APPENDIX L

ENGINEERING INVESTIGATIONS AND COST ESTIMATES

TERREBONNE BASIN BARRIER SHORELINE RESTORATION
FINAL FEASIBILITY REPORT

APPENDIX L - ENGINEERING INVESTIGATIONS AND COST ESTIMATES

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L1. GENERAL

L1.1 INTRODUCTION

This document serves as the Engineering Appendix Report for the Louisiana Coastal Area, Terrebonne Basin Barrier Shoreline Restoration (LCA TBBSR) Study.

The overarching problem affecting the Terrebonne Basin barrier shoreline is the lack of sustainability of the ecosystem, primarily due to coastal land loss. Natural processes and human actions have resulted in extensive habitat loss and ecosystem degradation, and therefore threaten the long-term viability of the barrier islands (USACE, 2004a).

The LCA TBBSR Study, located in LCA Subprovince 3, provides for the restoration of the Timbalier and Isles Dernieres Barrier Island reaches located in Terrebonne and Lafourche Parishes, Louisiana. The Study Area (Figure L1-1) is located in the 3rd Congressional District. The barrier islands being considered for restoration are presented in Figure L1-2.

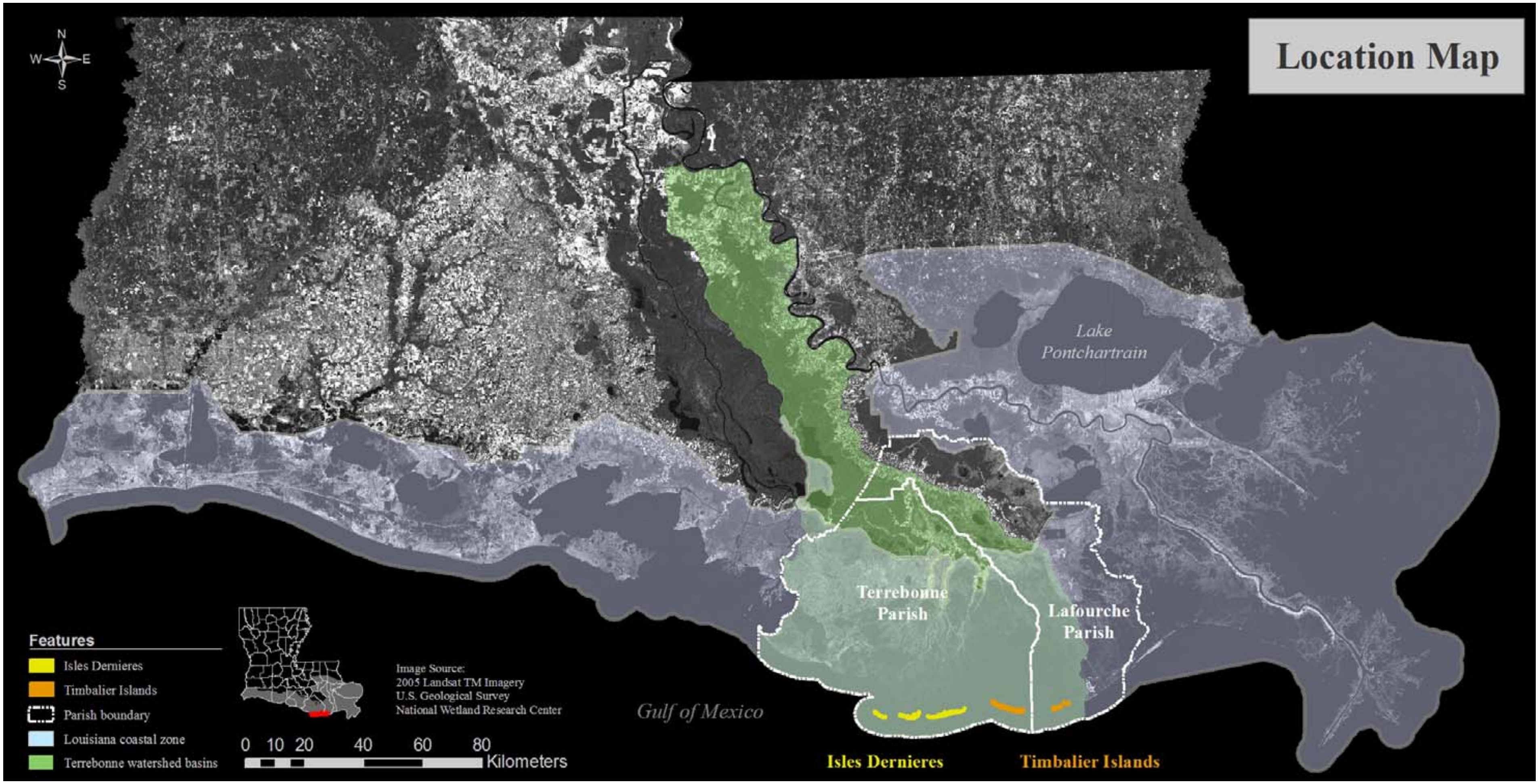


Figure L1-1. Study Area Location Map.

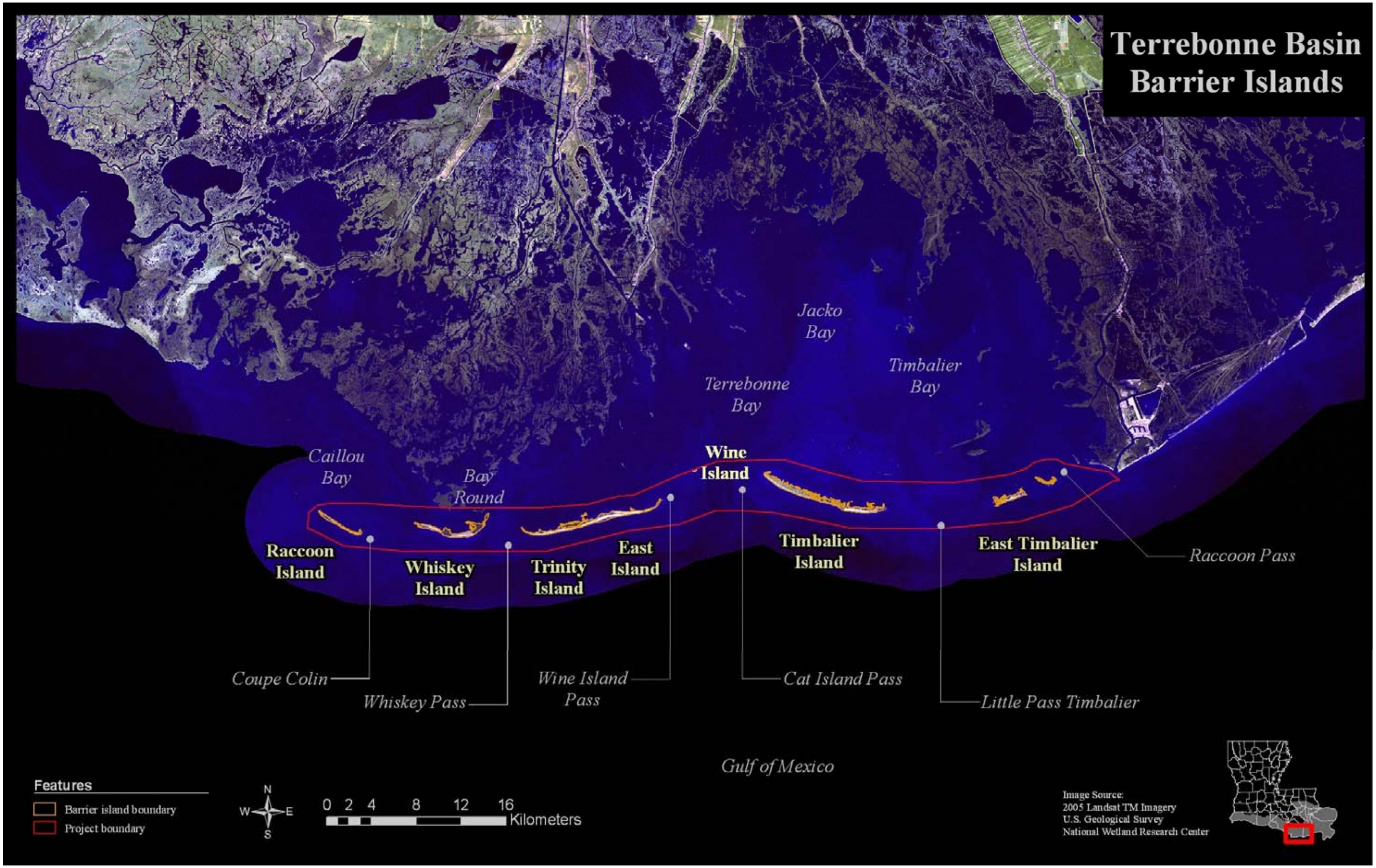


Figure L1-2. Terrebonne Basin Barrier Islands Study Area.

L1.2 EXISTING CONDITIONS

The Terrebonne Basin, similar to the rest of coastal Louisiana, including its wetlands, lakes, bays, and barrier shorelines, were produced by the deltaic processes of the Mississippi River in the east and Gulf and riverine processes in the west. The Terrebonne Basin barrier islands provide unique habitats that are crucial to the viability of migratory birds, commercial and recreational fisheries, and a great variety of aquatic species. In addition, the barrier islands reduce the impact of storm-induced flooding and surges on infrastructure in the coastal region, including highways, oil and gas production facilities, pipelines, and navigation features, such as ports and channels (USACE, 2008).

L1.2.1 Isles Dernieres Reach

The Isles Dernieres reach represents a barrier island arc approximately 22 miles long in the southern reaches of Terrebonne Parish and extends from Caillou Bay east to Cat Island Pass. Raccoon, Whiskey, Trinity, East, and Wine, the primary islands that comprise the Isles Dernieres reach, are backed by Bay Blanc, Bay Round, Caillou Bay and Terrebonne Bay, and bordered by the Gulf of Mexico (GOM) on the seaward side. The remnant of Wine Island is located in Wine Island Pass, about midway between East and Timbalier Islands. The islands of the Isles Dernieres reach range from approximately 0.1 to 0.85 miles wide and are typically composed of a thin sand cap over a thick mud platform. Elevations are generally low and the islands are frequently overwashed (USACE, 2004c).

For more than a century, the Isles Dernieres have experienced significant and persistent degradation and fragmentation. The average historic (1887–2002) rate of shoreline change for the Isles Dernieres was -34.7 ft/yr with a range of -56.0/-17.0 ft/yr. The average short-term (1988–2002) rate of shoreline change was -61.9 ft/yr with a range of -60.5/-38.6 ft/yr (USACE, 2004c).

For more than 150 years, the Isles Dernieres has been an important commercial and recreational resource for Louisiana and the nation. The primary commercial activities in the area, oil and gas mineral extraction and fisheries harvesting, are interwoven inshore and offshore of the islands. As well, the islands have historically played an important role in coastal Louisiana recreation. The Isles Dernieres contained the first major coastal resort in Louisiana (later washed away by the great hurricane of 1856), and continues to provide premier hunting and fishing recreation for both State residents and non-residents alike (USACE, 2004c).

L1.2.2 Timbalier Reach

The Timbalier reach is comprised of Timbalier Island and East Timbalier Island. Timbalier and East Timbalier Islands are on the western edge of the Lafourche barrier shoreline and are located about 60 miles southwest of New Orleans, Louisiana. This barrier island shoreline is approximately 20 miles long and backed by Terrebonne and Timbalier Bay to the north and delimited by Raccoon Pass to the east and Cat Island Pass to the west. The islands range from 0.1 to 0.6 miles wide, with low elevations. Though onshore and offshore oil and gas development and production facilities are supported by both Timbalier and East Timbalier Islands, those facilities are prevalent on and around the East Timbalier but are few and scattered along Timbalier Island. Oil and gas canals are present on both islands (USACE, 2004c).

According to USACE (2004c), the average historic rates of shoreline change for the Timbalier Islands was -36.1 ft/yr with a range of -61.2/-4.1 ft/yr between 1887 and 2002. The average short-term rate of shoreline change was -76.4 ft/yr with a range of -179.4/-13.4 ft/yr between 1988 and 2002.

L1.3 PROBLEM IDENTIFICATION

This Project was designed to address general barrier island restoration problems and opportunities in the Study Area. In 1990, passage of the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, PL-101-646, Title III) provided authorization and funding for the Louisiana Coastal Wetlands Conservation and Restoration Task Force to begin actions to curtail wetland losses.

Numerous regional and site-specific investigations of erosion and shoreline loss have been conducted along the Terrebonne Basin barrier island reaches. Five of the most comprehensive studies conducted are listed below:

- Coast 2050 Plan: Toward a Sustainable Coastal Louisiana;
- Louisiana Coastal Area (LCA), Louisiana Ecosystem Restoration Study (2004 LCA Plan);
- Louisiana Coastal Protection and Restoration (LACPR) Technical Plan;
- Ecosystem Restoration and Hurricane Protection in Louisiana (CPRA); and
- T. Baker Smith Barrier Shoreline Feasibility Study.

In the 2004 LCA Plan, the Terrebonne Basin barrier shoreline was considered near-critical due to the greatly degraded state of this shoreline and its key role in defining, protecting, and preserving larger inland wetland areas and bay systems. If these fragile areas were not addressed quickly, restoration would be far more difficult and costly. As a result, the 2004 LCA Plan identified the LCA TBBSR as one of 10 critical projects that could be implemented within the near-term, based on proven restoration techniques.

L2. COASTAL PROCESSES

L2.1 INTRODUCTION

The major processes operating to shape the Terrebonne Basin barrier islands include waves, storms, tides, relative sea level rise, tidal inlets and tidal prism, currents, and sediment transport.

The Wave Information Studies (WIS) database was utilized to analyze wind and wave conditions specific to the Terrebonne Basin barrier shoreline. WIS project (Hubertz, 1992) produces a high-quality online database of hindcast, nearshore wave conditions covering U.S. coastlines (http://chl.erdc.usace.army.mil/). The data cover a 20-year period from January 1, 1980 through December 31, 1999. The time interval of the data is one hour. Figure L2-1 presents a location map of WIS stations off the coast of Louisiana.

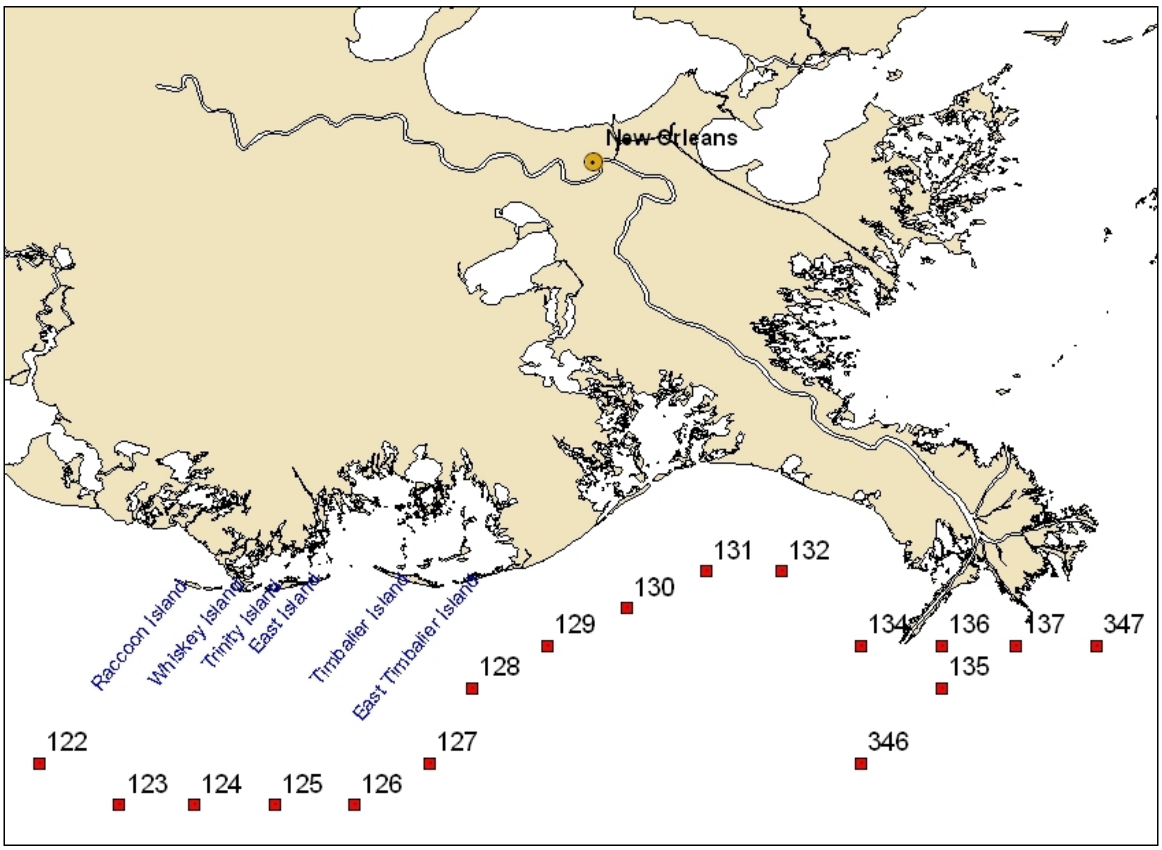


Figure L2-1: WIS Station Location Map

WIS data used in the analysis were obtained at Station 128 (WIS-128) located in 66 ft water depth at (LAT=28.83N, LON=90.33W), approximately 17 miles southeast of Timbalier Island, and Station 125 (WIS-125) located in 59 ft water depth at (LAT=28.58N, LON=90.75W), approximately 32 miles south of East Island.

L2.2 WINDS

Figures L2-2 and L2-3 and Tables L2-1 and L2-2 present wind roses and directional wind statistics based on the 20-year period at WIS-128 and WIS-125, respectively.

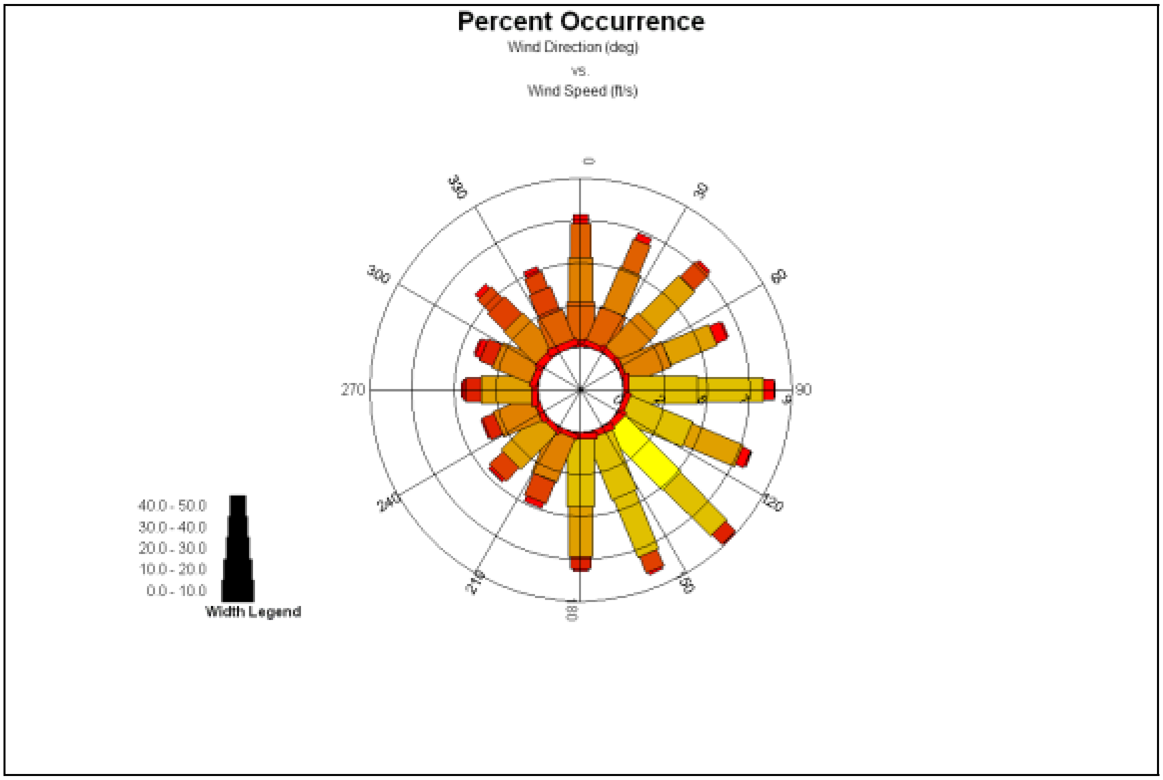


Figure L2-2: Wind Rose at WIS Station 128

Table L2-1. Directional Wind Statistics at WIS-128

Angle Band	Average Wind Speed (ft/s)	% Occurrence
348.75 - 11.24	25.1	7.3
11.25 - 33.74	24.8	6.8
33.75 - 56.24	22.6	7.3
56.25 - 78.74	21.6	6.3
78.75 - 101.24	20.4	8.4
101.25 - 123.74	20.1	7.7
123.75 - 146.24	20.4	9.3
146.25 - 168.74	21.4	8.5
168.75 - 191.24	20.2	7.6
191.25 - 213.74	18.6	4.5
213.75 - 236.24	17.5	4.3
236.25 - 258.74	16.7	3.4
258.75 - 281.24	17.2	4.2
281.25 - 303.74	18.6	3.9
303.75 - 326.24	21.7	5.5
326.25 - 348.74	23.3	4.9

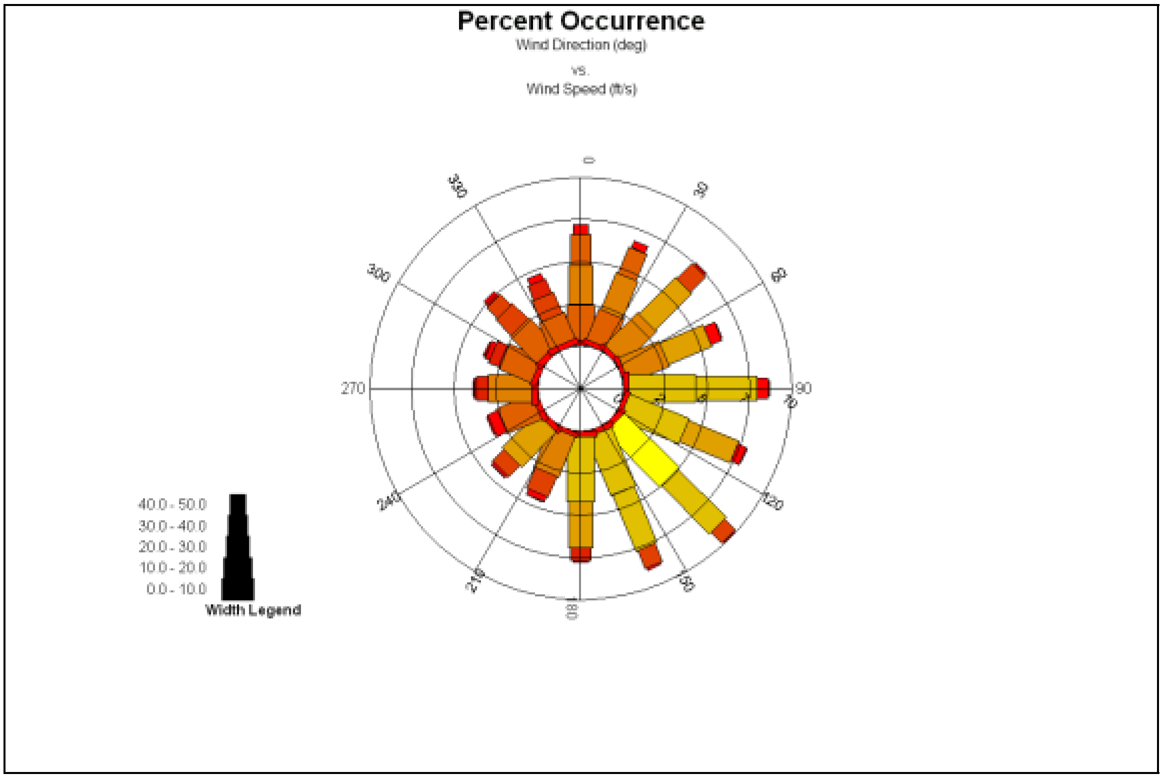


Figure L2-3: Wind Rose at WIS Station 125

Table L2-2. Directional Wind Statistics at WIS-125

Angle Band	Average Wind Speed (ft/s)	% Occurrence
348.75 - 11.24	25.5	7.2
11.25 - 33.74	24.8	6.7
33.75 - 56.24	22.4	7.5
56.25 - 78.74	21.6	6.3
78.75 - 101.24	20.4	8.6
101.25 - 123.74	20.2	7.9
123.75 - 146.24	20.7	9.9
146.25 - 168.74	21.7	8.9
168.75 - 191.24	20.5	7.7
191.25 - 213.74	18.9	4.5
213.75 - 236.24	17.2	4.4
236.25 - 258.74	16.4	3.3
258.75 - 281.24	16.9	3.8
281.25 - 303.74	18.8	3.5
303.75 - 326.24	22.4	5.2
326.25 - 348.74	23.8	4.7

L2.3 WAVES

The wave climate along the Louisiana coast is a product of seasonal wind patterns and the passage of tropical and extra-tropical storms. Wave data statistics from 1980 to 1999 were also generated using WIS data at Stations 128 and 125. Figure L2-4 presents a wave rose at WIS-128 based on the 20-year period. Directional and seasonal wave statistics for WIS-128 are presented in Tables L2-2 and L2-3, respectively. The mean significant wave height, period and dominant wave direction for all the waves were approximately 3.4 ft, 4.5 seconds, and 112.5 degrees, respectively.

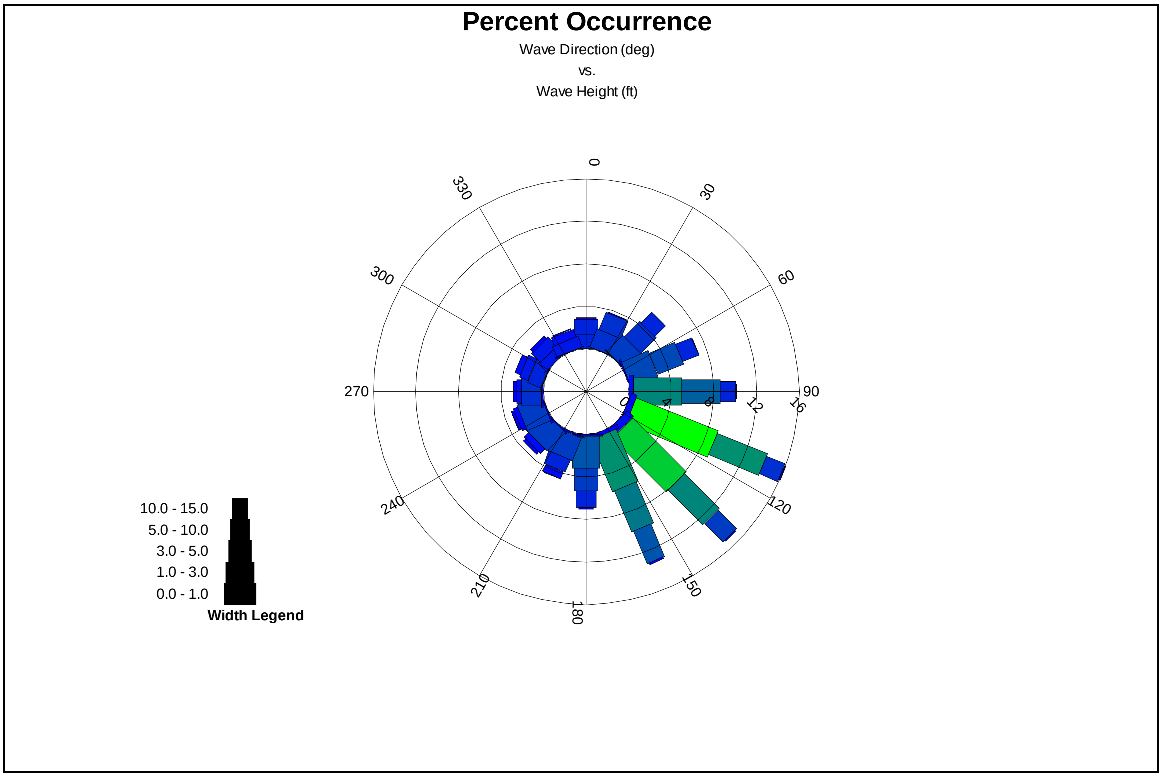


Figure L2-4: Wave Rose at WIS-128

Table L2-3. Directional Wave Statistics at WIS-128

Angle Band (deg)	Avg. Wave Height (ft)	% Occurrence	Avg. Period (sec)
348.75 - 11.24	3.1	2.9	3.8
11.25 - 33.74	3.1	3.6	3.8
33.75 - 56.24	3.7	5.5	4.4
56.25 - 78.74	3.7	6.9	4.5
78.75 - 101.24	3.4	9.9	4.6
101.25 - 123.74	3.1	15.6	4.5
123.75 - 146.24	3.3	14.8	4.7
146.25 - 168.74	3.9	13.0	5.0
168.75 - 191.24	3.8	6.9	4.9
191.25 - 213.74	3.3	4.4	4.5
213.75 - 236.24	2.6	3.4	4.1
236.25 - 258.74	2.6	3.1	4.1
258.75 - 281.24	3.0	2.8	4.2
281.25 - 303.74	3.5	2.8	4.2
303.75 - 326.24	3.4	2.4	4.0
326.25 - 348.74	3.1	2.0	3.8

Table L2-4. Seasonal Wave Statistics at WIS-128

Month	Wave Height (ft)		Period* (sec)	Direction* (deg)
	Avg.	Max		
Jan.	4.0	15.4	11	163
Feb.	4.1	15.4	10	90
March	4.1	14.1	11	154
April	3.9	12.8	9	280
May	3.1	10.8	10	167
June	2.7	7.9	7	209
July	2.2	11.2	8	161
Aug.	2.1	21.7	11	111
Sept.	3.0	17.4	12	102
Oct.	3.6	29.2	14	132
Nov.	4.0	13.8	14	118
Dec.	4.0	13.1	9	281
Overall	**3.4**	**29.2**	**14**	**132**

*period and direction associated with MAX wave height

Figure L2-5 presents a wave rose at WIS-125 and Tables L2-4 and L2-5 present directional and seasonal wave statistics for WIS-125, respectively. The mean significant wave height, period and dominant wave direction for all the waves were approximately 3.6 ft, 4.7 seconds, and 112.5 degrees, respectively.

