

**TECHNICAL PUBLICATION
ASB-WQTT-12-002**

**2012 Updated Everglades Stormwater Treatment Area
Average Ground Elevations, Stage-Area/Stage-Volume
Relationships and Effective Treatment Areas**

**Tracey Piccone, P.E., Jeremy McBryan, P.E.,
Hongying Zhao, Ph.D., P.E., and Yaoyang Yan, Ph.D.**

**South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406**

**December 2012 (Original)
Revised May 2013**



2012 Updated Everglades Stormwater Treatment Area Average Ground Elevations, Stage-Area/Stage-Volume Relationships and Effective Treatment Areas

Tracey Piccone, P.E., Jeremy McBryan, P.E., Hongying Zhao, Ph.D., P.E, and Yaoyang Yan, Ph.D.¹

I. Background

Stormwater Treatment Area (STA) average ground elevations, stage-area/stage-volume relationships and effective treatment areas are critical parameters for STA operations, water balance calculations, performance evaluations, and other STA management activities. Through design, construction and operation, the values for these parameters have evolved to reflect updated data and STA-specific information. This technical publication summarizes the method used to develop the updated effective treatment areas referenced in the 2012 National Pollutant Discharge Elimination System (NPDES) and Everglades Forever Act (EFA) Watershed permits and associated consent orders for the Everglades STAs including Compartments B and C. This technical publication also includes updated average ground elevations and stage-area/stage-volume relationships for each Everglades STA treatment cell, including the recently completed STAs on Compartments B and C, using the latest available topographic data for each STA. Schematics for STA-1E, STA-1W, STA-2 (including Compartment B), STA-3/4, and STA-5/6 (including Compartment C) are shown in **Figures 1 through 5**. It is recommended that for consistency the values in this technical publication be applied to STA operation plans, water budgets, mass balances, day-to-day STA operations, and other STA management activities.

II. Updated STA Effective Treatment Areas

STA effective treatment area is defined simply as the area that contains treatment wetland vegetation, whereas total area includes the effective treatment area plus the area associated with STA-related canals, levees, control structures, and all other areas related to the STA facility. Typically, the total area is about 15 percent larger than the effective treatment area. Over the years, methods to more accurately estimate STA effective treatment area have been developed and refined using detailed topographic survey data and resultant estimates of wetted areas at STA target depths. In an effort to consolidate and simplify previous efforts, a consistent method to estimate STA effective treatment areas was developed in 2011. The spatial extent of effective treatment area for each STA treatment cell was generated using existing STA geospatial data along with recently acquired high resolution aerial photography. The updated effective treatment areas for the STAs are summarized in **Table 1** along with previously published effective treatment areas and treatment cell areas using levee centerlines. A summary of the differences between previously published effective treatment areas is provided below and **Table 2** provides effective treatment areas for individual STA treatment cells.

¹ *Respectively, Chief Engineer; Principal Engineer; Lead Engineer, and Senior Geographer at South Florida Water Management District, West Palm Beach, FL 33406. (email: tpiccone@sfwmd.gov)*

Table 1. STA Effective Treatment Areas

STA	Updated Effective Treatment Areas ¹ (acres)	Previously Published Effective Treatment Areas (acres)	Treatment Cell Areas using Levee Centerlines ^{1,2} (acres)
STA-1E	5,000	5,132	5,100
STA-1W	6,500	6,670	7,000
STA-2 (with Comp. B)	15,500	15,057	15,900
STA-3/4	16,300	16,543	16,500
STA-5/6 (with Comp. C)	13,700	13,009	15,900
Total	57,000	56,411	60,400

Notes:

1 – Areas provided are rounded to the nearest 100 acres.

2 – Treatment Cell Areas using levee centerlines include non-effective treatment areas within STA treatment cells, and exclude inflow, outflow and seepage canals and other areas associated with the STA facility. These areas are provided for informational purposes only.

STA-1E

The previously published effective treatment area appears to have been estimated using levee centerlines, which slightly overestimated the effective treatment area.

STA-1W

The previously published effective treatment area appears to have underestimated Cell 5A and 5B areas, included the Florida Power & Light (FPL) easement within Cell 3, included the north test cells within Cell 1A and included the south test cells within Cell 3. In addition, previously published effective treatment areas for Cells 2A and 2B did not accurately reflect the areas that resulted from the levee construction in 2005 that divided Cell 2 into Cells 2A and 2B.

STA-2 (including Compartment B)

The previously published effective treatment area appears to have included the FPL easement within Cells 1 and 8 (approximately 420 acres) while other cells were underestimated.

STA-3/4

The previously published effective treatment area appears to have been slightly overestimated. In addition, the previously published effective treatment areas for Cells 2B, 3A and 3B did not accurately reflect the areas that resulted from the levee construction during 2004 and 2005 that divided Cell 3 into Cells 3A and 3B and separated the Periphyton-based STA (PSTA) Demonstration Project cells from Cell 2B. **Note:** the STA-3/4 PSTA Project cells (approximately 450 acres) are included in the effective treatment area estimated for Cell 2B.

STA-5/6 (including Compartment C)

The previously published effective treatment area did not include the non-effective treatment area located in western Cell 5-1A (previously referred to as STA-5 Cell 1A; approximately 360 acres). Internal earthwork improvements were completed in 2009 in this area as part of a

major enhancement project to improve STA performance. This area is documented as effective treatment area in the 2012 NPDES and EFA Watershed permits and associated consent orders. In addition, the previously published effective treatment area for Compartment C cells appears to have been underestimated. **Note:** the updated effective treatment area excludes the non-effective treatment areas of Cells 5-2A and 5-3A (previously referred to as STA-5 Cells 2A and 3A) and Cells 5-4A and 5-5A (previously referred to as STA-5 Cells 4A and 5A) (approximately 1,900 acres).

Table 2. Effective Treatment Areas for Individual STA Treatment Cells

STA Cell	Updated Effective Treatment Areas (acres)	Previously Published Effective Treatment Areas (acres)
STA-1E		
Cell 1	541	556
Cell 2	541	552
Cell 3	572	589
Cell 4N	635	645
Cell 4S	732	752
Cell 5	542	571
Cell 6	1,033	1,049
Cell 7	398	418
STA-1E Total ¹	4,994	5,132
STA-1W		
Cell 1A	713	745
Cell 1B	577	745
Cell 2A	701	471
Cell 2B	309	470
Cell 3	881	1,026
Cell 4	359	358
Cell 5A	602	562
Cell 5B	2,402	2,293
STA-1W Total ¹	6,544	6,670
STA-2		
Cell 1	1,840	1,798
Cell 2	2,373	2,270
Cell 3	2,296	2,270
Cell 4	1,942	1,902
Cell 5	2,183	2,096
Cell 6	1,865	1,786
Cell 7	1,537	1,525
Cell 8	1,458	1,410
STA-2 Total ¹	15,495	15,057
STA-3/4		
Cell 1A	3,020	3,039
Cell 1B	3,456	3,488
Cell 2A	2,506	2,542

STA Cell	Updated Effective Treatment Areas (acres)	Previously Published Effective Treatment Areas (acres)
Cell 2B ²	2,843	2,894
Cell 3A	2,415	2,153
Cell 3B	2,087	2,427
STA-3/4 Total ¹	16,327	16,543
STA-5/6		
Cell 5-1A	1,195	835
Cell 5-1B	1,223	1,220
Cell 5-2A ³	835	835
Cell 5-2B	1,233	1,220
Cell 5-3A ³	1,002	1,002
Cell 5-3B	920	983
Cell 5-4A ³	1,403	1,330
Cell 5-4B	468	460
Cell 5-5A ³	1,938	1,647
Cell 5-5B	704	690
Cell 6-2	1,361	1,387
Cell 6-3	242	245
Cell 6-4	539	530
Cell 6-5	621	625
STA-5/6 Total ¹	13,685	13,009

Notes:

1 – STA Total Areas may not equal the sum of individual STA cell areas listed due to rounding to the nearest integer value.

2 – STA-3/4 Cell 2B includes the STA-3/4 Periphyton-based STA Demonstration Project (approximately 450 acres)

3 – STA-5/6 Cells 5-2A, 5-3A, 5-4A, and 5-5A exclude non-effective treatment areas (approximately 1,900 acres).

III. Updated STA Topographic Survey Data

Updated STA topographic survey data is acquired periodically to improve or refine data used in operational decision making and STA performance evaluations. For example, updated topographic data is used to refine treatment cell target stages, to update the relationship between treatment cell stage and wetted area, and to perform various hydraulic analyses such as two-dimensional hydrodynamic modeling.

In Fiscal Year (FY) 2010, updated topographic surveys were completed at STA-1W, STA-2, STA-5, and STA-6. The STA-1W survey was conducted by Woolpert, Inc., the STA-2 survey was conducted by Morgan & Eckland, Inc., and the STA-5 and STA-6 surveys were conducted by Erdman Anthony, Inc. All surveys were conducted under the direct supervision of a Professional Surveyor and Mapper in accordance with the Minimum Technical Standards (MTS) set forth in Chapter 61G 17-6 of the Florida Administrative Code. All horizontal data were collected in and based on the North American Datum of 1983 (NAD 83) and all vertical measurements were conducted in the North American Vertical Datum of 1988 (NAVD 88) and converted to the National Geodetic Vertical Datum of 1929 (NGVD 29) using the difference for each STA's control points. The topographic survey data were collected on a 500-foot x 1000-

foot grid pattern. Efforts were made to ensure that each data point was representative of the surrounding marsh with the intent that no data points be taken on levees, remnant farm roads, in remnant farm ditches or canals. Additionally a six-inch diameter plate was placed on the bottom of the surveying rod to ensure that accurate bottom elevations were obtained in the marsh environment.

Updated surveys were not completed at STA-1E and STA-3/4 in FY2010, therefore the updated STA average ground elevations and stage-area/stage-volume relationships for these two STAs were developed using the latest available topographic data. STA-1E was surveyed in 2005 by Wantman Group, Inc., and the topographic survey data were collected on a 500-foot x 1000-foot grid pattern. STA-3/4 was surveyed in 2008 by MACTEC Engineering and Consulting, Inc., and the topographic survey data were collected on a 500-foot x 500-foot grid pattern.

The Compartment B topographic survey was completed in 2006 by SFRN, Inc., and the Compartment C topographic survey was completed in 2006 by Betsy Lindsay, Inc. The topographic survey data were collected on a 500-foot x 500-foot grid pattern for the Compartment B and C surveys.

IV. Updated STA Topographic Maps and Average Ground Elevations

Spatially averaged ground elevation estimations were generated for STA-1E, STA-1W, STA-2, STA-3/4, STA-5, STA-6, Compartment B and Compartment C using the latest available topographic data and digital elevation model (DEM) techniques. A DEM is a raster representation of a continuous surface. It is one of the most common digital data representations of the shape of the earth's surface. ARCGIS 9.3 Spatial Analyst extension includes several tools to interpolate spatial data. "Spline" and "Kriging" are two options commonly used to interpolate topographic data. The "Spline" method estimates values using a mathematical function that minimizes overall surface curvature. This results in a smooth surface that passes exactly through each survey data point. The "Kriging" method uses a powerful statistical technique that employs sophisticated weighted average techniques; however the surface created using the "Kriging" method does not always pass exactly through the survey data points. For the purpose of this report, the average ground elevations are based on the DEMs developed using the "Spline" interpolation method employed with the following settings:

- a. Spline type – tension
- b. Output cell size – 22.5 feet x 22.5 feet
- c. Weight – 0.1 (default)
- d. Number of points – 12

The resulting topographic maps for the Everglades STAs are shown in **Figures 6 through 13**.

