



Earthwork – The Value of Utilizing On-site
Resources vs. Import Fill
and **Pond Design**

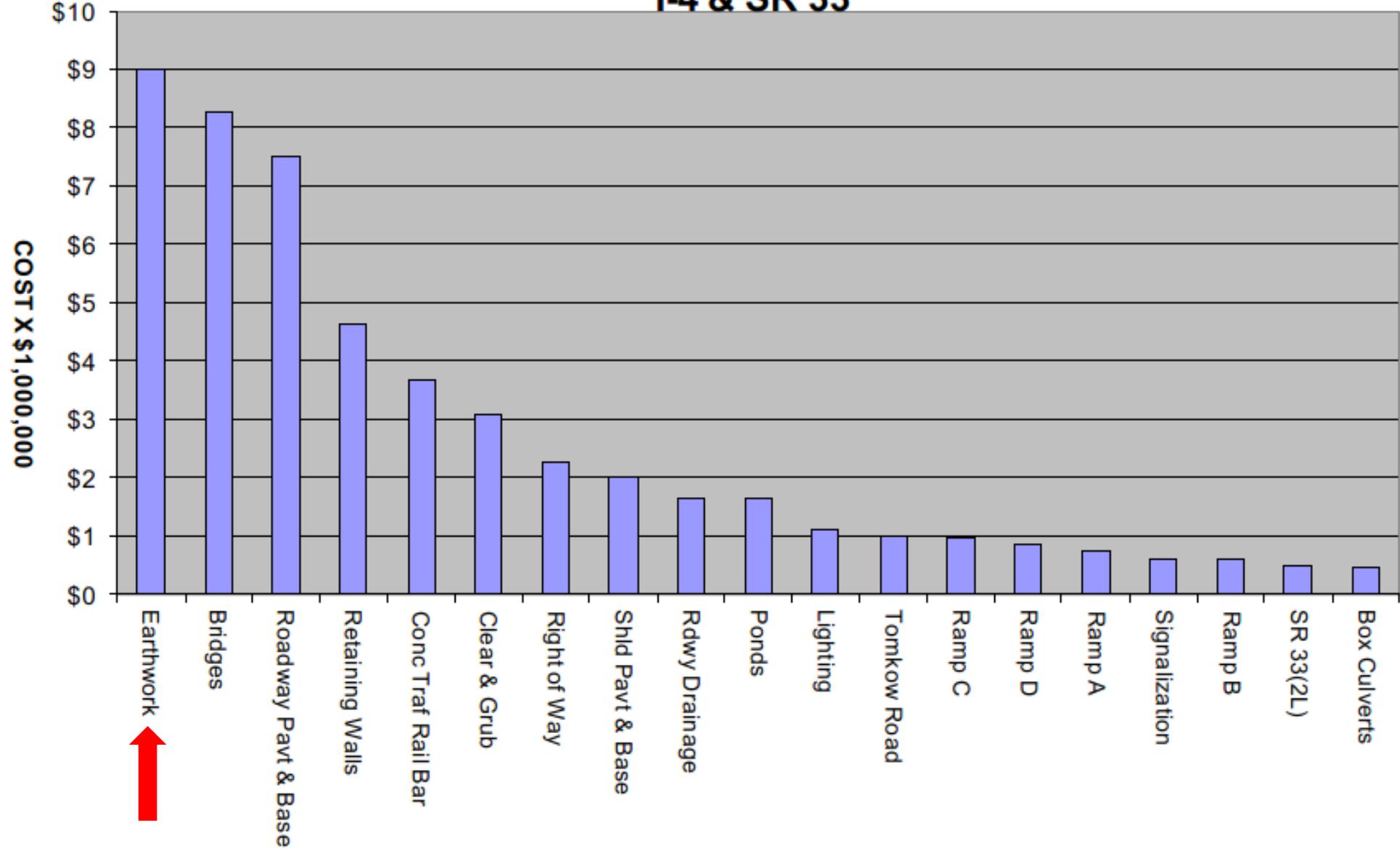
Brent Setchell, P.E.

FDOT District 1

Agenda

- Estimating Earthwork
- Contractor's Method of Estimating Earthwork
- Example Projects
- Wet Detention Pond Design Considerations

PARETO CHART I-4 & SR 33



FDOT Pay Items

- 0120-1 Regular Excavation (CY)
- 0120-2 Borrow Excavation (TCY)
- 0120-6 Embankment (CY)
- No Pay Item for “Import Fill”