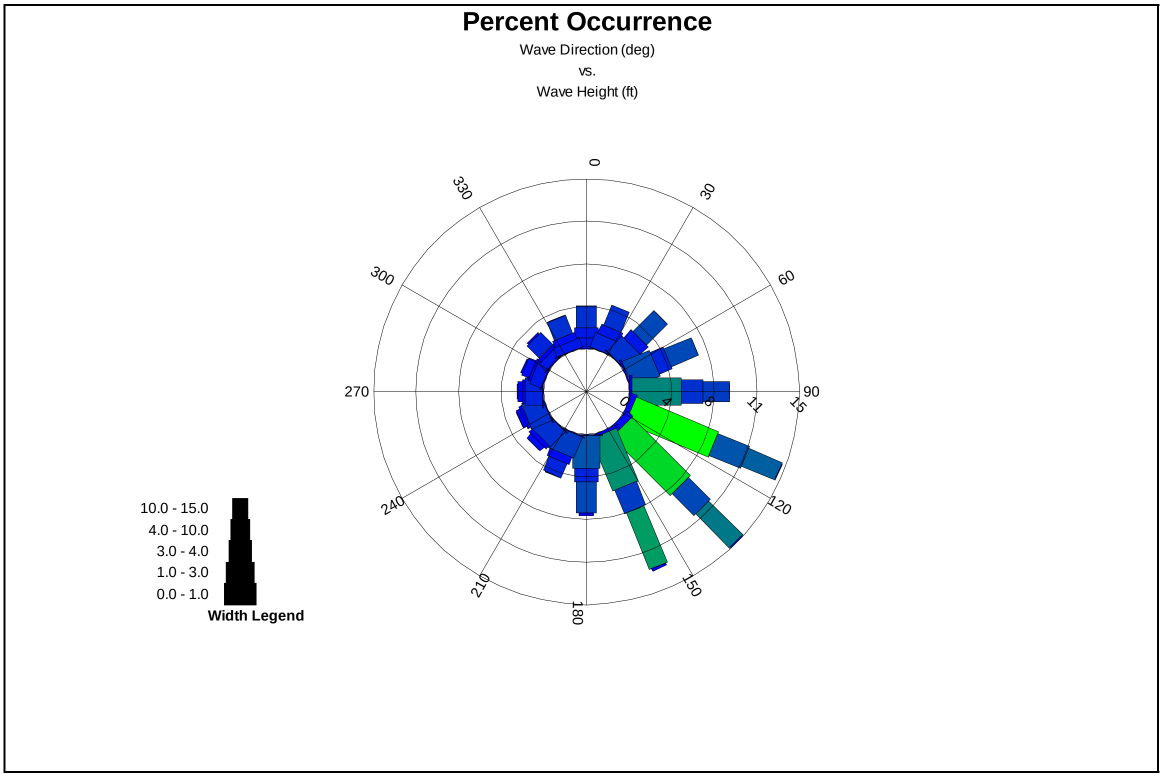


Figure L2-5: Wave Rose at WIS-125

Table L2-5. Directional Wave Statistics at WIS-125

Angle Band (deg)	Avg. Wave Height (ft)	% Occurrence	Avg. Period (sec)
348.75 - 11.24	4.2	3.8	4.6
11.25 - 33.74	4.0	4.2	4.5
33.75 - 56.24	4.0	5.5	4.6
56.25 - 78.74	3.7	6.7	4.5
78.75 - 101.24	3.3	9.0	4.5
101.25 - 123.74	3.0	14.8	4.5
123.75 - 146.24	3.3	15.1	4.6
146.25 - 168.74	4.0	13.2	5.1
168.75 - 191.24	4.1	7.2	5.0
191.25 - 213.74	3.7	4.2	4.7
213.75 - 236.24	2.9	2.9	4.3
236.25 - 258.74	2.8	2.7	4.2
258.75 - 281.24	3.1	2.4	4.4
281.25 - 303.74	4.1	2.2	4.8
303.75 - 326.24	5.0	3.0	5.2
326.25 - 348.74	4.4	3.2	4.8

Table L2-6. Seasonal Wave Statistics at WIS-125

Month	Wave Height (ft)		Period* (sec)	Direction* (deg)
	Avg.	Max		
Jan.	4.4	17.1	12	177
Feb.	4.5	15.4	11	86
March	4.5	15.1	11	162
April	4.1	12.5	8	283
May	3.2	11.5	8	174
June	2.8	9.5	9	139
July	2.2	13.1	10	138
Aug.	2.2	21.7	11	148
Sept.	3.1	17.7	12	154
Oct.	3.9	26.2	13	129
Nov.	4.4	16.4	14	130
Dec.	4.4	13.1	11	157
Overall	**3.6**	**26.2**	**13**	**129**

*period and direction associated with MAX wave height

Figures L2-6 and L2-7 present extremal wave height distributions at WIS-128 and WIS-125, respectively, based on which wave parameters associated with various return periods were determined. These parameters are presented in Tables L2-7 and L2-8.

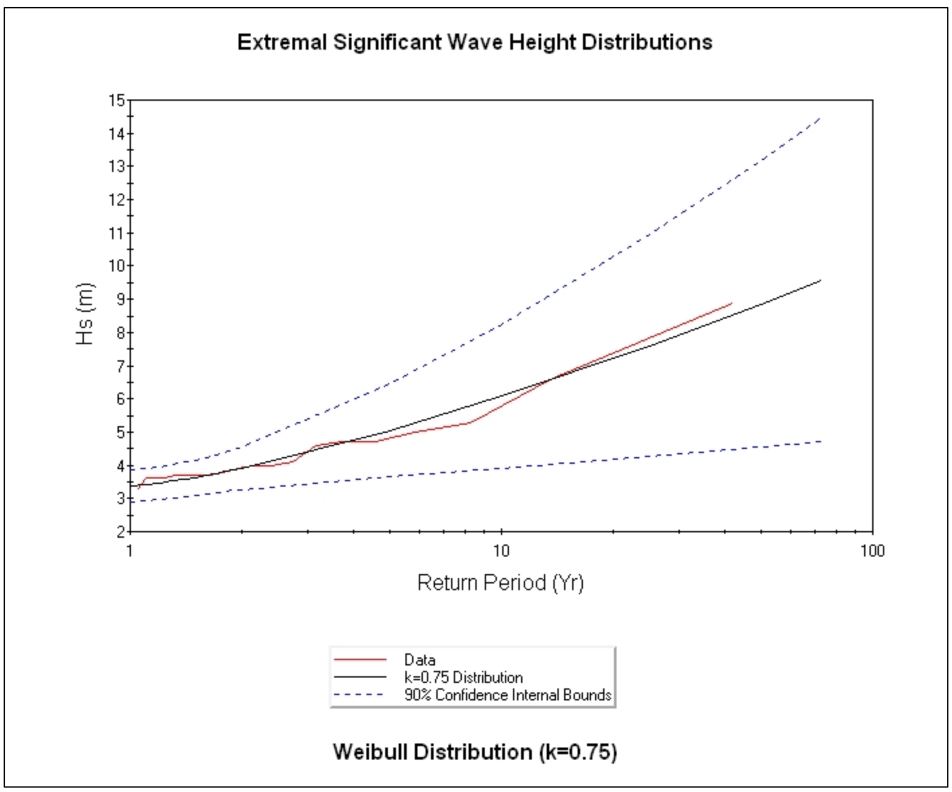


Figure L2-6: Extremal Wave Height Distribution at WIS Station 128

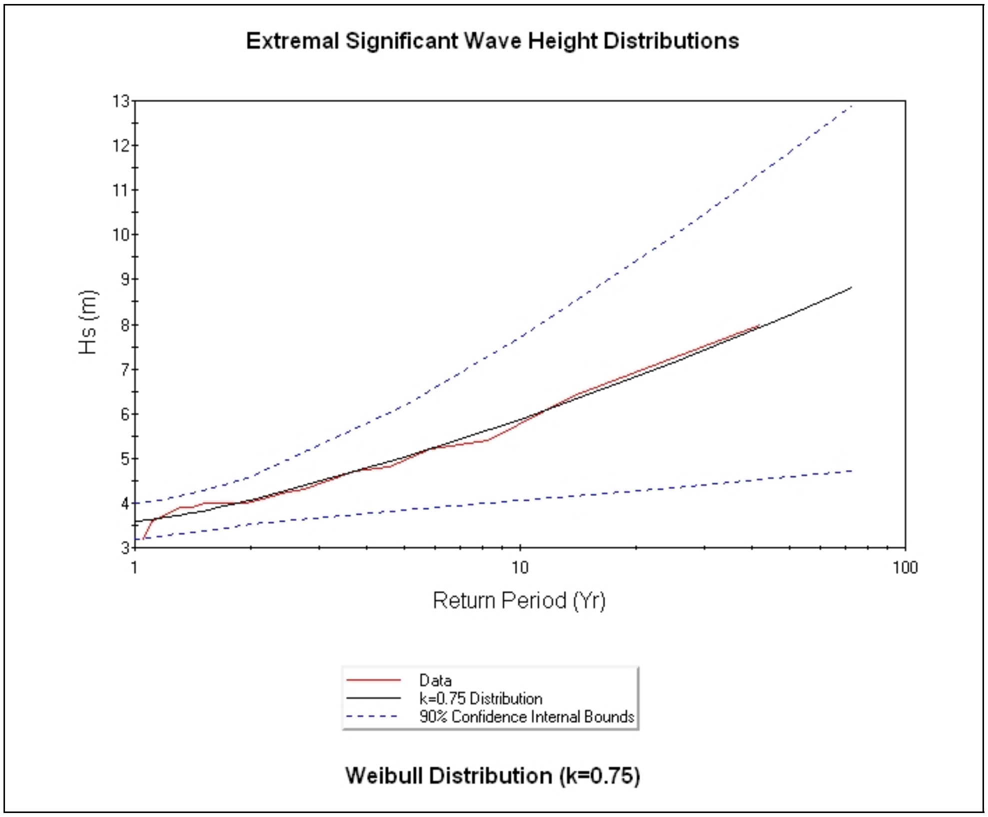


Figure L2-7: Extremal Wave Height Distribution at WIS Station 125

Table L2-7. Extremal Wave Parameters vs. Return Period for Station 128

Return Period (years)	Wave Height (ft)	Wave Period (sec)	Probability*	Probability**
1	11.1	8.5	1.0	1.000
2	12.9	9.1	0.5	0.750
5	16.6	10.3	0.2	0.672
10	19.9	11.3	0.1	0.651
20	23.6	12.3	0.05	0.641
50	29.1	13.7	0.02	0.636
100	31.4	14.2	0.01	0.634

* indicates the probability of the event occurring in any given year (e.g., the probability of a 20-year storm occurring in 2009 is 0.05 or 5% chance)

** indicated the probability of the event occurring during the corresponding return period (e.g., the probability of a 10-year storm occurring during 2009-2018 is 0.651 or 65.1% chance)

Table L2-8. Extremal Wave Parameters vs. Return Period for Station 125

Return Period (years)	Wave Height (ft)	Wave Period (sec)	Probability*	Probability**
1	11.8	8.7	1.0	1.000
2	13.3	9.2	0.5	0.750
5	16.4	10.3	0.2	0.672
10	19.3	11.2	0.1	0.651
20	22.3	12.0	0.05	0.641
50	27.0	13.2	0.02	0.636
100	28.9	13.7	0.01	0.634

* indicates the probability of the event occurring in any given year (e.g., the probability of a 20-year storm occurring in 2009 is 0.05 or 5% chance)

** indicated the probability of the event occurring during the corresponding return period (e.g., the probability of a 10-year storm occurring during 2009-2018 is 0.651 or 65.1% chance)

L2.4 TIDES

In the delta region including Raccoon Pass (west), Grand Isle (central), and the northern Chandeleur Islands (east) tides are strongly diurnal. At Raccoon Pass, the tidal range varies from a low of 0.5 ft during equatorial tidal conditions to a high of 3.2 ft during tropic tides (USACE, 2004c).

The tidal datum at Grand Isle is presented in Table L2-9. The tidal datum is based on a five year record from January 1997 through December 2001. The tidal epoch is 1983 to 2001 (NOAA).

Table L2-9. Grand Isle Tidal Datum

Description	NAVD 88 (ft)
Mean Higher High Water (MHHW)	1.604
Mean High Water (MHW)	1.598
Mean Sea Level (MSL)	1.083
Mean Tide Level (MTL)	1.076
Mean Low Water (MLW)	0.554
Mean Lower Low Water (MLLW)	0.545
North American Vertical Datum of 1988 (NAVD 88)	0.000

L2.5 CURRENTS

Tidal prism dynamics and the pattern of tidal exchange dictate the occurrence and geometry of tidal inlets along the various barrier island reaches. Tidal inlets along the Timbalier Islands have highly variable geometries due to the segmented nature of the barrier system. Much of the tidal exchange between the back-barriers of Caillou Bay, Terrebonne Bay and Timbalier Bay and that of the Gulf of Mexico occurs through broad shallow channels where the transgressive barriers have undergone extensive erosion.

However, there are several relatively deep passes (20 to 33 ft deep) that are maintained by strong tidal currents on the order of 3.3 ft/s (USACE, 2004b).

L2.6 STORMS

The Gulf Coast region is affected by tropical and extra-tropical storms. Since 1893, over 130 tropical storms and hurricanes have struck or indirectly impacted Louisiana's coastline. On average, a tropical storm or hurricane affects Louisiana every 1.2 years. During the past 100 years, over 50 hurricanes and tropical storms have made landfall along the Louisiana coast with the highest incidence occurring in September (USACE, 2004a). Table L2-10 presents hurricanes that impacted the Terrebonne Basin from 1985 to 2008. Storm selection was based primarily on landfall location, but also on wave height and water level elevations associated with the storm. Landfall locations were obtained from NOAA Coastal Services Historical Hurricane storm track data (http://maps.csc.noaa.gov/hurricanes/).

Table L2-10. Historical Hurricanes (1985-2008)

Storm Name	Year*	Month*	Day*	Wind Speed* (knots)	Category*
Danny	1985	8	15	80	H1
Elena	1985	9	2	100	H3
Juan	1985	10	29	70	H1
Bonnie	1986	6	26	75	H1
Andrew	1992	8	26	120	H4
Opal	1995	10	4	110	H3
Danny	1997	7	18	65	H1
Earl	1998	9	3	80	H1
Georges	1998	9	28	90	H2
Isidore	2002	9	26	55	TS
Lili	2002	10	3	80	H1
Ivan	2004	9	16	105	H3
Katrina	2005	8	29	125	H4
Rita	2005	9	24	100	H3
Gustav	2008	9	1	95	H2
Ike	2008	9	13	95	H2

* at landfall

Figure L2-8 presents tracks of four most recent storms including Hurricanes Katrina (2005), Rita (2005), Gustav (2008), and Ike (2008). Hurricane Gustav made landfall along the Terrebonne Basin barrier shoreline as a Category 2 hurricane. According to the Grand Isle water level records, the highest observed water level in station's history occurred during Katrina when it was measured at approximately 6.0 ft NAVD 88.

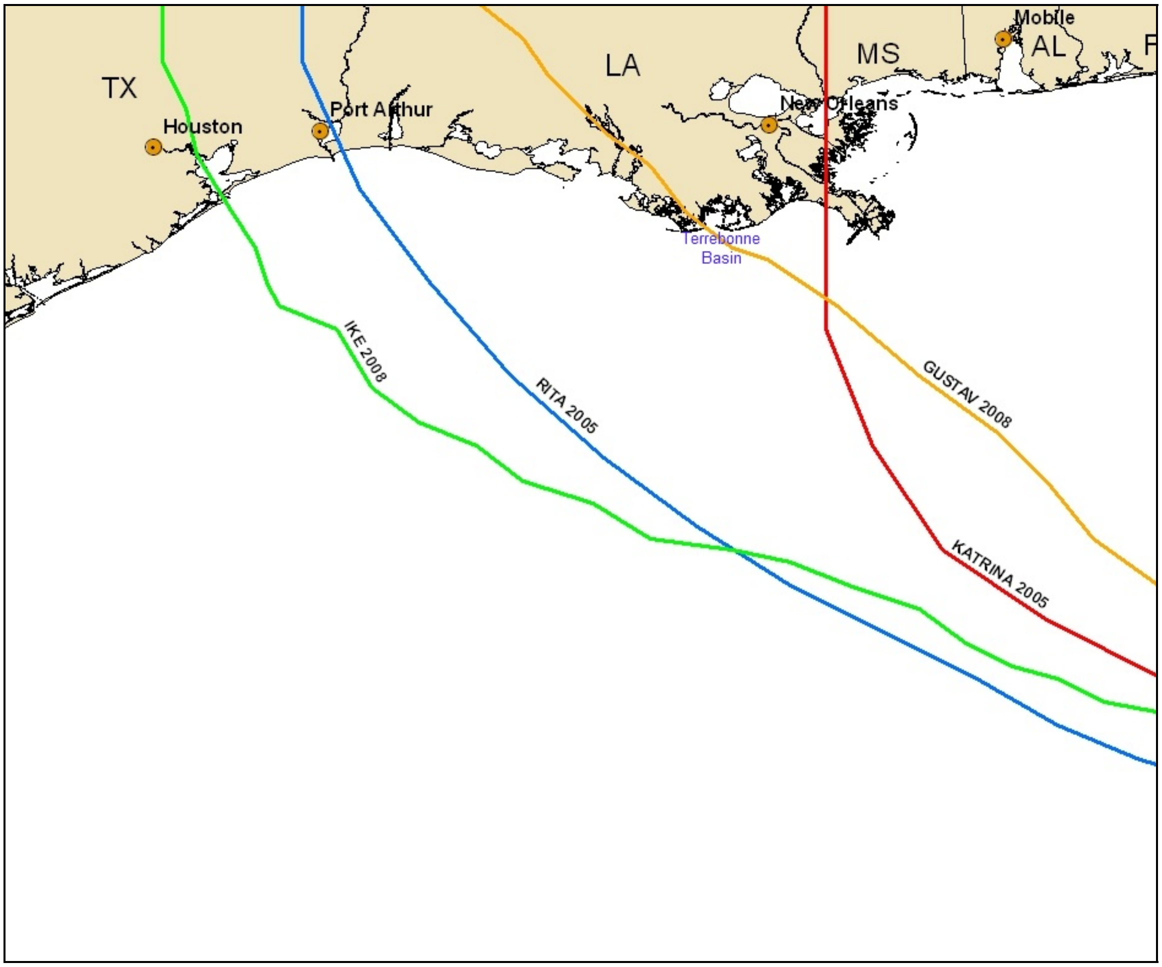


Figure L2-8: Tracks of Recent Hurricanes

Water level, wave and wind data for the four hurricanes were assembled. Water level data were obtained from verified historical records at NOAA/NOS CO-OPS Station 8761724 located at the Coast Guard Station on Grand Isle. Wave and wind data were obtained from the NOAA/NWS/NCEP operational ocean wave predictions based on the output from the WAVEWATCH III model (http://polar.ncep.noaa.gov/waves/index2.shtml). The wave and wind data were obtained near the WIS-128 and WIS-125 locations. Figures L2-9 and L2-10 present water level and wave data near WIS-128 during Hurricanes Katrina and Rita, and Gustav and Ike, respectively. Similarly, Figures L2-11 and L2-12 present the data near WIS-125.

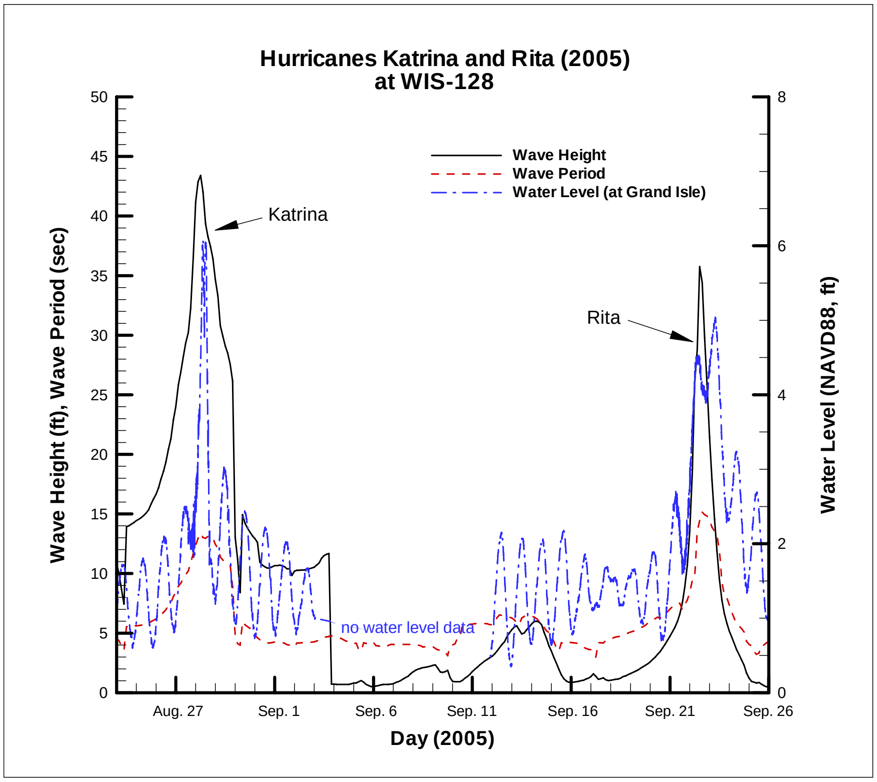


Figure L2-9: Water Level (Grand Isle) and Wave Data (WIS-128) During Katrina and Rita

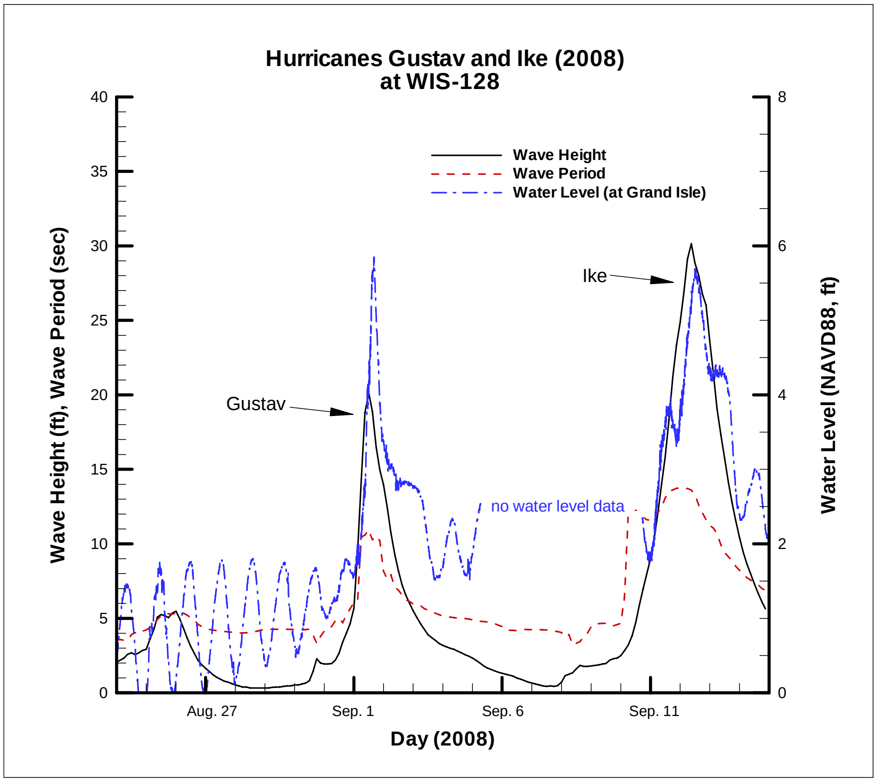


Figure L2-10: Water Level (Grand Isle) and Wave Data (WIS-128) During Gustav and Ike

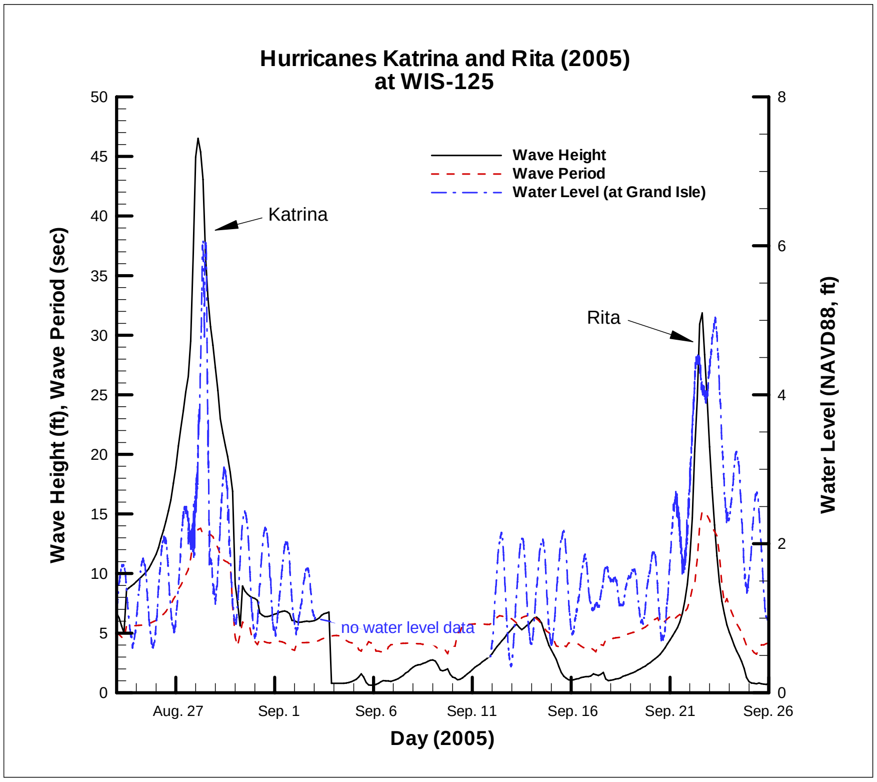


Figure L2-11: Water Level (Grand Isle) and Wave Data (WIS-125) During Katrina and Rita

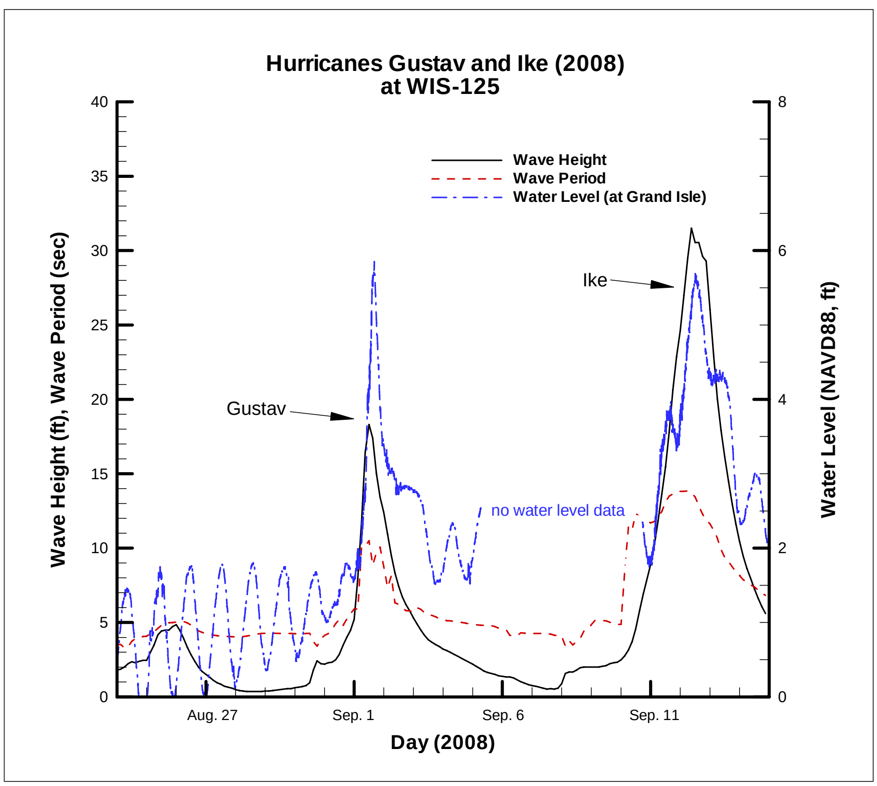


Figure L2-12: Water Level (Grand Isle) and Wave Data (WIS-125) During Gustav and Ike

The largest wave heights during Katrina and Rita at WIS-128 were approximately 43.4 ft and 35.7 ft, respectively. The largest wave heights during Katrina and Rita at WIS-125 were approximately 46.3 ft and 31.8 ft, respectively. The maximum water levels that occurred at the Grand Isle Station were 6.0 ft NAVD 88 and 5.0 ft NAVD 88, respectively.

