Appendix H

Calculations Package

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ABBREVIATIONS

CPRA	Coastal Protection and Restoration Authority
CRMS	Coastwide Reference Monitoring System
CY	Cubic Yard
ECD	Earthen Containment Dike
ESLR	Eustatic Sea Level Rise
FT	Foot
ITD	Internal Training Dike
LF	Linear Foot
MCA	Marsh Creation Area
MHW	5-year Mean High Water
MLW	5 year Mean Low Water
MN	5-year Mean Tide Range
MTL	5-year Mean Tide Level
RSLR	Relative Sea Level Rise
SF	Square Foot
TY	Target Year

1.0 TIDAL DATUM EVALUATION

a) Given

Hourly hydrologic data was obtained from the CIMS database for the Coastwide Reference Monitoring System (CRMS) Station 0146. The coordinates of the station are in the table below.

Station	Latitude	Longitude
CRMS0146	29.795421	-93.416819

Data was obtained for the most recent 5-year period from August 17, 2016 to August 17, 2021.

b) Calculations

The Mean High Water (MHW), Mean Low Water (MLW) and Mean Tide Level (MTL) were calculated for the 5 year period. The MHW is the mean of all high water elevations, MLW is the mean of all low water elevations, and MTL is the average of the MHW and MLW.

CRMS Station	MHW (ft. NAVD88, GEOID12A)	MLW (ft. NAVD88, GEOID12A)	MTL (ft. NAVD88, GEOID12A)
CRMS 0146	0.99	0.41	0.62

2.0 PERCENT INUNDATION DETERMINATION

a) Given

The same hourly hydrologic data from CRMS0146 explained in Section 1.0 was used for the percent inundation determination.

b) Calculations

Each percent inundation was calculated for the entire five year data set according to their corresponding percentile. Calculations are summarized in the following table.

% inundated	Calculation	Inundation Elevation, ft. (NAVD88 Geoid12A)
1%	99th percentile of water elevations	2.904
10%	90th percentile of water elevations	1.470
20%	80th percentile of water elevations	1.140
30%	70th percentile of water elevations	0.940
40%	60th percentile of water elevations	0.780
50%	50th percentile of water elevations	0.630
60%	40th percentile of water elevations	0.480
65%	35th percentile of water elevations	0.400
70%	30th percentile of water elevations	0.320
80%	20th percentile of water elevations	0.120
90%	10th percentile of water elevations	-0.150

3.0 SEA LEVEL RISE

Sea level rise was calculated by using the 2017 Coastal Master Plan predicted sea level rise rates for use in the design of marsh creation projects. The predicted rates range from 0.5 to 1.98 meters of sea level rise by 2100. The CPRA Planning and Research Division recommends the 1.0-m scenario for the purposes of this project. This accounts for approximately 6 inches of sea level rise over the 20 year project life.