Updated treatment cell average ground elevations for all Everglades STA treatment cells including notes on the data points used to develop the average ground elevations are presented in **Tables 3 through 8**, and an overall summary of the treatment cell average ground elevations is shown in **Table 9**.

V. Updated STA Stage-Area/Stage-Volume Relationships

Further utilization of the updated topographic data and DEM analyses included developing updated stage-area/stage-volume tables for each STA treatment cell. The areas of the treatment cells were calculated at half-foot intervals using Geospatial Informational System (GIS) analysis. Correspondingly, the accumulated volumes were calculated at each stage. These relationships are summarized in the **Tables 10 through 52**.

STA-1E Cell 2 stage-area/stage-volume relationships will be developed upon receipt of As-built information following the topographic modifications to be completed by the U.S. Army Corps of Engineers in approximately 2013.

VI. Other Related Activities

In March 2012, the updated average ground elevations were implemented in the District's Stormwater Treatment Area Reporting (STAR) database used for weekly operational decision making, and in May 2012, target stages in six STA treatment cells² were revised utilizing the updated average ground elevation information in close concert with field observations of depths and vegetation conditions. Finally, in June 2012, the STA Water Budget Tool was updated with the revised average ground elevations with an effective date of May 1, 2011.

² STA-1W Cells 1A, 1B, 3, 5A and 5B; STA-2 Cell 2.

