefficient
- Z = Side slope (horizontal distance for one foot vertical change)
- S = Longitudinal slope
- i = infiltration rate (inches/hr)

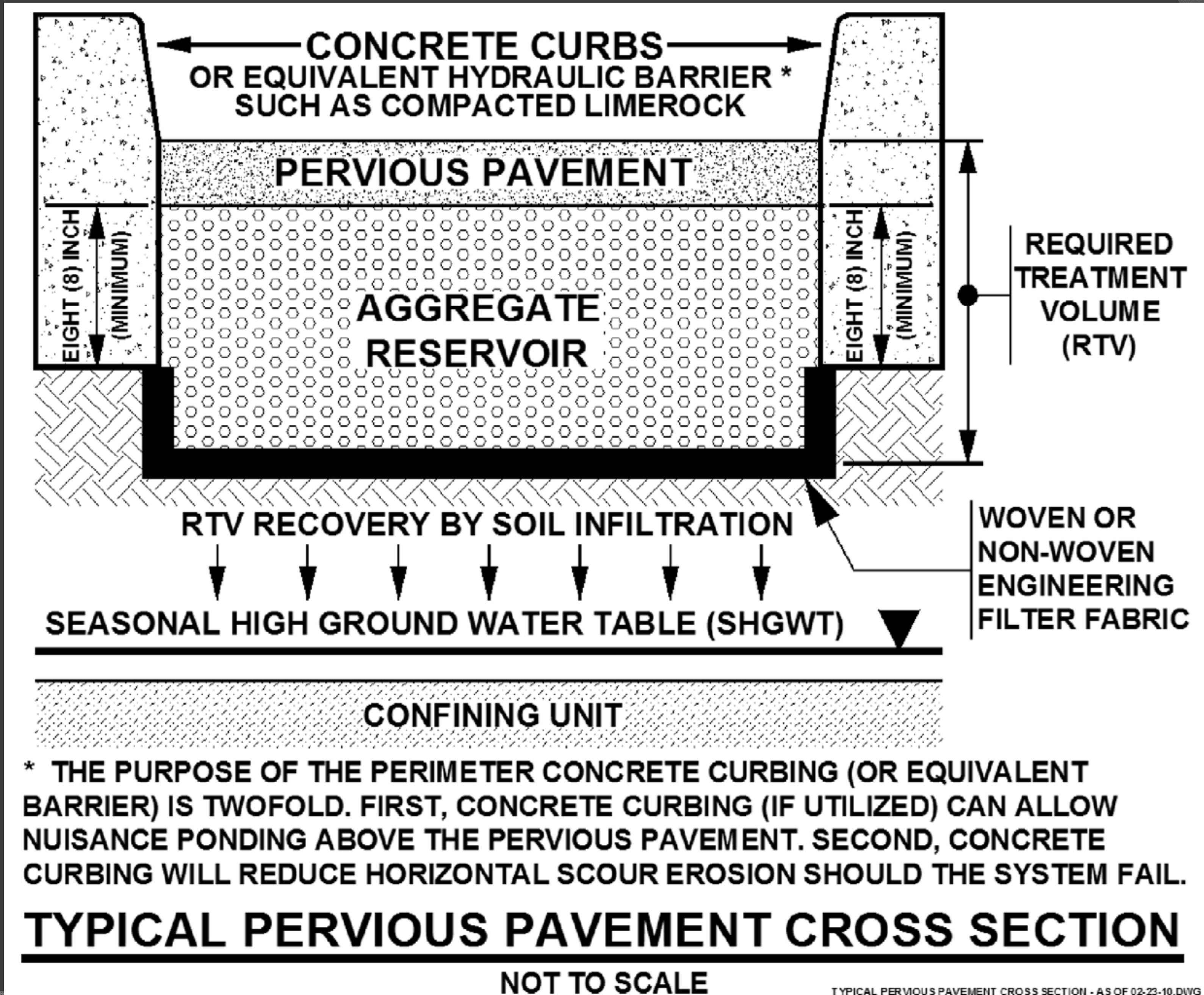
Swales

- Solve to determine the volume of stormwater runoff infiltrated for an average rainfall year.
- Seasonal high ground water table shall be at least two feet below the bottom of the swale, unless system performance can be demonstrated, by modeling, etc.
- Minimum infiltration rate through the vegetation and soil shall be at least one inch per hour.
- Consult FDEP handbook for additional requirements.