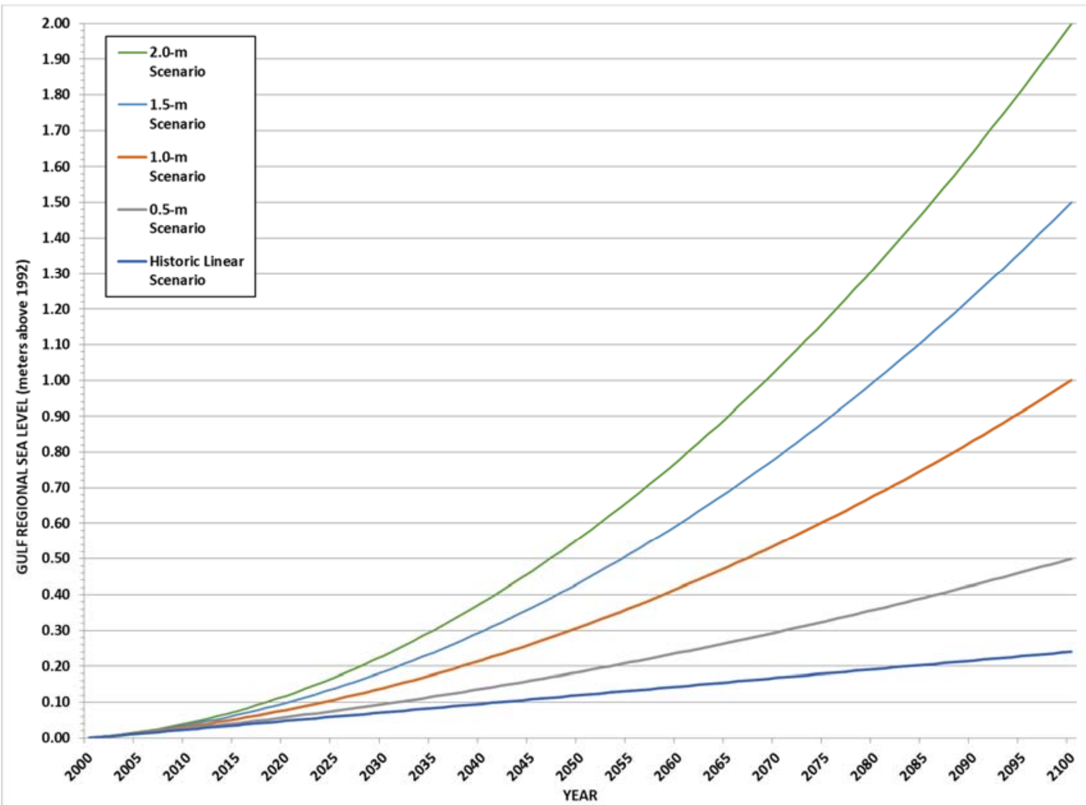


Figure 1: Gulf Sea-Surface Change Relative to 1992

Eustatic sea level rise was calculated using the following formula:

$$E(t) = at + bt^2$$

Where E is the change in eustatic sea level rise at time, t
a is the rate of ESLR, and
b is the acceleration factor

Subsidence rates are based on recent detailed subsidence studies completed in 2019 by Applied Coastal Research and Engineering (ACRE) and C.H. Fenstermaker and Associates in the Breton Sound and Barataria basin. The 2019 CPRA/ACRE report determined that Holocene geology and sediment consolidation are primary factors controlling subsidence. Results from this study indicate that the subisdence rates in the Breton Sound Basin generally range from 3.0-4.0 mm per year (0.16 inches/yr) (ACRE, 2019).