Figure 1. STA-1E Schematic

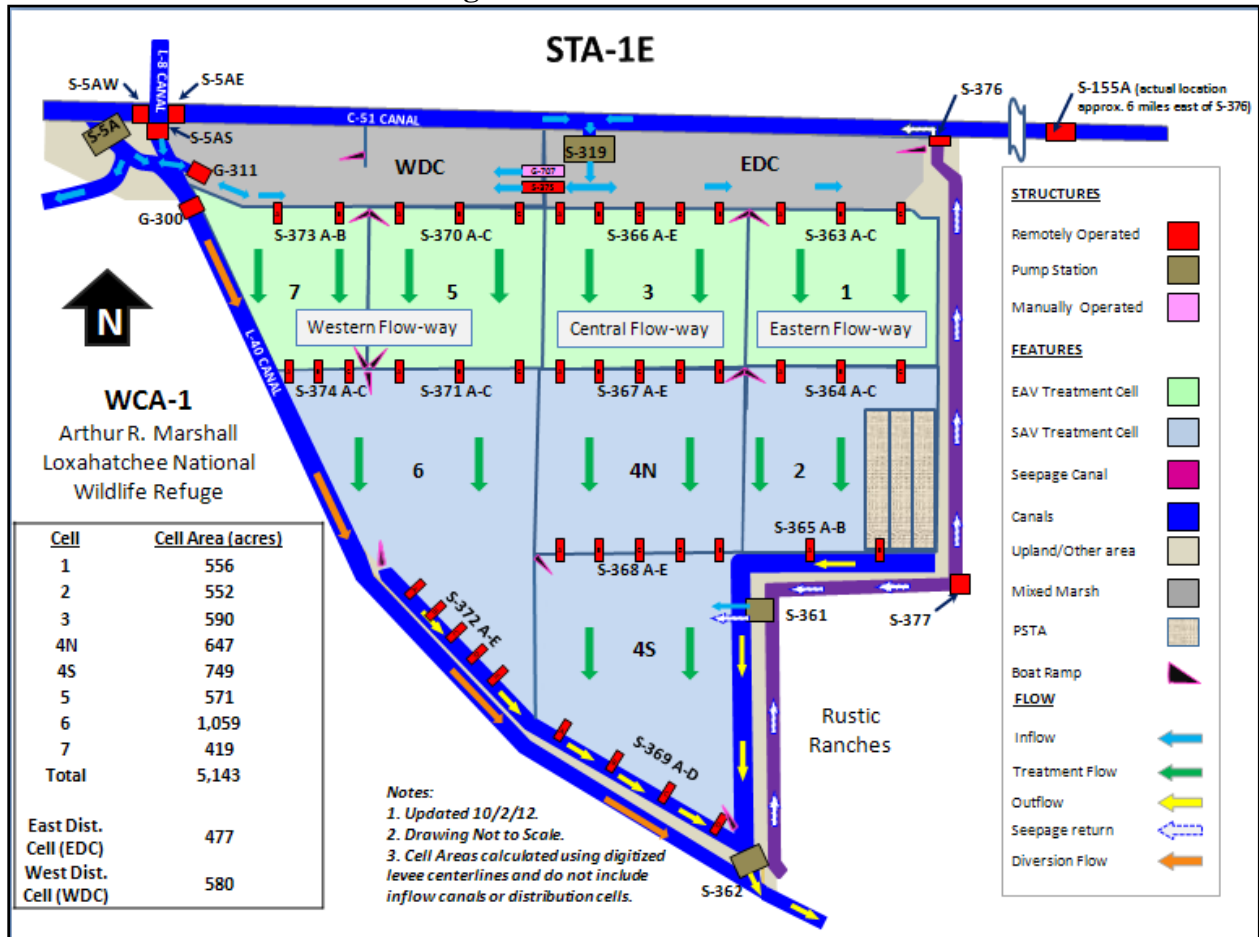


Figure 2. STA-1W Schematic

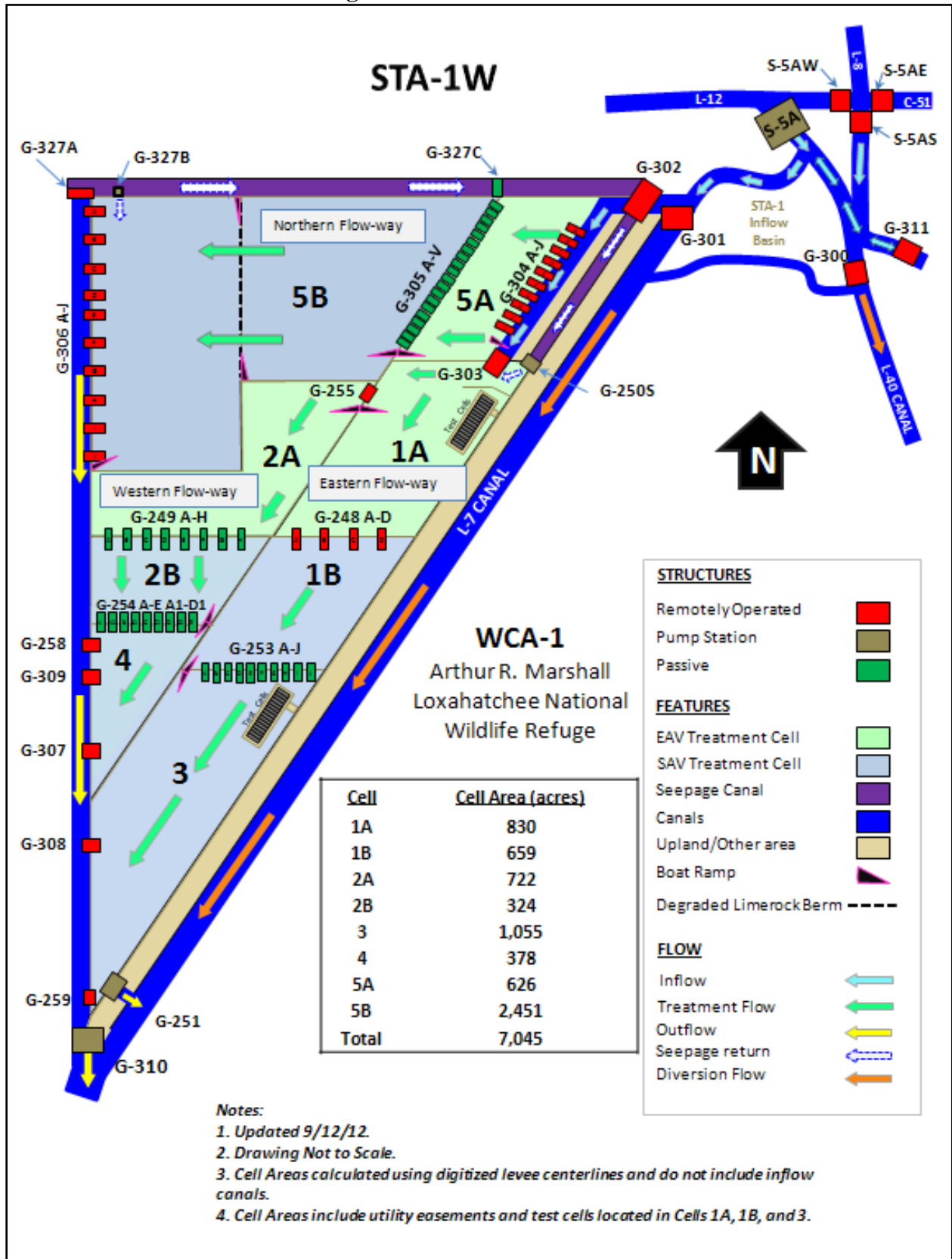


Figure 3. STA-2 Schematic

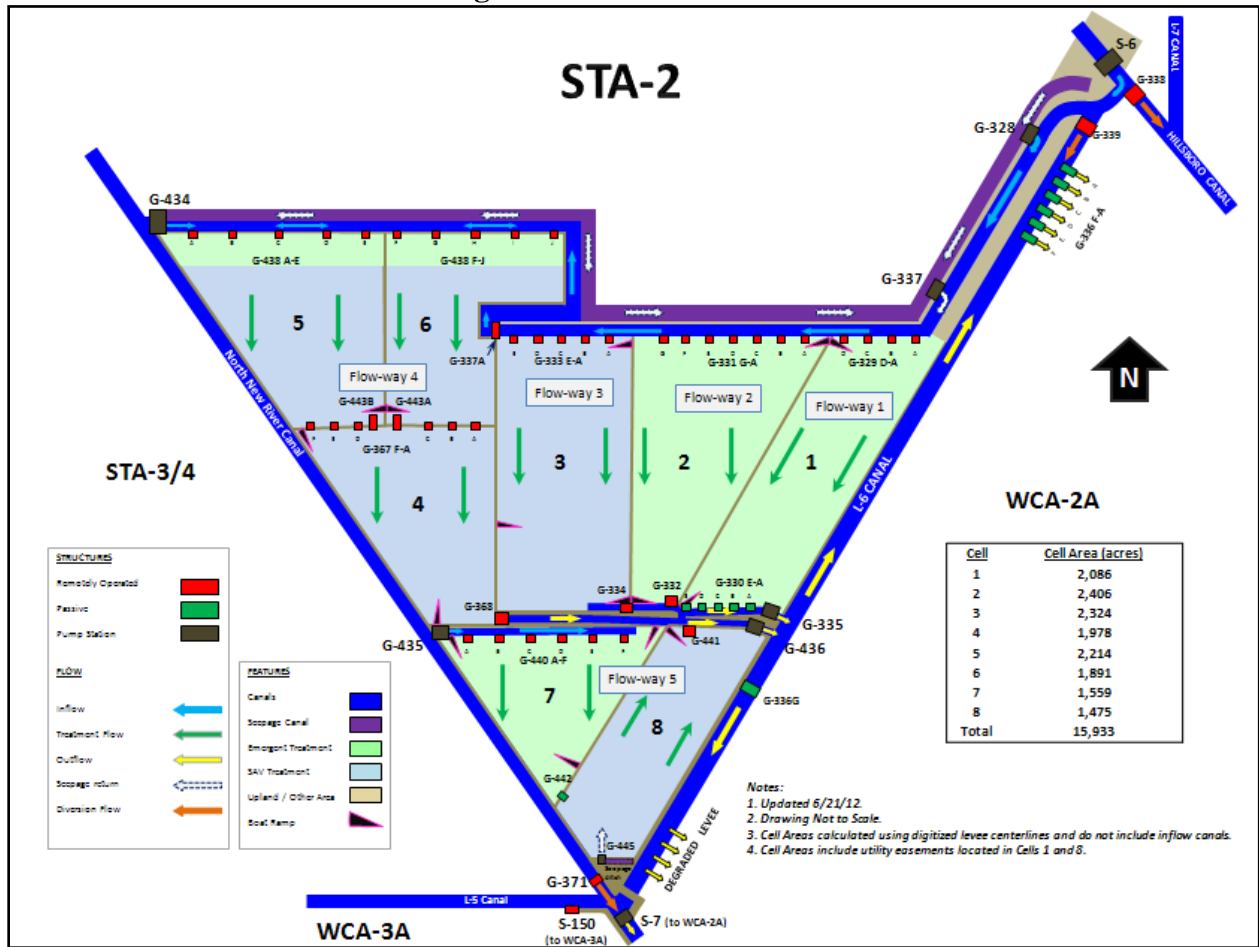


Figure 4. STA-3/4 Schematic

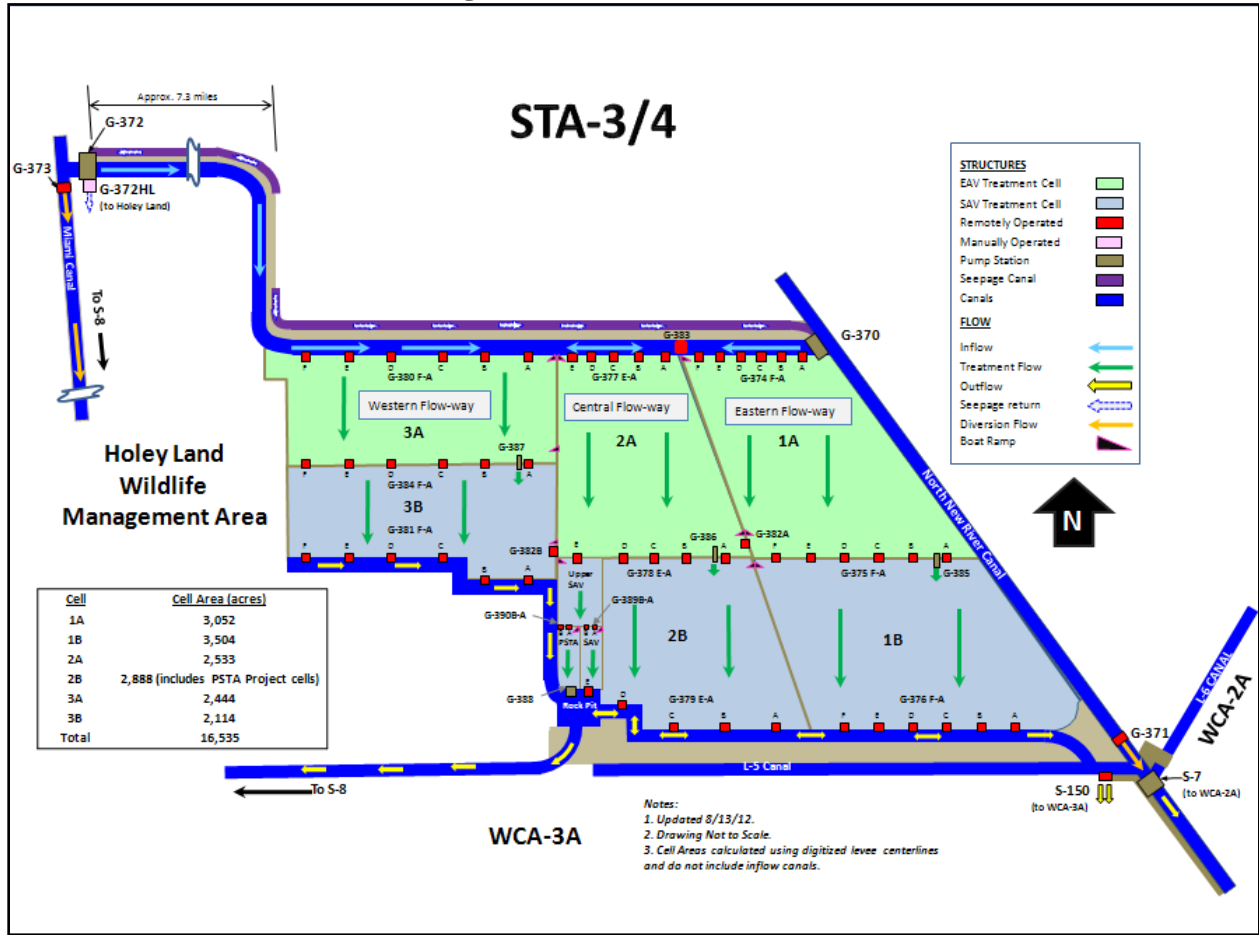


Figure 5. STA-5/6 Schematic

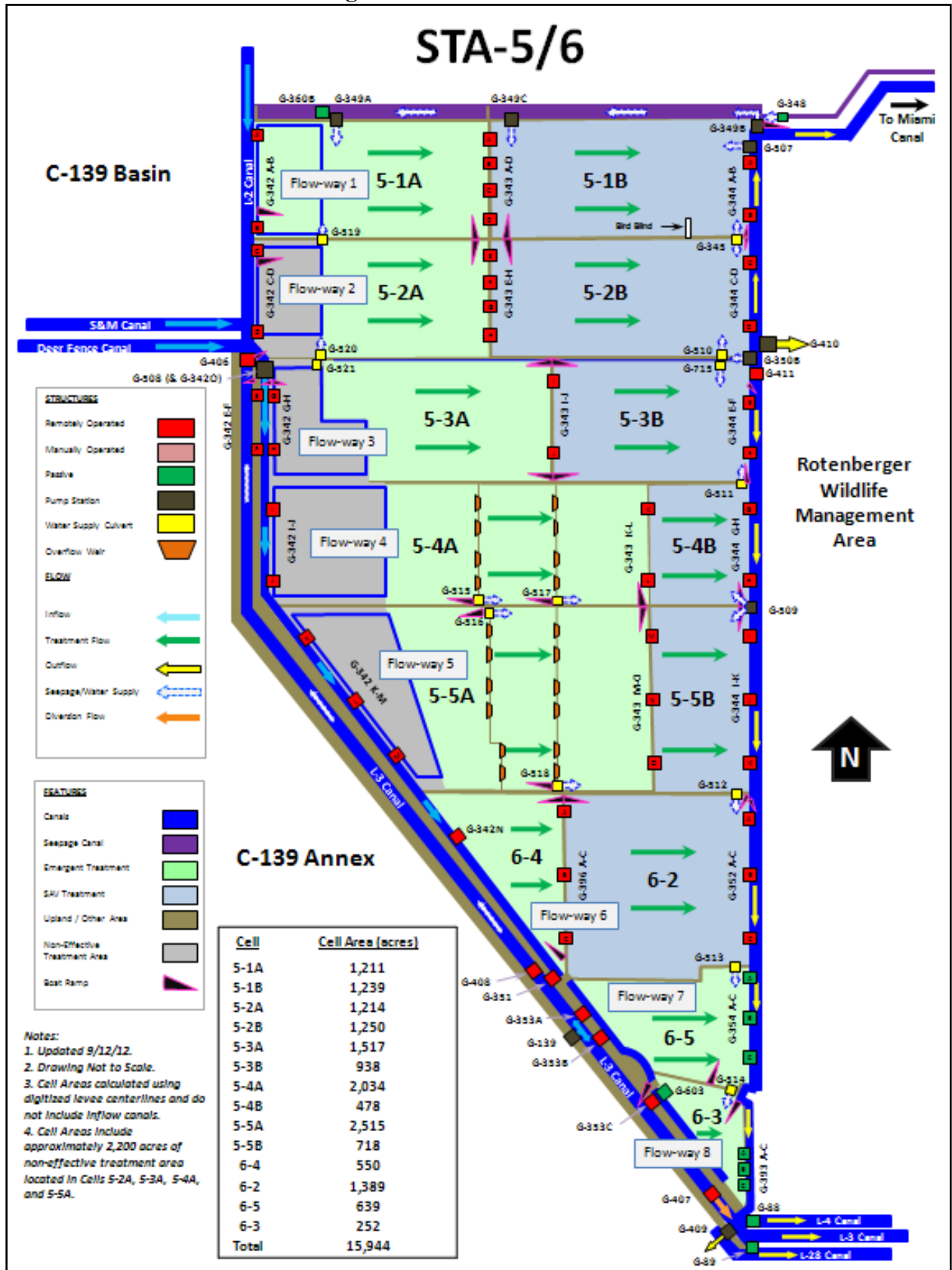


Figure 6. STA-1E DEM based on 2005 Topographic Survey Data

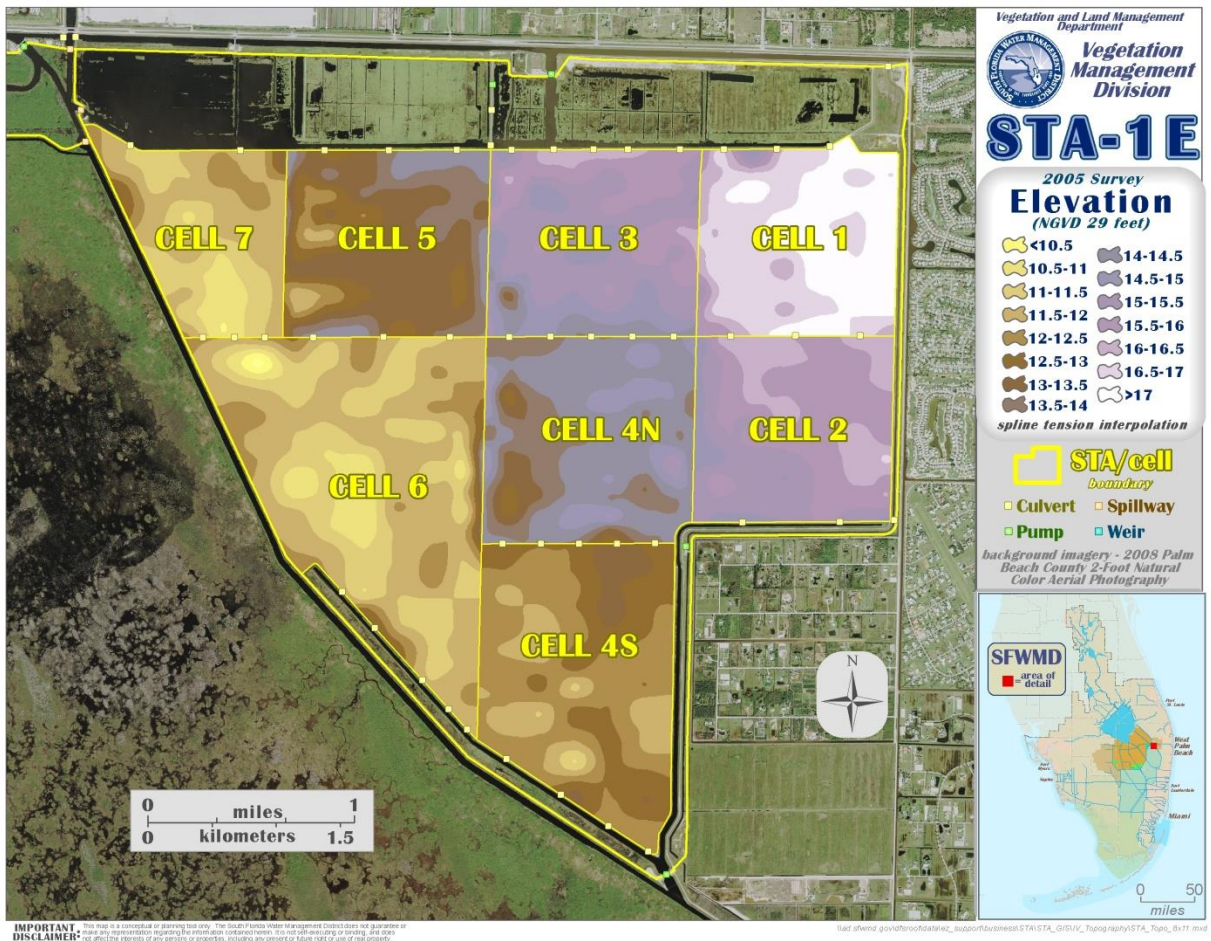


Figure 7. STA-1W DEM based on 2010 Topographic Survey Data

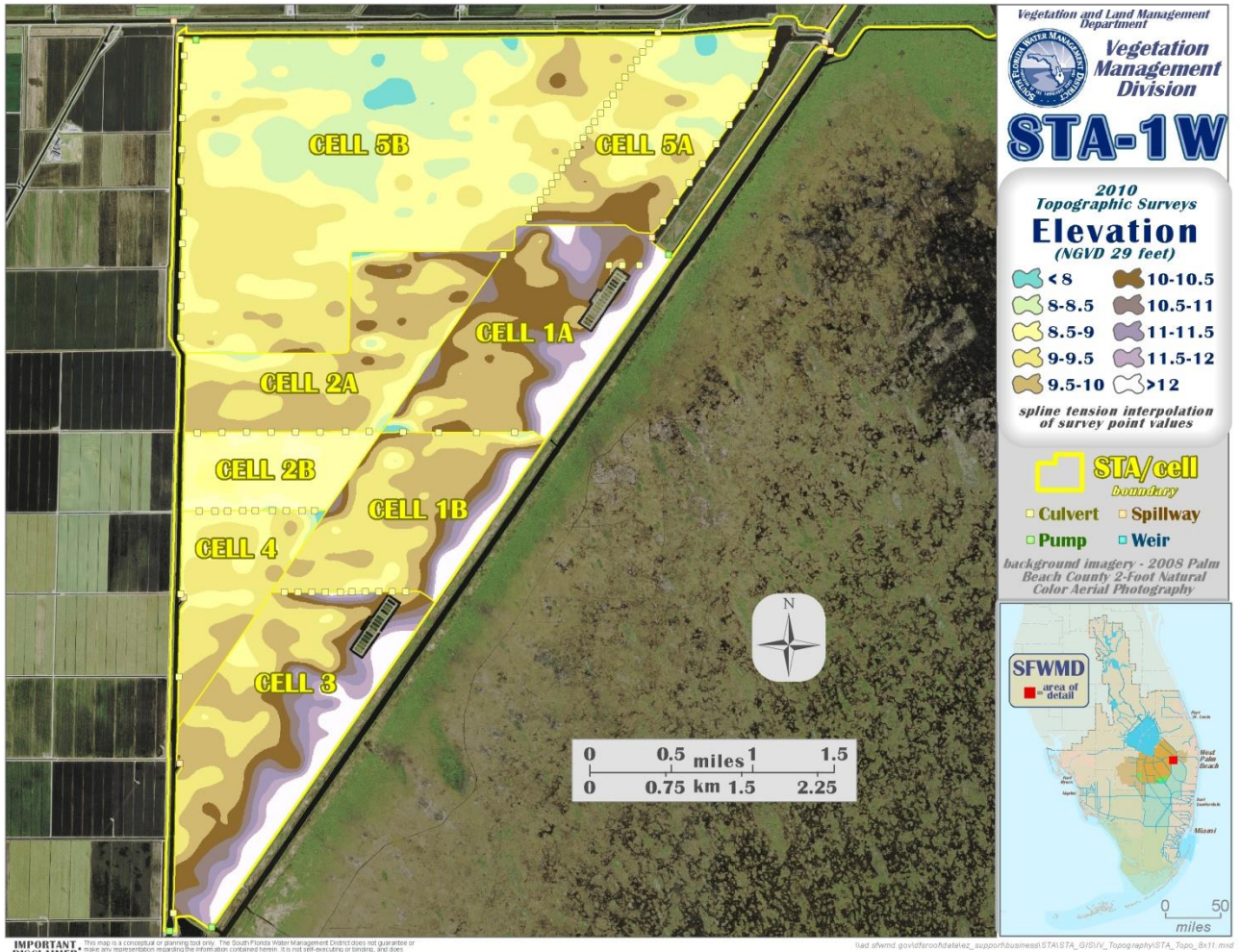