Item	No. of Conts	Weighted Average	Total Amount	Total Quantity	Unit Meas	Obs?	Description
0102912	1	\$3.10	\$440.20	142.000	LF	N	PAVT MARKING REMOVABLE TAPE, YELLOW, SKIP
0102912	2	\$1.57	\$142,171.53	90,587.000	LF	N	PAVT MARKING REMOVABLE TAPE, YELLOW, SOLID
0102912	3	\$5.00	\$2,400.00	480.000	SF	N	PAVT MARKING REMOVABLE TAPE, YELLOW, OTHER
0104	1	\$1.88	\$116,427.08	61,866.000	SY	N	ARTIFICIAL COVERINGS / ROLL EROSION CNTL
0104	6	\$15.16	\$2,698.48	178.000	LF	N	TEMPORARY SLOPE DRAIN / RUNOFF CONT STR
0104	10	\$1.36	\$1,057,006.47	777,856.000	LF	N	SEDIMENT BARRIER
0104	11	\$8.56	\$376,763.52	44,040.000	LF	N	FLOATING TURBIDITY BARRIER
0104	12	\$5.13	\$190,334.45	37,071.000	LF	N	STAKED TURBIDITY BARRIER- NYL REINF PVC
0104	15	\$2,335.25	\$172,808.64	74.000	EA	N	SOIL TRACKING PREVENTION DEVICE
0104	18	\$110.22	\$385,233.66	3,495.000	EA	N	INLET PROTECTION SYSTEM
0107	1	\$27.77	\$967,114.63	34,830.270	AC	N	LITTER REMOVAL
0107	2	\$39.12	\$985,851.98	25,202.120	AC	N	MOWING
0108	1	\$8,958.06	\$152,287.00	17.000	LS	N	MONITOR EXISTING STRUCTURES- SETTTL
0108	2	\$14,082.24	\$239,398.00	17.000	LS	N	MONITOR EXISTING STRUCTURES- VIBRA
0108	3	\$1,225.00	\$2,450.00	2.000	LS	N	MONITOR EXISTING STRUCTURES- GROUND
0110	1	\$10,324.67	\$7,440,780.43	720.680	AC	N	CLEARING & GRUBBING
0110	2	\$11,000.00	\$11,000.00	1.000	AC	N	CLEARING & GRUBBING (PUSH BUTTON CONT)
0110	3	\$25.28	\$3,421,976.15	135,348.000	SF	N	REMOVAL OF EXISTING STRUCTURES/BRIDGES
0110	4	\$37.58	\$1,045,687.57	27,823.000	SY	N	REMOVAL OF EXISTING CONCRETE PAVEMENT
0110	4	\$38.00	\$19,000.00	500.000	SF	N	REMOVAL OF EXIST CONC SIDEWALK
0110	5	\$5,000.00	\$5,000.00	1.000	EA	N	PLUGGING WATER WELLS, ARTESIAN
0110	7	\$148.13	\$47,106.72	318.000	EA	N	MALIBOX, F&I SINGLE
0110	8	\$5,791.67	\$34,750.00	6.000	DA	N	UNDERWATER DEBRIS REMOVAL
0110	12	\$3,600.00	\$104,400.00	29.000	SY	N	HYDRODEMOLITION, REM OF DECK SURFACE
0110	71	\$356.40	\$108,345.60	304.000	LF	N	BRIDGE FENDER SYSTEM, REMOVAL & DISPOSAL
0110	73	\$65.00	\$32,240.00	496.000	LF	N	REMOVE EXISTING BULKHEAD
0110	86	\$12,467.59	\$149,611.04	12.000	LS	N	DELIVERY OF SALVAGEABLE MATERIAL TO FDOT
0120	1	\$7.58	\$3,388,216.30	446,756.680	CY	N	REGULAR EXCAVATION
0120	2	\$9.49	\$531,355.79	55,972.800	CY	N	BORROW EXCAVATION, TRUCK MEASURE
0120	3	\$5.45	\$59,958.10	10,998.000	CY	N	LATERAL DITCH EXCAVATION
0120	4	\$4.59	\$1,549,161.86	337,700.000	CY	N	SUBSOIL EXCAVATION
0120	5	\$10.44	\$341,822.12	32,737.800	CY	N	CHANNEL EXCAVATION
0120	6	\$13.41	\$21,342,255.90	1,591,579.450	CY	N	EMBANKMENT
0120	71	\$24,397.05	\$585,529.08	24.000	LS	N	REGULAR EXCAVATION (3-R PROJECTS ONLY)
0120	74	\$12.28	\$1,255,544.04	102,243.000	CY	N	SURCHARGE EMBANKMENT
0121	70	\$238.17	\$235,028.56	986.800	CY	N	FLOWABLE FILL
0141	70	\$400.00	\$12,400.00	31.000	AS	N	SETTLEMENT PLATE ASSEMBLY
0144	1	\$80.00	\$60,000.00	750.000	LF	N	DIGITAL INCLINOMETER CASING, VERTICAL
0144	71	\$2,500.00	\$15,000.00	6.000	EA	N	PORE-PRESSURE TRANSDUCER- PIEZOMETER, CNTL
0144	74	\$1,200.00	\$1,200.00	1.000	EA	N	PORE-PRESSURE TRANSDUCER, CNTL/READOUT, VW



Estimating Earthwork Costs

- FDOT's Estimate

	6' deep ponds			10' deep ponds		
	CY	Cost per CY	Cost	CY	Cost per CY	Cost
Excavation	200,000	\$ 4.75	\$ 950,000	300,000	\$ 4.75	\$ 1,425,000
Embankment	320,000	\$ 8.50	\$ 2,720,000	320,000	\$ 8.50	\$ 2,720,000
			\$ 3,670,000			\$ 4,145,000

**Saves FDOT \$475,000
using shallow ponds!!!**

Estimating Earthwork Costs

- FDOT's Estimate

	6' deep ponds			10' deep ponds		
	CY	Cost per CY	Cost	CY	Cost per CY	Total
Excavation	200,000	\$ 4.75	\$ 950,000	300,000	\$ 4.75	\$ 1,425,000
Embankment	320,000	\$ 8.50	\$ 2,720,000	320,000	\$ 8.50	\$ 2,720,000
			\$ 3,670,000			\$ 4,145,000

- Simplified Contractor's Estimate

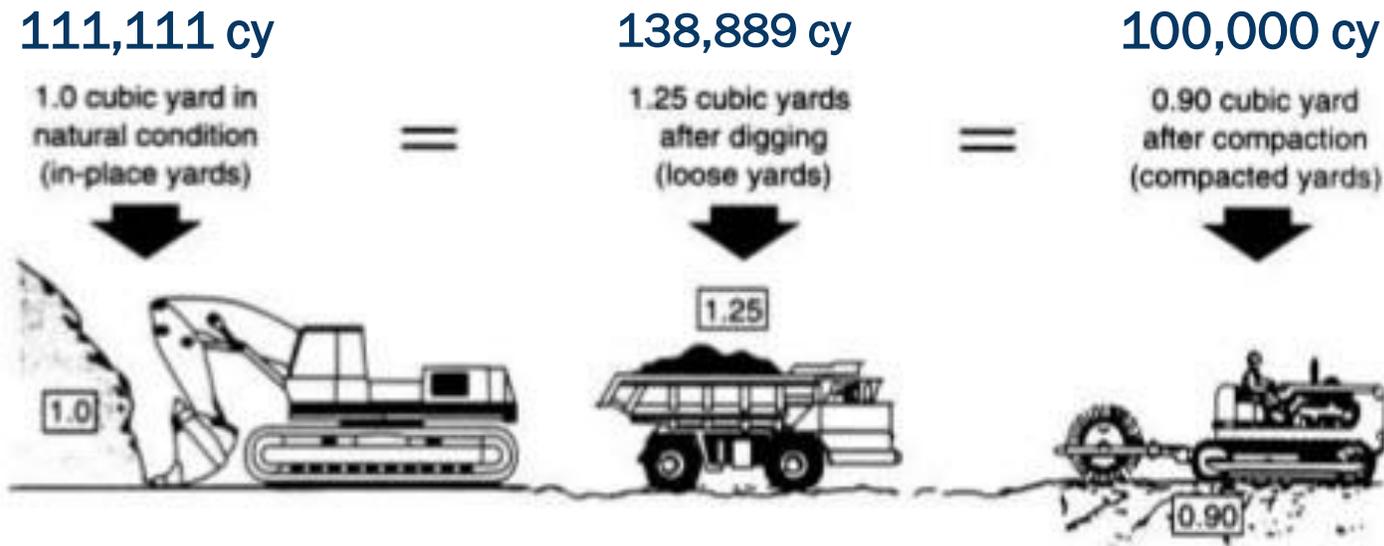
	6' deep ponds			10' deep ponds			Comments
	CY of Material	Cost per CY	Cost	CY of Material	Cost per CY	Cost	
Excavation	200,000	\$ 6.00	\$ 1,200,000	300,000	\$ 6.00	\$ 1,800,000	Includes Placement
Embankment	320,000	\$ -	\$ -	320,000	\$ -	\$ -	
Import Fill	150,000	\$ 13.00	\$ 1,950,000	25,000	\$ 13.00	\$ 325,000	Includes Fluff factor
			\$ 3,150,000			\$ 2,125,000	