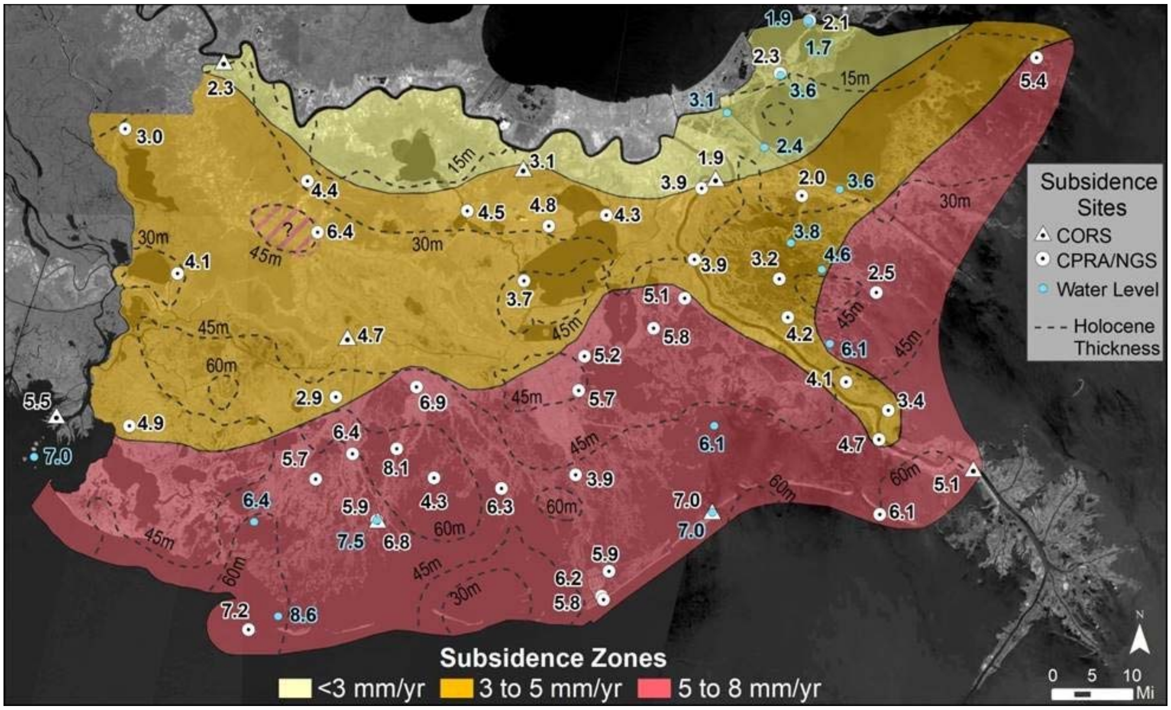


Figure 2: Regional Subsidence Zones for the south Louisiana deltaic plain as determined using recent high-resolution GPS surveys and water-level measurements.

The subsidence rate chosen for the design of BS-0037 was 4.0 mm per year.

The rates of eustatic sea level rise (ESLR) and subsidence were used to determine the annual incremental relative sea level rise (RSLR) for the BS-0037 project area over the 20-year project life.

$$E(t) = at + bt^2 + St$$

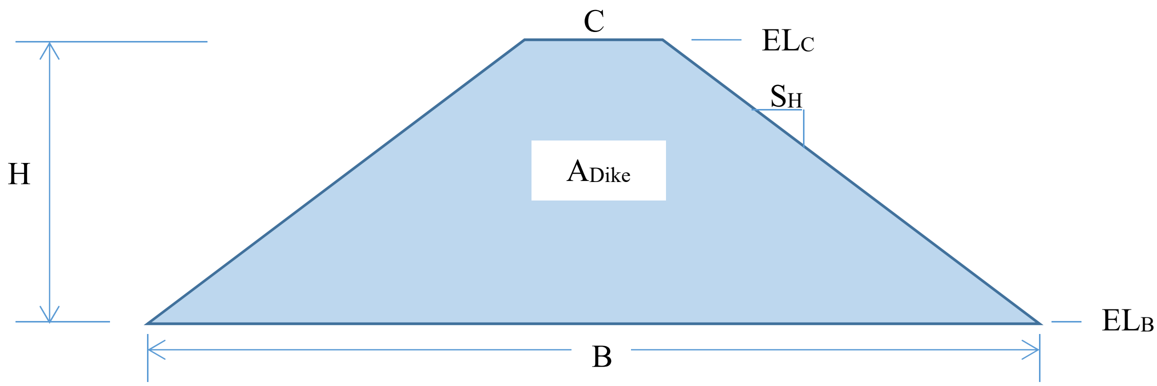
Where E is the change in relative sea level at time, t
a is the rate of ESLR
b is an acceleration factor, and
S is the rate of subsidence

The calculated annual incremental ESLR and RSLR are shown in the following table:

Year	Annual Incremental Subsidence (St) (ft.)	Annual Incremental Eustatic Sea Level Rise ($at + bt^2$) (ft.)	Annual Incremental Relative Sea Level Rise ($at + bt^2 + St$) (ft.)
2020	0.000	0.000	0.000
2021	0.013	0.018	0.0313
2022	0.027	0.037	0.0637
2023	0.040	0.056	0.0960
2024 (TY 0)	0.053	0.075	0.1283
2025	0.067	0.095	0.1617
2026	0.080	0.116	0.1960
2027	0.093	0.137	0.2303
2028	0.107	0.159	0.2657
2029	0.120	0.181	0.3010
2030	0.133	0.203	0.3363
2031	0.147	0.226	0.3727
2032	0.160	0.25	0.4100
2033	0.173	0.274	0.4473
2034	0.187	0.299	0.4857
2035	0.200	0.324	0.5240
2036	0.213	0.349	0.5623
2037	0.227	0.375	0.6017
2038	0.240	0.402	0.6420
2039	0.253	0.429	0.6823
2040	0.267	0.457	0.7237
2041	0.280	0.485	0.7650
2042	0.293	0.513	0.8063
2043	0.307	0.542	0.8487
2044	0.32	0.572	0.892