The largest wave heights during Gustav and Ike at WIS-128 were approximately 20.1 ft and 30.0 ft, respectively. The largest wave heights during Gustav and Ike at WIS-125 were approximately 18.3 ft and 31.2 ft, respectively. The maximum water levels that occurred at the Grand Isle Station were 5.8 ft NAVD 88 and 5.7 ft NAVD 88, respectively.

Figures L2-13 through L2-16 present wind speed during Katrina and Rita, and Gustav and Ike, at WIS-128 and WIS-125. The maximum wind speeds at WIS-128 during Katrina, Rita, Gustav, and Ike were approximately 60 mph, 68 mph, 45 mph, and 53 mph, respectively. The maximum wind speeds at WIS-125 during Katrina, Rita, Gustav, and Ike were approximately 72 mph, 62 mph, 45 mph, and 59 mph, respectively.

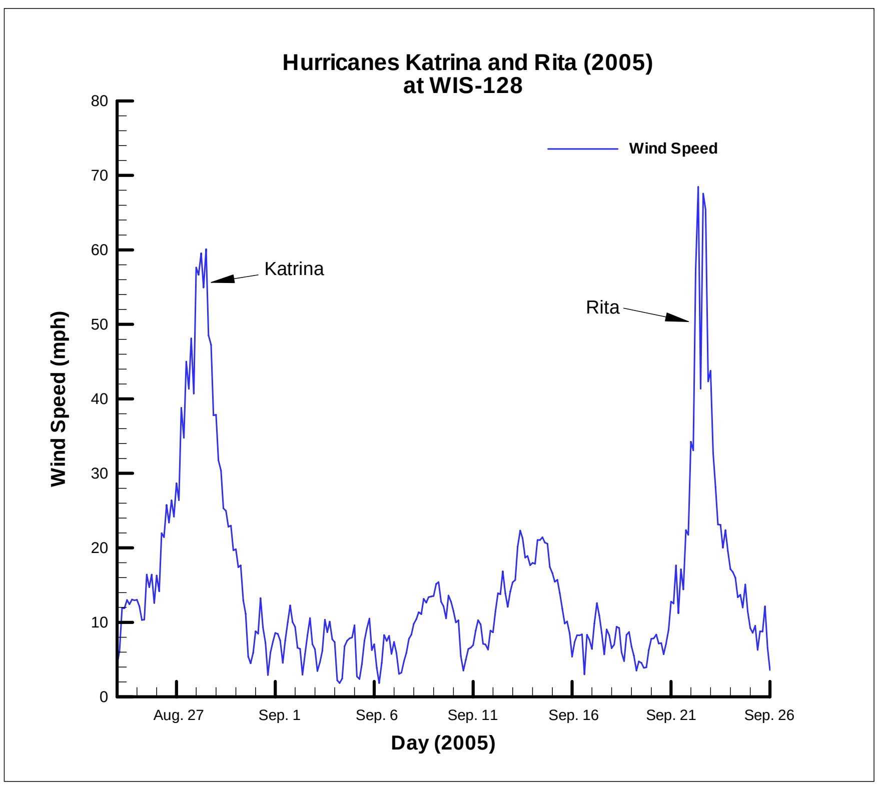


Figure L2-13: Wind Speed During Katrina and Rita at WIS-128

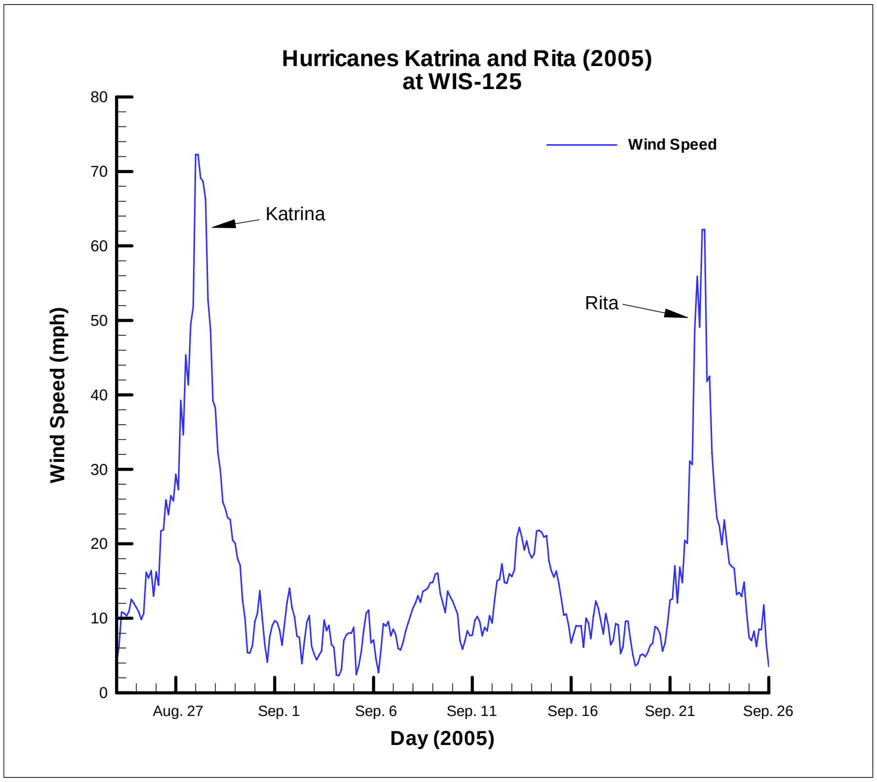


Figure L2-14: Wind Speed During Gustav and Ike at WIS-128

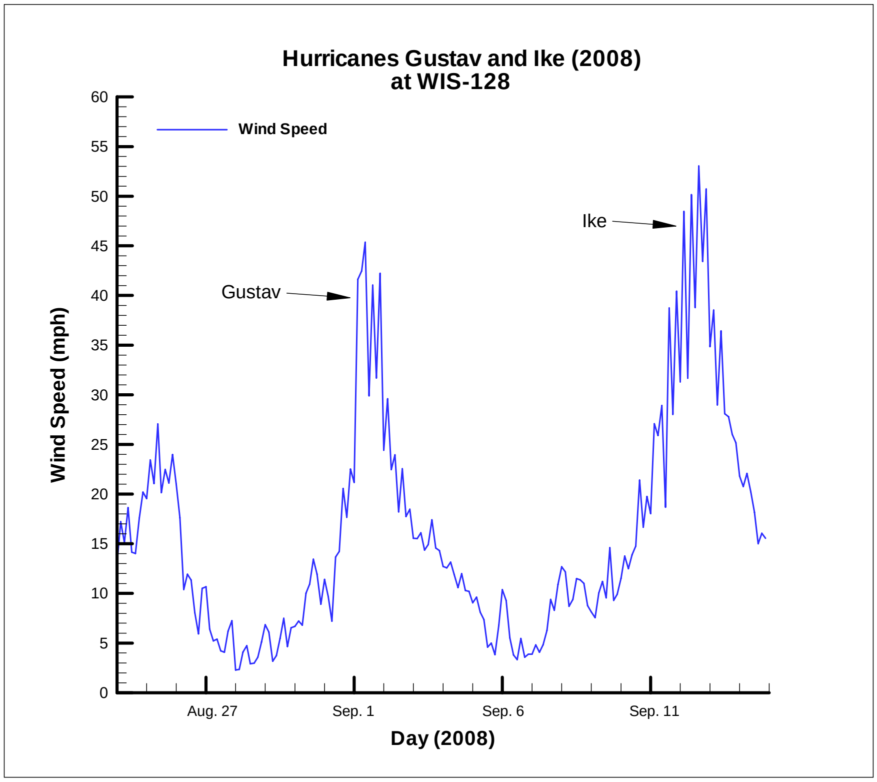


Figure L2-15: Wind Speed During Katrina and Rita at WIS-125

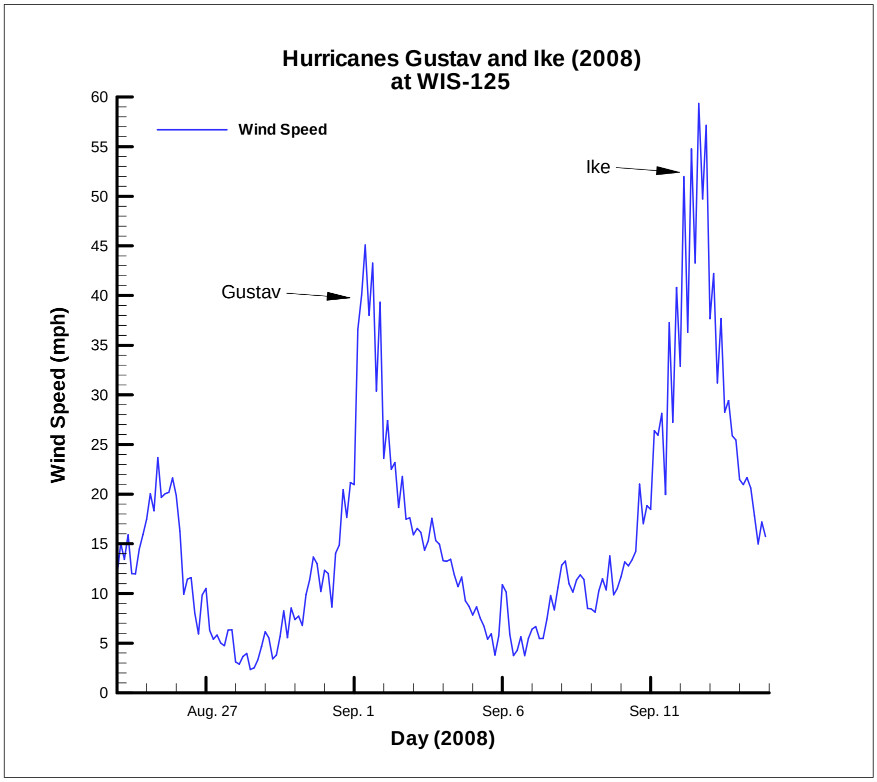


Figure L2-16: Wind Speed During Gustav and Ike at WIS-125

L2.7 RELATIVE SEA LEVEL CHANGE

According to NOAA (http://tidesandcurrents.noaa.gov), the mean sea level (MSL) trend at Grand Isle, LA is 9.24 millimeters/year (mm/yr) with a 95% confidence interval of +/- 0.59 mm/yr which is equivalent to a change of 0.030 ft/yr. Figure L2-17 presents the trend based on monthly MSL data from 1947 to 2006. It should be noted that the published information for the tide gauge at Grand Isle is a combination of data from two tide gauges, Bayou Rigaud and East Point, about 0.9 miles apart along the northwest shore of Grand Isle. The zero-marks on these two gauges, and thus their data sets, were connected by leveling observations to form a continuous water level observation set (Shinkle and Dokka, 2004).

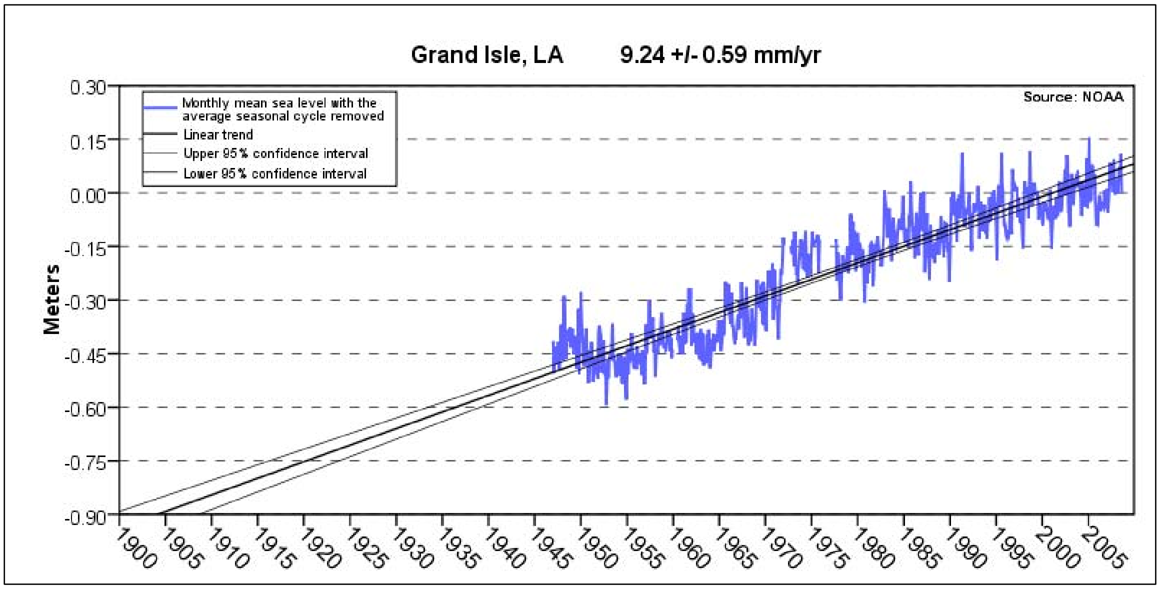


Figure L2-17: Sea Level Rise at Grand Isle

This estimated MSL trend combines the global MSL rise and the local vertical land motion, subsidence. A similar MSL rise trend, 0.034 ft/yr, developed by Penland and Ramsey (1990) was used in the designs of the Raccoon (TE-48) (NRCS, 2007) and Whiskey (TE-50) (TBS and M&N, 2007) projects.

Estimates of projected design sea level change were determined by following an 18-step guidance developed by USACE to account for future changes in MSL (USACE, 2009). A flowchart of the steps is presented in Figure L2-18.

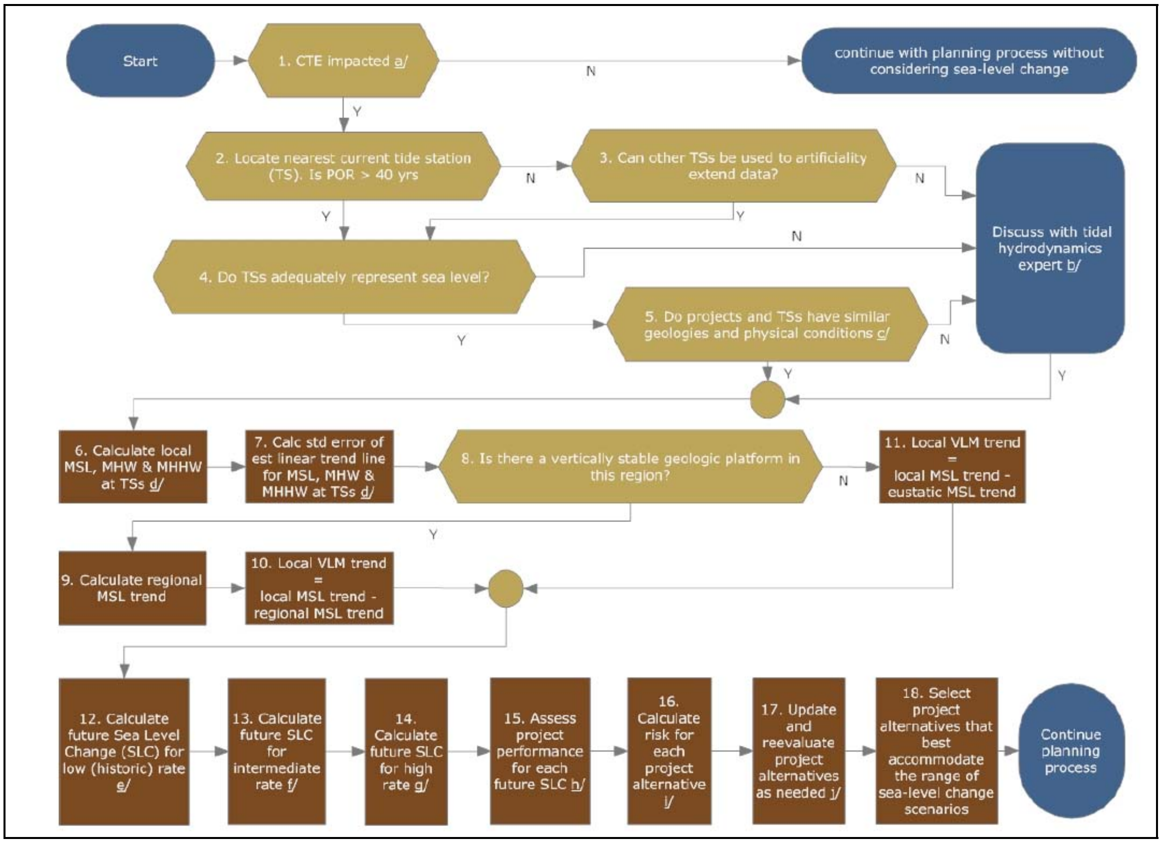


Figure L2-18: 18-step Flowchart to Account for Changes in MSL (USACE, 2009)

Below are answers to each step throughout the flowchart applied to this Study. Because the 2006 Barrier Island Comprehensive Monitoring (BICM) survey data were used in designing this Study with estimated project start in 2012, Target Year 0 (TY0), eustatic sea level changes were computed relative to the 2006 sea level.

Step 1: Yes → Step 2
Step 2: Yes (Grand Isle, 59 years worth of data) → Step 4
Step 4: Yes → Step 5
Step 5: Yes → Step 6
Step 6: Low/Historic MSL rise trend is 0.030 ft/year → Step 7
Step 7: Standard error is 0.002 ft/year with a 95% confidence interval → Step 8
Step 8: No → Step 11
Step 11: Subtract 0.006 ft/year (1.7 mm) from 0.030 ft/yr which results in 0.024 ft/yr, this is the design vertical land movement (VLM) or subsidence rate → Step 12
Step 12: Low/Historic eustatic sea level rise values are
Between 2006 and 2012 (TY0) = 0.033 ft
Between 2006 and 2017 (TY5) = 0.061 ft
Between 2006 and 2022 (TY10) = 0.089 ft
Between 2006 and 2037 (TY25) = 0.173 ft → Step 13
Step 13: Intermediate (NRC Curve I) eustatic sea level rise values are
Between 2006 and 2012 (TY0) = 0.055 ft
Between 2006 and 2017 (TY5) = 0.105 ft

Between 2006 and 2022 (TY10) = 0.159 ft
Between 2006 and 2037 (TY25) = 0.343 ft → Step 14

Step 14: High (NRC Curve III) eustatic sea level rise values are
Between 2006 and 2012 (TY0) = 0.124 ft
Between 2006 and 2017 (TY5) = 0.246 ft
Between 2006 and 2022 (TY10) = 0.385 ft
Between 2006 and 2037 (TY25) = 0.899 ft → Step 15

Steps 15 through 18 are to determine project performance and evaluate risk.

Table L2-11 presents low/historic, intermediate and high relative sea level changes for TY0, TY5, TY10, TY25, and TY50, which combine the eustatic sea level rise and subsidence rates. Figure L2-19 presents the three curves computed to year 2062, TY50.

Table L2-11. Estimated Design Relative Sea Level Changes

Rate Type	Period	Eustatic SLR, ft	Subsidence, ft	Relative SLR, ft
Low/Historic	2006-2012 (TY0)	0.033	0.144	0.177
	2006-2017 (TY5)	0.061	0.264	0.325
	2006-2022 (TY10)	0.089	0.384	0.473
	2006-2037 (TY25)	0.173	0.744	0.917
	2006-2062 (TY50)	0.312	1.344	1.656
Intermediate (NRC Curve I)	2006-2012 (TY0)	0.055	0.144	0.199
	2006-2017 (TY5)	0.105	0.264	0.369
	2006-2022 (TY10)	0.159	0.384	0.543
	2006-2037 (TY25)	0.343	0.744	1.087
	2006-2062 (TY50)	0.729	1.344	2.073
High (NRC Curve III)	2006-2012 (TY0)	0.124	0.144	0.268
	2006-2017 (TY5)	0.246	0.264	0.510
	2006-2022 (TY10)	0.385	0.384	0.769
	2006-2037 (TY25)	0.899	0.744	1.643
	2006-2062 (TY50)	2.085	1.344	3.429

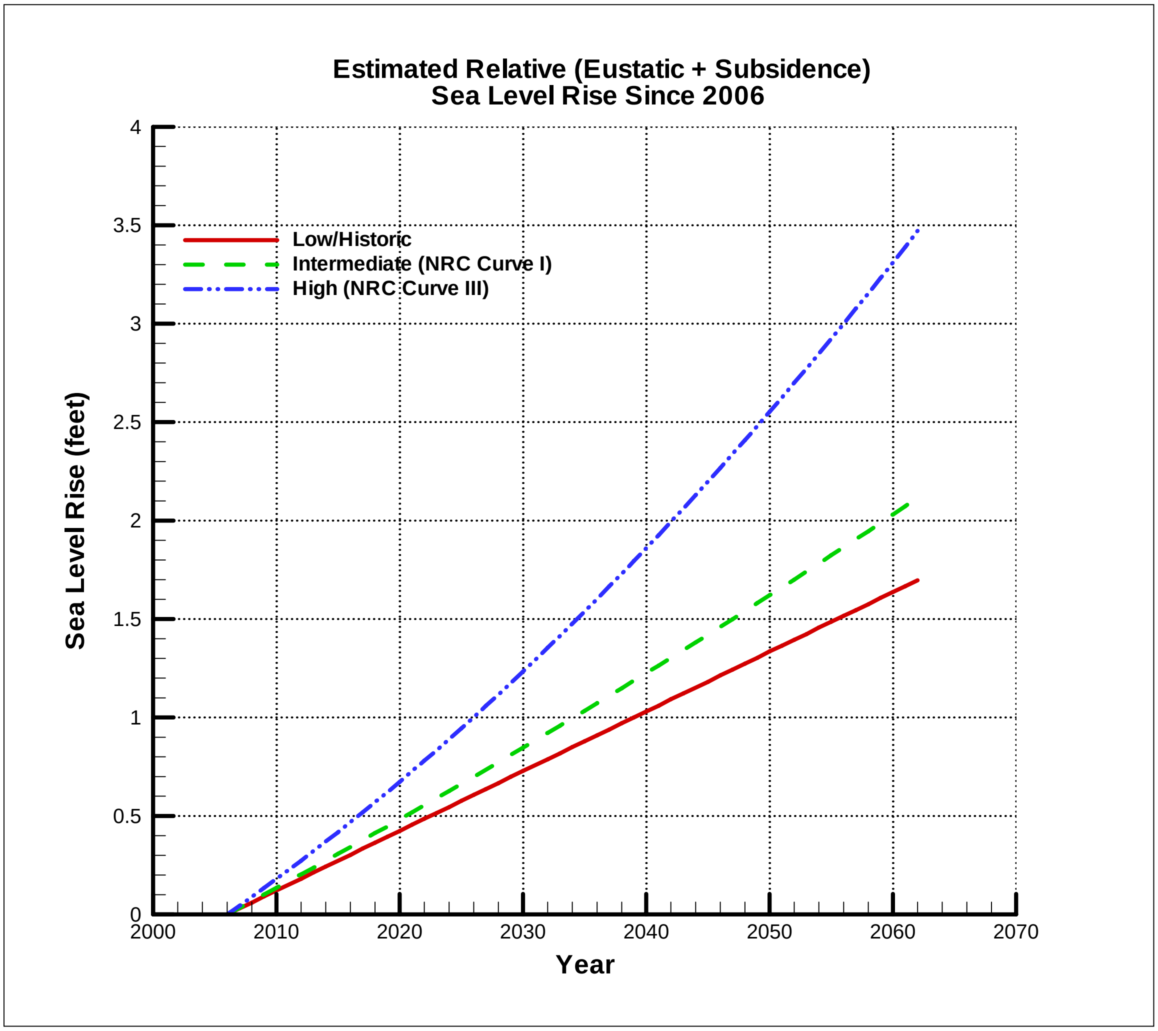


Figure L2-19: Estimated Relative Sea Level Rise since 2006

According to the Bruun Rule (Bruun, 1962), a sea level change results in profile response. When sea level change occurs, beach profiles try to reach new equilibrium and erode causing shoreline recession. Erosion due to sea level change is one of several components that comprise shoreline erosion as a whole.

Variation in future sea level change rates yields a range of future erosion rates associated with sea level change. To analyze how the low/historic, intermediate and high relative sea level changes influence the future erosion rates, the Bruun Rule equation presented below was applied to the three trends:

$$\Delta y = -S \frac{W_*}{(h_* + B)}$$

where

Δy = shoreline change

S = sea-level change

h_* = depth of closure

B = berm height

W_* = width of active profile to depth of closure

A berm height of 3.8 ft was determined based on the restoration design plans presented in Section L6. The depth of closure presented in Section L2.8 was determined to be 10.5 ft. The widths of active profiles were calculated for individual islands based on the 2006 BICM bathymetric data. The width was equivalent to the distance between contour lines representing MHW and depth of closure. Table L2-12 presents sea level change induced shoreline recession computed for the three trends for the 2006 to 2062 period of analysis. The results indicate that the there is a 25% increase in erosion from low/historic to intermediate trend, and a 107% increase from low/historic to high trend.

Table L2-12. Sea-Level Rise Induced Shoreline Recession Rates, 2006 to 2062

Island	W_*,ft	Shoreline Recession, ft		
		Low/Historic Trend	Intermediate Trend	High Trend
Raccoon	3,900	-8.1	-10.1	-16.7
Whiskey	2,500	-5.2	-6.5	-10.7
Trinity/East	950	-2.0	-2.5	-4.1
Wine	3,500	-7.2	-9.1	-15.0
Timbalier	2,000	-4.1	-5.2	-8.6
East Timbalier	7,000	-1.4	-1.8	-3.0

L2.8 DEPTH OF CLOSURE

The depth of closure is defined as the seaward limit of active sand transport. It is determined by one of two methods, either empirically or using historic profile comparisons. Both methods are employed herein and the depth of closure is defined.

WIS-125 data were utilized to compute the "effective" wave height, H_e, which is the significant wave height that is exceeded during only 12 hours per year. The effective wave height at WIS-125 was equal to 13.1 ft and the associated period, T_e, was equal to 8.5 seconds. The STWAVE model was used to propagate the WIS-125 effective wave closer to the shore. The calculated nearshore effective wave height and period were 7.2 ft and 9.0 seconds, respectively. These data were used to calculate the depth of closure, h_c, by applying the empirical method developed by Birkemeier (1985):

$$h_c = 1.75H_e - 57.9\left(\frac{H_e^2}{gT_e^2}\right)$$

The calculated depth of closure was equal to approximately 11.5 ft referenced to Mean Sea Level (MSL) or approximately -10.5 ft NAVD 88.