10' Deep Ponds Saves FDOT \$1,025,000 !!!

Contractor's Fluff Factors

- Swell
- Shrinkage
- Load and Shrinkage Factors

39% Increase
For Import Fill



Where to find suitable soils data

- Geotechnical Engineer provides the Roadway Soil Survey sheet.
- Review which strataums are suitable for fill material.
- Refer to the geotechnical reports for additional, detailed information.

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION
MATERIALS AND RESEARCH

DISTRICT: One
ROAD NO.: SR 35
COUNTY: Hardee

FINANCIAL PROJECT ID #: 414547-1-52-01
PROJECT NAME: US 17 (SR 35) from DeSoto County Line to CR 634 (Sweetwater Road)

CROSS SECTION SOIL SURVEY FOR THE DESIGN OF ROADS
SURVEY BEGINS STA.: 32+00 SURVEY ENDS STA.: 37+00

REFERENCE: Centerline

STRATUM NO.	NO. OF TESTS	DEPTH (FOOT)	MOISTURE CONTENT (%)	FLUIDITY	SIEVE ANALYSIS RESULTS										DESCRIPTION	CORROSION TEST RESULTS				
					NO. OF TESTS	MEAN	MIN.	MAX.	NO. OF TESTS	MEAN	MIN.	MAX.	NO. OF TESTS	MEAN		MIN.	MAX.	NO. OF TESTS	MEAN	MIN.
1	12	1.4-3.4	---	---	12	70.8-80	62-85.8	54.5-87.2	42.7-77.9	61-11.8	12	---	MT	A-3/A-2-4	42g, brown sand with trace red and grey (MS).	8	4,300-13,000	60-80	1.6-3.0	7.1-8.1
2	10	0.1-2.1	3	3.2-4.0	10	66.2-80	51.4-88.6	45.7-86.6	33.3-63.2	5.8-23.9	10	---	MT	A-3/A-2-4	42g, brown sand with trace red and grey.	13	7,600-16,000	80-90	2.4-3.6	4.8-6.3
3	22	0.2-2.0	1	12.0	22	61.7-80	50.3-88.0	35.7-89.4	27.8-67.7	0.7-34.1	22	---	MT	A-4-4	42g, brown silt/clay.	13	1,500-61,000	4-300	2.0-200	4.0-7.8
4	3	1.8-7.0	---	---	3	51-68	40-88	35.4-111	23.2-38	3.2-5.4	3	---	MT	A-4-4	42g, brown sand with black and grey silt/clay.	---	---	---	---	---
5	0	0.2-1.0	---	---	13	65	57-89.7	43.4-89.3	37.1-81.6	0.3-25.4	0	---	MT	A-4-4	Dark brown sand with trace silt.	7	1,300-15,000	50-80	4.8-15.2	1.0-4.7
6	1	1.2-6.0	1	18.4	0	71.3-80	63.8-87.7	50-89.1	33.8-81.8	15.5-75.4	13	18-17	0-38	A-6/A-5-7/A-4/A-3/A-2-4	Brown and grey sandy clay.	4	MT-10,000	60-80	0.5-3.8	1.8-4.5
7	0	1.6-10.2	1	18.7-20	0	70	58.8-80.2	46-80.7	38.1-85.4	18.8-25.4	0	---	MT	A-3/A-2-4	Dark brown silt/clay.	1	25,000	100	3.8	6.6

EMBANKMENT AND SUBGRADE MATERIAL
STRATA BOUNDARIES ARE APPROXIMATE. MAKE FINAL CHECK AFTER GRADING.
SI - WATER TABLE ENCOUNTERED
GNE - GROUNDWATER NOT ENCOUNTERED

*MT = Not Tested

The material from Strata number 1 is select A-3/A-2-4 material and appears satisfactory for use in the embankment when utilized in accordance with Index 505.

The material from Strata number 2 & 3 is select A-3/A-2-4 material and appears satisfactory for use in the embankment when utilized in accordance with Index 505. However, this material is likely to retain excess moisture and may be difficult to dry and compact. It should be used in the embankment above water level existing at the time of construction.

The material from Strata number 3 is select A-4-4 material and appears satisfactory for use in the embankment when utilized in accordance with Index 505. However, this material is likely to retain excess moisture and may be difficult to dry and compact. It should be used in the embankment above water level existing at the time of construction.

The material from Strata number 4 is select A-4-4 material with organics and appears satisfactory for use in the embankment when utilized in accordance with Index 505. However, this material may not be used in the embankment due to its organic content.

The material from Strata number 5 is select A-4-4 material and shall be removed in accordance with Index 500. It may be placed above the existing water level (at the time of construction) to wide of base. It should be placed uniformly in the lower portion of the embankment for some distance along the project rather than full depth for short distances.

The material from Strata number 7 is select A-3/A-2-4 material and shall be removed in accordance with Index 500. The material shall not be used within the embankment or subgrade portion of the roadbed unless used in accordance with the AASHTO Standard Specifications.

DATE	DESCRIPTION	REVISION	DESIGNED BY	CHECKED BY	IN CHARGE	STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION MATERIALS AND RESEARCH	ROAD NO.	COUNTY	PROJECT NO.	SHEET NO.
						ROADWAY SOIL SURVEY	35	HARDEE	414547-1-52-01	217

The material from Stratum number 1 is select A-3/A-2-4 material and appears satisfactory for use in embankment when utilized in accordance with Index 505.