Figure 8. STA-2 DEM based on 2010 Topographic Survey Data

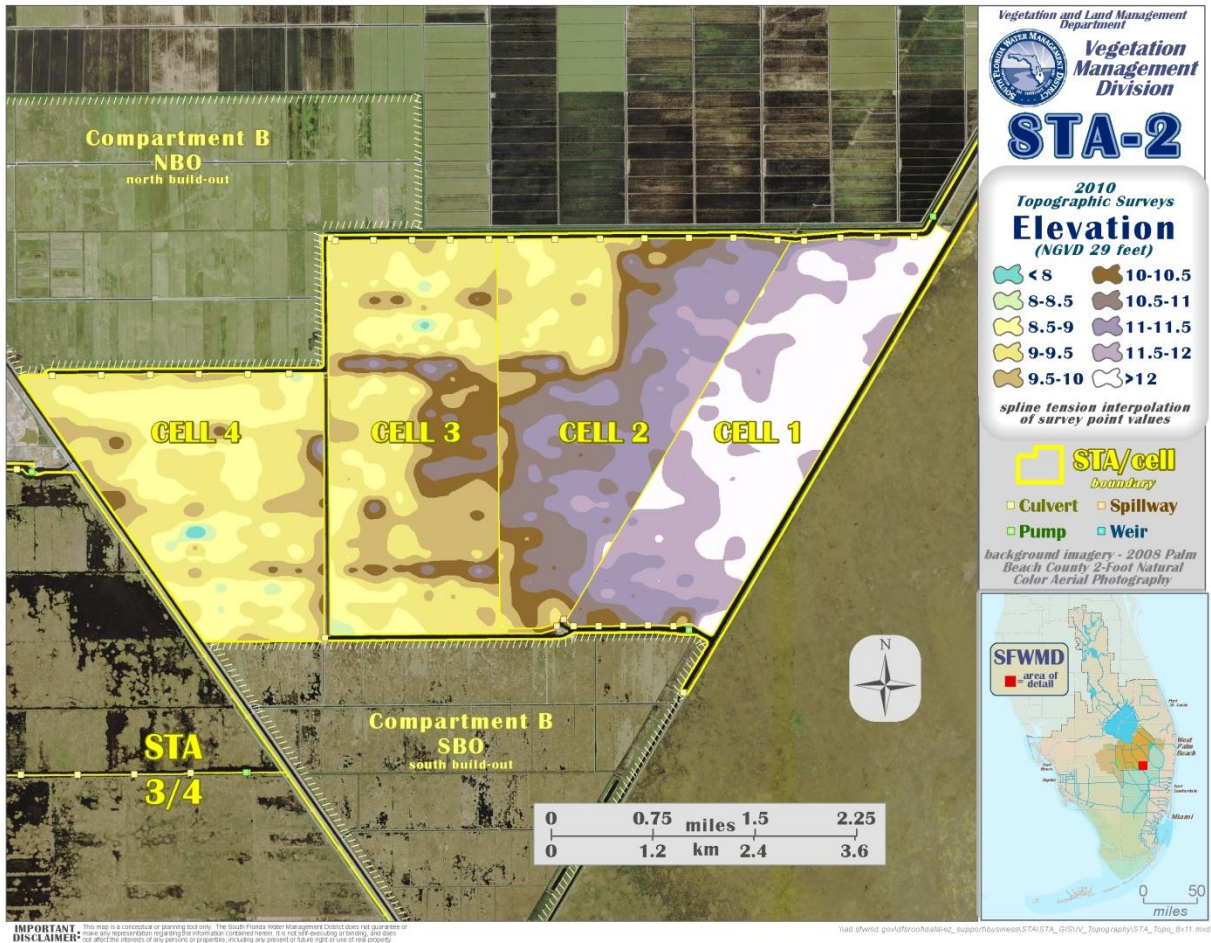


Figure 9. STA-3/4 DEM based on 2008 Topographic Survey Data

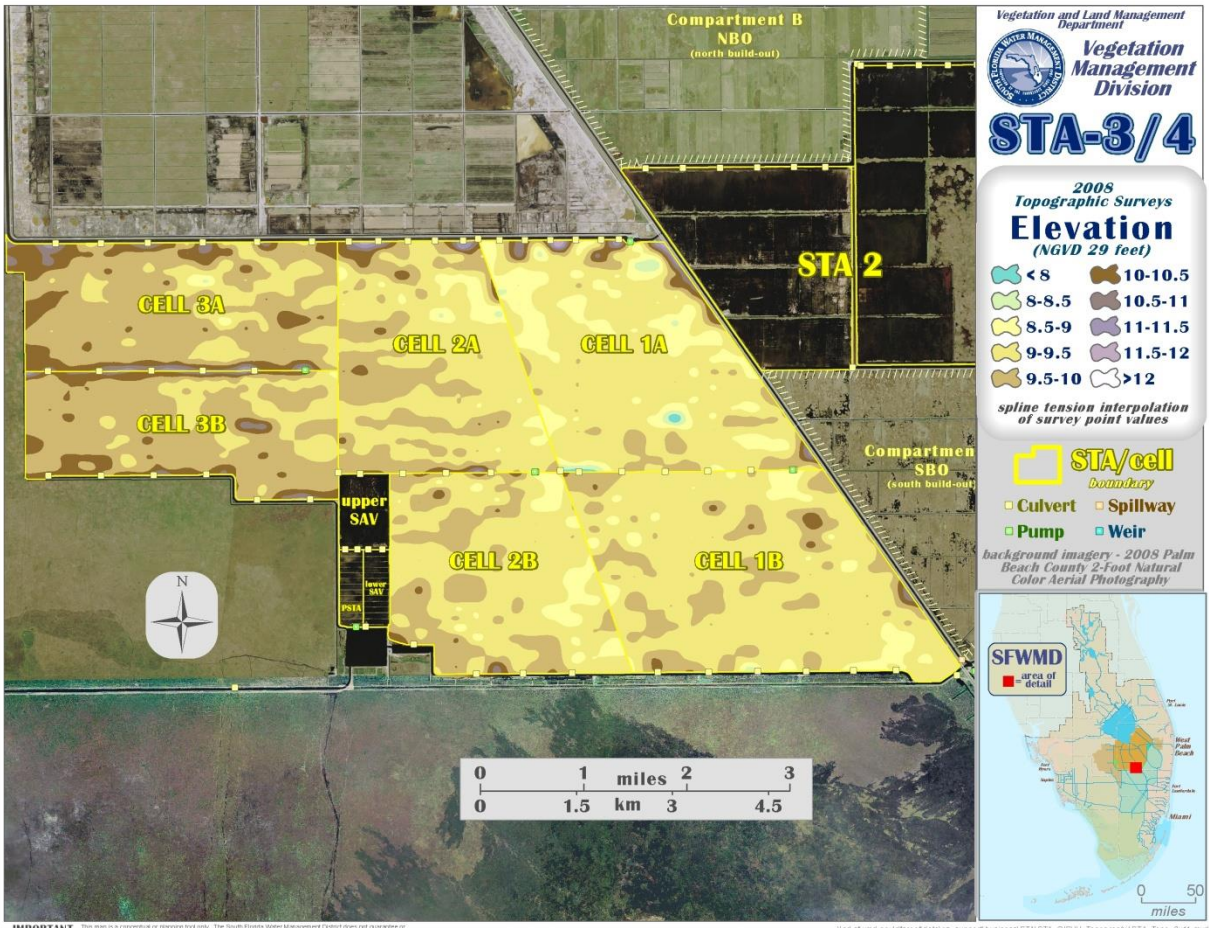


Figure 10. STA-5 DEM based on 2010 Topographic Survey Data

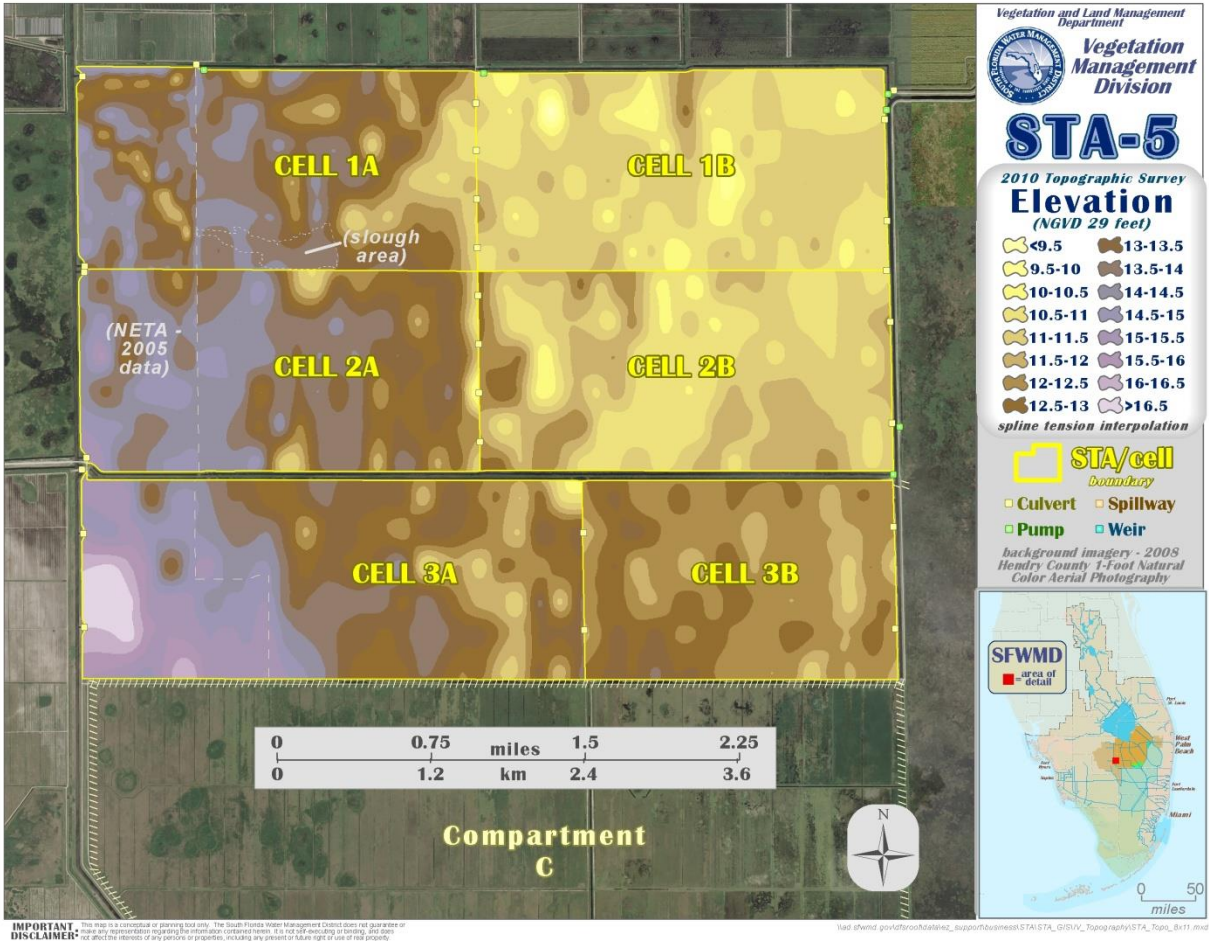
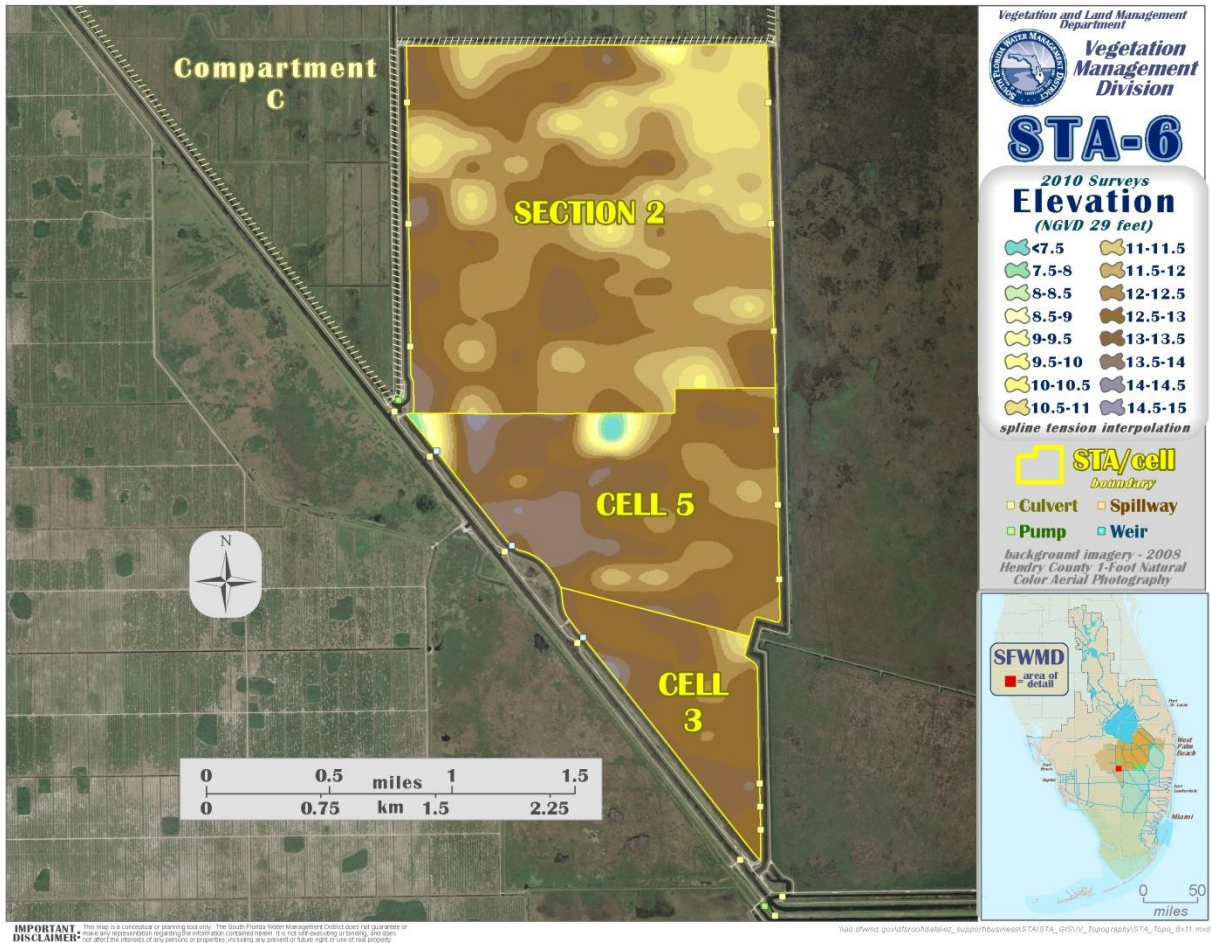


Figure 11. STA-6 DEM based on 2010 Topographic Survey Data



Note: In STA-6 Cell 5, three (3) of the 2010 survey points were several feet lower than the same survey points measured in 2004 and were several feet lower than the majority of the other 2010 survey points, resulting in an apparent skewing of the overall average ground elevation for the cell. Field verification indicated that these three points were likely located in small remnant ditches within the cell. Since the goal of the topographic surveys is to characterize the average ground elevation of the marsh area, these three (3) points were removed from the average ground calculation shown in **Tables 8 and 9**.

Figure 12. Compartment B* DEM based on 2006 Topographic Survey Data
 (*The Compartment B treatment cells are now referred to as STA-2 Cells 5, 6, 7 and 8).