4.0 EARTHEN CONTAINMENT DIKE DESIGN

Parameter	Measure
Crown Width (ft.)	5.0 ft.
Side Slope (H:V)	4H:1V
Crown Elevation (ft.)	ECD: +5.0 ft. NAVD88, Geoid12A
Base Elevation (ft.)	Surface created from xyz survey data



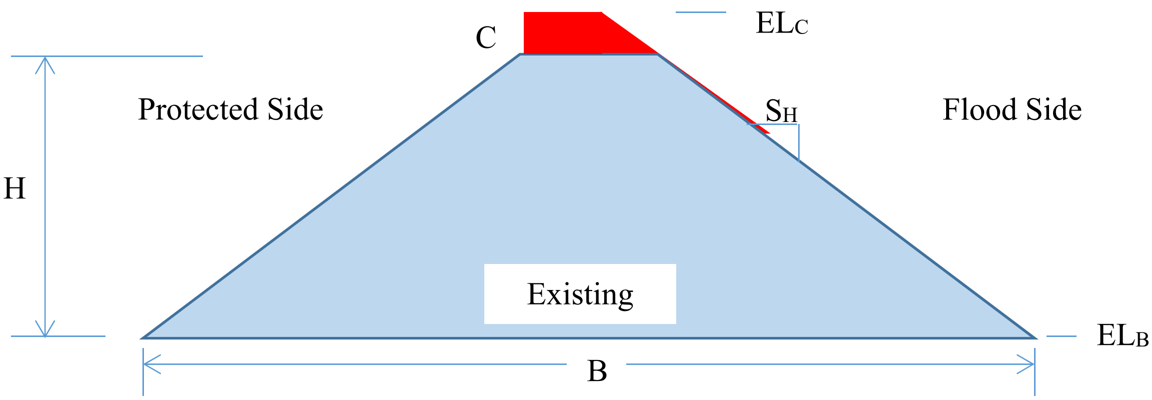
H = Dike Height
B = Base Width
C = Crown Width
EL_B = Base Elevation
EL_C = Crown Elevation
S_H = Side Slope

The total ECD lengths and fill volumes were calculated using AutoCAD Civil 3D. Results are summarized in the following tables.

Marsh Creation Area	**ECD Elevation** (ft. NAVD88 Geoid 12A)	**ECD Length** (LF)	**ECD Fill Volume** (CY)	**C:F**	**ECD Cut Volume** (CY)
ECD 1	+5.0	10,029	74,402	1.5:1	111,603
ECD 2	+5.0	4,913	36,495	1.5:1	54,743

5.0 EARTHEN TIDAL LEVEE ENHANCEMENT (IN-SITU CAP)

Parameter	Measure
Crown Width (ft.)	5.0 ft.
Cap Width (ft.)	5.0 ft.
Side Slope (H:V)	6H:1V
Crown Elevation (ft.)	ECD: +5.0 ft. NAVD88, Geoid12A
Base Elevation (ft.)	Surface created from xyz survey data