A review of recent Louisiana projects was conducted to identify the published depth of closure values in similar geologic settings experiencing similar coastal processes. USACE (July 2004) computed the depth of closure equal to -12 ft NAVD 88 on Grand Isle. SJB and CEC (2005) determined the depth of closure for the Bay Joe Wise Headland, CWPPRA Project BA-35, Pass Chaland to Grand Bayou Barrier Restoration Project, by conducting a field study to accurately measure the thickness of the sand veneer over the underlying cohesive soils. Their field study and analyses yielded a depth of closure equal to -11 ft NAVD 88. In the Whiskey Island West Flank Restoration Project, Moffatt & Nichol used a depth of closure of -10 ft NAVD 88 (Moffatt & Nichol, 2004) which is one of the Terrebonne Basin barrier islands under consideration for restoration.

The computed depth of closure of -10.5 ft NAVD 88 falls within the range of the published depth of closure values and thus was chosen for this Study.

L3. SURVEYING AND MAPPING

L3.1 HISTORICAL SURVEYS

L3.1.1 Land and Water Area Surveys

Fourteen U.S.Geological Survey (USGS) land-water data sets summarizing land and water areas from 1956 to 2006 in Coastal Louisiana are presented in Table L3-1. According to Barras et al. (2008), these data sets were derived from (1) modified, photo-interpreted National Wetlands Inventory data created for wetland habitat classifications and (2) Landsat Thematic Mapper satellite imagery obtained from the USGS Center for Earth Resources Observation and Science and then classified by land and water coverage. These data sets are routinely used to provide summaries of land area and information on land change for coastal restoration projects and were utilized to develop land loss rates for this Study (Section L3.3).

Table L3-1. Summary of Land and Water Area Surveys in Coastal Louisiana

Survey Date	Data Source
10/01/1956	National Wetlands Inventory Habitat Data
10/01/1978	National Wetlands Inventory Habitat Data
01/19/1985*	Landsat Thematic Mapper Classified Imagery
01/26/1988*	Landsat Thematic Mapper Classified Imagery
10/01/1988*	National Wetlands Inventory Habitat Data
11/01/1990*	Landsat Thematic Mapper Classified Imagery
02/24/1998*	Landsat Thematic Mapper Classified Imagery
11/18/1999*	Landsat Thematic Mapper Classified Imagery
10/1/2000	Louisiana Coastal Area 2000 Landsat Thematic Mapper Classified Mosaic
10/30/2001*	Landsat Thematic Mapper Classified Imagery
02/27/2002	Landsat Thematic Mapper Classified Imagery
11/07/2004*	Landsat Thematic Mapper Classified Imagery
10/25/2005	Landsat Thematic Mapper Classified Imagery
10/28/2006*	Landsat Thematic Mapper Classified Imagery

* denotes data sets that were used to derive land loss rates for the Terrebonne Basin Barrier Islands in Section L3.3

L3.1.2 Bathymetric Surveys

Only a few region-wide bathymetric and topographic surveys were conducted between 1934 and 2006. Table L3-2 presents a summary of these historical regional surveys. The National Oceanic and Atmospheric Administration (NOAA) surveys date back to 1934 and 1936. The latest and most comprehensive data set that encompassed all of the Terrebonne Basin barrier islands is the BICM survey that was conducted in 2006 and included bathymetric survey (UNO and USGS, 2009) and LIDAR topographic survey. The BICM data presented in Figure L3-1 were used to develop representative profiles for each island. These profiles were also used in the SBEACH simulations to compute storm-induced erosion and served as the basis for calculating fill volumes required for the restoration design plans (Section L6). Additional island specific surveys conducted as part of the CWPPRA projects including TE-27, TE-40, and TE-50, were also reviewed, however, few if any of the data sets were more recent than the BICM survey or temporally consistent, thus they were not utilized for plan formulation.

Table L3-2. Summary of Bathymetric and Topographic Surveys in Terrebonne Basin Area

Survey Year	Data Source	Area	Data Type
1934	NOAA	Caillou Bay, Lake Pelto, Southern Part of Terrebonne Bay, Southern Part of Timbalier Bay, and Outer Coast	Bathymetry
1936	NOAA	Ship Shoal, South Ship Shoal, and South of Timbalier Island	Bathymetry
1997	Picciola & Associates	Whiskey Island	TE-27 Pre-Construction
1998	T. Baker Smith	Whiskey Island	TE-27 Post-Construction
2004	Shaw Coastal	Timbalier Island	TE-40 Pre-Construction
2005	Weeks Marine	Timbalier Island	TE-40 As-Built
2006	T. Baker Smith	Whiskey Island	TE-50 Pre-Construction
2006	BICM	Terrebonne Basin Barrier Islands	Bathymetry and Topography

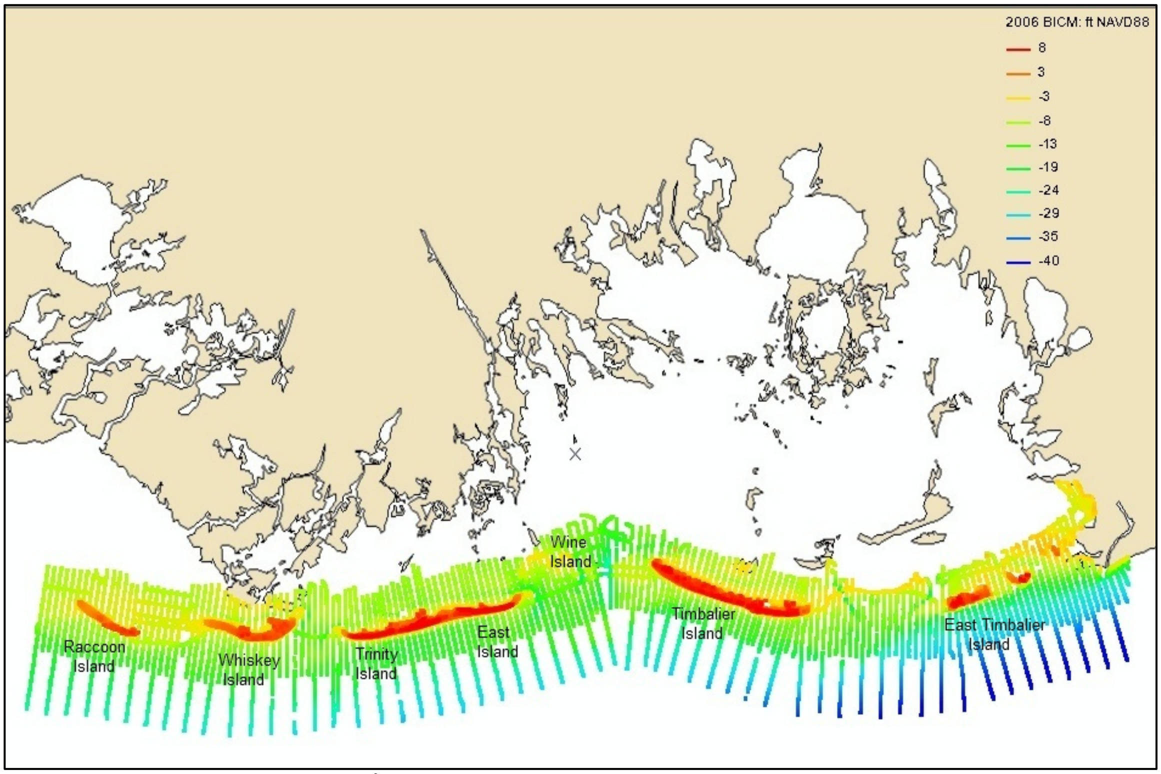


Figure L3-1. 2006 BICM Survey.

L3.2 SHORELINE CHANGE ANALYSIS

For more than a century, the Isles Dernieres have experienced significant and persistent degradation and fragmentation. The average historic (1887–2002) rate of shoreline change for the Isles Dernieres was -34.7 ft/yr with a range of -56.0/-17.0 ft/yr. The average short-term (1988 to 2002) rate of shoreline change was -61.9 ft/yr with a range of -60.5/-38.6 ft/yr (USACE, 2004c).

The average historic rates of shoreline change for the Timbalier Islands was -36.1 ft/yr with a range of -61.2/-4.1 ft/yr between 1887 and 2002. The average short-term rate of shoreline change was -76.4 ft/yr with a range of -179.4/-13.4 ft/yr between 1988 and 2002 (USACE, 2004c).

Utilizing the data and representative transects contained within the atlas of shoreline changes in Louisiana (Williams et al., 1992), the following average long-term (1956–1988) rates of shoreline change were developed for each individual island:

- Raccoon -28.6 ft/yr;
- Whiskey -42.7 ft/yr;
- Trinity/East -39.7 ft/yr;
- Wine -21.6 ft/yr;
- Timbalier -32.5 ft/yr;
- East Timbalier -21.4 ft/yr;

It was assumed these long-term rates would be most representative of Future With Project conditions and during the 50-year period of analysis.

L3.3 LAND LOSS RATE ANALYSIS

The USGS performed a short-term land loss trend analysis for the Terrebonne Basin, covering the period from 1985 to 2006. A regression analysis on the data was performed. Figures L3-2 through L3-6 present the derived regression trend lines and the 95% confidence intervals.

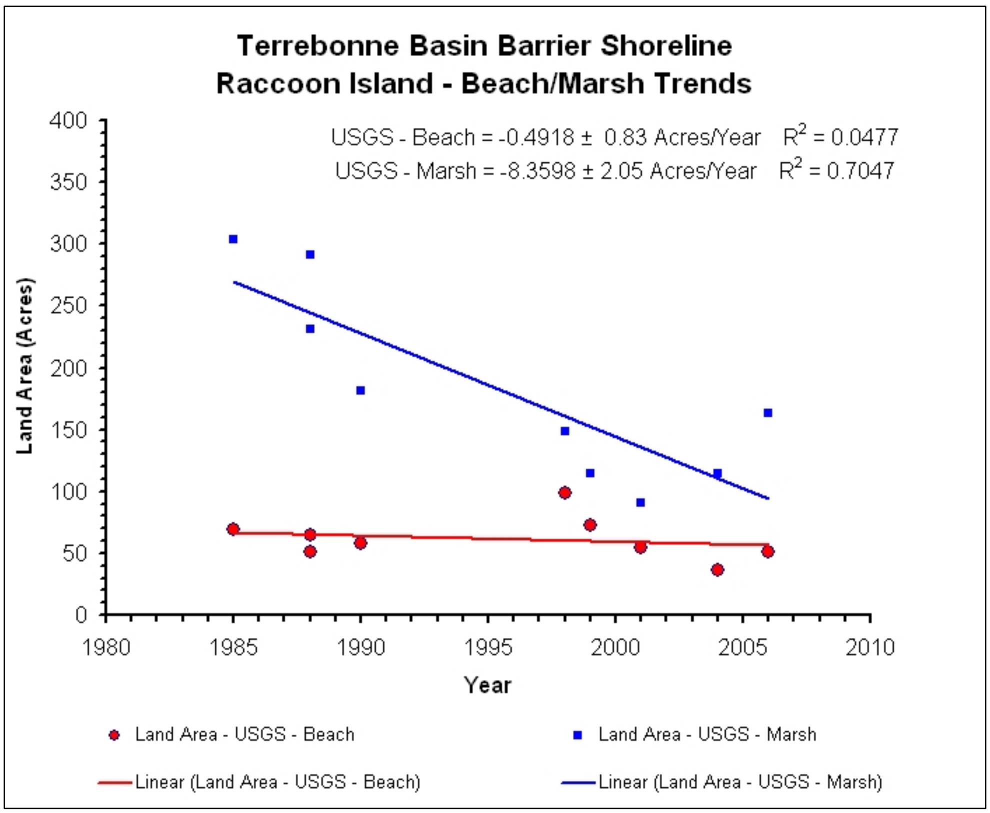


Figure L3-2. Raccoon Island USGS Land Loss Trend Analysis from 1985 to 2006.

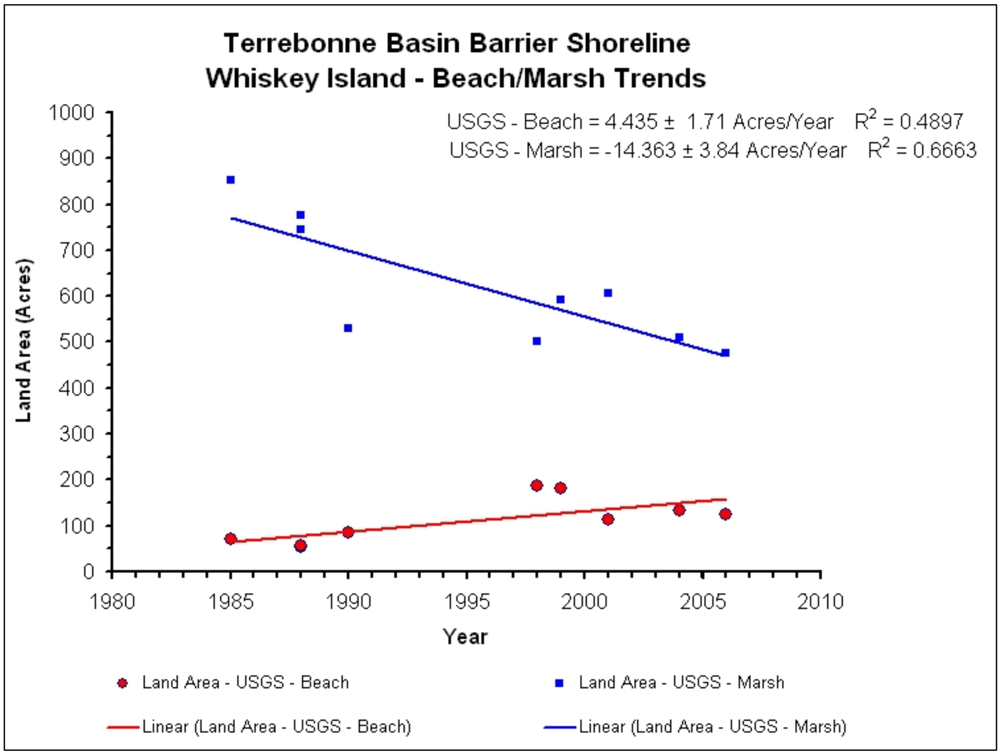


Figure L3-3. Whiskey Island USGS Land Loss Trend Analysis from 1985 to 2006.

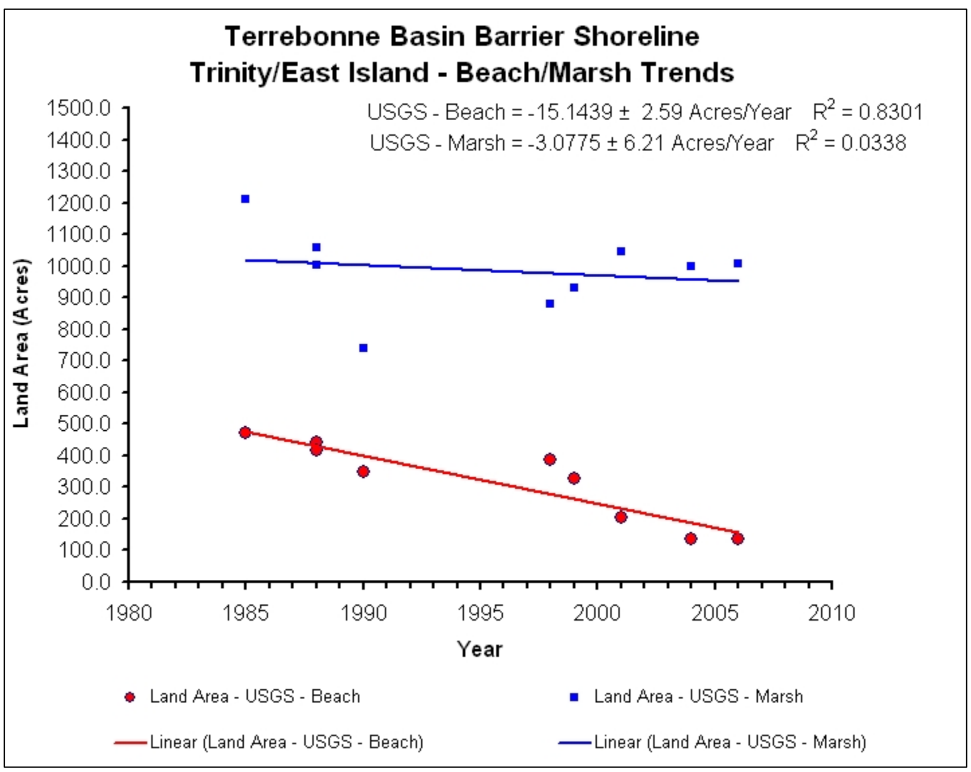


Figure L3-4. Trinity/East Island USGS Land Loss Trend Analysis from 1985 to 2006.

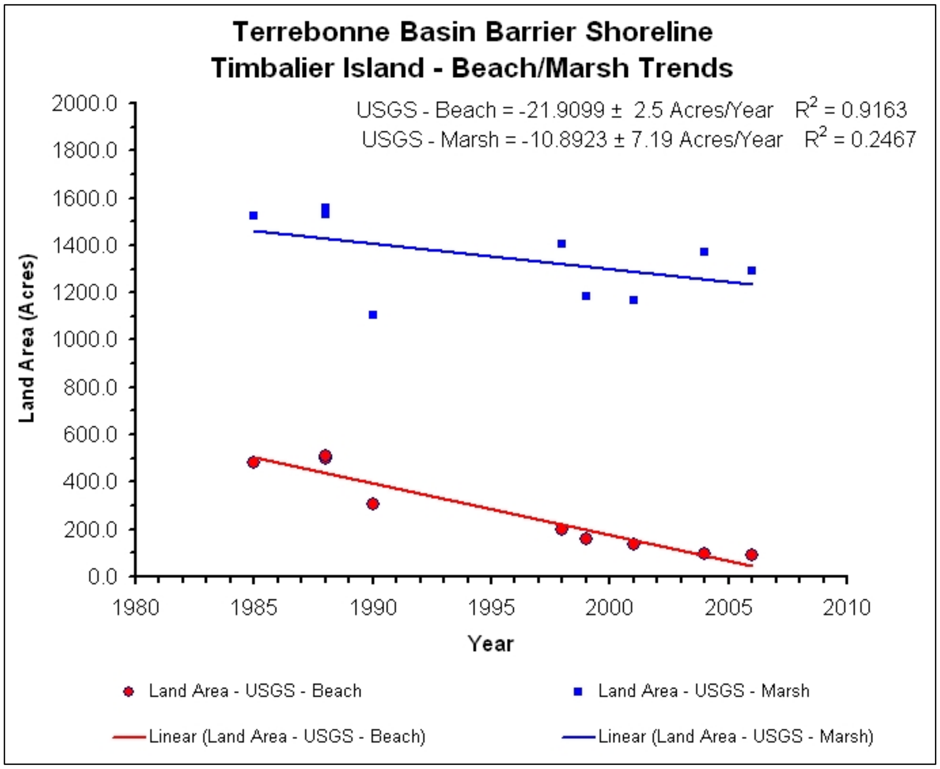


Figure L3-5. Timbalier Island USGS Land Loss Trend Analysis from 1985 to 2006.

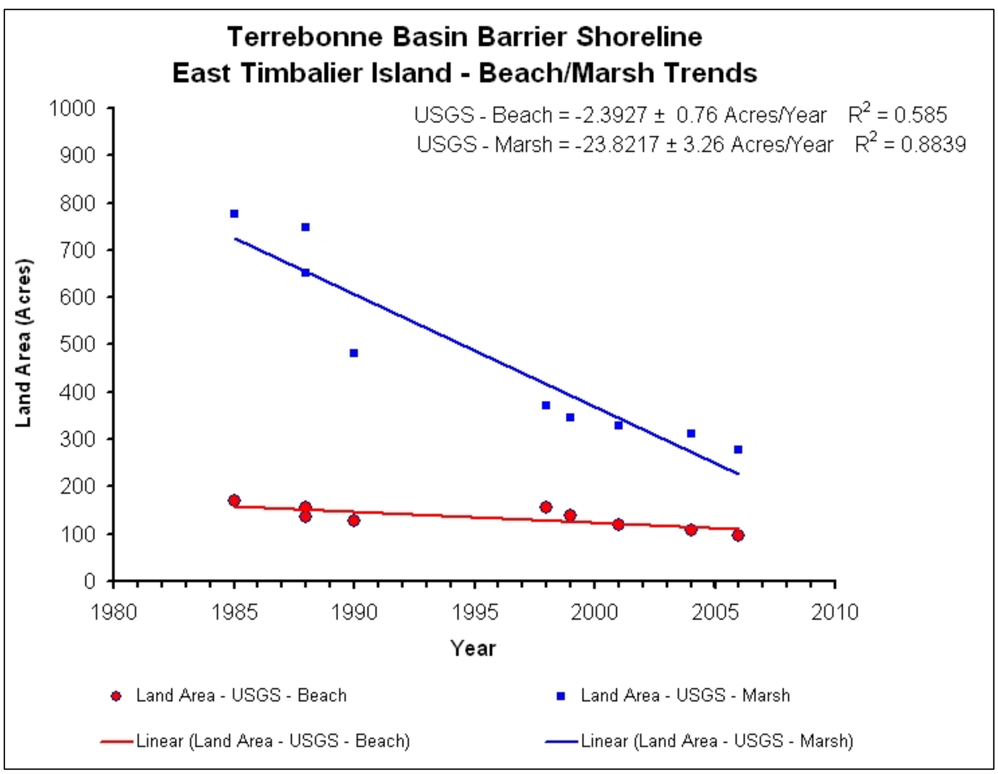


Figure L3-6. East Timbalier Island USGS Land Loss Trend Analysis from 1985 to 2006.

While the long-term shoreline change rates developed from Williams et al, (1992) were similar to the USGS beach land loss trends, the USGS beach land gain trend for Whiskey Island could not be verified.

Table L3-3 presents a summary of the design criteria selected for the analysis of island habitat evolution over time including the lond-term shoreline change rates based on Williams et al. (1992) and the USGS short-term marsh land loss trends.

Table L3-3. Historical Shoreline and Marsh Land Loss Change Rates

Island	Shoreline Change Rate (ft/yr)	Marsh Land Loss Change Rate (ac/yr)
Raccoon	-28.6	-8.4
Whiskey	-42.7	-14.4
Trinity/East	-39.7	-3.1
Timbalier	-32.5	-10.9
East Timbalier	-21.4	-23.8

The island dimensions and habitat composition of each island were determined by applying vertical adjustments (subsidence and sea level rise) and horizontal adjustments (background erosion and overwash) or in the case of Wine Island, background land loss, to the existing island footprints. Utilizing the above design criteria and intermediate SLR trend (NRC Curve I) in the analysis, the approximate years of disappearance (YOD) for each habitat type for each island were determined (Table L3-4).

Table L3-4. Year of Disappearance Based on Shoreline & Marsh Change Rates and Intermediate SLR Trend

Island	Dune YOD	Beach YOD	Marsh YOD
Raccoon	before 2012	2042	2052
Whiskey	before 2012	2029	2043
Trinity	2032	2045	2052
East	2032	2041	2052
Wine	2013	2041	2047
Timbalier	2032	2058	after 2062
East Timbalier	2022	2055	after 2062

It should be noted that all these projections are based on long-term shoreline change and short-term marsh land loss change rates which accounted for the presence of all three habitat components, dune, beach, and marsh, and thus are conservative. Disappearance of the dune component will most likely result in accelerated loss of beach and marsh and subsequent disappearance of the beach will accelerate the loss of marsh. Therefore, the future land loss rates are likely to increase which will result in earlier-than-projected YOD of the islands.

L3.4 SEDIMENT BUDGET

According to Georgiou et al. (2005), in coastal Louisiana, direct measurements of longshore transport are limited. The rates of transport are typically based on historical studies of erosional and depositional trends as demarcated by shoreline change analyses, sedimentation patterns in the vicinity of coastal structures, and numerical wave refraction modeling. The general trends of sand movement along the Louisiana coast are presented in Figure L3-7 and Table L3-5.

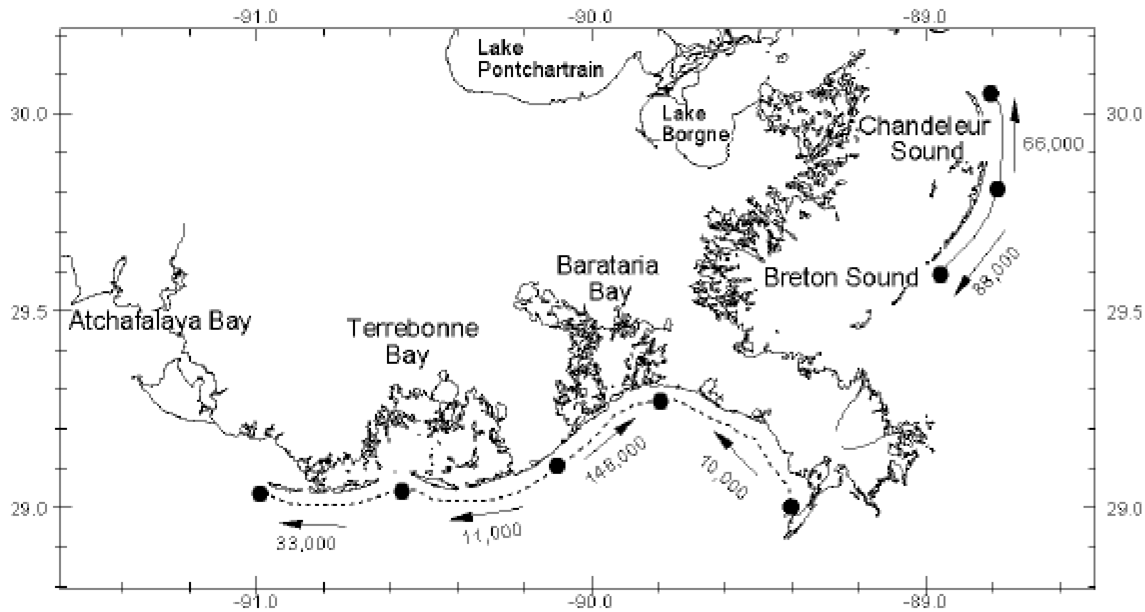


Figure L3-7. Longshore Sediment Transport Estimates in Coastal Louisiana. Rates are in Cubic Meters per Year; Arrows Indicate Net Dominant Transport Direction (from Georgiou et al., 2005).

Table L3-5. Longshore Sediment Transport Estimates in Coastal Louisiana (after Georgiou et al., 2005)

Location	From	To	Rate (m^3/yr)	Rate (cy/yr)	Dominant Direction
Holly Beach area	Calcasieu Pass	Sabine Pass	30,000	39,000	Westward
Isle Dernieres reach	East Island	Raccoon Island	33,000	43,000	Westward
Timbalier reach	Raccoon Pass	Cat Island Pass	11,000	14,000	Westward
Caminada Headland	Belle Pass	Grand Pass	146,000	191,000	Eastward
Sandy Point	South Pass	Grand Pass	10,000	13,000	Westward
Chandeleur Islands	Southwest flank	Island center	88,000	115,000	Westward
Chandeleur Islands	Island center	Northeast flank	66,000	86,000	Eastward

L3.4.1 Isles Dernieres

Sediment transport along the Isles Dernieres is complex, given their fragmented nature (Georgiou et al., 2005). Overall, sediment moves in a westerly direction along the Isles Dernieres reach, although local bidirectional transport occurs on Trinity and Whiskey Islands. Sediment movement around Whiskey Pass is largely nonexistent. Waves propagating through the passes break along the marsh shoreline in Lake Pelto (Stone and Zhang, 2001). The dominance of wave-generated and flood-tidal currents facilitates landward sand transport at many of the inlets, thereby minimizing inlet sediment bypassing and sand nourishment of the downdrift barrier shorelines. Although net transport rates are variable, net westward transport of approximately 78,000 cy/yr has been derived numerically (Stone and Zhang, 2001).

L3.4.2 Timbalier Islands

According to Georgiou et al. (2005), net sediment movement along the Timbalier Islands is to the west, and the rate increases from east to west. Subscale transport trends are evident on both islands. East Timbalier Island is dominated by westward transport, with a net increase in rate to the west attaining a maximum of approximately 65,000 cy/yr. However, the sand transport system along the island has been greatly diminished because of the extent of coastal structures in the area. The potential for transferring sand from the Caminada Moreau Headland to East Timbalier Island is minimal, given the large width of Raccoon Pass and the net landward movement of sand to its flood-tidal delta (Georgiou et al., 2005).