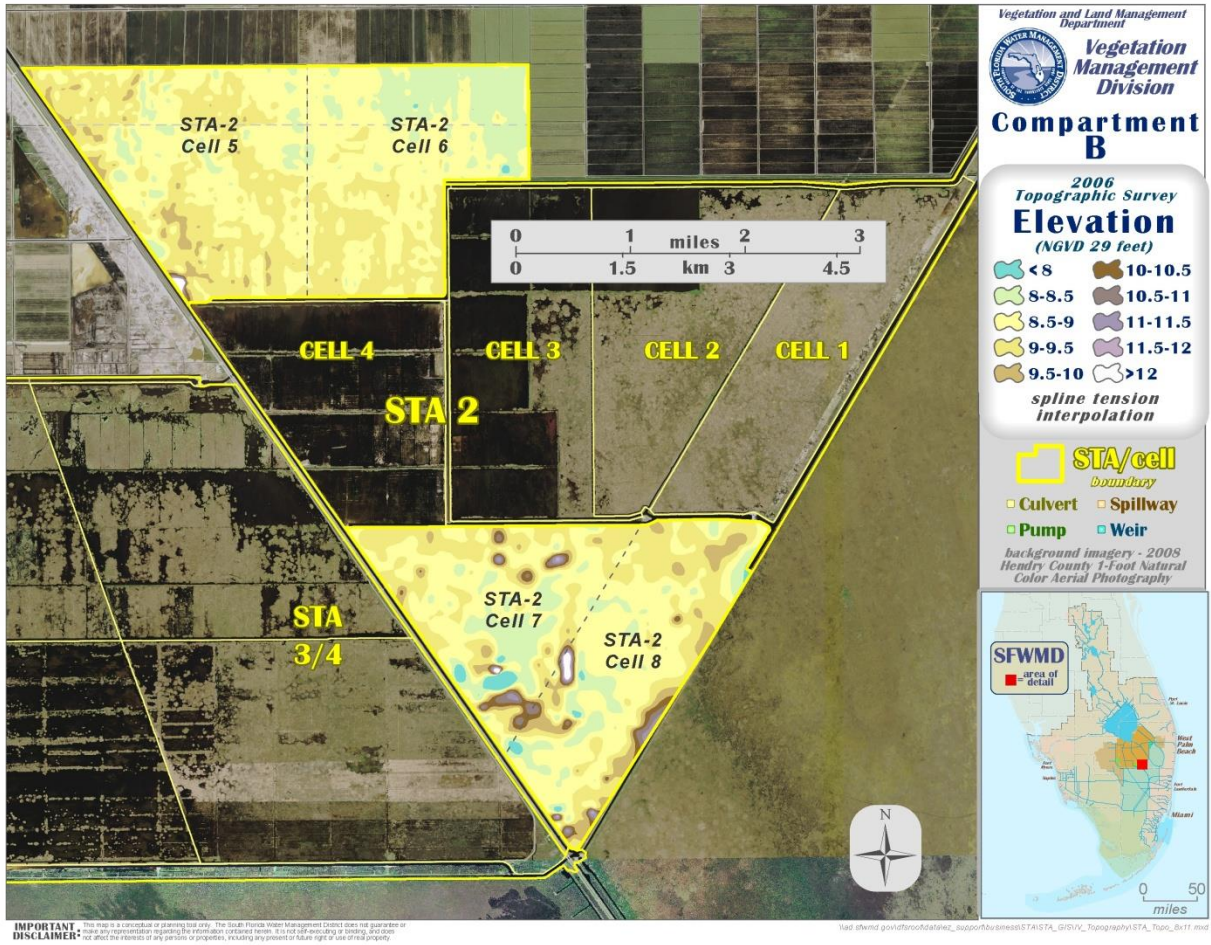


Figure 13. Compartment C* DEM based on 2006 Topographic Survey Data
(*The Compartment C treatment cells are now referred to as
STA-5 Cells 4A, 4B, 5A, 5B and STA-6 Cell 4).

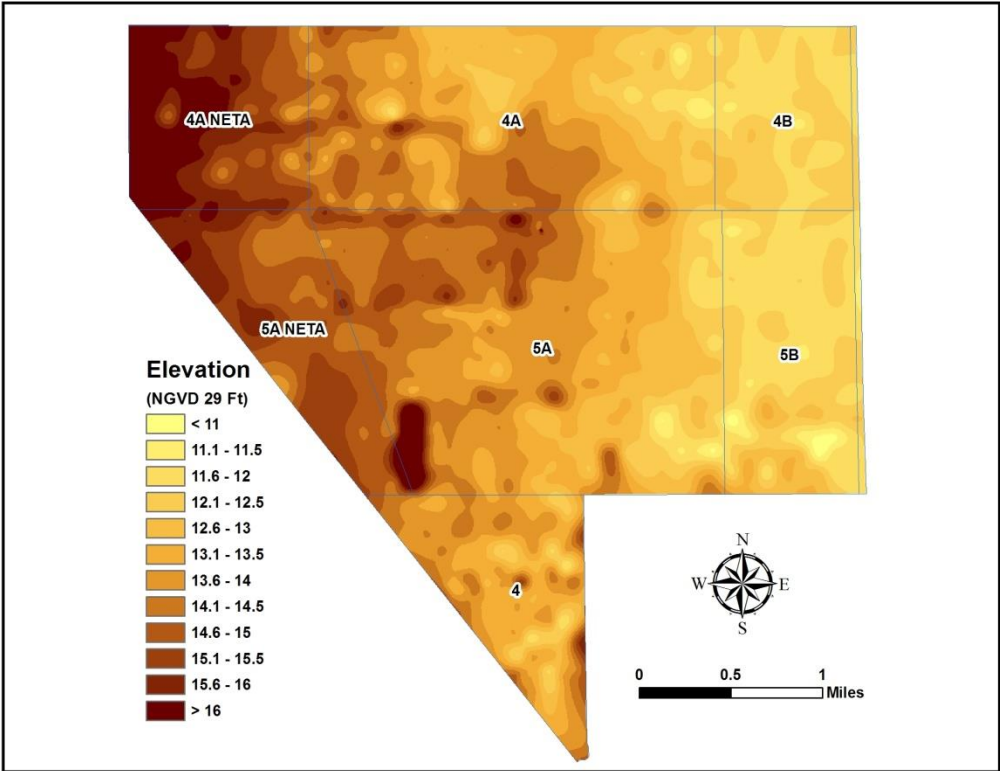


Table 3. STA-1E Average Ground Elevations

STA-1E: <i>(elevation values in feet NGVD 29)</i>			
	Survey	Spline DEM	
Cell	Year	Avg	Comments
1	2005	16.9	All survey points used
2	2005	15.7	All survey points used
3	2005	15.2	All survey points used
5	2005	13.3	All survey points used
7	2005	11.6	All survey points used
4N	2005	14.1	All survey points used
4S	2005	12.4	All survey points used
6	2005	11.6	All survey points used
EDC	2005	16.7	All survey points used
WDC	2005	14.9	All survey points used

Table 4. STA-1W Average Ground Elevations

STA-1W: <i>(elevation values in feet NGVD 29)</i>			
	Survey	Spline DEM	
Cell	Year	Avg	Comments
1A	2010	10.4	Not including area under FPL lines or test cells
2A	2010	9.5	All survey points used
5A	2010	9.0	All survey points used
1B	2010	9.6	Not including area under FPL lines. Post-2007 scraping of 150,000 cubic yards of sediment
2B	2010	9.2	All survey points used
3	2010	10.2	Not including area under FPL lines or test cells
4	2010	9.2	All survey points used. Post-2007 scraping of 150,000 cubic yards of sediment
5B	2010	8.8	All survey points used

Table 5. STA-2 Average Ground Elevations

STA-2: <i>(elevation values in feet NGVD 29)</i>			
	Survey	Spline DEM	
Cell	Year	Avg	Comments
1	2010	12.0	All survey points used
2	2010	10.5	All survey points used
3	2010	9.5	All survey points used
4	2010	9.1	All survey points used
5	2006	9	All survey points used
6	2006	8.8	All survey points used
7	2006	8.9	All survey points used
8	2006	9	All survey points used

Table 6. STA-3/4 Average Ground Elevations

STA-3/4: <i>(elevation values in feet NGVD 29)</i>			
	Survey	Spline DEM	
Cell	Year	Avg	Comments
1A	2008	9.2	All survey points used
2A	2008	9.4	All survey points used
3A	2008	9.8	All survey points used
1B	2008	9.3	All survey points used
2B	2008	9.4	All survey points used
3B	2008	9.7	All survey points used

Table 7. STA-5 Average Ground Elevations

STA-5: <i>(elevation values in feet NGVD 29)</i>			
	Survey	Spline DEM	
Cell	Year	Avg	Comments
1A	2010	13.1	All survey points used. Post 2009 slough filling and scraping of prior Non-Effective Treatment Area. <u>Includes</u> prior NETA area.
1B	2010	11.0	All survey points used
2A	2010	13.3	All survey points used. Excludes NETA.
2B	2010	11.3	All survey points used
3A	2010	13.0	All survey points used. Excludes NETA.
3B	2010	12.4	All survey points used
4A	2006	13.4	All survey points used. Excludes NETA.
4B	2006	12.0	All survey points used
5A	2006	13.7	All survey points used. Excludes NETA.
5B	2006	12.0	All survey points used

Table 8. STA-6 Average Ground Elevations

STA-6: <i>(elevation values in feet NGVD 29)</i>			
	Survey	Spline DEM	
Cell	Year	Avg	Comments
2	2010	12.2	All survey points used
3	2010	12.9	All survey points used
4	2006	13.5	All survey points used
5	2010	12.9	Three survey points in remnant canals deleted

Table 9. Summary of Updated STA Average Ground Elevations (Feet NGVD 29)

	Cell	Average
STA-1E	1	16.9
	2	15.7
	3	15.2
	5	13.3
	7	11.6
	4N	14.1
	4S	12.4
	6	11.6
	EDC	16.7
	WDC	14.9
STA-1W	1A	10.4
	2A	9.5
	5A	9.0
	1B	9.6
	2B	9.2
	3	10.2
	4	9.2
	5B	8.8
STA-2	1	12.0
	2	10.5
	3	9.5
	4	9.1
	5	9
	6	8.8
	7	8.9
	8	9
STA-3/4	1A	9.2
	2A	9.4
	3A	9.8
	1B	9.3
	2B	9.4
	3B	9.7
STA-5	1A	13.1
	1B	11.0
	2A*	13.3
	2B	11.3
	3A*	13.0
	3B	12.4
	4A*	13.4
	4B	12
	5A*	13.7
5B	12	
STA-6	2	12.2
	3	12.9
	4	13.5
	5	12.9

*Does not include Non-Effective Treatment Area on west side of cell.

Table 10. STA-1E Cell 1 Stage-Area and Stage-Volume Relationships

<i>STA-1E, Cell 1</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
14.9	1.6	0.3
15.4	5.0	1.9
15.9	19.3	8.0
16.4	53.3	26.1
16.9	258.7	104.1
17.4	470.6	286.5
17.9	540.0	539.1
18.0	540.7	602.5
18.5	540.7	872.9
19.0	540.7	1143.2
19.5	540.7	1413.5
20.0	540.7	1683.9

Table 11. STA-1E Cell 3 Stage-Area and Stage-Volume Relationships

<i>STA-1E, Cell 3</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
13.7	2.8	0.6
14.2	14.5	4.9
14.7	73.6	26.9
15.2	277.2	114.6
15.7	498.7	308.6
16.2	571.5	576.1
16.4	572.2	650.9
16.9	572.2	937.0
17.4	572.2	1223.1
17.9	572.2	1509.1
18.4	572.2	1795.2
18.9	572.2	2081.3
19.4	572.2	2367.4
19.9	572.2	2653.5

Table 12. STA-1E Cell 4N Stage-Area and Stage-Volume Relationships

<i>STA-1E, Cell 4N</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
13.1	15.1	3.2
13.6	69.7	24.4
14.1	283.1	112.6
14.6	574.1	326.9
15.1	631.3	628.3
15.3	634.8	749.0
15.8	634.8	1066.4
16.3	634.8	1383.8
16.8	634.8	1701.3
17.3	634.8	2018.7
17.8	634.8	2336.1
18.3	634.8	2653.5
18.8	634.8	2970.9
19.3	634.8	3288.3

Table 13. STA-1E Cell 4S Stage-Area and Stage-Volume Relationships

<i>STA-1E, Cell 4S</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
11.4	4.1	0.8
11.9	74.5	20.4
12.4	380.7	134.2
12.9	648.7	391.5
13.4	731.1	736.5
13.4	731.6	759.1
13.9	731.6	1124.9
14.4	731.6	1490.7
14.9	731.6	1856.6
15.4	731.6	2222.4
15.9	731.6	2588.2
16.4	731.6	2954.0
16.9	731.6	3319.8
17.4	731.6	3685.7

