Appendix B: Design Calculations

1. Tidal Datum Evaluation
2. Percent Inundation Evaluation
3. Fill Area Volume Evaluation

I. TIDAL DATAUM EVALUATION

The Tidal Datum at the project site is needed to establish the construction marsh fill elevation. Coastwide Reference Monitoring System (CRMS) Station CRMS0398 was used. This station has a 10 year (August 2007 through August 2017) data set of water levels that will be used for the tidal datum evaluation.

A. Given:

Station	**CRMS0164**
Location	N 29.389°
	W 90.9168°

B. Calculations:

Mean High Water (MHW) – Average of the daily maximum water elevation for period of analysis.
Mean Low Water (MLW) – Average of the daily minimum water elevation for period of analysis.
Mean Tide Level (MTL) – Average elevation of mean high and mean low water elevations.
Mean Tide Range (MTR) – Difference between mean high and mean low water elevations.

REFERENCE: Tides and Datums, noaa.gov

Tidal Datum – Period of Record	
8/2007 – 8/2017	
Tidal Datum	**Elevation (Ft. NAVD88 – 12A)**
MHW	**0.76**
MLW	**0.37**
MTL	**0.57**
MR	**0.38**

II. PERCENT INUNDATION DETERMINATION

Calculations:

Percent Inundated	**Equation**	**Inundation Elevation (FT, NAVD88 – 12A)**
1	*0.99*Raw Data Elevations*	1.61
10	0.9**Raw Data Elevations*	1.08
20	0.8**Raw Data Elevations*	0.90
30	0.7**Raw Data Elevations*	0.80
40	0.6**Raw Data Elevations*	0.70
50	0.5**Raw Data Elevations*	0.61
60	0.4**Raw Data Elevations*	0.51
65	*0.35*Raw Data Elevations*	0.45
70	0.3**Raw Data Elevations*	0.39
80	0.2**Raw Data Elevations*	0.22
90	0.1**Raw Data Elevations*	0.00

REFERENCE: Snedden and Swenson, 2012

III. **RELATIVE SEA LEVEL RISE CALCULATION**

20 Year Project Life

YEAR	MHW + ESLR	MLW + ESLR
2018	0.756	0.375
2019	0.776	0.394
2020	0.796	0.414
2021	0.816	0.434
2022	0.837	0.455
2023	0.858	0.476
2024	0.879	0.497
2025	0.901	0.519
2026	0.923	0.541
2027	0.946	0.564
2028	0.969	0.587
2029	0.992	0.610
2030	1.016	0.634
2031	1.040	0.658
2032	1.065	0.683
2033	1.090	0.708
2034	1.115	0.733
2035	1.141	0.759
2036	1.167	0.785
2037	1.194	0.812
2038	1.221	0.839
2039	1.248	0.866
2040	1.276	0.894

III. FILL AREA DESIGN

A. Given:

1. Cross-Sectional Survey Data of Marsh Fill Sites: XYZ data for each fill area cross-section
2. Volume Calculation Fill Elevations: +1.5 ft NAVD88
3. Licensed Surveyor Point Files/AutoCad Drawing

B. Methodology:

1. Area Calculations: The cross-sectional area of each marsh fill transect was calculated using the XYZ data mentioned above. Due to the large number of points involved with each cross-section, the following simplified example is used to show the method of calculating cross-sectional areas:

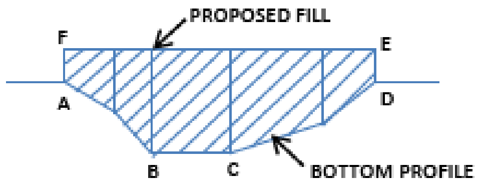

Figure 1

The area of this section can be obtained by incrementally computing the areas of each of the trapezoids ABCDEF shown in Figure 1. By treating the section as a traverse, fundamental survey methods can be utilized to calculate this area. These areas are calculated using the given data from the survey datasets with each point having a corresponding XYZ value. The incremental area calculations are carried out using the following formula:

$A_i = ½\ [D_i(Z_{i=1}-Z_{i-1})]$

Where: A_i=incremental area

D_i=cumulative distance from beginning of transect to point i

Z_{i+1}=elevation of previous point

Z_{i-1}=elevation of next point

The cumulative distance is computed by continuously summing the distance between each point, which is calculated with the distance formula:

$L_i = [(X_2-X_1)^2+(Y_2-Y_1)^2+(Z_2-Z_1)^2]^{1/2}$

Where: X=easting

Y=northing

Z=elevation

And

$D_i=\sum L_i$

The total area of the cross sections can be then obtained by summing each incremental area. Because these computations are so labor intensive, a spreadsheet was used for these area calculations.