Kulp et al. (2002) have documented extensive growth of the Raccoon Pass flood-tidal delta during the past 10 years. This suggests that little sand bypasses the inlet but rather is moved onshore into Timbalier Bay. Similarly, transport trends occur along Timbalier Island with a net increase in the rate along the eastern flank of the barrier island to approximately 65,000 cy/yr (Georgiou et al., 2005). Conversely, the rate decreases to the western end of the island. This pattern suggests that sand eroded from the eastern flank is transported to the west where it is deposited along the west flank of the barrier as well as in Cat Island Pass (Georgiou et al., 2005). Bypassing of sand across Little Pass Timbalier is minimal. Waves propagate through this inlet prior to breaking in Timbalier Bay. In addition, dense armoring along East Timbalier Island decreases the longshore export of sediment to the west (Georgiou et al., 2005).

L3.5 Aerial Photography

Aerial imagery acquired in 2008 is the latest set of aerial photographs that encompassed all of the Terrebonne Basin barrier islands. The set was developed primarily to support multi-use applications including wetlands restoration efforts conducted by CWPPRA. The restoration design templates were superimposed on the 2008 aerial photography to create the conceptual plans (Annex L).

L4. ENVIRONMENTAL

L4.1 ENVIRONMENTAL SETTING

L4.1.1 Hydrology

The Mississippi River and its distributaries historically provided immense volumes of land-building sediment and nutrients throughout Louisiana's coastal areas. Levee construction activity along the Mississippi River in coastal Louisiana began as early as the 1700s. By the early 1900s the levee system along the River was nearly complete, protecting the surrounding areas by reducing the number of overbank flooding events. The flood protection afforded by the levee system allowed for increased economic development and human habitation in the coastal areas. With this development came the construction of roads, railways, ports and harbors, oil and gas access canals within the wetlands, and drainage projects. Consequences of these activities were disruption of the natural hydrologic and deltaic cycles, which in turn deprived surrounding wetlands of sediment- and nutrient-rich floodwaters, leading to increases in subsidence and land loss (USACE, 2004a).

The Terrebonne Basin drainage area encompasses approximately 1,455 square miles. Major navigation channels within the basin are the Atchafalaya River, Wax Lake Outlet, Houma Navigation Canal (HNC), Gulf Intracoastal Waterway (GIWW), and Lower Atchafalaya. These navigation channels introduce and/or compound marine influences in many of the interior coastal wetlands and water bodies within the Terrebonne Basin (USACE, 2004a).

The Terrebonne Basin wetland communities experience different hydrological influences. The eastern portions of the basin are hydrologically isolated from the influence of the major sediment rich waters of the Atchafalaya and Mississippi Rivers. The same is true for the northwestern portions, both above and below the GIWW, where the hydrologic influence comes from a widely-variable pattern of Atchafalaya River backwater effect, rainfall runoff events, and marine processes. Conversely, the southwestern portion of the basin receives nourishment from the Atchafalaya River and has some of the lowest land loss rates in the state (USACE, 2004a).

The Terrebonne Basin is separated from the GOM by the Isle Dernieres and the Timbalier barrier islands. These barrier islands protect the interior wetlands by buffering wave action and storm surge. The islands are constantly changing due to normal coastal hydrologic processes, including water-level changes induced by tides and sea level change, currents, and wave action, as well as subsidence. With the passage of tropical storms and hurricanes, these processes are magnified. The net effect of the interaction of the physical process is the control of the amount and location of these forces that move sediment and modify the island's morphology and habitats (USEPA, 1997).

L4.1.2 Habitat Types

The basic coastal wetland habitats within the Terrebonne Basin are typically described as swamp, fresh marsh, intermediate marsh, brackish marsh, and saline marsh (Day et al., 1989; Mitsch and Gosselink, 2000), while those typically found in the Study Area are brackish marsh and saline marsh. As their designations imply, these habitats are strongly influenced and characterized by the salinity regime of the surface water.

L4.1.3 Land Cover

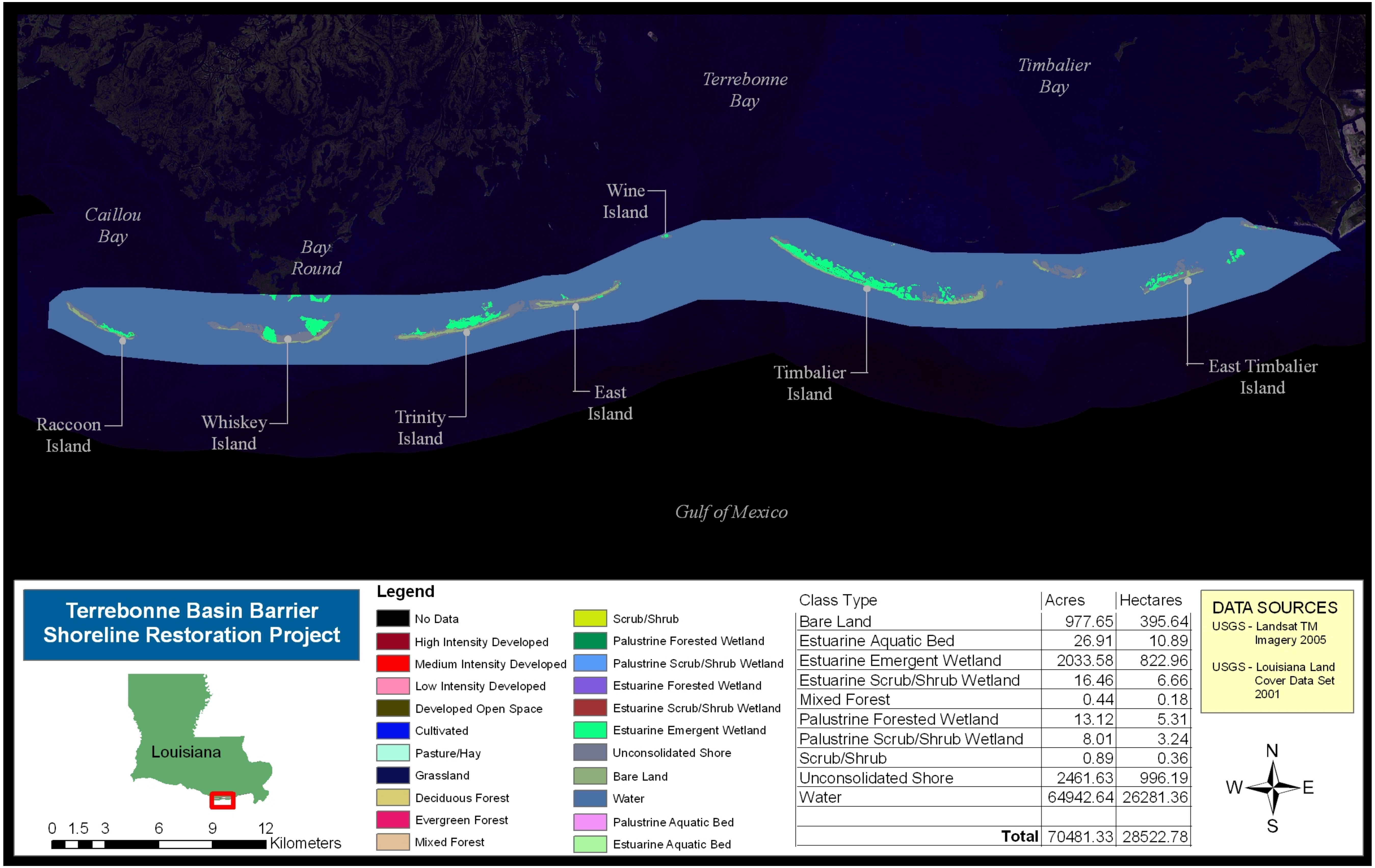
There are approximately 70,480 acres within the LCA TBBSR Study Area. The USGS vegetation classification descriptions within the Study Area are provided below and acreages of the vegetation classifications are presented in Figure L4-1.

- Bare Land (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
- Estuarine Aquatic Bed - Includes tidal wetlands and deepwater habitats in which salinity due to ocean-derived salts is equal to or greater than 0.5% and which are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, kelp beds, and rooted vascular plant assemblages.
- Estuarine Emergent Wetland - Includes all tidal wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens) and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5% and that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands.
- Estuarine Scrub/Shrub Wetland - Includes all tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5%. Total vegetation coverage is greater than 20%.
- Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
- Palustrine Forested Wetland -Includes all tidal and non-tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5%. Total vegetation coverage is greater than 20%.
- Palustrine Scrub/Shrub Wetland - Includes all tidal and non-tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5%. Total vegetation coverage is greater than 20%. The species present could be true shrubs, young trees and shrubs or trees that are small or stunted due to environmental conditions.
- Scrub/Shrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true

shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

- Unconsolidated Shore - Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.
- Water - All areas of open water, generally with less than 25% cover of vegetation or soil.

Based on the USGS 2001 land cover data set of Louisiana, the majority of the Terrebonne Basin barrier islands land, approximately 2,461 acres, is classified as unconsolidated shore. The other two dominant land types are estuarine emergent wetland, approximately 2,033 acres, and bare land, approximately 977 acres. The remaining land types composing the Terrebonne Basin barrier islands, excluding open water, account for approximately 68 acres.



Class Type	Acres	Hectares
Bare Land	977.65	395.64
Estuarine Aquatic Bed	26.91	10.89
Estuarine Emergent Wetland	2033.58	822.96
Estuarine Scrub/Shrub Wetland	16.46	6.66
Mixed Forest	0.44	0.18
Palustrine Forested Wetland	13.12	5.31
Palustrine Scrub/Shrub Wetland	8.01	3.24
Scrub/Shrub	0.89	0.36
Unconsolidated Shore	2461.63	996.19
Water	64942.64	26281.36
Total	70481.33	28522.78

Figure L4-1. Land Cover Classifications.

L4.1.4 Wildlife Resources

Coastal Louisiana's wetlands support neotropical migratory, and other avian species, such as rails, gallinules, and numerous wading birds and songbirds. In addition, they support alligators and smaller reptiles, plus mammals, ranging from small furbearers, to rabbits, coyote, and deer.

Coastal Louisiana has the Nation’s largest concentrations of colonial nesting wading birds and seabirds. One hundred ninety-seven colonies of wading birds and seabirds (representing 215,249 pairs of nesting birds) were observed in coastal Louisiana during a 2001 survey (USACE, 2004b). Louisiana coastal wetlands provide essential stopover habitat for migratory birds on their annual migration route. Without stopover sites to provide adequate food supply for the quick replenishment of fat reserves, shelter from predators, and water for rehydration, migratory birds may be negatively affected. It is estimated that approximately 382 species of finfish, shellfish, reptiles, amphibians, and mammals, as well as 353 species of birds (of which 185 are annual returning migrants) spend all or part of their life cycles in the Barataria-Terrebonne estuary (USACE, 2004a).

Historically, the extreme land and shoreline erosion in coastal Louisiana has had negative impacts on key physical, chemical, and biological processes, resulting in the conversion of or reduction in nursery habitat, waterfowl wintering habitat, neotropical migrant nesting and feeding areas, vegetative habitat and communities, soil formation and organic matter accretion, and water quality (USACE, 2004a). For several decades, these changes have resulted in continued shifts in habitat complexity and species diversity within the Terrebonne Basin, and therefore a continuation in overall wildlife population decline is expected (USACE, 2004b).

L4.2 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

A Phase I Environmental Site Assessment (ESA) of the Study Area was conducted and recorded in *HTRW Phase I Environmental Site Assessment, Terrebonne Basin Barrier Shoreline Restoration Project, Contract No. 2503-07-15* for Louisiana Office of Coastal Protection and Restoration (SJB, Unpublished).

The purpose of this Phase I ESA is to identify historical or overt physical evidence of current or past activities or materials at the Site and its immediate vicinity which constitute "recognized environmental conditions"(REC) defined by the ASTM Standard to be "the presence or likely presence of any hazardous, toxic, and radioactive substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release… into structures on the property or into the ground, groundwater, or surface water of the property."

This Phase I ESA is consistent with the scope of work provided by the USACE and protocols established in the American Society for Testing and Materials publication "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process for Forestland or Rural Property" (Designation E 2247-08, referred to as the ASTM Standard) to provide "due diligence" for rural transactions. However, it will require a second Study Area visit and interviews related to ASTM Standard to be conducted at a later date that is closer to expected time of construction for the year 2012 (SJB, Unpublished).

On November 20, 2008, SJB's environmental specialists performed an aerial reconnaissance of the Study Area and a field visit on July 27-30, 2009 at selected locations throughout seven major barrier islands that included East Timbalier Island, Timbalier Island, Wine Island, East Island, Trinity Island, Whiskey Island, and Raccoon Island. Photographs were taken documenting field observations.

SJB obtained historical documentation of the Study Area's past uses and activities in order to identify possible recognized environmental conditions. Sources of historical documentation included historical aerial photographs, topographic maps, and Environmental Database Report.

SJB performed a Phase I ESA in conformance with the scope and limitations of ASTM Standard E 1527-05 on the Isle Dernieres and the Timbalier Islands located within Terrebonne Basin in Terrebonne Parish, Louisiana. Any exceptions to or deletions from this practice were described. The Emergency Response Notification System (ERNS) entries were thought to represent historical REC. After reviewing the monitoring reports, SJB found indications of release of petroleum products for all 6 incidents. These releases were addressed in compliance with Environmental Protection Agency (EPA) regulations. Therefore, the ERNS entries were considered historical REC. Since SJB was unable to inspect the production facilities at this time; current REC(s) were unable to be identified within the Study Area. However, without proper investigation of these facilities, current REC(s) may be present within the project area near or within these production facilities (SJB, Unpublished).

Based on historical sources that were provided dating back to the late 1800's, environmental database reviews, and a limited inspection, SJB could not adequately identify any current and historical recognized environmental conditions as defined in ASTM standard E 2247-08 at that time.

L4.3 Geologic Setting

L4.3.1 Geomorphic and Physiographic Setting

The morphology and integrity of the Terrebonne Basin barrier island reach is directly related to the deltaic processes operating on the coast of Louisiana. The Deltaic Plain consists of a generally fine-grained sedimentary package deposited within a wide variety of fluvial, deltaic, and coastal depositional environments (USACE, 2004c).

L4.3.1.1 Deltaic Cycle

The geologic development of coastal Louisiana and the resulting coastal landscape were dependent upon shifting Mississippi River courses and are influenced by the orderly progression of events related to the "deltaic cycle." The deltaic cycle is a dynamic and episodic process alternating between periods of "delta-building" with seaward advancement (progradation) of deltas, and their subsequent landward retreat (degradation). The Mississippi River has changed its course several times during the last 7,000 years. Each time the Mississippi River has built a major delta it has eventually abandoned that river course in favor of a shorter, more direct route to the GOM. As deltas are abandoned, the seaward edges are reworked into barrier headlands and barrier islands. Subsequently, the wetland complex behind the headlands and islands, without a significant and continuous source of sediment and nutrients, eventually succumbs to subsidence and becomes submerged by marine waters.

The Deltaic Plain is composed of 6 major delta complexes: 2 prograding and 4 degrading (Figure L4-2). The Atchafalaya and “Modern Delta” (Plaquemine/Balize) complexes are active and prograding, while the Maringouin, Teche, St. Bernard, and Lafourche complexes are inactive. Present day Terrebonne Basin is the result of the Lafourche delta formation, through seaward advancement from deposition of Mississippi River distributary sediment, the subsequent delta degradation and detachment, and the reworking of seaward headlands to form barrier islands (USACE, 2004a).

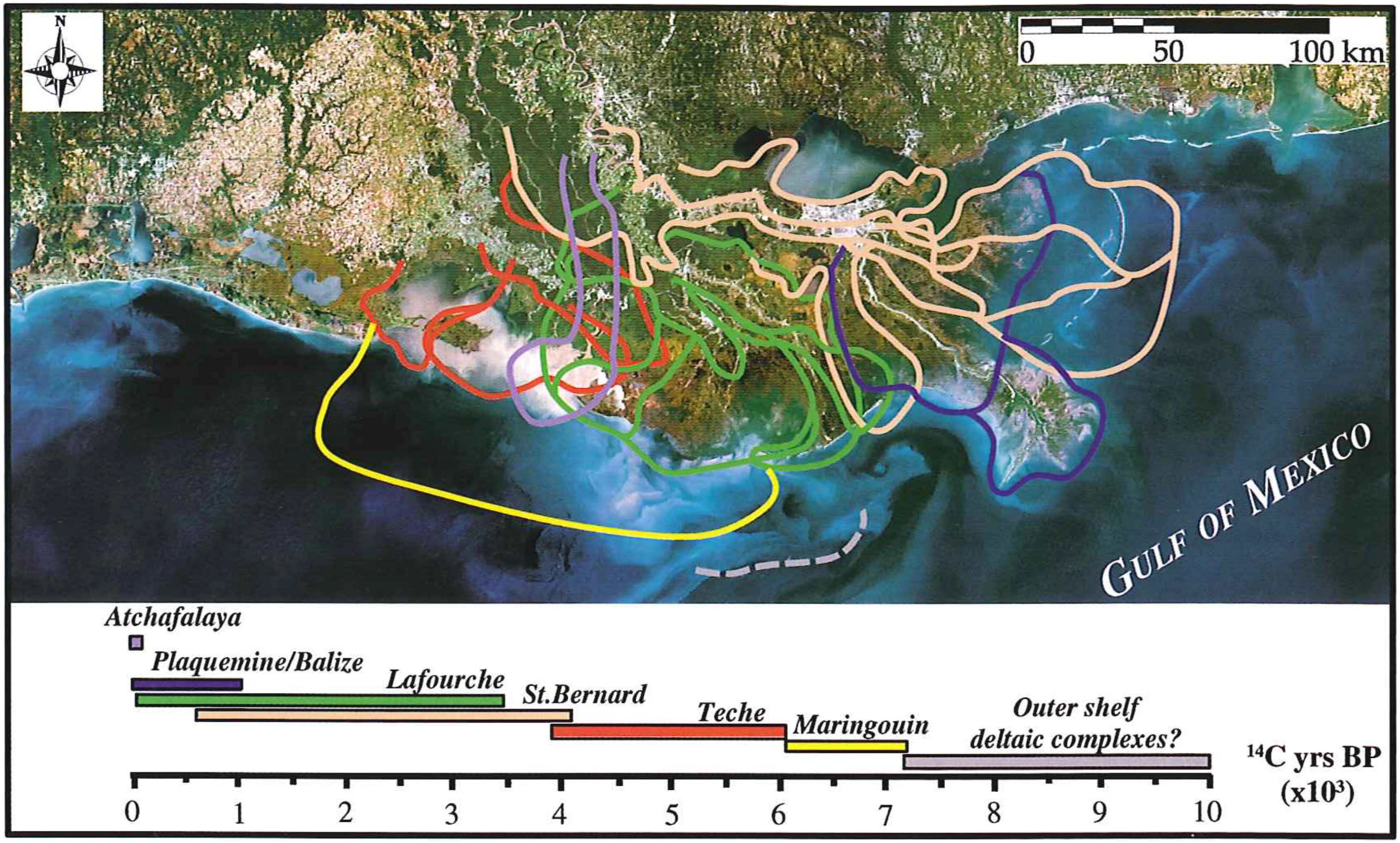


Figure L4-2. Mississippi River Deltaic Plain.

L4.3.1.2 Delta Advancement

The Mississippi River Deltaic Plain wetland ecosystem developed as a result of delta-building processes, during which sea level conditions were relatively stable. The deltaic cycle is initiated when the Mississippi River, enters an open water body, such as a coastal lake or bay, which slows the velocity of the river's flow, thus limiting the river's ability to transport sediment. Consequently, most of the larger-grained sediment carried by the river drops out of the water column and falls to the bottom. Over time, the river deposits enough sediment to create land, which then becomes colonized by wetland plants. The organic deposition from additional river-borne sediment and decomposing wetland vegetation are the primary factors behind the land-building process. In this fashion, large expanses of wetlands, or deltas, form and extend seaward between the distributaries, or "fingers" of the delta, as long as the river continues to supply freshwater, nutrients, and land-building sediment (USACE, 2004a).

L4.3.1.3 Delta Abandonment

As a delta grows and extends into the GOM, the river stage gradually heightens. Eventually, the river breaks through a weak point in its bank and/or shifts its main water flow into a distributary, thus providing a shorter route for the river to travel to the Gulf. About every 1,000 years, the Mississippi River altered its path to the GOM, sometimes flowing down the western portion of the current Deltaic Plain and sometimes down the eastern portion. Whenever the river changed course, the location of active delta building also changed. Areas that no longer received sufficient volumes of freshwater laden with sediment and nutrients began to succumb to subsidence, while those areas that received the majority of river water input began a new phase of delta building. These meandering changes in the course of the Mississippi River and accompanying shifts in centers of sediment deposition are responsible for the distribution of deltaic sediment along the entire Louisiana coast and into Texas.

Once the Mississippi River altered its course and began to form a new delta, tidal influences and a lack of sediment and nutrient inputs slowly degraded the previously active delta location. Over time, the interior wetlands were submerged and marine influences reworked the gulfward edge of the delta into a series of barrier headlands. As the shoreline facing the GOM matured, and as the marshes behind the shoreline broke up and eventually disappeared, the barrier headlands transitioned into barrier islands.

Figure L4-3 presents the three-stage geomorphic model that summarizes the genesis and evolution of transgressive depositional systems in the Mississippi River Deltaic Plain (USACE, 2004a).

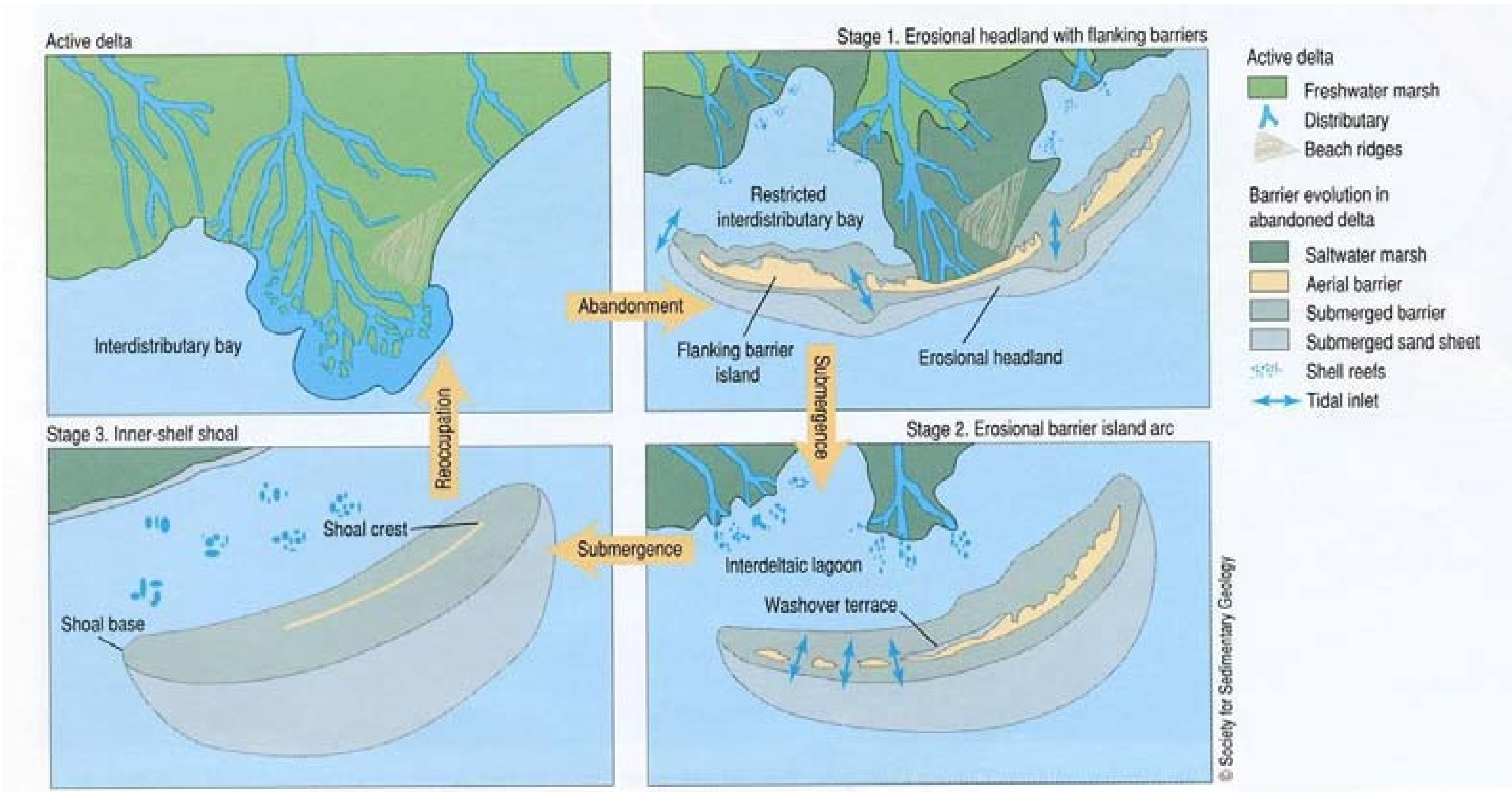


Figure L4-3. Three-Stage Geomorphic Model

The present Louisiana barrier islands are the product of the coupling of the deltaic cycle with the complex interactions between storm events, longshore sediment supply, anthropogenic events, coastal structures, and inlet dynamics that have all contributed to island formation, migration, and erosion.

L4.3.2 Soils

The deltaic and Chenier Plains of coastal Louisiana consist of soils that can be divided into 6 primary associations. These soils are primarily mineral deltaic, or mineral coastal deposits formed from alluvial or aeolian processes. The soils that exist nearest to the coast may also be formed or deposited by marine processes and sediments. The 6 coastal associations often contain soils with organic matter in the upper horizon, or throughout the whole profile (USACE, 2004b).

Examples of these soil types are found along the Isles Dernieres and Timbalier Islands barrier shorelines. The seaward edges of these islands are linear or curvilinear forms consisting of loamy fine sand (fluid mineral soils) formed by means of marine reworking. The back-barrier saltwater marshes consist of level, very poorly drained soils that have a mucky surface layer (high levels of organic matter), and a mucky or clayey underlying material (USDA, 2007).

Specific geotechnical investigations including test borings were conducted on the islands as part of the CWPPRA project designs. For Whiskey Island, auger borings taken on the beach and dune revealed fine sand with shell fragments while the back-bay and marsh borings indicated soft clays and silty clays with lenses of sand, silt and shell comprised the upper 65 ft, and were underlain by medium stiff pro-delta clays with silt and sand lenses (LDNR, 2007). On Raccoon Island, the results of the test borings indicated that generally the soils are loose sands underlain by weak compressible clays to depths of over 100 ft. The upper 12 to 15 feet was classified as fine sand and silt, underlain by soft clays and silty clays to 50 ft (NRCS, 2007). These soil types are characteristic of the Terrebonne Basin barrier islands.

L5. GEOTECHNICAL INVESTIGATIONS

L5.1 BORROW AREA INTRODUCTION

L5.1.1 Introduction and Sediment Search Effort

The search for sediment resources to repair and restore the Louisiana barrier islands has been underway for decades. For both the Isles Dernieres and the Timbalier Island reaches, this expansive search effectively commenced in the early 1980's, undertaken by the Louisiana Geological Survey. The findings were summarized in a 1991 report, whose authors analyzed the geophysical data and geotechnical samples, reporting on 55 nearshore sand body "targets" (Suter et al., 1991). Twenty-three of these were in the vicinity (inshore, between, and offshore) of the Terrebonne Basin Barrier Islands. Their initial estimates of available sediment volumes indicated the presence of adequate quantities of sediment for both beach/dune and marsh creation. Subsequent continuing and expanded research has been summarized for a volume dedicated to restoration of Louisiana's barrier islands and wetlands (Kulp et al., 2005). While the estimates of available sand and marsh fill sediment appear impressive, they often do not consider the web of petroleum production and processing infrastructure, primarily pipelines, which extends from the interior bays between and beneath the barrier islands to well out onto the continental shelf. In addition, required magnetometer and sonar surveys may uncover shipwrecks and other archeological features that must be avoided. When those "cultural resources" and their surrounding buffer zones are accurately mapped, and consideration is given to the issue of excavation side slope stability versus depth of excavation, the volumes of sediment that are actually available may be significantly reduced (Nairn et al., 2004, 2005). In addition, the shapes of the proposed borrow areas may make dredging more technically difficult.

The consensus of numerous studies regarding the potential restoration of the Isles Dernieres and Timbalier Islands holds that available sand resources are limited and those that have been identified for restoration projects are typically constrained by the presence of petroleum extraction and distribution infrastructure.