Table 14. STA-1E Cell 5 Stage-Area and Stage-Volume Relationships

<i>STA-1E, Cell 5</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
11.8	3.7	0.4
12.3	26.9	8.1
12.8	84.6	35.9
13.3	257.8	121.5
13.8	470.4	303.6
14.3	537.0	555.4
14.5	542.4	690.4
15.0	542.4	961.6
15.5	542.4	1232.8
16.0	542.4	1504.0
16.5	542.4	1775.2
17.0	542.4	2046.4
17.5	542.4	2317.5
18.0	542.4	2588.7

Table 15. STA-1E Cell 6 Stage-Area and Stage-Volume Relationships

<i>STA-1E, Cell 6</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
10.1	2.1	0.3
10.6	12.0	3.8
11.1	129.5	39.2
11.6	526.0	203.1
12.1	954.9	573.3
12.6	1013.7	1065.5
12.8	1022.3	1320.0
13.1	1027.3	1576.2
13.6	1031.7	2090.9
14.1	1033.0	2607.1
14.4	1033.1	2955.3
14.9	1033.1	3471.8
15.4	1033.1	3988.4
15.9	1033.1	4504.9
16.4	1033.1	5021.5

Table 16. STA-1E Cell 7 Stage-Area and Stage-Volume Relationships

<i>STA-1E, Cell 7</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
10.6	2.8	0.1
11.1	54.5	14.5
11.6	197.3	77.4
12.1	352.7	214.9
12.6	388.5	400.2
12.8	393.1	497.9
13.1	396.4	596.6
13.3	397.8	672.9
13.8	397.8	871.8
14.3	397.8	1070.6
14.8	397.8	1269.5
15.3	397.8	1468.4
15.8	397.8	1667.3
16.3	397.8	1866.2
16.8	397.8	2065.1
17.3	397.8	2264.0
17.8	397.8	2462.9

Table 17. STA-1W Cell 1A Stage-Area and Stage-Volume Relationships

<i>STA-1W, Cell 1A</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.9	10.1	6.7
9.4	24.4	15.3
9.9	201.8	71.9
10.4	434.8	231.0
10.9	554.8	478.4
11.4	612.8	770.3
11.6	634.6	926.3
11.9	663.9	1088.6
12.4	683.0	1425.3
12.9	691.7	1769.0
13.4	696.0	2115.9
13.9	697.7	2464.3
14.4	699.1	2813.5
14.7	699.8	3031.0
15.2	699.8	3381.0
15.7	699.8	3730.9
16.2	699.8	4080.8

Table 18. STA-1W Cell 1B Stage-Area and Stage-Volume Relationships

<i>STA-1W, Cell 1B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.1	0.2	0.0
8.6	6.2	1.6
9.1	60.6	18.3
9.6	363.2	124.3
10.1	498.1	339.6
10.6	532.0	597.1
10.9	544.1	731.6
11.1	554.2	868.9
11.6	569.9	1149.9
12.1	574.9	1436.1
12.6	628.3	1736.9
13.1	632.8	2015.2
13.6	632.8	2331.6
14.1	632.8	2648.0
14.6	632.8	2964.4
15.1	632.8	3280.9
15.6	632.8	3597.3
16.1	632.8	3913.7

Table 19. STA-1W Cell 2A Stage-Area and Stage-Volume Relationships

<i>STA-1W, Cell 2A</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
7.5	0.2	0.0
8.0	1.6	0.4
8.5	12.9	4.1
9.0	76.8	26.5
9.5	302.0	121.2
10.0	643.3	357.5
10.5	690.2	690.9
10.7	699.0	864.5
11.0	700.9	1039.5
11.4	701.5	1308.6
11.9	701.5	1659.3
12.4	701.5	2010.1
12.9	701.5	2360.8
13.4	701.5	2711.5
13.9	701.5	3062.3
14.4	701.5	3413.0

Table 20. STA-1W Cell 2B Stage-Area and Stage-Volume Relationships

<i>STA-1W, Cell 2B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.7	6.4	0.9
9.2	147.4	39.4
9.7	299.9	151.2
9.8	309.1	199.9
10.3	309.1	354.5
10.8	309.1	509.1
11.3	309.1	663.6
11.8	309.1	818.2
12.3	309.1	972.8
12.8	309.1	1127.3
13.3	309.1	1281.9
13.8	309.1	1436.5

Table 21. STA-1W Cell 3 Stage-Area and Stage-Volume Relationships

<i>STA-1W, Cell 3</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
9.0	21.9	2.8
9.5	228.7	65.4
10.0	470.9	240.3
10.5	595.0	506.8
11.0	687.7	827.4
11.3	729.2	1004.5
11.5	771.6	1192.1
12.0	833.9	1593.5
12.5	862.0	2017.5
13.0	867.9	2445.9
13.5	867.9	2879.9
14.0	867.9	3313.8
14.5	867.9	3747.8
15.0	867.9	4181.7

Table 22. STA-1W Cell 4 Stage-Area and Stage-Volume Relationships

<i>STA-1W, Cell 4</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
7.7	0.2	0.0
8.2	2.3	0.6
8.7	6.6	2.9
9.2	206.8	56.2
9.7	329.9	190.4
10.0	358.7	284.7
10.5	358.7	464.0
11.0	358.7	643.4
11.5	358.7	822.8
12.0	358.7	1002.2
12.5	358.7	1181.5
13.0	358.7	1360.9
13.5	358.7	1540.3
14.0	358.7	1719.6
14.5	358.7	1899.0
15.0	358.7	2078.4

Table 23. STA-1W Cell 5A Stage-Area and Stage-Volume Relationships

<i>STA-1W, Cell 5A</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.1	17.0	2.6
8.6	141.4	42.2
9.1	323.1	158.3
9.6	476.5	358.2
10.1	551.7	615.2
10.4	580.7	756.8
10.6	601.9	904.6
10.7	602.4	966.5
11.2	602.4	1267.7
11.7	602.4	1568.9
12.2	602.4	1870.1
12.7	602.4	2171.4
13.2	602.4	2472.6

Table 24. STA-1W Cell 5B Stage-Area and Stage-Volume Relationships

<i>STA-1W, Cell 5B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
7.8	1.6	0.1
8.3	250.7	63.1
8.8	1224.3	431.9
9.3	2108.7	1265.1
9.8	2381.9	2387.8
10.1	2397.5	2985.2
10.3	2401.6	3585.1
10.8	2401.6	4785.9
11.3	2401.6	5986.7
11.8	2401.6	7187.5
12.3	2401.6	8388.3
12.8	2401.6	9589.2
13.3	2401.6	10790.0

Table 25. STA-2 Cell 1 Stage-Area and Stage-Volume Relationships

<i>STA-2, Cell 1</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
10.0	1.9	0.2
10.5	21.6	6.1
11.0	70.6	29.1
11.5	224.1	102.8
12.0	869.6	376.2
12.5	1902.7	1069.2
13.0	2008.5	2047.1
13.2	2015.1	2550.0
13.5	2022.6	3054.7
14.0	2031.6	4068.3
14.5	2032.6	5084.3
15.0	2032.6	6100.6
15.5	2032.6	7116.9

Table 26. STA-2 Cell 2 Stage-Area and Stage-Volume Relationships

<i>STA-2, Cell 2</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
9.0	74.7	4.6
9.5	458.7	137.9
10.0	625.2	408.9
10.5	887.9	787.2
11.0	1549.6	1396.6
11.5	2260.0	2349.0
11.8	2367.4	2927.4
12.0	2371.6	3519.8
12.2	2373.2	3995.8
12.7	2373.2	5182.4
13.2	2373.2	6369.0
13.7	2373.2	7555.6
14.2	2373.2	8742.2
14.7	2373.2	9928.8

Table 27. STA-2 Cell 3 Stage-Area and Stage-Volume Relationships

<i>STA-2, Cell 3</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.0	1.7	0.2
8.5	22.5	6.3
9.0	359.5	101.8
9.5	1310.4	519.3
10.0	1834.6	1305.5
10.5	2176.3	2308.3
10.8	2266.9	2863.7
11.0	2289.7	3433.2
11.4	2296.3	4346.2
11.9	2296.3	5494.4
12.4	2296.3	6642.5
12.9	2296.3	7790.7
13.4	2296.3	8938.8
13.9	2296.3	10087.0

Table 28. STA-2 Cell 4 Stage-Area and Stage-Volume Relationships

<i>STA-2, Cell 4</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
7.1	0.0	0.0
7.6	2.8	0.7
8.1	8.9	3.6
8.6	97.3	30.2
9.1	1079.5	324.3
9.6	1762.7	1034.9
10.1	1915.9	1954.6
10.4	1931.8	2435.5
10.6	1936.2	2919.0
11.1	1940.7	3888.3
11.4	1941.9	4305.1

Table 29. STA-2 Cell 5 Stage-Area and Stage-Volume Relationships

<i>STA-2, Cell 5</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.5	135.3	11.2
9.0	1136.7	297.3
9.5	2062.7	1147.2
10.0	2172.0	2221.1
10.5	2174.2	3307.7
11.0	2175.9	4395.2
11.5	2177.2	5483.5
12.0	2178.4	6572.4
12.5	2179.6	7661.9
13.0	2180.8	8752.0
13.5	2182.1	9842.7
14.0	2183.8	10934.2

Table 30. STA-2 Cell 6 Stage-Area and Stage-Volume Relationships

<i>STA-2, Cell 6</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
7.5	0.9	0.2
8.0	3.6	1.2
8.5	420.5	62.8
9.0	1403.9	518.7
9.5	1860.8	1387.0
10.0	1862.3	2318.1
10.5	1862.3	3249.3
11.0	1862.3	4180.4
11.5	1862.3	5111.5
12.0	1862.3	6042.7

Table 31. STA-2 Cell 7 Stage-Area and Stage-Volume Relationships

<i>STA-2, Cell 7</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
7.5	17.7	24.3
8.0	30.8	35.9
8.5	273.6	89.2
9.0	947.5	376.4
9.5	1401.7	995.9
10.0	1477.7	1719.6
10.5	1514.8	2468.2
11.0	1537.2	3232.0
11.5	1543.9	4002.8
12.0	1545.3	4775.2

Table 32. STA-2 Cell 8 Stage-Area and Stage-Volume Relationships

<i>STA-2, Cell 8</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
7.5	0.2	0.0
8.0	12.1	1.6
8.5	209.9	35.1
9.0	1017.2	355.3
9.5	1439.2	985.4
10.0	1572.6	1746.5
10.5	1608.8	2542.5
11.0	1631.9	3353.2
11.5	1641.8	4172.3
12.0	1645.5	4994.1

Table 33. STA-3/4 Cell 1A Stage-Area and Stage-Volume Relationships

<i>STA-3/4, Cell 1A</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
7.7	2.2	0.3
8.2	20.3	5.9
8.7	158.2	50.5
9.2	1721.3	520.4
9.7	2849.1	1663.0
10.2	2947.4	3112.1
10.5	2977.7	3852.8
10.7	2998.2	4599.7
11.2	3012.9	6102.5
11.7	3017.7	7610.2
12.0	3019.6	8535.1
12.5	3019.6	10044.9
13.0	3019.6	11554.7
13.5	3019.6	13064.5
14.0	3019.6	14574.3
14.5	3019.6	16084.1