What is suitable material?

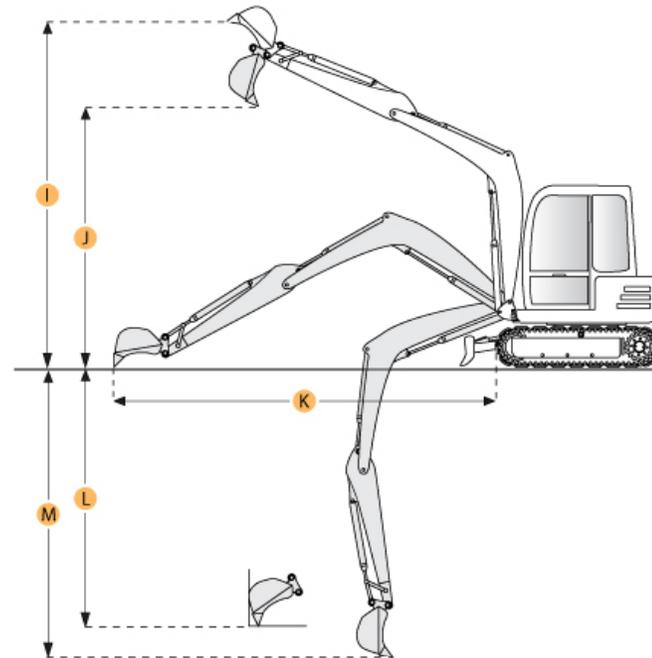
- Per Spec 120-8.2.1.1, the contractor may use maximum 12” lifts for A-3, and A-2-4 materials with up to 15% fines.
- Ensure the percentage of fines passing the No. 200 US Standard Sieve in the A-2-4 material does not exceed 15%.

How deep can I make the pond(s)?

- Limitations

- Water Management District Permit Criteria (SJRWMD max 12' deep)
- Dewatering costs
- Suitable Soils
- Excavator reach
- Side slopes

- **ANSWER: It Depends!**
- **10-12' is a good starting point**



What cost savings should I use for On-site Fill vs Import Fill?

- Import Fill Costs include:
 - Acquisition Cost of Fill
 - Haul Distance (Fuel costs)
 - Additional Fill from Shrinkage Losses
- On-site Fill Costs include:
 - Clearing and Grubbing
 - Dewatering
 - Species mitigation (panther or skink)
- **ANSWER: It Depends!**
- **\$4-\$7 per cy is a good starting point**

When do you estimate Earthwork?

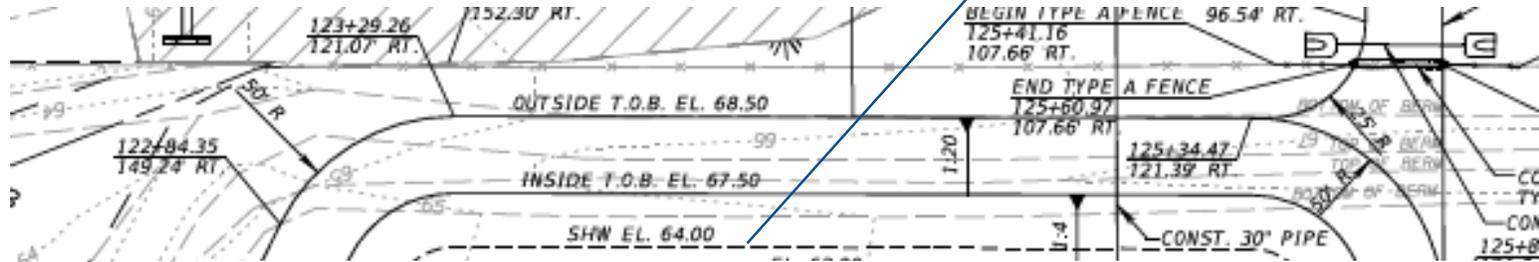
- Consultant says: “We don’t provide quantities until Phase 3 plans.”
- How can you set your profile without having a basic understanding of your project’s earthwork balance (or imbalance)?
- How do you determine your wet detention pond depths if you don’t understand your project’s earthwork needs?
- Answer: Early and Often

Deeper Pond Considerations

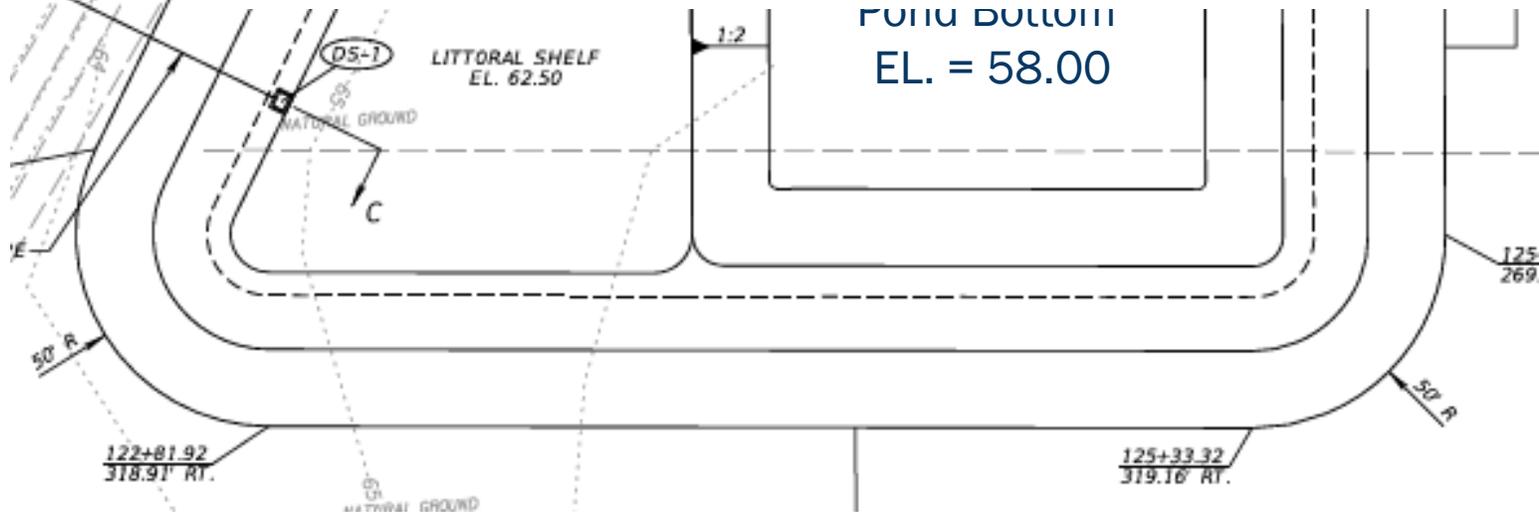
- Advantages
 - Reduces Import Fill
 - Additional Nutrient Removal (Longer Residence Time)
 - Reduces contractor need to **locate**, **permit**, and **haul** import fill
- Considerations
 - Check soil borings to verify suitability (muck, limerock)
 - Verify project needs the fill (Balanced?)
 - District 1 requires Consultants to use contractor's style earthwork estimate when comparing different types of ponds in PSR