L5.1.2 Available Project Documentation

Khalil et al. (2010) mapped numerous potential sediment borrow areas along the Louisiana Gulf coast, from South Pass west to Sabine Pass. Six large-volume areas were delineated off the Terrebonne Basin Barrier Islands. Three of these are on the Outer Continental Shelf (OCS) and three are in State waters, closer to shore. The latter included a group of five small borrow areas associated with a Timbalier Island project, three north of the island, in the bay, and two to the south.

Designation and use of both inshore and offshore borrow areas has been associated with individual restoration projects for many years. Eleven CWPPRA projects have been completed in the Study Area since 1996 and eight of them involved dredging fill material from nearby borrow areas. These projects were described the December 2008 LCA TBBSR Study Feasibility Report (SJB and CEC, 2008). The criteria for evaluating potential borrow sites/sources have evolved over time. Several early projects utilized borrow sites that were in close proximity to the restoration sites, either in the bay to the north or an adjacent pass. While such areas may be convenient, and relatively inexpensive to exploit, they pose several potential problems: if too close to an island they can function as sinks and facilitate sediment loss from adjacent shorelines and shoals, and their depth and breadth can lead to unexpected changes in wave dynamics, also leading to shoreline erosion. As a result of these problems, the State of Louisiana has discouraged use of bay and pass borrow areas.

Seven CWPPRA projects have already utilized borrow sites in the vicinity of the Terrebonne Basin Barrier Islands. The projects constructed beach, dune, and/or marsh habitats on Whiskey, Trinity, East, Timbalier, and East Timbalier Islands, and one of them also closed the breach between Trinity and East Islands. One borrow area was located offshore from Whiskey Island, and the rest were located either in passes or in Lake Pelto, north of the islands. To ascertain the fates of these borrow areas, the available documentation was reviewed including project information sheets, status reports, completion reports, monitoring plans, monitoring reports, and environmental assessments. In addition, where information has been lacking, there has been personal communication with the PDT Team.

Three CWPPRA projects have proposed using borrow sites that are logical sources of sediment for the LCA TBBSR Study. The projects are: Ship Shoal Whiskey Island West Flank Restoration (TE-47), Raccoon Island Shoreline Protection/Marsh Creation, Phase 2 (TE-48), and Whiskey Island Back Barrier Marsh Creation (TE-50). TE-50 was recently completed.

During PDT meetings and conference calls from mid- to late-2009, two additional potential sand sources were proposed and discussed. The first was reported as an accumulation of sand in Cat Island Pass, located off the west end of Timbalier Island. It was assumed that it was comprised of sediment that had been transported from Timbalier by normal coastal processes. The second proposed source was the HNC Channel, where it crosses beneath the open water of Terrebonne Bay and extends offshore south of Cat Island Pass.

L5.1.3 Offshore Borrow Areas

As previously stated, the starting point for the PDT's borrow area search effort was the information compiled by Khalil et al. (2010). Their tabular compilation included the location of the borrow area, estimated volume of available fill material, volume of material already dredged from the borrow area, and pertinent geotechnical and geophysical references. Figure L5-1 presents the Terrebonne Basin portion of the Khalil and Cantu map.

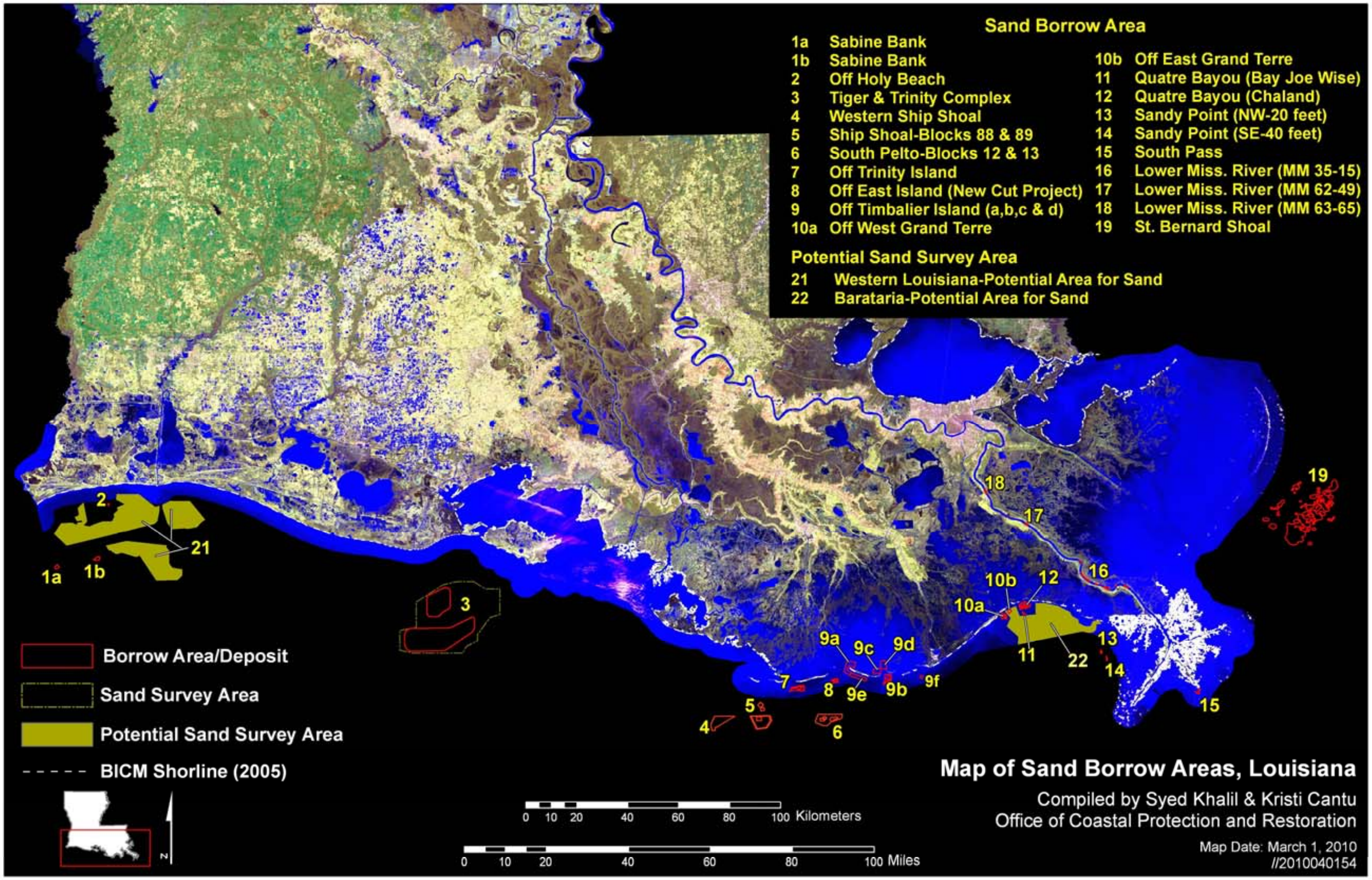


Figure L5-1. Coastal Louisiana Borrow Areas, Courtesy Khalil *et al.*, 2010.

L5.1.3.1 Ship Shoal

Ship Shoal is an east-west elongate sand body approximately 42 miles long and four miles wide located approximately five miles south of the Isles Dernieres. Its east-west extent runs from about 15 miles west of Raccoon Island eastward to the area of Cat Island Pass. It has been characterized as one of a number of submerged relict deltaic headlands, deposited during earlier stages in the evolution of the Mississippi Delta (Kulp et al., 2005). As the need for material to stabilize and restore the shorelines and marshes of Coastal Louisiana has increased in intensity, Ship Shoal has been studied extensively in recent years because of its size and large volume of sandy sediment. Analyses have indicated that greater than 90% the sediment in Ship Shoal is quartz sand (Kulp et al., 2001). Most relevant to the LCA TBBSR Study are studies of the potential borrow sites referred to as Ship Shoal Blocks 88 and 89, located south of Raccoon Island, and South Pelto Blocks 12 and 13, located on the eastern end of Ship Shoal, south of Trinity-East Island. Extensive geophysical and archaeological studies of the area of these blocks were undertaken in 2003. Analyses, including geotechnical data previously acquired by the Louisiana Geological Survey and the USGS, were presented in two 2003 reports from the U.S. Environmental Protection Agency (EPA): the first covering portions of Ship Shoal Blocks 87, 88, 89, 94, and 95 and the second South Pelto Blocks 12, 13, 14, 18 and 19, that included High Resolution Geophysical and Archaeological Surveys (C&C, 2003a and 2003b).

L5.1.3.2 Raccoon Island Borrow Area

The eastern end of Raccoon Island has been stabilized by a field of eight shore-parallel breakwaters since 1997, when they were initially installed as a demonstration project (TE-29 project). The field was extended by an additional eight breakwaters in 2005 (TE-48 project, Raccoon Island Shoreline Protection/Marsh Creation). The presence of two buried distributary channels off Raccoon Island was noted by Suter et al. (1991). During the course of geological investigations for the TE-48 project, a portion of one buried river channel was located approximately four to six miles south of Raccoon Island. The channel is sublinear, oriented along a northwest/southwest alignment, with a width ranging from 500 to 750 ft, and at least 20,000 ft in length. Analysis of vibracore samples from the sediment within the delineated channel found it to be mixed sediment with an average grain size of 0.10 mm, with the coarse fraction averaging 16.5% of the material, and an average of 83.5% finer material, potentially suitable for marsh fill. The borrow area designed for the TE-48 project was 8,850 ft long, from 440 to 890 ft wide, with a maximum cut depth of 20 ft and an estimated volume of 830,000 cubic yards (cy). The estimated volume of the entire borrow area is 3.42 mcy (SJB et al., 2006).

L5.1.3.3 Whiskey Island Back-Barrier Marsh Borrow Areas

According to LDNR (2007), Ocean Surveys, Inc. (OSI) carried out an extensive geophysical and geotechnical search in an LDNR-designated potential offshore borrow area south of Trinity and Whiskey Islands and Whiskey Pass. Their analyses of the sub-bottom profiles for strata indicative of sandy material and finer, silt-clay material led to delineation of three potential offshore borrow areas, assumed to contain suitable sediment for beach, dune, and marsh restoration. OSI then conducted a vibracore investigation of the three subareas within the Khalil and Cantu (2008) Borrow Area 7, designated as Areas 1, 2, and 3.

Excluding avoidance areas, based on pipeline corridors and other magnetic anomalies, the estimated volumes of sand available in Subareas 2a and 3a are 1.15 and 4.72 mcy, respectively. Above the identified sand strata in Areas 2 and 3 is a layer of overburden, consisting of silt and clay, suitable for marsh creation. The estimated volumes of overburden available in Subareas 2a and 3a are 3.05 and 7.97 mcy, respectively (LDNR, 2007).

OSI also estimated the volumes of overburden and sand contained in Subareas 3b and 3c. Subarea 3b contains approximately 730,000 cy of overburden and 1.13 mcy of sand. Subarea 3c contains approximately 180,000 cys of overburden and 200,000 cy of sand, however those areas were not subjected to cultural resource surveys (magnetometer and side-scan sonar studies).

L5.1.3.4 New Cut Dune and Marsh Borrow Area

Initially, a considerable effort was expended characterizing a borrow site in Wine Island Pass, one that was estimated to contained more than two million cubic yards (mcy) of suitable sediment (Armbruster, 2000). Strong local opposition to the use of that site resulted in its withdrawal from consideration. An alternate borrow area was subsequently designated three miles offshore. The available ecological review and the project status reports did not provide any detailed information on the borrow site finally utilized for this project. However, sufficient detail was obtained from the bid documents to address it. Finkl et al. (2005) estimated that the borrow area contained 4.2 mcy of material.

L5.1.3.5 Timbalier Island Borrow Areas

As previously discussed, Khalil and Cantu (2008) showed five borrow areas, numbered 9a through 9e, in the vicinity of Timbalier Island.

L5.2 Borrow Area Characteristics and Screening Criteria

The criteria that the PDT used to screen potential borrow areas were a combination of physical, geographic, and socioeconomic characteristics.

L5.2.1 Location Relative to Depth of Closure

The depth of closure represents the offshore extent of the active beach face, thus sediment inshore of it must be considered as part of the sand budget for that particular reach, and conservation of that resource is essential in a sand-starved system, such as the Louisiana coast. Excavations inshore of the depth of closure become sinks that accumulate sediment that is normally part of the longshore/onshore and offshore transport system. Of concern here is conservation of the sand resources and avoidance of interference with coastal processes from excavating these resources for island restoration.

Recognition of the sand-starved status of Coastal Louisiana resulted in development of a hydrogeomorphic planning objective of the LCA 2004 Plan, specifically to import sediment from sources outside of the estuarine basins (*i.e*., beyond the depth of closure) (LCA, 2004). Therefore the borrow areas shall be located seaward of the depth of closure which was defined in Section L2 to be equal to -10.5 ft NAVD 88.

L5.2.2 Borrow Area Geotechnical and Geophysical Data, Analyses, and Interpretation

The sediment particle size ranges and distributions should match the characteristic of the beach and dune where it will be placed. In the case of marsh material, there should be variability in particle size to match the existing marsh environment. The sediment should be compatible with the sediment at the fill placement site to avoid accelerated loss of sand and changes in beach face morphology. To maximize efficiency of the excavation process, the core data and seismic profiles should indicate adequate stratum thickness for efficient mining. If the strata are too thin, the excavation process can create a blend of material that may be compatible with the native sediment at the fill placement site, but that must be determined from the data, and not left to chance.

L5.2.3 Borrow Area Volumes

The sediment volume must equal or exceed the estimate of volume needed to complete the LCA TBBSR Study.

L5.2.4 Cultural Resources/Petroleum Infrastructure Clearance

Cultural resources can be significant constraints. Shipwrecks and pipelines must be avoided. Side-scan sonar and magnetometer survey are a requisite for clearance by the State Historic Preservation Office (SHPO) and other involved agencies. Use of borrow areas must often be approved or cleared by the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE), formally the Department of Interior, Materials Management Service (MMS) or the LDNR.

L5.2.5 Technical Difficulty

Borrow site location factors, such as water depth and distance to disposal site, can dictate use of hopper or cutterhead dredge. Depending on the alternative, different measures are required to transfer the dredged material to the disposal site(s). The issue involves double handling of dredged material. If the disposal site depth is inadequate to accommodate the draft of a hopper dredge it may require offshore dumping and re-dredging by cutterhead or offshore booster pumps to move material ashore. Inadequate depth at the borrow area to accommodate a hopper dredge may require use of a cutterhead dredge. The latter type is less seaworthy than the former, thus introducing heightened concern about weather-related production interruptions.

L5.2.6 Navigation Features

The HNC, its channel across Terrebonne Bay, and the Bayou Grand Caillou Safety Fairway are Federally-designated waterways in which interference with navigation is an issue. Constraining use of such channels with fill material, structures, or equipment, even temporarily, requires advance notice and authorization from the USACE.

L5.2.7 Mining Impacts

Offshore shoals, bypassing bars, and similar bodies interact with the waves that pass across them. Waves can be attenuated and their directions changed, so that the wave energy that impacts a nearby shoreline is changed. Depending on the wave length, height, and direction, the changes can be beneficial or detrimental, resulting in either accretion or erosion of the shoreline. The results of wave refraction modeling, based on wind and wave direction and intensity data, must be carefully analyzed to ensure that excavation of the borrow area does not result in detrimental changes to the shoreline or nearby passes.

L5.3 Initial Borrow Area Screening

The locations of the borrow areas considered in the LCA TBBSR Study are presented in Figure L5-1. The initial screening was finalized during the PDT meeting on August 11, 2009. The PDT Team had previous discussions with CPRA staff regarding potential borrow areas and their supporting information, and this was incorporated into the screening process. The initial screening criterion applied was borrow area location. Table L5-1 and Figure L5-2 present the known information and depict the nine potential borrow areas that passed the initial screening. It should be noted that the numbers assigned to each area differ from those presented in the Khalil and Cantu (2008) map (Figure L5-1) because several previously unnumbered areas were identified and added to the evaluation.

The potential borrow areas that were eliminated during this screening were:

- Timbalier Island Dune and Marsh Restoration (TE-40) borrow areas 9a through 9d, as shown on the Khalil and Cantu (2008) map. They were eliminated because all four are well inshore of the depth of closure isobath. Note that area 9e was retained.

Table L5-1. Initial Borrow Area Screening Table

Map ID	Location	Water Depth, ft	Sed. Size, mm	Type	Thickness, ft	% Material	Potential Available Volume, mcy	Appli-cability	Cultural Resources Survey Data	Cultural Resources Clearance
1	Whiskey Island TE-50 Area 1	< 16	-	Mixed, silt, clay (overburden)	N/A	N/A	N/A	Marsh	N/A	
	Whiskey Island TE-50 Area 1		-	Sand	0.8-2.4	N/A	N/A	Beach/ Dune	N/A	
2	Whiskey Island TE-50 Area 2 (subarea 2a)	16-20	-	Mixed, silt, clay (overburden)	8-9.5	6-47% sand 13.5-66.5% silt 20.7-83.4% clay	0.29*	Marsh	[1] 2006 Chirp, magnetic, and side scan sonar surveys by OSI	
	Whiskey Island TE-50 Area 2 (subarea 2a)	-	0.105 - 0.135	Sand	2.5-7.6	90% sand	0.79**	Beach/ Dune	[1] 2006 Chirp, magnetic, and side scan sonar surveys by OSI	
3	Whiskey Island TE-50 Area 3 (subarea 3a)	16-22	-	Mixed, silt, clay (overburden)	3.5-17.4	20% sand 30.0-49.7 silt 27.4-68.7% clay	7.97	Marsh	[1] 2006 Chirp, magnetic, and side scan sonar surveys by OSI	
	Whiskey Island TE-50 Area 3 (subarea 3a)	-	0.107 - 0.166	Sand	2.5-14	80% sand	4.72	Beach/ Dune	[1] 2006 Chirp, magnetic, and side scan sonar surveys by OSI	
	Whiskey Island TE-50 Area 3 (subarea 3b)	16-22	-	Mixed, silt, clay (overburden)	7.5	6-47% sand	0.73	Marsh	N/A	
	Whiskey Island TE-50 Area 3 (subarea 3b)	-	0.113 - 0.135	Sand	2.7-6.4	80% sand	1.13	Beach/ Dune	N/A	
	Whiskey Island TE-50 Area 3 (subarea 3c)	16-22	-	Mixed, silt, clay (overburden)	8	22% sand	0.18	Marsh	N/A	
	Whiskey Island TE-50 Area 3 (subarea 3c)	-	0.120	Sand	8.5	85% sand	0.20	Beach/ Dune	N/A	

Map ID	Location	Water Depth, ft	Sed. Size, mm	Type	Thickness, ft	% Material	Potential Available Volume, mcy	Appli-cability	Cultural Resources Survey Data	Cultural Resources Clearance
4	New Cut TE-37 Area	13-16	-	Sand	6	-	2.5***	Beach/ Dune	vibracore and magnetic surveys	
5	Raccoon Island TE-48	22.5-31	0.09-0.13	Mixed sand, silt, clay	10-20	16.5-24.6% above #200 sieve	2.4†	Marsh	[2] 2008 remote sensing side scan and magnetometer surveys by Goodwin	BOEMRE Lease Pending (NRCS)
6	South Pelto blocks 12&13	26-48	0.15-0.20	Sand	13-20	< 5% silt	21.3††	Beach/ Dune	[3] 2003 seismic, sonar, and magnetic surveys by C&C	BOEMRE Grand-fathering Pending (CPRA)
7	Ship Shoal block 88	17-23	0.19	Sand	10-19	< 5% silt	17.3	Beach/ Dune	[4] 2003 seismic, sonar, and magnetic surveys by C&C [5] 2004 echosounder and vibracore surveys and sediment sampling analysis by STE	BOEMRE Grand-fathering Pending (CPRAR)
	Ship Shoal blocks 88,89,94,&95	16-32	0.19	Sand	8-12	< 5% silt	47.5	Beach/ Dune	[4] 2003 seismic, sonar, and magnetic surveys by C&C	
8	Western Ship Shoal blocks 84,85,98,&99	9-15	N/A	Sand	13	N/A	124†††	Beach/ Dune	N/A	
9	Cat Island Pass	10-20	N/A	Sand	5-10	silty sand	6.6††††	Beach/ Dune	N/A	

N/A denotes data not available

* Excludes a volume of 2.76 mcy of overburden material estimated for Whiskey Island TE-50 Project.

** Excludes a volume of 360,000 cy of dune material estimated for Whiskey Island TE-50 Project.

*** Available volume based upon personal communication with CPRA, August 2009.

† Excludes a volume of 1 mcy estimated for Raccoon Island TE-48 Project.

†† Excludes a volume of 7 mcy estimated for Caminada Headland Restoration Project.

††† Harry. H. Roberts and DeWitt Braud. March 2009. Results of the Western Ship Shoal Geophysical Survey: Evaluation of Sand Available for Coastal Restoration.

†††† Estimated based on September 2003 geologic profiles obtained from USACE through personal communication.

[1] Ocean Surveys, Inc. (OSI) 2006. Hydrographic, Geophysical and Geotechnical Survey Program Whiskey Island Back Barrier Marsh Creation Project TE-50, Final report, LDNR, 2006.

[2] Goodwin & Associates, Inc. December 2008. Raccoon Island Shoreline Protection/Marsh Creation (TE-48) Submerged Cultural Resources Investigations.

[3] C&C Technologies. (C&C) 2003b. New Cut Dune/Marsh Restoration Project Using Ship Shoal Sediment Coastal Terrebonne Parish, Louisiana: High Resolution Geophysical and Archaeological Survey of the South Pelto Area Block 13 Vicinity of Ship Shoal.
[4] C&C Technologies. (C&C) 2003a. Whiskey Island West Flank Restoration Project Using Ship Shoal Sediment Coastal Terrebonne Parish, Louisiana: High Resolution Geophysical and Archaeological Survey of the Portions of Blocks 87, 88, 89, 94, and 95 Ship Shoal Area.
[5] Soil Testing Engineers, Inc. (STE) 2004. Sand Source Investigation Ship Shoal - Block 88, Louisiana Department of Natural Resources Ship Shoal – Whiskey Island West Flank (TE-47) Restoration Project Terrebonne Parish, Louisiana, LDNR, 2005a.

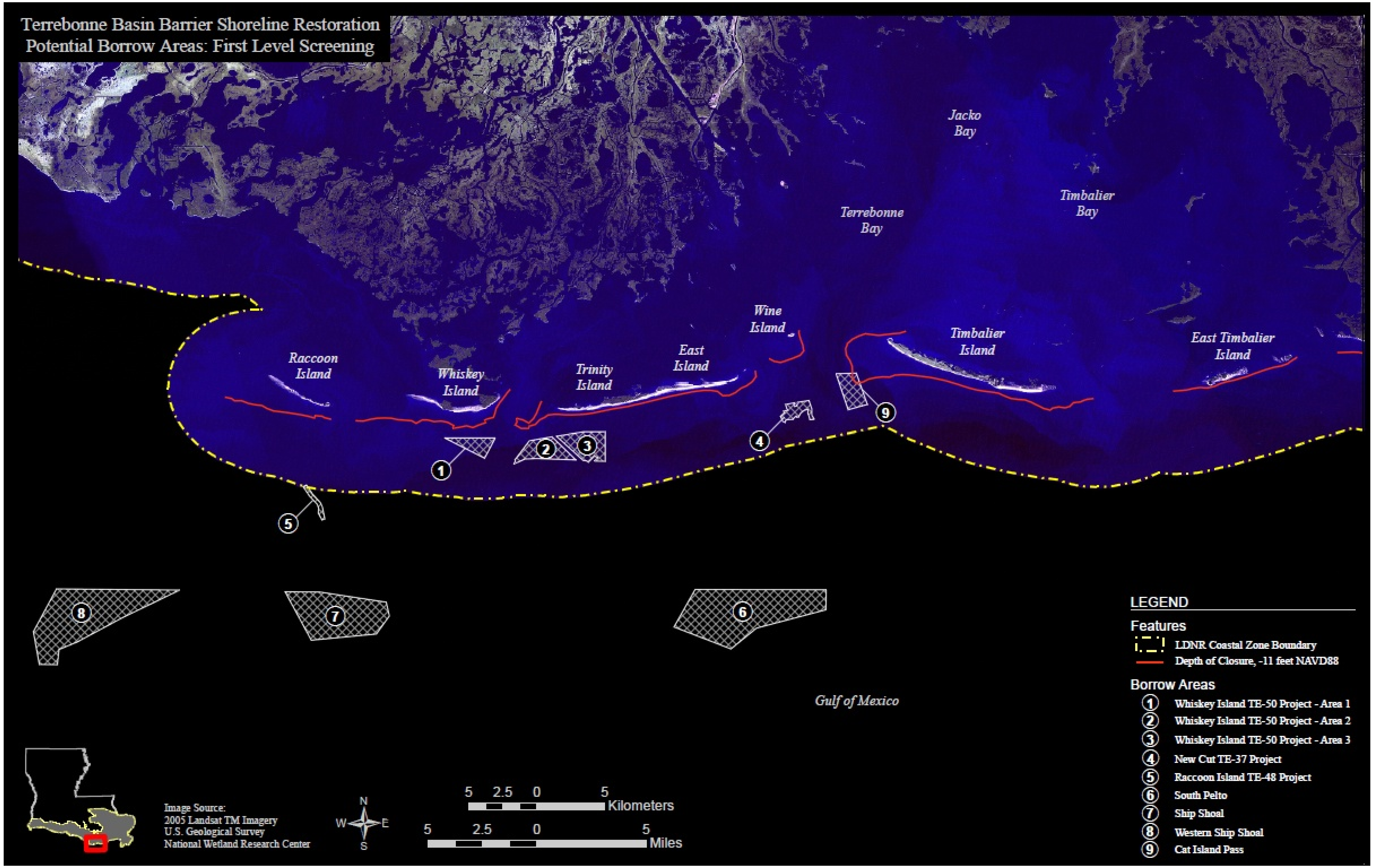


Figure L5-2. Initial Borrow Area Screening Map

L5.4 FINAL BORROW AREA SCREENING PROCESS AND RESULTS

The process of screening potential borrow areas continued by reducing them down to those that provide the requisite volume of sediment, have the geotechnical information, detailed geophysical survey data, and cultural resources clearance needed to develop conceptual excavation plans.

The potential borrow areas that were eliminated during this screening were:

- Timbalier Island Dune and Marsh Restoration (TE-40) Borrow Area 9e; as shown on the Khalil and Cantu (2008) map, Figure L5-1. It was eliminated because a portion of it was landward of the depth of closure and the entire area lacked cultural resources clearance.
- Western Ship Shoal (Blocks 84, 85, 98, & 99), Borrow Area 4 as shown on the Khalil and Cantu (2008) map, Figure L5-1. It was eliminated because it lacked detailed geophysical surveys and cultural resources clearance.
- HNC Channel. It was eliminated because of the risk and uncertainty of relying on a sediment source that is under the control of interests with a requirement to maintain navigability without undue delay, particularly following storm events that could cause shoaling. The LCA TBBSR Study cannot use the HNC if there is an emergency. Further, geotechnical and cultural resources data are only available for the portions of the channel that are periodically maintenance dredged, not necessarily the channel offshore from Cat Island Pass, the logical portion to serve as a borrow area because it is seaward of the depth of closure. There are also restrictions on width of dredge cut, one cannot dredge outside of the designated channel without an Environmental Assessment, and cut depth, one cannot dredge deeper than the authorized channel depth. Taken together, these constraints and restrictions were felt to introduce too much risk to retain the HNC as a viable borrow area. Because of its location, the PDT Team felt that the HNC should be retained as an alternative borrow area to be considered in PED if the cultural resources clearance is obtained and the timing of its use is compatible with the USACE's navigation interests.
- Whiskey Island Back Barrier Marsh Creation (TE-50), Borrow Area 1 as shown in Figure L5-2. It was eliminated because it lacked geotechnical and borrow area volume information, detailed geophysical surveys, and cultural resources clearance.
- Whiskey Island Back Barrier Marsh Creation (TE-50), Borrow Area 2 as shown in Figure L5-2. During the course of planning for the TE-50 project, T. Baker Smith (TBS) and Moffatt & Nichol (M&N) refined the designs of Borrow Areas 2 and 3, designating one subarea in 2 (2a) and three subareas in 3 (3a, 3b, and 3c). They recommended use of Subarea 2a. Since the TE-50 project has already utilized both the overburden and sand resource volumes in Subarea 2a, Borrow Area 2 was eliminated from further consideration (TBS and M&N, 2007).

The PDT further refined Borrow Area 3. Subareas 3b and 3c were eliminated because detailed geophysical surveys were not conducted and they lack appropriate clearance. The Borrow Area 3 outline was reduced to depict only the outline of Subarea 3a.