2. Distance Between Cross Sections: Before the volume of the fill sites can be calculated, the distance between cross sections must be obtained. These distances represent the plan view area that each cross section will represent and were computed from the surveyor's CAD drawing.

3. Volume Calculations: The volume calculations for each cross section are computed by taking the product of the cross-sectional area and its corresponding distance. The incremental volumes are then added together to get the total volume of the fill site. This is accomplished using the simple formulas shown below:

$V_{xs}=(A_{xs})(d)$

Where: V_{xs}=Cross-sectional volume

A_{xs}=Cross-sectional area

D=Distance between cross-sections

$V_{tot}=\sum V_{xs}$

These calculations were performed in Excel as well as in CAD. The table below details the results of both calculations.

Bayou De Cade Ridge and Marsh Creation		
Comparison of Civil3D Volume vs. Spreadsheet Volume		
Marsh Fill Elevation:	1.5 feet NAVD88, Geoid12A	Cubic Yards
Civil 3D Volume		2,397,118
Excel Spreadsheet Volume (Average End Area Method)		2,323,846
Percent Error		**3%**

The volume of fill material found between each survey transect is summarized below.

Transect	Area (sq ft.)	Average End Area (sq. ft.)	Length (ft)	Volume (cu. Yds.)
2	627.5420344		250	
3	648.1896673	637.8658508	250	5906.165286
4	1265.298277	956.7439722	250	8858.740483
5	1578.31427	1421.806274	250	13164.87291
6	1409.960156	1494.137213	250	13834.60383
7	1478.778208	1444.369182	250	13373.78872
8	1662.288909	1570.533559	250	14541.9774
9	665.3594848	1163.824197	250	10776.14997
10	2092.180034	1378.769759	250	12766.38666
11	2494.060491	2293.120262	250	21232.59502
12	2858.919929	2676.49021	250	24782.31676
13	2305.332582	2582.126255	250	23908.57644
14	2443.845891	2374.589237	250	21986.93738
15	3124.735683	2784.290787	250	25780.47025
16	2074.534148	2599.634916	250	24070.69366
17	2730.348618	2402.441383	250	22244.82762
18	3455.943202	3093.14591	250	28640.23991
19	5078.023758	4266.98348	250	39509.1063
20	4939.903608	5008.963683	250	46379.29336
21	4329.800159	4634.851883	250	42915.29522
22	5277.479309	4803.639734	250	44478.14568
23	3987.929128	4632.704218	250	42895.40943
24	7762.046289	5874.987709	250	54398.03434
25	3924.321858	5843.184074	250	54103.55624
26	6416.707735	5170.514797	250	47875.13701
27	4988.24775	5702.477743	250	52800.71984

28	6587.88289	5788.06532	250	53593.19741
29	4704.242042	5646.062466	250	52278.35617
30	8117.094739	6410.668391	250	59358.04065
31	11145.90838	9631.501558	250	89180.56998
32	10846.8749	10996.39164	250	101818.4411
33	9298.421186	10072.64805	250	93265.25968
34	7213.508623	8255.964905	250	76444.11949
35	15198.25562	11205.88212	250	103758.1678
36	12855.81482	14027.03522	250	129879.9557
37	7206.104292	10030.95956	250	92879.25515
38	8097.704923	7651.904607	250	70850.96859
39	5762.823626	6930.264275	250	64169.11365
40	7071.332612	6417.078119	250	59417.38999
41	11992.50335	9531.91798	250	88258.49982
42	6485.714191	9239.10877	250	85547.30342
43	14029.75497	10257.73458	250	94979.02388
44	11821.65009	12925.70253	250	119682.4308
45	6976.935938	9399.293013	250	87030.49086
46	5154.288925	6065.612431	250	56163.07807
47	1060.285391	3107.287158	250	28771.17739
48	83.88009032	572.0827407	250	5297.062414