Earthwork Example

SHWE =
64.00



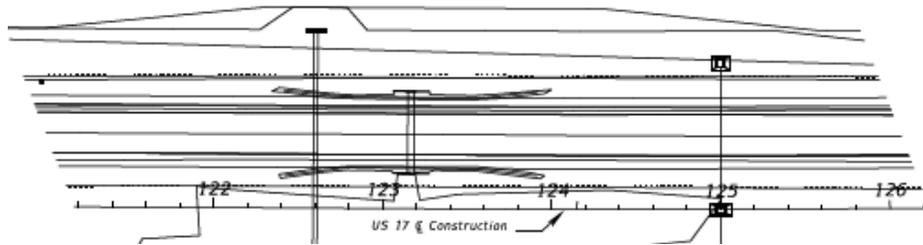
Completed 30% Design and determined project requires 100,000 CY of Import Fill.



Earthwork Example

Check Soil Suitability

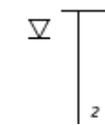
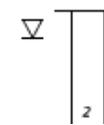
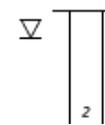
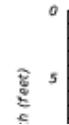
All borings are Stratum #2 to a depth greater than 15' below existing grade



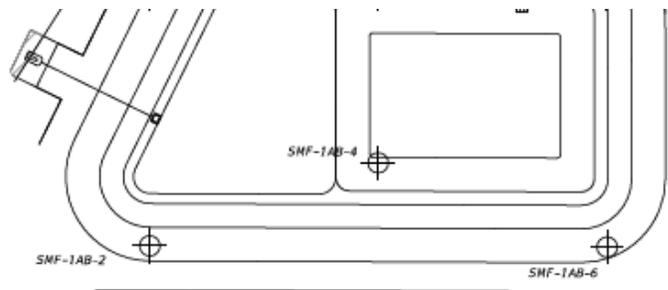
BOR # SMF-1AB-1
STA. 122+80 CL Construction
OFF. 160' Rt.
DATE 10-4-11

BOR # SMF-1AB-2
STA. 122+80 CL Construction
OFF. 310' Rt.
DATE 10-4-11

BOR # SMF-1AB-3
STA. 124+15 CL Construction
OFF. 160' Rt.
DATE 10-4-11



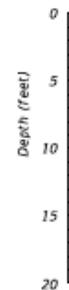
The material from **Strata number 2** is **select A-3/A-2-4 material** and **appears satisfactory for use in the embankment** when utilized in accordance with Index 505. However, this material is likely to retain excess moisture and may be difficult to dry and compact. It should be used in the embankment above water level existing at the time of construction.



BOR # SMF-1AB-4
STA. 124+15 CL Construction
OFF. 260' Rt.
DATE 10-4-11

BOR # SMF-1AB-5
STA. 125+50 CL Construction
OFF. 160' Rt.
DATE 10-4-11

BOR # SMF-1AB-6
STA. 125+50 CL Construction
OFF. 310' Rt.
DATE 10-4-11



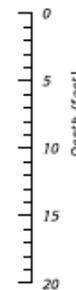
Boring Terminated at Depth of 20 Ft.



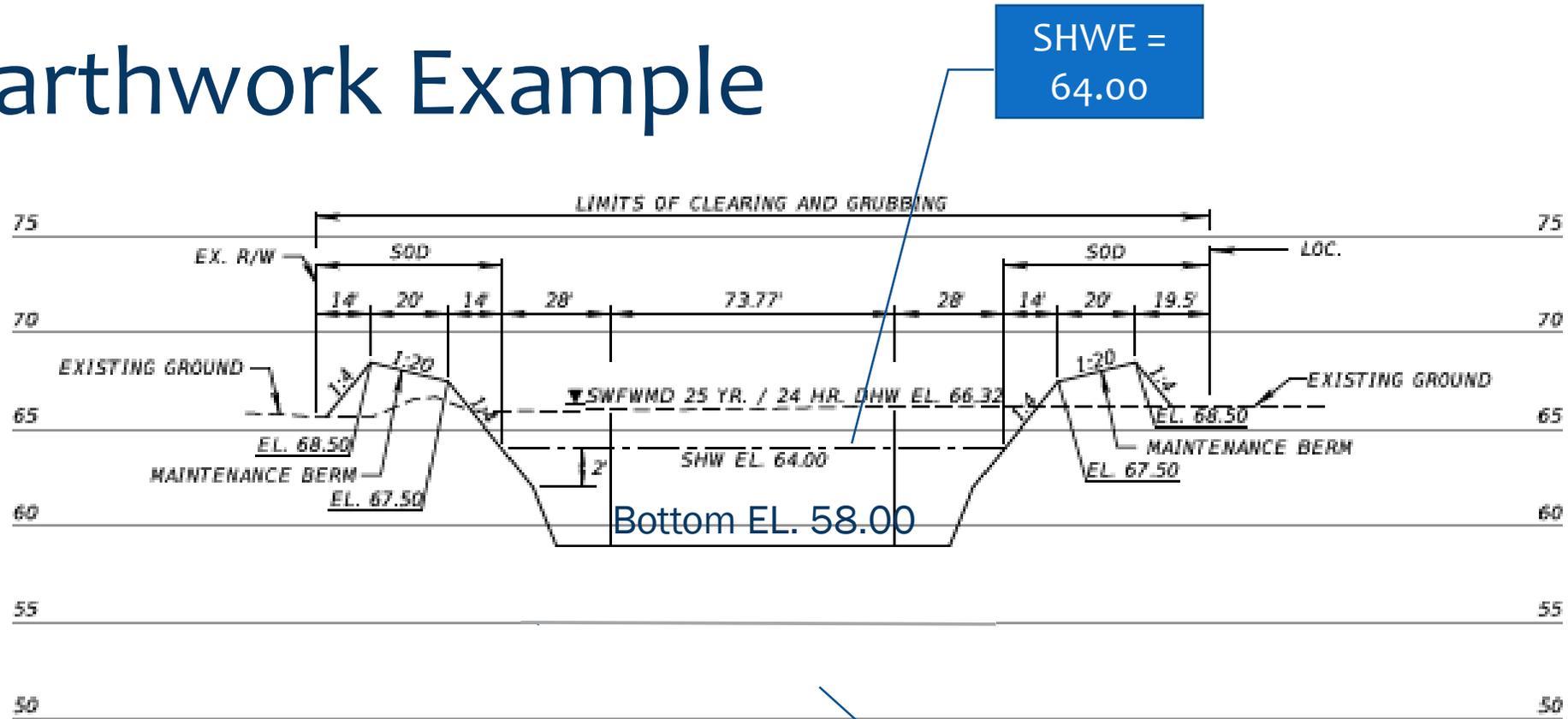
Boring Terminated at Depth of 15 Ft.