In a similar manner, the outline of Area 6, the South Pelto Blocks of Ship Shoal, was reduced to represent the actual outline of the combined borrow areas identified in Blocks 12 and 13.

Results of the final screening effort are summarized in Table L5-2 and Figure L5-3.

Table L5-2. Final Borrow Area Screening Table

Map ID	Location	Water Depth, ft	Sed. Size, mm	Type	Thickness, ft	% Material	Potential Available Volume, mcy	Appli-cability	Cultural Resources Survey Data	Cultural Resources Clearance
3	Whiskey Island TE-50 Area 3 (subarea 3a)	16-22	-	Mixed, silt, clay (overburden)	3.5-17.4	20% sand 30.0-49.7 silt 27.4-68.7% clay	7.97	Marsh	[1]2006 Chirp, magnetic, and side scan sonar surveys by OSI	
	Whiskey Island TE-50 Area 3 (subarea 3a)	-	0.107 - 0.166	Sand	2.5-14	80% sand	4.72	Beach/ Dune	[1]2006 Chirp, magnetic, and side scan sonar surveys by OSI	
4	New Cut TE-37 Area	13-16	-	Sand	6	-	2.5[*]	Beach/ Dune	vibracore and magnetic surveys	
5	Raccoon Island TE-48	22.5-31	0.09-0.13	Mixed sand, silt, clay	10-20	16.5-24.6% above #200 sieve	2.4[†]	Marsh	[2] 2008 remote sensing side scan and magnetometer surveys by Goodwin	BOEMRE Lease Pending (NRCS)
6	South Pelto blocks 12&13	26-48	0.15-0.20	Sand	13-20	< 5% silt	21.3[††]	Beach/ Dune	[3] 2003 seismic, sonar, and magnetic surveys by C&C	BOEMRE Grand-fathering Pending (CPRA)

Map ID	Location	Water Depth, ft	Sed. Size, mm	Type	Thickness, ft	% Material	Potential Available Volume, mcy	Appli-cability	Cultural Resources Survey Data	Cultural Resources Clearance
7	Ship Shoal block 88	17-23	0.19	Sand	10-19	< 5% silt	17.3	Beach/ Dune	[4] 2003 seismic, sonar, and magnetic surveys by C&C [5] 2004 echosounder and vibracore surveys and sediment sampling analysis by STE	BOEMRE Grand-fathering Pending (CPRA)
	Ship Shoal blocks 88,89,94,&95	16-32	0.19	Sand	8-12	< 5% silt	47.5	Beach/ Dune	[4] 2003 seismic, sonar, and magnetic surveys by C&C	

N/A denotes data not available
[*] Available volume based upon personal communication with CPRA, August 2009.
[†] Excludes a volume of 1 mcy estimated for Raccoon Island TE-48 Project.
[††] Excludes a volume of 7 mcy estimated for Caminada Headland Restoration Project.
[1] Ocean Surveys, Inc. (OSI) 2006. Hydrographic, Geophysical and Geotechnical Survey Program Whiskey Island Back Barrier Marsh Creation Project TE-50, Final report.
[2] Goodwin & Associates, Inc. 2008. Raccoon Island Shoreline Protection/Marsh Creation (TE-48) Submerged Cultural Resources Investigations.
[3] C&C Technologies. (C&C) 2003b. New Cut Dune/Marsh Restoration Project Using Ship Shoal Sediment Coastal Terrebonne Parish, Louisiana: High Resolution Geophysical and Archaeological Survey of the South Pelto Area Block 13 Vicinity of Ship Shoal.
[4] C&C Technologies. (C&C) 2003a. Whiskey Island West Flank Restoration Project Using Ship Shoal Sediment Coastal Terrebonne Parish, Louisiana: High Resolution Geophysical and Archaeological Survey of the Portions of Blocks 87, 88, 89, 94, and 95 Ship Shoal Area.
[5] Soil Testing Engineers, Inc. (STE) 2004. Sand Source Investigation Ship Shoal - Block 88, Louisiana Department of Natural Resources Ship Shoal – Whiskey Island West Flank (TE-47) Restoration Project Terrebonne Parish, Louisiana.

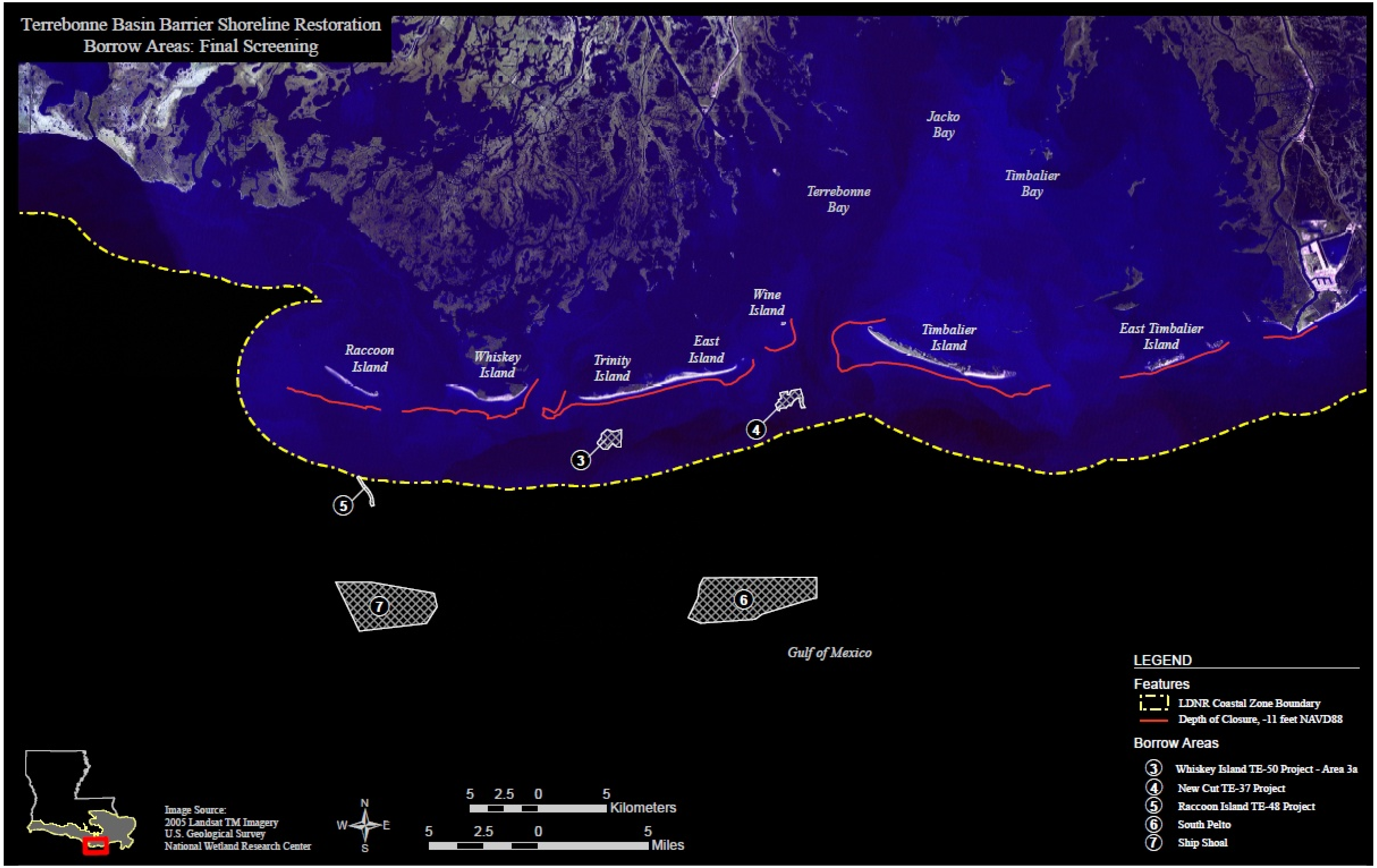


Figure L5-3. Final Borrow Area Screening Map

L5.5 SCREENED RESTORATION BORROW AREAS

The initially proposed source of borrow sand for beach and dune restoration was Ship Shoal, an elongate sand body in the Gulf, located 20 to more than 40 miles west of Belle Pass and four to ten miles south of the Isles Dernieres. It is approximately 31 miles long and 7 miles wide, lying in a water depth of 9 to 30 ft. Ship Shoal is composed of well-graded quartz sand (Kulp et al., 2001) and is ideal for use in restoring the Terrebonne Basin barrier islands, since its grain size is equal to or larger than the sand found on the islands. Coarser grain sand is more resistant to erosion. Ship Shoal is the nearest, accessible sand source that contains a sufficient quantity of sand of appropriate quality to match the native sand found on the islands and achieve the LCA TBBSR goals. Screened Borrow Areas 6 and 7 depicted in Figure L5-3 are both located on Ship Shoal. Several closer sand sources, previously identified for other CWPPRA project use, were proffered to the PDT, and they were investigated. The two most-promising are Subarea 3a of the Whiskey Island TE-50 Borrow Area 3 and the New Cut TE-37 Borrow Area 4.

The proposed sources of borrow sediments for marsh creation and restoration have also been identified. Nearshore resources seaward of the depth of closure will be utilized to provide mixed sediments consisting of fine sand, silts, and clays compatible with the existing island framework. The two marsh sediment borrow areas are the Raccoon Island TE-48 Borrow Area 5 and the overburden stratum on Subarea 3a of the Whiskey Island TE-50 Borrow Area 3.

Conceptual borrow area plans, showing available borings, cultural and infrastructure avoidance areas, along with typical cross sections were developed based on existing data and are presented below. The geotechnical and geophysical data for each borrow area are included in Annex L-1.

L5.6 WHISKEY ISLAND RESTORATION BORROW AREA 3

L5.6.1 Description

Two integrated hydrographic/geophysical surveys and a vibratory coring program were completed in the GOM in the waters offshore Whiskey Island for the TE-50 project (TBS and M&N, 2007).

Figures L5-4 and L5-5 present the TE-50 project Borrow Area 3 plan and typical section. The plan is as developed by TBS (2007), with the south border shifted to accommodate the requisite offset from the adjacent pipeline.

L5.6.2 Geophysical Analysis

OSI completed the surveys and coring during 2006. The resultant surveys included the acquisition and analysis of more than 260 statute miles of multi-sensor marine geophysical data (sounding, seismic/sub bottom Chirp profiling, and magnetometer) in a LDNR approved search area, encompassing a semi-rectangular area measuring approximately 23 square statue miles in size, located on the Gulf-side of Whiskey Island and depicted as Area 3 in Figure L5-3.

L5.6.3 Geotechnical Analysis

Area 3, an area slightly less than 1 square statute mile in size, was sampled by VC-02, VC-03, VC-05, VC-06, VC-08 through VC-12, VC-14, VC-15, and VC-41 through VC-48. As the largest of all the mapped subareas, it contains the largest quantity of sand resources. Water depth recorded in Area 3 varies between 16 and 22 ft.

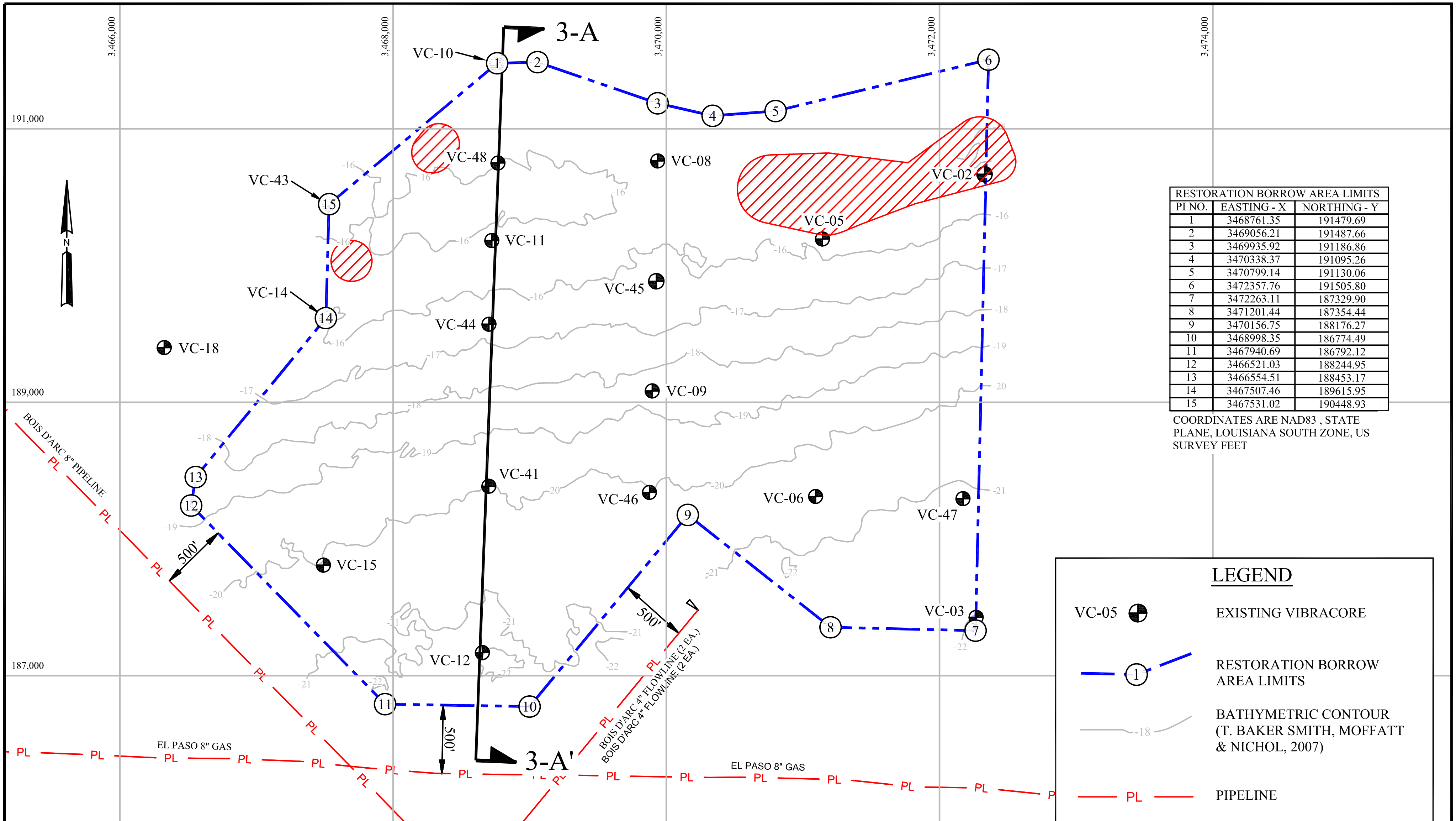
Core and sub bottom data within Area 3 indicate the subsurface sand unit mapped ranges in thickness from 2.5 to 14.0 ft and is overlain by a varying thickness of overburden, between 3.5 and 17.4 ft. The subsurface sand identified throughout Area 3 averages greater than 80% sand by weight with an average grain size between 0.107-0.166 mm. The percent sand in the overburden sediments, primarily composed of silts/clays, averages a little more than 20%. Percent silt in the fine component of the overburden samples, varies from 30.0 to 49.7%, and clay content varies between 27.4 and 68.7% as reported by OSI in TBS and M&N (2007).

L5.6.4 Volume and Summary

The volumes of overburden sediments and underlying sands estimated for Area 3, less volume included in the avoidance areas, are approximately 7.97 mcy and 4.72 mcy, respectively.

Available cultural resources within Area 3 include Chirp sub bottom, magnetometer, and side scan sonar surveys conducted by ARI in 2006 (OSI, 2006).

Numerical modeling was used to assess the impact that dredging a borrow area will have on nearshore wave conditions. Four wave conditions selected for evaluation. The selected wave conditions were developed from previous work and also used in the Ship Shoal: Whiskey Island West Flank Restoration Study (TE-47) to study the impacts on wave conditions from dredging the borrow sites (Stone, 2001). Model results (TBS and M&N, 2007) indicate that dredging Borrow Area 3 to -40 ft NAVD 88 will not produce a significant change in the wave conditions. Simulated impacts decrease with decreasing depth, such that they are almost negligible at the -10 ft contour, indicating that impacts to sediment transport at the nearby barrier shorelines should be minimal.



RESTORATION BORROW AREA LIMITS

PI NO.	EASTING - X	NORTHING - Y
1	3468761.35	191479.69
2	3469056.21	191487.66
3	3469935.92	191186.86
4	3470338.37	191095.26
5	3470799.14	191130.06
6	3472357.76	191505.80
7	3472263.11	187329.90
8	3471201.44	187354.44
9	3470156.75	188176.27
10	3468998.35	186774.49
11	3467940.69	186792.12
12	3466521.03	188244.95
13	3466554.51	188453.17
14	3467507.46	189615.95
15	3467531.02	190448.93

COORDINATES ARE NAD83 , STATE PLANE, LOUISIANA SOUTH ZONE, US SURVEY FEET

DATA AND INFORMATION SOURCES:

1. BATHYMETRIC CONTOURS DERIVED FROM FIGURE 5-2 ALTERNATIVE 1: BORROW SITE EXCAVATION PLAN INCLUDED IN REPORT TITLED "WHISKEY ISLAND BACK BARRIER MARSH CREATION, PROJECT NO. TE-50, 95% DESIGN REPORT", T. BAKER SMITH, 2007.
2. VIBRACORE LOCATIONS AND SPECIFICS OBTAINED FROM REPORT TITLED "HYDROGRAPHIC, GEOPHYSICAL AND GEOTECHNICAL SURVEY PROGRAM, WHISKEY ISLAND BACK-BARRIER MARSH CREATION PROJECT TE-50", APPENDIX 5 - VIBRATORY CORE SUMMARY TABLE, OCEAN SURVEYS, INC., 2007.
4. AVOIDANCE AREA LOCATIONS AND SPECIFICS OBTAINED FROM REPORT TITLED "HYDROGRAPHIC, GEOPHYSICAL AND GEOTECHNICAL SURVEY PROGRAM, WHISKEY ISLAND BACK-BARRIER MARSH CREATION PROJECT TE-50, OCEAN SURVEYS, INC., 2007.

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FIGURE L5-4: WHISKEY ISLAND RESTORATION BORROW AREA 3 PLAN VIEW

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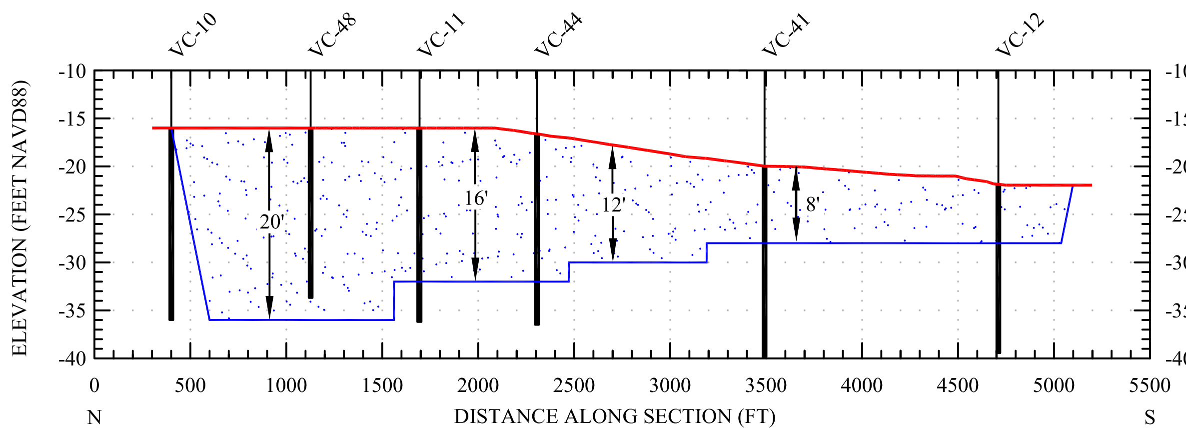
NOTES:

1. EXISTING GRADE DERIVED FROM FIGURE 5-2 ALTERNATIVE 1: BORROW SITE EXCAVATION PLAN INCLUDED IN REPORT TITLED "WHISKEY ISLAND BACK BARRIER MARSH CREATION, PROJECT NO. TE-50, 95% DESIGN REPORT", T. BAKER SMITH, 2007.
2. VIBRACORE SPECIFICS OBTAINED FROM REPORT TITLED "HYDROGRAPHIC, GEOPHYSICAL AND GEOTECHNICAL SURVEY PROGRAM, WHISKEY ISLAND BACK-BARRIER MARSH CREATION PROJECT TE-50", APPENDIX 5 - VIBRATORY CORE SUMMARY TABLE, OCEAN SURVEYS, INC., 2007.
3. RESTORATION BORROW AREA SIDE SLOPES 1V:10H.

SCALE:
H: 1" = 20'
V: 1" = 1000'



3-A TO 3-A'

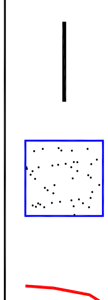


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FIGURE L5-5: WHISKEY ISLAND RESTORATION
BORROW AREA 3 TYPICAL SECTION

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L5.7 New Cut Borrow Area 4

L5.7.1 Description

Figure L5-6 presents New Cut Borrow Area 4. This area is an existing active borrow area previously utilized by LDNR. It is located south of Wine Island in distal deep water of the HNC Channel alignment. Figure L5-7 presents the New Cut Borrow Area 4 typical section.

L5.7.2 Geophysical Analysis

Seismic surveys have been obtained throughout this area. According to CP&E (2005), a calibrated seismic trace and the interpolation of reflectors between vibracores depicts a stratigraphy of good quality sand, shelly sediments, and fine sediments.

L5.7.3 Geotechnical Analysis

The 22 vibracores, taken within the delineated borrow area (Figure L5-6), all indicated that the surficial deposit was fine sand, varying in thickness from 3.5 to 16.9 ft (mean of 7.8 ft). Beneath that stratum of sand, the deposit consists of successive strata of clay and sand (CP&E, 2005).

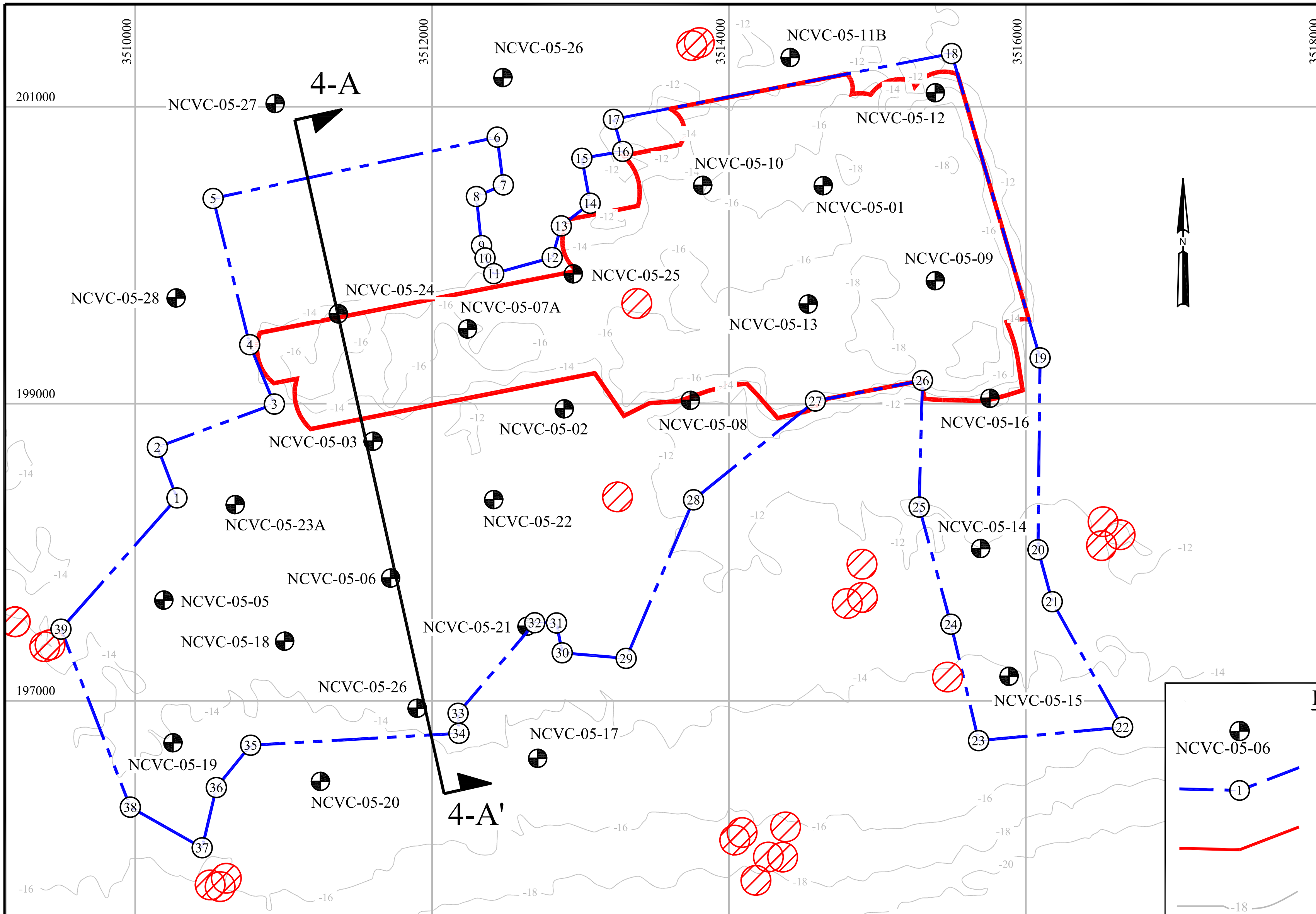
One New Cut cross-sectional diagram (north to south transect) shows a continuous surficial sand cover (up to 8 ft thick) overlapping coarse-grained shelly layers that thin out seaward, and layers of fine-grained materials (sand plus clay and clay) that thicken seawards (CP&E, 2005).

Another New Cut cross-sectional diagram (east-west) presents a continuous surficial sand layer (up to 10 ft thick) that overlies mixed sediments comprised of alternating layers of clay, sand plus silt, and sand plus clay. Sand is intermixed with finer-grained materials in vibracores NCYC-05-02, NCYC-05-03, and NCYC-05-23 (CP&E, 2005).

L5.7.4 Volume and Summary

As shown in Table L5-2, the borrow area was estimated to contain 4.2 mcy of sediment. A September 2007 CWPPRA project status report indicated that the project was completed using 850,000 cy of material (sand). Accounting for the cut to fill ratio, the remaining material, approximately 2.5 mcy (personal communication with CPRA, 2009) should be available for use as marsh fill, because of its alternating, relatively thin strata of sand and clay.

Cultural resources and other issues, such as nearshore wave refraction impacts from mining the sediment have been satisfactorily addressed since this area is an existing, recently used borrow area, there is no physical evidence of impacts, and the area is seaward of the depth of closure.