Additional BMPs:

Pervious Pavement Systems

Pervious Pavement



Pervious Pavement

- As with all infiltration BMPs, the treatment efficiency is based on the amount of annual runoff volume infiltrated, which depends on the available storage within the pavement, underlying soil permeability, and the ability of the system to readily recover the volume.
- Mostly used in parking lots, but can be used for other impervious applications (sidewalks, driveways, on-street parking, etc.).
- Must satisfy both structural and hydraulic design requirements.
- Minimum vertical hydraulic conductivity shall not be less than 2.0 inches per hour.
- Consult FDEP Stormwater Applicants Handbook for additional requirements.

Pervious Pavement

- Restricted to small commercial sites and not the heavily trafficked lanes -- just the parking slots.
- Requires a maintenance program.
- Will likely not be used on single family subdivisions since the municipalities responsible for pavement maintenance will not pay for burdensome costs.
- More suitable for redevelopment projects where a stormwater facility is not possible to insert into the layout.

Pervious Pavement

Should not be used in areas with:

- Heavy wheel loads.
- Frequent turning motions, regardless of wheel load.
- Heavy traffic volume (greater than 100 vehicles per day), regardless of wheel load.

Pervious Pavement

Past history of pervious pavement has been generally been fair to poor due to:

- Design errors
- Construction problems
- Improper maintenance

Ref: Hank Higginbotham, PowerPoint Presentation, Pervious Pavement System Training as of 11/01/09

Additional BMPs:

Underground Retention Vault/Chamber

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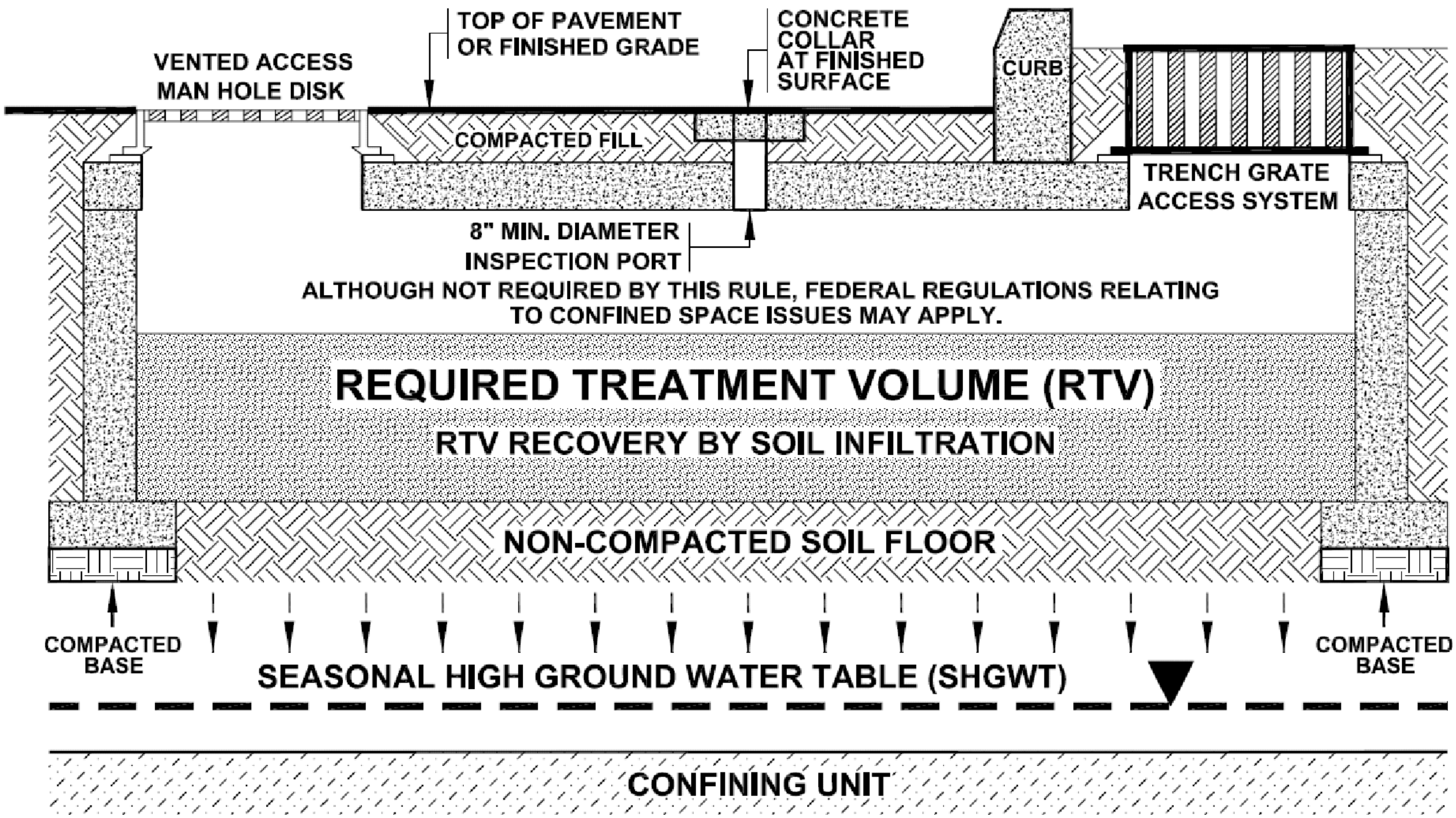
Underground Retention Vault/Chamber