Boring Terminated at Depth of 15 Ft.



Earthwork Example



SHWE =
64.00

Bottom
EL. 52.00

Earthwork Example

	6' Deep Pond	12' Deep Pond	18' Deep Pond
Excavation CY	12,000	22,000	32,000
Savings from Reduced Import Fill	\$ 48,000	\$ 88,000	\$ 128,000
Difference	N/A	\$ 40,000	\$ 80,000

PSR Earthwork Example

- Example:
 - 2-lane to 6-lane reconstruction
 - Basin 2 = 30 acre basin, 19 acre of total impervious area
 - Required Treatment Volume = 3.96 ac-ft
 - Consider earthwork costs for three treatment alternatives:
 - 1. Linear Ponds
 - 2. Off-site Pond
 - 3. Regional Pond

PSR Earthwork Example

- Design Considerations:
 - Project needs significant amount of earthwork
 - Suitable soils have been verified from preliminary borings

PSR Earthwork Example

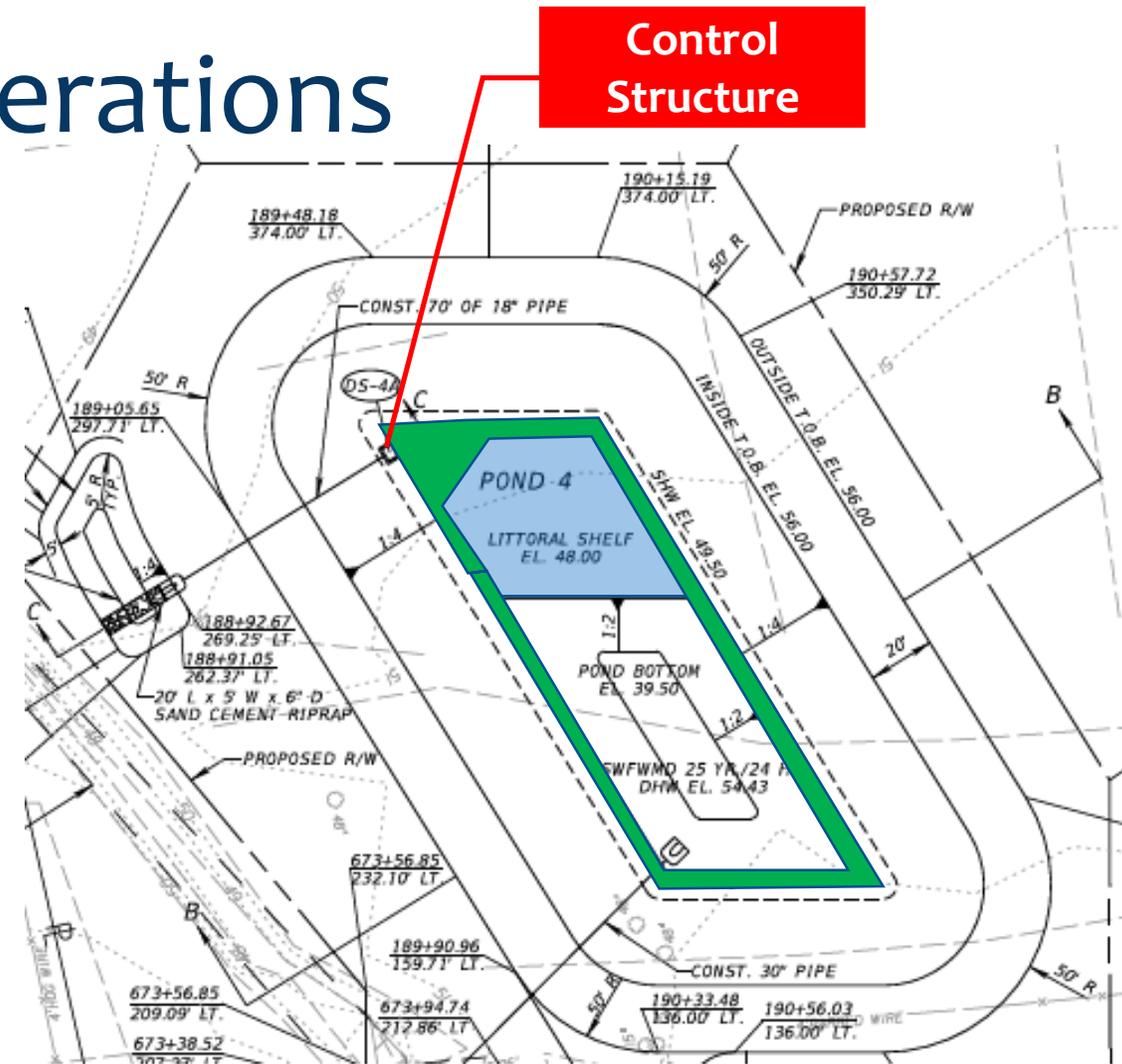
- Basin 2 Pond Comparison

	ROW Cost	Construction Cost	Earthwork Savings	Total Cost
Linear Ponds	\$ -	\$ 86,000	\$ -	\$ 86,000