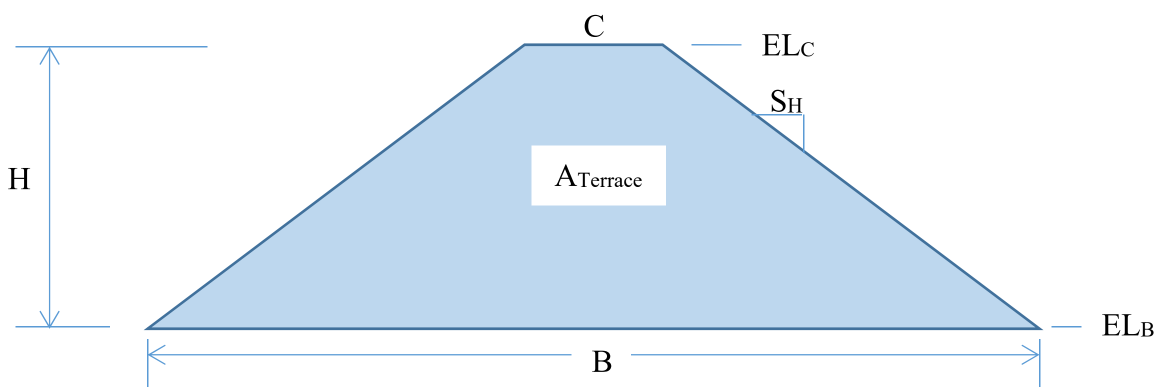
H = Dike Height
B = Base Width
C = Crown Width
EL_B = Base Elevation
EL_C = Crown Elevation
S_H = Side Slope

The total TPE lengths and fill volumes were calculated using AutoCAD Civil 3D. Results are summarized in the following tables.

Marsh Creation Area	ECD Elevation (ft. NAVD88 Geoid 12A)	ECD Length (LF)	ECD Fill Volume (CY)	C:F	ECD Cut Volume (CY)
1	+5.0	6,503	304	1.5:1	456
2	+5.0	3,834	4	1.5:1	6

6.0 EARTHEN TERRACE DESIGN

Parameter	Measure
Crown Width (ft.)	10.0 ft.
Side Slope (H:V)	5H:1V
Crown Elevation (ft.)	+4.0 (+0.25) ft. NAVD88, Geoid12A
Base Elevation (ft.)	Surface created from xyz survey data



H = Dike Height
B = Base Width
C = Crown Width
EL_B = Base Elevation
EL_C = Crown Elevation
S_H = Side Slope

The earthen terrace field contained a total of 30 linear earthen terraces each 500 feet long for a total of 15,000 feet. The sediment retention terrace is 3,880 feet long. The total fill volume for one earthen terrace was calculated using AutoCAD Civil 3D. This volume was multiplied by the total number of terraces to determine the approximate terrace fill volume. A cut to fill ratio of 1.5 was applied to determine the total terrace cut volume. These calculations are summarized in the table below.

Project Feature	Earthen Terrace Elevation (ft. NAVD88 Geoid 12A)	Earthen Terrace Length (LF)	Earthen Terrace Fill Volume (CY)	C:F	Earthen Terrace Cut Volume (CY)
Terrace Field	+4.25	15,000	143,337	1.5	216,506
Sediment Retention Terrace	+4.25	3,880	34,500	1.5	51,750

7.0 FILL AREA DESIGN

The elevation used for the volume calculations was determined by adding the total foundation settlement to the elevation at TY20 without subsidence. To account for the long-term predicted foundation settlement, each Marsh Creation Area is assigned a weighted value for foundation settlement based on the distribution of mudline elevations within the fill area. For example, MCA-2, approximately 34% of the mudline is below an elevation of -1.5 ft. NAVD88 and the remaining 67% is above an elevation of -1.5 ft. NAVD88. This equates to a weighted value of 0.79 ft. of foundation settlement for MCA-2. A similar approach for MCA-1 yields a weighted value of 0.86 ft. of foundation settlement. The respective weighted foundation settlement value shown in the table below for each MCA will be added to the elevation used for calculating volumes.

	MCA-1			MCA-2		
ML interval	**Settlement Value**	**Weighting Factor**	**Weighted Value**	**Settlement Value**	**Weighting Factor**	**Weighted Value**
-4 > EL< -1.5	0.98	0.60	0.59	0.98	0.34	0.33
-1.5 > EL < +2	0.69	0.40	0.28	0.69	0.67	0.46
Total		1	**0.86**		1	**0.79**

The elevation used for volume calculations for each Marsh Creation Area is summarized in the table below.