NOTES:

1. THIS IS A "GENERIC" CONCEPT SKETCH. THERE ARE SEVERAL COMMERCIAL MANUFACTURES OF UNDERGROUND VAULT / CHAMBER SYSTEMS THAT ARE ACCESSIBLE VIA THE INTERNET.
2. A SINGLE ACCESS MANHOLE IS PROHIBITED, AS IT WILL DISCOURAGE MAINTENANCE ACTIVITIES, AND INCREASE THE SAFETY RISK TO MAINTENANCE PERSONNEL.
3. DUE TO HIGH FAILURE RATES (AND THE INCREASED PROBABILITY OF OF INADEQUATE MAINTENANCE AND REHABILITATION EFFORTS), UNDER DRAIN DETENTION / RECOVERY SYSTEMS WILL NOT BE ALLOWED WITHIN AN AN UNDERGROUND RETENTION VAULT / CHAMBER SYSTEM.

GENERIC UNDERGROUND RETENTION VAULTS / CHAMBERS

NOT TO SCALE

GENERIC UNDERGROUND RETENTION VAULT - CHAMBERS - AS OF 01-30-10.DWG

Underground Retention Vault/Chamber

- Only permitted for projects operated by entities with single owners, or entities with full time maintenance staffs.
- Cannot be used under buildings or in areas where there is not reasonable assurance of maintenance access.
- Must recover within 72 hours with a safety factor of two.
- Seasonal high groundwater table must be at least two feet below the bottom of the system, unless system performance can be demonstrated from modeling, etc.

Additional BMPs:

Vegetative Natural Buffers

Vegetative Natural Buffers

- Defined as areas with vegetation suitable for nutrient uptake and soil stabilization, that are set aside between developed areas and a receiving water or wetland for stormwater treatment purposes.
- Under certain conditions, provides opportunities for filtration, deposition, infiltration, absorption, adsorption, decomposition and volatilization.
- Most commonly used only to treat rear-lot portions of a development that cannot be feasibly routed to the stormwater system serving the rest of the development.
- Treatment efficiency is calculate as a function of percolation into the ground, as with dry ponds.
- The seasonal high ground water table shall be at least two feet below the bottom of the vegetative natural buffer, unless system performance can be demonstrated, by modeling, etc.
- Minimum infiltration rate of at least one inch per hour

Additional BMPs:

Wetland Treatment

Wetland Treatment

- Wetlands must be isolated and owned by one person, or
- Are connected to other surface waters in a manner that could be hydrologically severed to make the wetland isolated and wholly owned by one person.
- Stormwater is routed to wetland stormwater treatment train and percolated into the ground.

Additional BMPs:

Green Roof/Cistern

Green Roof/Cistern

- A green roof consists of a vegetative roof followed by a storage cistern.
- A green roof/cistern system is a retention BMP, and its effectiveness is directly related to the annual volume of roof runoff that is captured.

Additional BMPs:

Low Impact Design

Low Impact Design

- Low impact design techniques can reduce stormwater volume and pollutants generated from development sites.
- Stormwater nutrient load reduction credits for low impact design BMPs are directly related to the amount of stormwater volume or pollutant load that is prevented.
- Certain site-specific requirements must be met to receive credits.

Low Impact Design

Low impact design BMPs that are eligible for stormwater nutrient load reduction credits include:

- Natural Area Conservation
- Site Reforestation
- Disconnecting Directly Connected Impervious Areas
- Florida-friendly landscaping
- Rural subdivisions

Additional BMPs:

Chemical Treatment

Chemical Treatment

- Chemical treatment of storm water runoff is a technology which uses metal salts to rapidly precipitate nutrients, solids, heavy metals, and bacteria from runoff.
- Virtually all of the existing chemical stormwater treatment systems in the State of Florida use alum for coagulation purposes.
- A chemical treatment system often has a smaller footprint than a traditional wet or dry pond but requires more frequent maintenance by a trained operator.
- Alum can be injected into stormwater lines on a flow weighted basis during rain events.