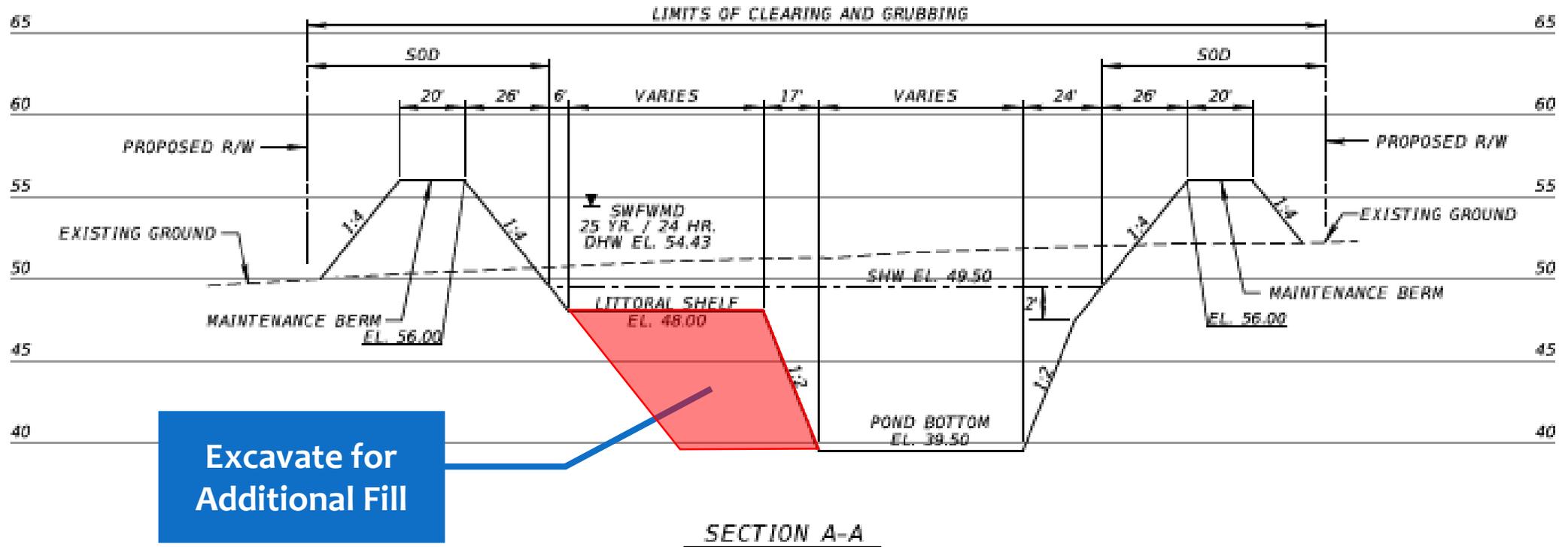
The Regional Pond is the lowest total cost due to Earthwork Savings.

Pond Design Considerations

- For ponds in SWFWMD consider reducing littoral shelf
 - Section 4.1a.1. of A.H. Vol. II requires a minimum 35% littoral zone concentrated at the outfall, for biological assimilation of pollutants.
- SWFWMD will consider reducing this requirement if nutrient loading calculations are provided showing greater nutrient removal due to longer residence time.



Pond Design Considerations



Pond Design Issues

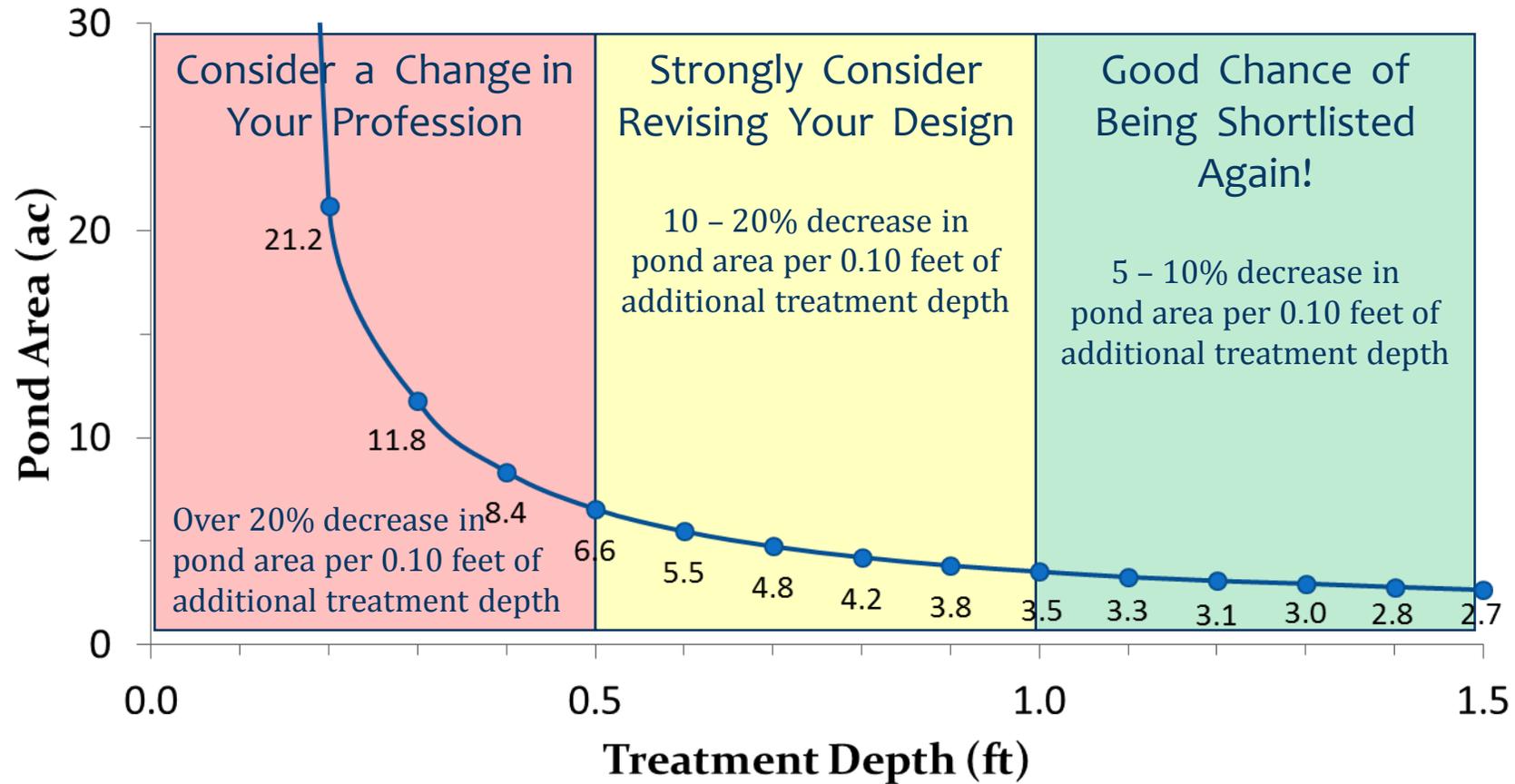
- Treatment Volume (TV) Depths
 - SFWMD does not limit TV depth in wet-detention ponds
 - SWFWMD limits TV depth to 18” above the control elevation in wet-detention ponds
 - District One was seeing a lot of very shallow TV depths (0.2’-1.0’).
 - This was causing larger pond sizes and ROW acquisition costs.