Table 34. STA-3/4 Cell 1B Stage-Area and Stage-Volume Relationships

<i>STA-3/4, Cell 1B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.3	0.8	0.0
8.8	60.0	15.2
9.3	1799.1	480.0
9.8	3341.2	1765.1
10.3	3450.6	3463.0
10.6	3455.3	4326.3
10.8	3456.1	5190.2
11.3	3456.1	6918.2
11.8	3456.1	8646.3
12.3	3456.1	10374.3
12.8	3456.1	12102.4
13.3	3456.1	13830.4
13.8	3456.1	15558.5
14.3	3456.1	17286.5

Table 35. STA-3/4 Cell 2A Stage-Area and Stage-Volume Relationships

<i>STA-3/4, Cell 2A</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.4	1.3	0.0
8.9	97.9	24.8
9.4	1358.4	388.9
9.9	2357.2	1317.8
10.4	2466.2	2523.7
10.7	2479.6	3141.9
10.9	2488.9	3762.9
11.4	2502.3	5010.7
11.8	2505.5	6018.3
12.3	2505.5	7271.0
12.8	2505.5	8523.8
13.3	2505.5	9776.6
13.8	2505.5	11029.4
14.3	2505.5	12282.1
14.8	2505.5	13534.9
15.3	2505.5	14787.7

Table 36. STA-3/4 Cell 2B Stage-Area and Stage-Volume Relationships

<i>STA-3/4, Cell 2B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.9	98.2	18.7
9.4	1183.8	339.2
9.9	2299.9	1210.1
10.4	2391.3	2382.9
10.6	2395.5	2981.2
10.7	2396.5	3081.0
11.2	2396.5	4279.3
11.7	2396.5	5477.5
12.2	2396.5	6675.7
12.7	2396.5	7873.9
13.2	2396.5	9072.2
13.7	2396.5	10270.4
14.2	2396.5	11468.6
14.7	2396.5	12666.9
15.2	2396.5	13865.1
15.7	2396.5	15063.3

Table 37. STA-3/4 Cell 3A Stage-Area and Stage-Volume Relationships

<i>STA-3/4, Cell 3A</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
8.8	9.3	1.8
9.3	110.5	31.7
9.8	1361.6	399.8
10.3	2218.9	1294.9
10.8	2382.6	2445.2
11.0	2404.9	3043.7
11.3	2414.3	3646.1
11.5	2415.1	4140.7
12.0	2415.1	5348.2
12.5	2415.1	6555.8
13.0	2415.1	7763.4
13.5	2415.1	8971.0
14.0	2415.1	10178.5
14.5	2415.1	11386.1
15.0	2415.1	12593.7
15.5	2415.1	13801.3

Table 38. STA-3/4 Cell 3B Stage-Area and Stage-Volume Relationships

<i>STA-3/4, Cell 3B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
9.3	22.2	3.6
9.8	1192.5	307.3
10.3	1967.5	1097.3
10.8	2070.8	2106.8
11.0	2082.8	2626.0
11.3	2085.9	3147.1
11.6	2086.7	3807.2
12.1	2086.7	4850.6
12.6	2086.7	5893.9
13.1	2086.7	6937.3
13.6	2086.7	7980.6
14.1	2086.7	9024.0
14.6	2086.7	10067.3
15.1	2086.7	11110.7
15.6	2086.7	12154.0

Table 39. STA-5 Cell 1A Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 1A</i>		
Stage (Feet NGVD 29)	Area* (Acres)	Volume (Acre-feet)
10.6	0.8	0.0
11.1	31.1	8.0
11.6	95.9	39.7
12.1	192.3	111.8
12.6	338.4	244.5
13.1	517.6	458.5
13.6	765.6	779.3
14.1	1056.8	1234.9
14.4	1140.4	1509.6
14.6	1184.8	1800.2
15.1	1194.1	2394.9
15.5	1194.9	2840.3
16.0	1194.9	3437.8
16.5	1194.9	4035.2

*Includes prior Non-Effective Treatment Area on west side of cell.

Table 40. STA-5 Cell 1B Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 1B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
9.0	0.7	0.1
9.5	3.6	1.1
10.0	14.7	5.7
10.5	111.6	37.3
11.0	578.8	209.9
11.5	1156.2	643.6
12.0	1209.7	1235.1
12.3	1219.8	1538.8
12.5	1222.5	1844.1
12.6	1223.3	1996.5
13.1	1223.3	2608.1
13.6	1223.3	3219.8
14.1	1223.3	3831.4
14.6	1223.3	4443.1
15.1	1223.3	5054.8
15.6	1223.3	5666.4

Table 41. STA-5 Cell 2A Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 2A</i>		
Stage (Feet NGVD 29)	Area* (Acres)	Volume (Acre-feet)
9.8	0.5	0.1
10.3	1.5	0.6
10.8	3.8	1.9
11.3	16.6	7.0
11.8	38.6	20.8
12.3	83.3	51.3
12.8	181.2	117.4
13.3	386.2	259.3
13.8	604.6	507.0
14.3	763.5	849.0
14.5	831.8	1048.4
14.7	844.6	1199.0
15.2	844.6	1621.4
15.7	844.6	2043.7
16.2	844.6	2466.0
16.7	844.6	2888.3

*Does not include Non-Effective Treatment Area on west side of cell.

Table 42. STA-5 Cell 2B Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 2B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
10.3	8.1	0.9
10.8	221.5	58.3
11.3	655.7	277.6
11.8	1031.2	699.4
12.3	1178.9	1251.9
12.6	1213.9	1551.0
12.8	1229.6	1856.4
13.0	1233.2	2029.0
13.5	1233.2	2645.6
14.0	1233.2	3262.2
14.5	1233.2	3878.7
15.0	1233.2	4495.3
15.5	1233.2	5111.9

Table 43. STA-5 Cell 3A Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 3A</i>		
Stage (Feet NGVD 29)	Area* (Acres)	Volume (Acre-feet)
10.5	2.9	0.4
11.0	8.6	3.3
11.5	30.5	13.1
12.0	126.2	52.3
12.5	269.7	151.3
13.0	519.7	348.6
13.5	785.2	674.9
14.0	935.9	1105.1
14.3	975.3	1344.0
14.5	1005.6	1591.7
15.0	1031.5	2100.9
15.5	1046.7	2574.1
16.0	1046.7	3097.5
16.5	1046.7	3620.8
17.0	1046.7	4144.1
17.5	1046.7	4667.5

*Does not include Non-Effective Treatment Area on west side of cell.

Table 44. STA-5 Cell 3B Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 3B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
11.4	7.7	1.4
11.9	66.9	20.0
12.4	488.2	158.8
12.9	831.5	488.7
13.4	916.4	925.7
13.6	920.3	1147.6
14.1	920.3	1607.7
14.6	920.3	2067.9
15.1	920.3	2528.0
15.6	920.3	2988.2
16.1	920.3	3448.3
16.6	920.3	3908.5
17.1	920.3	4368.6

Table 45. STA-5 Cell 4A Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 4A</i>		
Stage (Feet NGVD 29)	Area* (Acres)	Volume (Acre-feet)
11.0	0.0	0.0
11.4	7.4	1.1
11.9	32.1	9.9
12.4	175.9	56.1
12.9	469.5	219.1
13.4	724.4	520.8
13.9	930.7	934.3
14.4	1227.4	1470.1
14.9	1399.0	2140.9
15.4	1418.3	2847.4
15.9	1420.7	3571.4

*Does not include Non-Effective Treatment Area on west side of cell.

Table 46. STA-5 Cell 4B Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 4B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
11.3	0.0	0.0
11.5	6.7	0.4
12.0	251.3	43.0
12.5	460.1	238.7
12.6	475.4	285.6

Table 47. STA-5 Cell 5A Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 5A</i>		
Stage (Feet NGVD 29)	Area* (Acres)	Volume (Acre-feet)
10.9	0.0	0.0
11.2	3.1	0.3
11.7	30.9	6.3
12.2	126.2	42.3
12.7	311.8	144.0
13.2	600.4	374.3
13.7	948.6	762.3
14.2	1359.4	1345.9
14.7	1706.0	2116.6
15.2	1877.3	3021.3
15.7	1916.9	3972.7
16.2	1925.3	4933.4
16.7	1931.9	5897.8
17.2	1937.6	6865.1
17.7	1944.9	7835.6
18.2	1955.8	8810.8
18.4	1958.7	9241.5

*Does not include Non-Effective Treatment Area on west side of cell.

Table 48. STA-5 Cell 5B Stage-Area and Stage-Volume Relationships

<i>STA-5, Cell 5B</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
10.7	0.0	0.0
11.0	9.2	1.4
11.5	38.4	11.1
12.0	423.0	103.0
12.5	633.6	381.1
13.0	695.6	713.9
13.5	712.2	1068.3
13.8	712.6	1303.4

Table 49. STA-6 Cell 2 Stage-Area and Stage-Volume Relationships

<i>STA-6, Cell 2</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
9.2	0.3	0.0
9.7	1.5	0.5
10.2	3.4	1.7
10.7	19.7	7.5
11.2	168.9	54.7
11.7	332.3	180.0
12.2	548.7	400.3
12.7	1012.8	790.6
13.2	1292.1	1366.8
13.4	1342.3	1696.1
13.7	1354.3	2033.2
14.0	1361.4	2524.9
14.5	1361.4	3205.6
15.0	1361.4	3886.2
15.5	1361.4	4566.9
16.0	1361.4	5247.6

Table 50. STA-6 Cell 3 Stage-Area and Stage-Volume Relationships

<i>STA-6, Cell 3</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
10.9	0.6	0.1
11.4	2.9	0.9
11.9	6.0	3.1
12.4	12.1	7.7
12.9	109.7	38.1
13.4	229.7	123.0
13.9	239.9	240.4
14.1	241.2	300.5
14.4	241.9	360.9
14.4	241.9	365.3
14.9	241.9	486.2
15.4	241.9	607.2
15.9	241.9	728.1
16.4	241.9	849.1

Table 51. STA-6 Cell 4 Stage-Area and Stage-Volume Relationships

<i>STA-6, Cell 4</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
11.6	0.0	0.0
12.0	5.1	0.8
12.5	43.8	11.6
13.0	104.1	46.5
13.5	281.7	137.2
14.0	473.4	323.6
14.5	554.7	586.7
15.0	570.1	868.9
15.5	573.6	1155.0
16.0	575.0	1430.8

Table 52. STA-6 Cell 5 Stage-Area and Stage-Volume Relationships

<i>STA-6, Cell 5</i>		
Stage (Feet NGVD 29)	Area (Acres)	Volume (Acre-feet)
12.1	21.6	5.4
12.6	154.6	49.4
13.1	425.3	194.4
13.6	551.7	438.6
14.1	627.1	733.4
14.3	631.3	878.1
14.8	631.3	1193.7
15.3	631.3	1509.3
15.8	631.3	1825.0
16.3	631.3	2140.6
16.8	631.3	2456.2

References

Childs, Colin. Interpolating Surfaces in ARCGIS Spatial Analyst. ESRI Education Services.

Summary of Revisions

1. May 2013 – The DEM for the Compartment C treatment cells (STA-5 Cells 4A, 4B, 5A, 5B, and STA-6 Cell 4) (Figure 13) that was included in the December 2012 version was labeled as being referenced to NGVD29 but was actually showing data referenced to NAVD88. In order to correct this error, the Figure 13 DEM was re-created using the correct datum (NGVD29). As a result of this correction, the Average Ground Elevations and Stage-Area/Stage-Volume Tables for these five cells were revised (Tables 7, 8 , 9, 45, 46, 47, 48, and 51).