MCA	**Proposed CMFE** (ft. NAVD88 Geoid 12A)	**TY20 Elevation** (ft. NAVD88 Geoid 12A)	**Total subsidence settlement** (ft.)	**Total Foundation Settlement** (ft.)	**Elevation for Volume Calcs.** (ft. NAVD88 Geoid 12A)
1	+3.25	+1.0	0.30	0.86	+2.16
2	+3.25	+1.0	0.30	0.79	+2.09

A surface was created in AutoCAD Civil 3D utilizing the survey data. The marsh fill volume was calculated in AutoCAD Civil 3D. The total cut for the earthen containment dikes was added to the marsh fill volume to account for backfill. A 1.1 cut to fill ratio was applied to determine the total cut volume. The results are summarized in the following table.

Marsh Creation Area	**Proposed CMFE** (ft. NAVD88 Geoid 12A)	Area (ac.)	**MCA Fill Volume** (CY)	**ECD Backfill Volume** (CY)	**Total Fill Volume** (CY)	**C:F**	**Total Cut Volume** (CY)
1	+3.25	300	1,686,763	111,603	1,798,822	1.1	1,978,704
2	+3.25	114	526,467	54,743	581,216	1.1	639,337
Total		414					2,618,041

8.0 ESTIMATING VOLUME OF WATER USING SPECIFIC GRAVITY OF SLURRY DURING DREDGING

A. Given:

a. Dredge:

- **i.** Pipe diameter = 18 inch
- **ii.** Borrow Area Specific Gravity (SG_{borrow}) = 2.69
- **iii.** Slurry Specific Gravity (SG_{slurry}) = varies during dredging the S.G. can vary from 1.10 to 1.40

b. Marsh Creation Area 2:

- **i.** Area = 114 acres
- **ii.** Existing Mudline = -2.0 feet NAVD88
- **iii.** Volume Solids = 650,000 yd^3 [to achieve Target Elevation @TY20 (+1.00 ft. NAVD88)]

Notes:

1. The following equations shown below must be iterated by inputting a “Top Elevation of Slurry” and the volume by mass of solids is the output. This volume must match the volume of solids @TY20.
2. The following methodology is considered an open system with mass transfer (slurry) only coming inside the system and no mass is leaving.
3. In this case the top elevation of slurry is at the top of the proposed containment dike, however during construction:
   a. The system is not loaded instantaneously, as this calculation is assuming.
   b. Water within the system is flowing out of the system using weir boxes. This loss of volume is not accounted for.
4. Rainfall is not accounted for.

B. Methodology:

- **i.** The slurry thickness and total volume can be calculated by using the following equations:

  Slurry thickness (ft.) = Top of Slurry – Existing Mudline
  Total volume of slurry = Area × Slurry Thickness

- **ii.** The total volume of solids & water can be calculated by using the following equations:

  Where: **SG** = specific gravity

1. **Percent solids (mass)** = $\frac{-SG_{borrow}+\frac{SG_{borrow}}{SG_{dredge}}}{1-SG_{borrow}} x\ 100\%$

2. **Percent water (mass)** = $total\ volume \times (\frac{100 - Percent\ Solids\ (mass)}{100})$
3. **Solids concentration (mass)** = $total\ volume \times (\%\ solids)$
4. **Volume of Solids** = $Total\ Volume \times \frac{\%\ Solids\ (Mass)}{100}$
5. **Volume of Water** = $Total\ Volume \times \frac{\%\ Water}{100}$

9.0 BORROW AREA DESIGN

A surface of the borrow area was created in AutoCAD Civil 3D using the borrow area survey data. The total available borrow volume was calculated for the cut elevation of -20 feet. The volume from all five (5) avoidance areas in the borrow area was deducted from the total available borrow quantity. The results are summarized in the following table.

Borrow Area	Area (Acres)	Available Volume (yd^3)
Primary	130	3,096,703
Secondary	42	1,001,023
Total	172	4,097,726

10.0 REFERENCES

All references used for design computations can be found in the references section of the BS-0037 30% Design Report.