Treatment Volume Depth

TV Depth	Area at TV Elev. (Acre)	Area at ROW line (Acre)	ROW Cost	ROW Savings
0.40'	5.00	6.90	\$552,000	N/A
1.00'	2.00	3.26	\$260,800	\$291,200
1.50'	1.33	2.45	\$196,000	\$356,000

- Project Length = 5,000 ft, ROW Width = 200 ft
- Pre Impervious Width = 39 ft, Post Impervious Width = 72 ft
- Pond Assumptions: 20' berm width, 1' freeboard, 4H:1V side slopes
- ROW Costs = \$80,000/acre

Treatment Depth vs. Pond Area



Treatment Volume Depth (cont.)

- **FDOT District 1 now requires approval from the District Drainage Engineer for Wet-Detention TV depths less than 1.0 ft.**
- Justifications could include:
 - Clearance between existing road profile and SHWE not sufficient
 - Cost of reconstruction/raising profile exceeds ROW acquisition costs
 - Pollutant loading calculations/attenuation requirements dictate pond size
 - Liners/lowering SHWE not practical

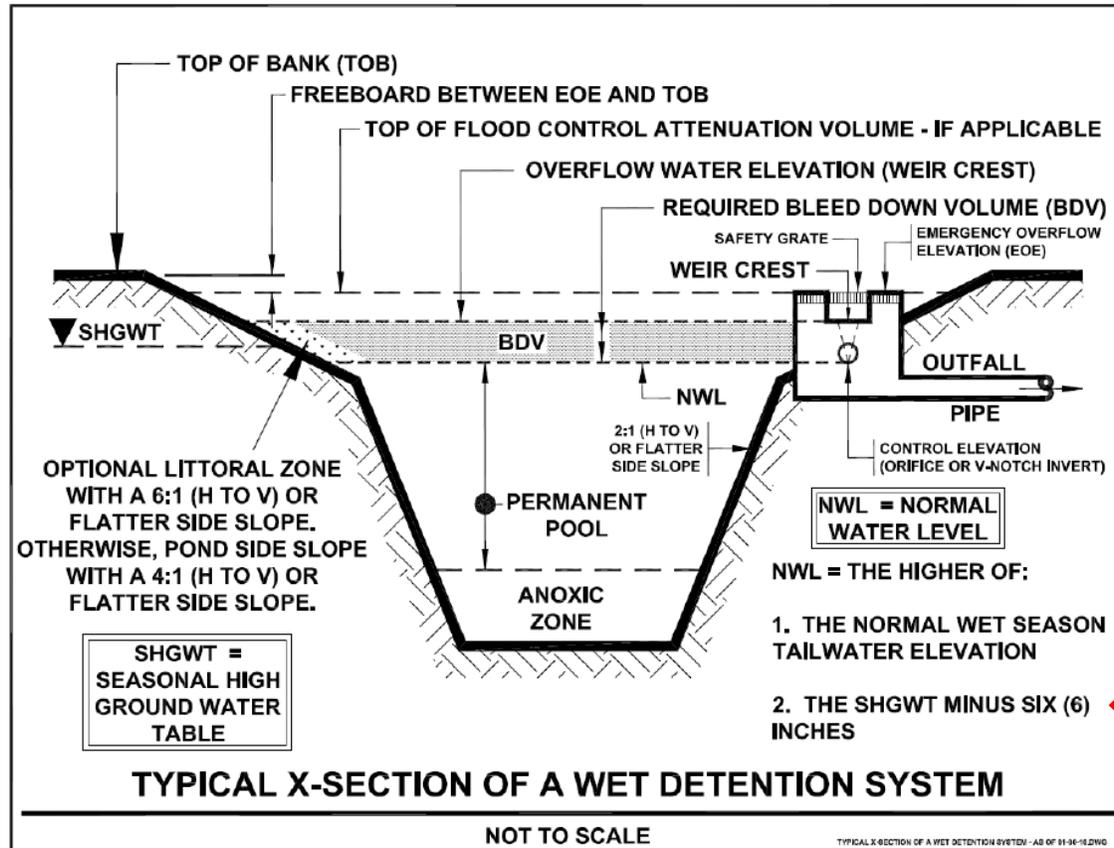
Treatment Volume Requirements

- Maximize Treatment Volume Depth (1.5')
- Don't provide significantly more treatment or attenuation volume to be "conservative"
- Example: Don't provide 4.0 ac-ft if only 2.0 ac-ft is required.

Other Treatment Volume Considerations

- Water Management Districts require an additional 50% of the required TV for direct discharges to OFWs.
- For FDOT projects SFWMD should **not** require an additional 50% for direct discharges to **Impaired Waters**.
- Provide nutrient loading calculations demonstrating net improvement for discharges to Impaired Waters.

Control Elevation 6" below SHWE



From the 2010 Draft Applicant's Handbook, allowed to set control elevation 6" below SHWE if you have a positive outfall



Figure 13.1 Typical Cross Section of a Wet Detention System

SHWE Set too High



SWFWMD POND with Littoral Shelf

SHWE Set too High



Questions?