BORROW AREA LIMITS		
PI NO.	EASTING - X	NORTHING - Y
1	3510280.67	198366.01
2	3510148.93	198708.29
3	3510936.83	198998.67
4	3510770.80	199398.22
5	3510524.13	200382.91
6	3512437.95	200795.76
7	3512479.98	200474.30
8	3512297.96	200396.32
9	3512332.65	200066.07
10	3512356.54	199982.31
11	3512414.83	199876.84
12	3512808.55	199985.23
13	3512870.20	200198.44
14	3513064.64	200350.64
15	3513008.55	200653.68
16	3513283.55	200700.09
17	3513221.44	200915.69
18	3515499.62	201358.90
19	3516095.89	199309.02
20	3516081.97	198017.16
21	3516177.86	197667.45
22	3516651.66	196821.94
23	3515681.49	196731.69
24	3515495.36	197515.16
25	3515281.02	198304.83
26	3515303.58	199157.15
27	3514581.93	199018.82
28	3513761.07	198353.26
29	3513306.82	197285.32
30	3512876.18	197323.09
31	3512837.98	197523.94
32	3512692.15	197525.50
33	3512174.94	196915.77
34	3512180.36	196780.36
35	3510777.33	196700.84
36	3510546.11	196415.72
37	3510450.66	196009.79
38	3509966.34	196283.53
39	3509499.34	197472.32

COORDINATES ARE NAD83 , STATE PLANE, LOUISIANA SOUTH ZONE, US SURVEY FEET

LEGEND

- NCVC-05-06 — EXISTING VIBRACORE
- BORROW AREA LIMITS
- TE-37 NEW CUT DUNE/MARSH RESTORATION EXCAVATION LIMITS (LDNR, 2006)
- BATHYMETRIC CONTOUR (LDNR, 2006)
- AVOIDANCE AREA (LDNR, 2006)

0' 500' 1000' 2000'

DATA AND INFORMATION SOURCES:

1. BATHYMETRIC CONTOURS DERIVED SURVEY DATA PRESENTED IN AUTOCAD FILE 061619-POST DREDGE AREA.DWG FOR NEW CUT DUNE/MARSH RESTORATION PROJECT TE-37 PROVIDED BY LOUISIANA DEPARTMENT OF NATURAL RESOURCES, OFFICE OF COASTAL RESTORATION AND PROTECTION. SURVEY CONDUCTED IN JULY, 2007.
2. VIBRACORE LOCATIONS AND SPECIFICS OBTAINED FROM "BID PACKAGE FOR NEW CUT DUNE/MARSH RESTORATION (TE-37), LOUISIANA DEPARTMENT OF NATURAL RESOURCES, COASTAL ENGINEERING DIVISION, 2005.
3. AVOIDANCE AREA LOCATIONS AND SPECIFICS OBTAINED FROM NEW CUT DUNE/MARSH RESTORATION PROJECT TE-37 AS-BUILT DRAWINGS SHEET 9 OF 21. LOUISIANA DEPARTMENT OF NATURAL RESOURCES, COASTAL ENGINEERING DIVISION, 2006.
4. CONCEPTUAL BORROW AREA LIMITS OBTAINED FROM NEW CUT DUNE/MARSH RESTORATION PROJECT TE-37 AS-BUILT DRAWINGS SHEET 8 OF 21. LOUISIANA DEPARTMENT OF NATURAL RESOURCES, COASTAL ENGINEERING DIVISION, 2006.

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FIGURE L5-6: NEW CUT BORROW AREA 4 PLAN VIEW

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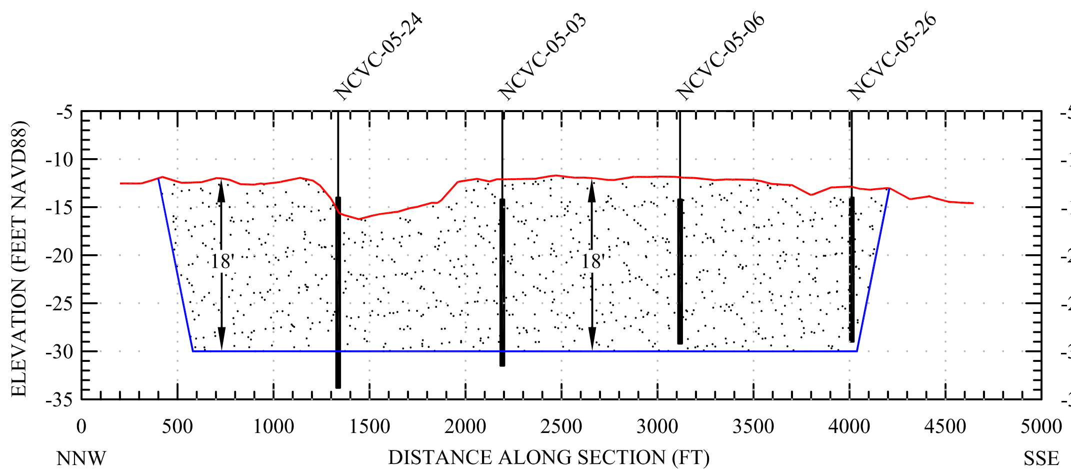
NOTES:

1. BORROW AREA CUT DEPTHS DERIVED FROM VIBRACORE LOGS OBTAINED FROM "BID PACKAGE FOR NEW CUT DUNE/MARSH RESTORATION (TE-37), LOUISIANA DEPARTMENT OF NATURAL RESOURCES, COASTAL ENGINEERING DIVISION, 2005.
2. BORROW AREA SIDE SLOPES 1V:10H.
3. EXISTING GRADE PROFILES DERIVED FROM SURVEY DATA PRESENTED IN AUTOCAD FILE 061619-POST DREDGE AREA.DWG FOR NEW CUT DUNE/MARSH RESTORATION PROJECT TE-37 PROVIDED BY LOUISIANA DEPARTMENT OF NATURAL RESOURCES, OFFICE OF COASTAL RESTORATION AND PROTECTION. SURVEY CONDUCTED IN JULY, 2007.

SCALE:
H: 1" = 20'
V: 1" = 1000'



4-A TO 4-A'

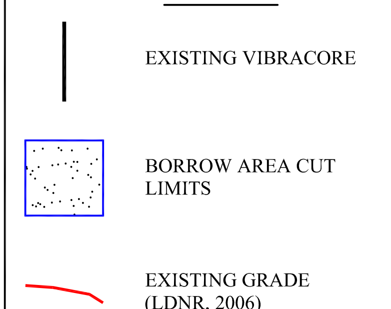


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FIGURE L5-7: NEW CUT BORROW AREA 4
TYPICAL SECTION

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L5.8 Raccoon Island Restoration Borrow Area 5

L5.8.1 Description

The presence of two buried distributary channels off Raccoon Island was noted by Suter et al. (1991). During the course of geological investigations for the TE-48 project, a portion of one buried river channel was located approximately four to six miles south of Raccoon Island (SJB et al., 2006) on behalf of the Natural Resources Conservation Service and LDNR. The channel is sublinear, oriented along a northwest/southwest alignment, with a width ranging from 500 to 750 ft, and at least 20,000 ft in length.

Figures L5-8 and L5-9 present the Raccoon Island Borrow Area 5 plan and typical section.

L5.8.2 Geophysical Analysis

Geophysical surveys, consisting of sub-bottom, sidescan, bathymetric profiling, and magnetometer surveying have been conducted in the area offshore of the south coast of Raccoon Island in Terrebonne Parish, Louisiana. A total of approximately 100 nautical miles of geophysical survey lines were run (SJB et al., 2006).

L5.8.3 Geotechnical Analysis

A detailed geotechnical investigation consisting of sediment sampling using coring equipment capable of penetrating and recovering samples to 20 ft below the sea floor within the primary channel was conducted to determine the sediment characteristics. Five preliminary short vibracores and thirteen long vibracores were collected during the project. Laboratory analysis of the sediments indicated the material located within the northern reach of the primary channel has the most potential for marsh building at Raccoon Island. The cores taken within the northern reach had an average grain size of 0.10 mm and an average percent coarse fraction retained above the No. 200 sieve of 16.5 %. The texture of the material is mixed sediment with minor sand fractions (SJB et al., 2006).

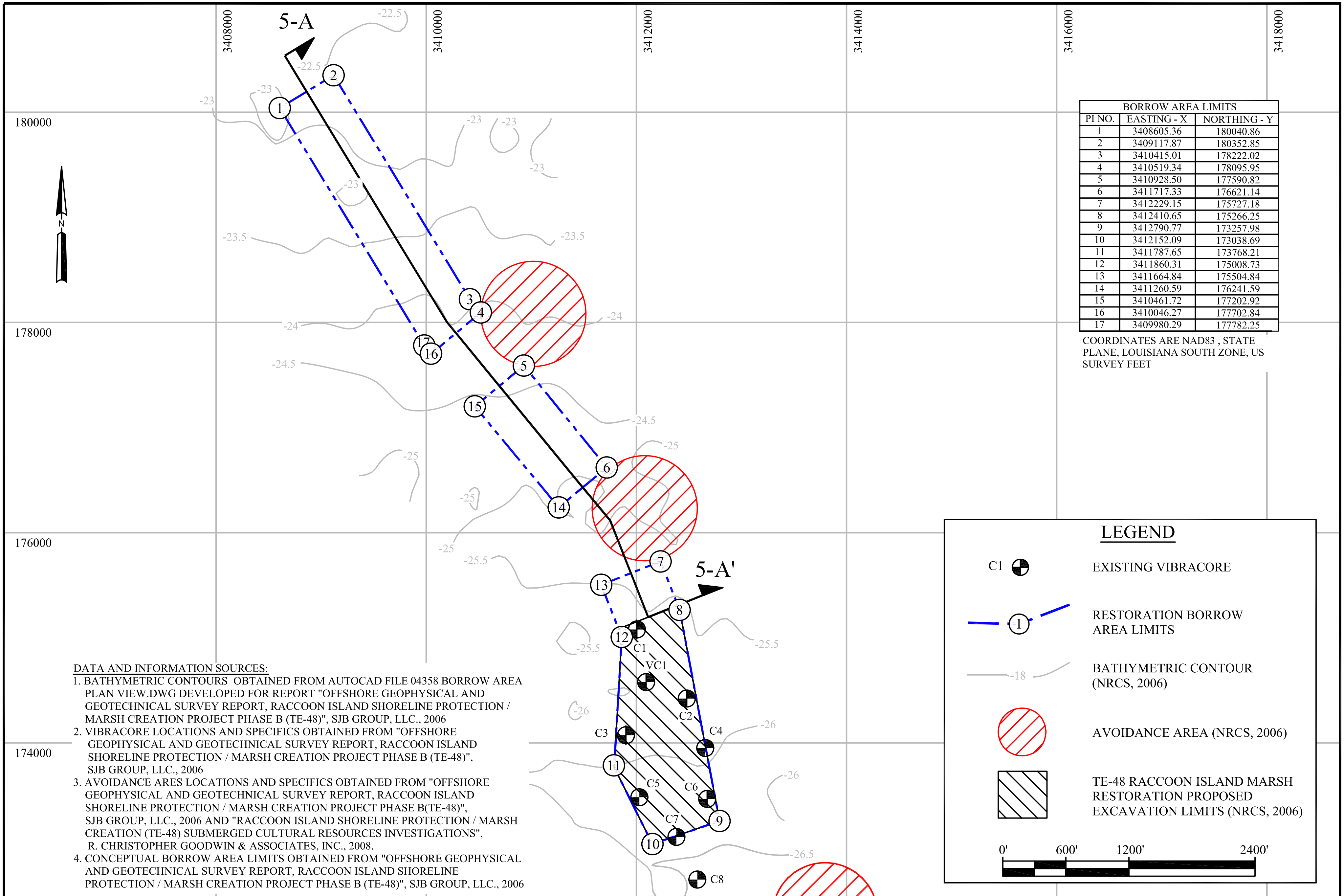
L5.8.4 Volume and Summary

By examining the seismic data in concert with core logs and individual grain size analyses, the geometry, length, width, and depth of a structural basin was developed for the borrow area plan. The borrow area is approximately 600 ft in width and 10 to 20 ft in depth, with a range in composite grain size from 0.09 to 0.13 mm.

The borrow area designed for the TE-48 project was 8,850 ft long, from 440 to 890 ft wide, with a maximum cut depth of 20 ft and an estimated volume of 830,000 cy (NRCS, 2006). The estimated volume of the entire borrow area is approximately 3.0 mcy. The bottom depth at the north end of the borrow area is -23.5 ft NAVD 88, sloping downward to -26.5 ft NAVD 88 at the lower end (SJB et al., 2006). Approximately 1.0 mcy are expected to be used in the TE-48 project, which yields a remaining potential available volume of approximately 2.4 mcy.

Wave modeling was performed to evaluate changes to wave refraction and sediment transport patterns resulting from excavation of the proposed borrow area. Based on the analysis, it was determined that the proposed borrow area will have minor affects on wave height, wave refraction and resultant sediment transport patterns in the vicinity of Raccoon Island. Thus, it is predicted that there will be no adverse impacts on the island's shoreline (SJB et al., 2006).

Available cultural resources documentation includes remote sensing side scan and magnetometer surveys conducted in 2008 (Goodwin, 2008). The Natural Resource Conservation Service (NRCS) has applied for a BOEMRE lease for this borrow area. The lease is pending.



BORROW AREA LIMITS		
PI NO.	EASTING - X	NORTHING - Y
1	3408605.36	180040.86
2	3409117.87	180352.85
3	3410415.01	178222.02
4	3410519.34	178095.95
5	3410928.50	177590.82
6	3411717.33	176621.14
7	3412229.15	175727.18
8	3412410.65	175266.25
9	3412790.77	173257.98
10	3412152.09	173038.69
11	3411787.65	173768.21
12	3411860.31	175008.73
13	3411664.84	175504.84
14	3411260.59	176241.59
15	3410461.72	177202.92
16	3410046.27	177702.84
17	3409980.29	177782.25

COORDINATES ARE NAD83 , STATE PLANE, LOUISIANA SOUTH ZONE, US SURVEY FEET

DATA AND INFORMATION SOURCES:

1. BATHYMETRIC CONTOURS OBTAINED FROM AUTOCAD FILE 04358 BORROW AREA PLAN VIEW.DWG DEVELOPED FOR REPORT "OFFSHORE GEOPHYSICAL AND GEOTECHNICAL SURVEY REPORT, RACCOON ISLAND SHORELINE PROTECTION / MARSH CREATION PROJECT PHASE B (TE-48)", SJB GROUP, LLC., 2006
2. VIBRACORE LOCATIONS AND SPECIFICS OBTAINED FROM "OFFSHORE GEOPHYSICAL AND GEOTECHNICAL SURVEY REPORT, RACCOON ISLAND SHORELINE PROTECTION / MARSH CREATION PROJECT PHASE B (TE-48)", SJB GROUP, LLC., 2006
3. AVOIDANCE ARES LOCATIONS AND SPECIFICS OBTAINED FROM "OFFSHORE GEOPHYSICAL AND GEOTECHNICAL SURVEY REPORT, RACCOON ISLAND SHORELINE PROTECTION / MARSH CREATION PROJECT PHASE B(TE-48)", SJB GROUP, LLC., 2006 AND "RACCOON ISLAND SHORELINE PROTECTION / MARSH CREATION (TE-48) SUBMERGED CULTURAL RESOURCES INVESTIGATIONS", R. CHRISTOPHER GOODWIN & ASSOCIATES, INC., 2008.
4. CONCEPTUAL BORROW AREA LIMITS OBTAINED FROM "OFFSHORE GEOPHYSICAL AND GEOTECHNICAL SURVEY REPORT, RACCOON ISLAND SHORELINE PROTECTION / MARSH CREATION PROJECT PHASE B (TE-48)", SJB GROUP, LLC., 2006

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FIGURE L5-8: RACCOON ISLAND RESTORATION BORROW AREA 5 PLAN VIEW

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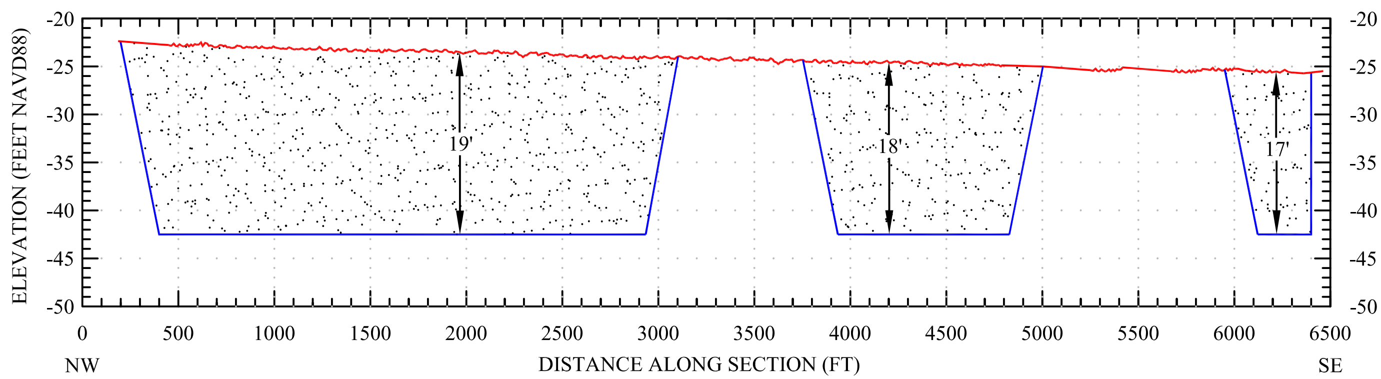
NOTES:

1. EXISTING GRADE PROFILE DERIVED FROM AUTOCAD FILE 04358 BORROW AREA PLAN VIEW.DWG DEVELOPED FOR REPORT "OFFSHORE GEOPHYSICAL AND GEOTECHNICAL SURVEY REPORT, RACCOON ISLAND SHORELINE PROTECTION / MARSH CREATION PROJECT PHASE B (TE-48)", SJB GROUP, LLC., 2006
2. RESTORATION BORROW AREA SIDE SLOPES 1V:10H.

SCALE:
H: 1" = 20'
V: 1" = 1000'



5-A TO 5-A'

LEGEND

RESTORATION BORROW AREA CUT LIMITS

EXISTING GRADE (NRCS, 2006)

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FIGURE L5-9: RACCOON ISLAND RESTORATION
BORROW AREA 5 TYPICAL SECTION

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L5.9 South Pelto Borrow Area 6

L5.9.1 Description

South Pelto Borrow Area 6 lies in Federal waters of the Gulf of Mexico approximately 9.5 miles south of the Isle Dernieres within South Pelto Blocks 12 and 13 (Figure L5-3). The specific locations designated for dredging on the basis of environmental, engineering, and archaeological investigations are depicted in Figure L5-10. Figure L5-11 presents the South Pelto Borrow Area 6 typical sections.

L5.9.2 Geophysical Analysis

Extensive geophysical surveys have been conducted in South Pelto Blocks 12, 13, 14, 18 and 19. Available cultural resources include seismic, sonar, and magnetic surveys conducted by C&C in 2003 (C&C, 2003b). Based on these surveys, buffers around oil and gas infrastructures and other magnetic anomalies occurring in and around the surveyed area were avoided during borrow area design to ensure quality of borrow sediments and safety of dredging operations and are depicted in Figure L5-10.

Seafloor depths range from 26 to 48 ft NAVD 88 across the surveyed area.

The magnetometer and sidescan sonar surveys for the Ship Shoal borrow areas were conducted according to BOEMRE guidelines at the time of the survey, which specified 50-meter (164 ft) grid spacing. Numerous sonar targets and magnetometer hits were recorded. In addition, historical records for pipelines and shipwrecks were acquired and presented in the appendix of the C&C report. All of this information was incorporated into an “Archaeological and Hazard Map” for each borrow area (C&C, 2003b).

L5.9.3 Geotechnical Analysis

Analyses including geotechnical data previously acquired by the Louisiana Geological Survey and the USGS were presented in a 2003 report covering portions of South Pelto Blocks 12, 13, 14, 18, and 19, which included high resolution geophysical and archaeological surveys (C&C, 2003b).

C&C did not collect vibracore samples, however the above-referenced C&C report presented data from four previously-acquired vibracores from the South Pelto blocks. One of the South Pelto cores, SS-86-25, had 14.3 ft of sand beneath the surface, followed by 2.4 ft of lean clay, another 3.6 ft of sand, and then 23.9 ft of clay. The remaining three cores averaged 5.6 ft of recovery and all of it was sand.

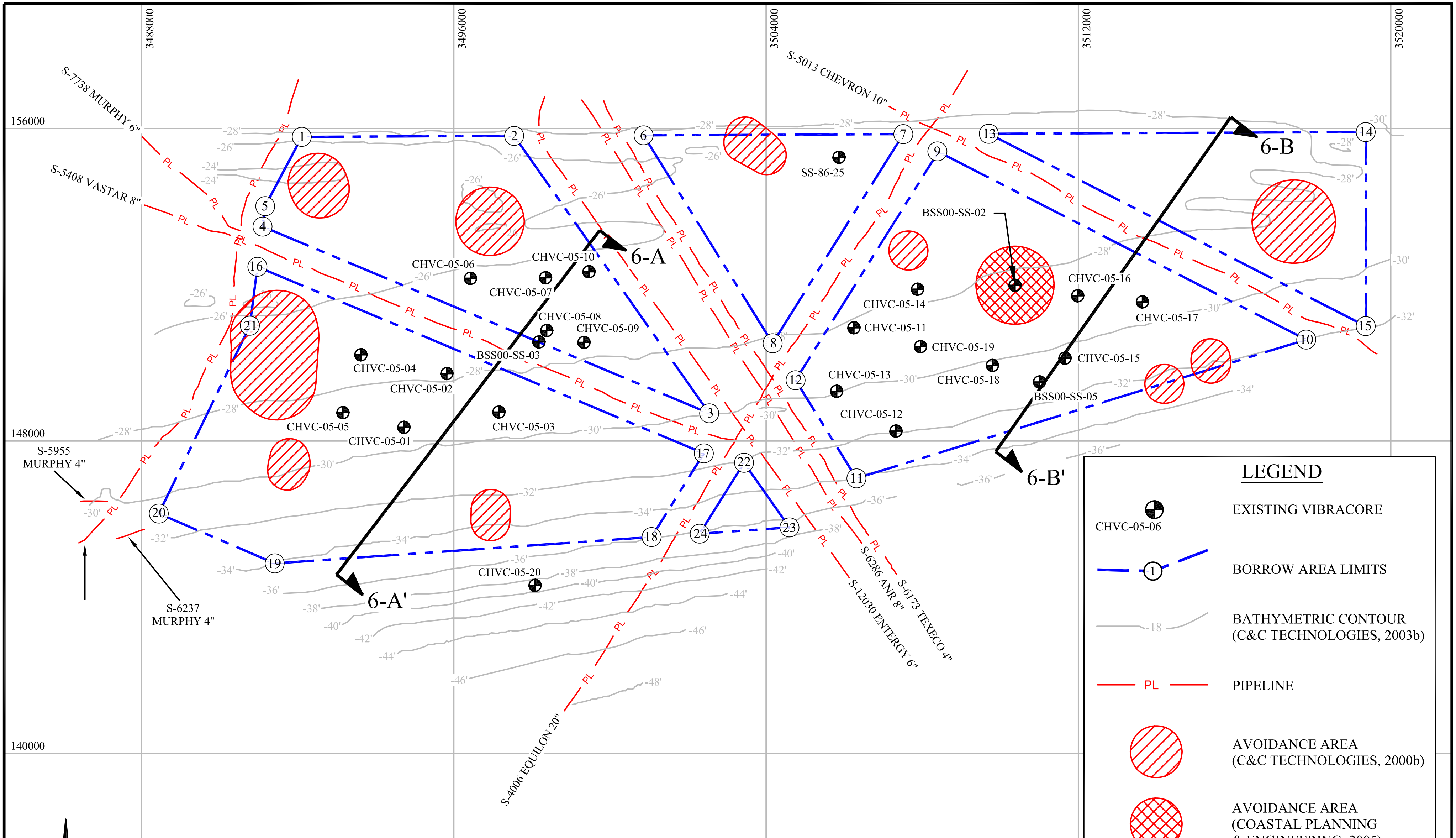
An additional six vibracore samples taken by Coastal Planning & Engineering, Inc. (Finkl, et al., 2005) to depths of approximately 15 to 20 ft below the sediment surface have been used to confirm seismic data as part of the analysis.

Khalil et al. (2007) reported that the South Pelto area contained very clean sand (less than 5% silt in the upper shoal units) in a surficial stratum that ranged in thickness from 13 to 20 ft and generally ranged in grain size from 0.15 to 0.2 mm .

L5.9.4 Volume and Summary

About 21.3 mcy of clean sand is estimated within South Pelto Borrow Area 6. An archaeological and hazard map, a sand isopach map, and available cultural resources documentation, including remote sensing side scan and magnetometer surveys, are included in C&C (2003b).

The wave refraction discussion by Stone et al. (2004) pertains to the South Pelto Blocks of Ship Shoal. The modeling and monitoring data suggest that excavation of Ship Shoal in its entirety would not influence the wave climate on the shorelines of the Terrebonne Basin barrier islands.



BORROW AREA LIMITS

PI NO.	EASTING - X	NORTHING - Y	PI NO.	EASTING - X	NORTHING - Y	PI NO.	EASTING - X	NORTHING - Y	PI NO.	EASTING - X	NORTHING - Y
1	3492105.07	155787.41	7	3507512.53	155856.82	13	3509703.72	155866.70	19	3491413.08	144866.33
2	3497544.99	155811.92	8	3504166.08	150502.27	14	3519357.50	155910.19	20	3488443.86	146141.91
3	3502541.80	148709.91	9	3508386.57	155416.02	15	3519357.50	150942.02	21	3490775.60	150952.59
4	3491101.12	153489.65	10	3517833.97	150596.61	16	3490969.14	152461.03	22	3503433.27	147442.87
5	3491168.34	154013.62	11	3506312.76	147044.39	17	3502404.45	147683.53	23	3504597.83	145787.67
6	3500860.53	155826.86	12	3504753.72	149555.69	18	3501065.31	145540.82	24	3502298.39	145626.99

COORDINATES ARE NAD83 , STATE PLANE, LOUISIANA SOUTH ZONE, US SURVEY FEET

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FIGURE L5-10: SOUTH PELTO BORROW AREA 6 PLAN VIEW

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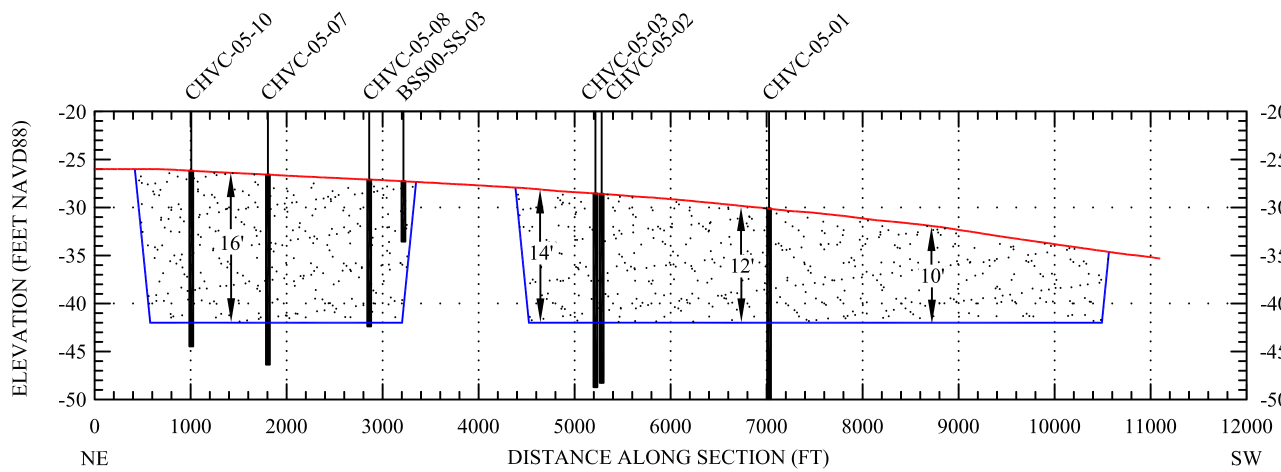
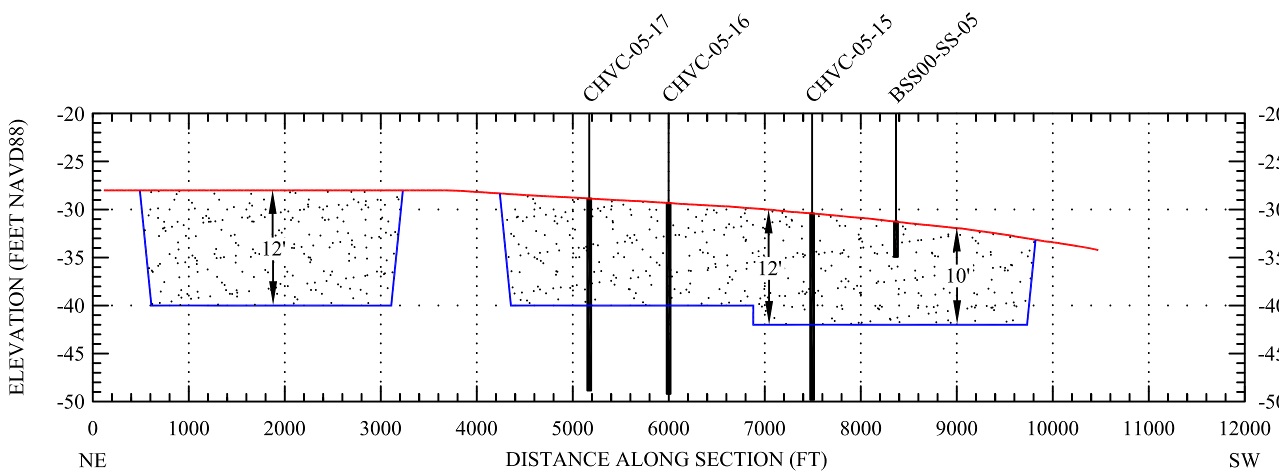
FAX (225) 769-3596

NOTES:
1. EXISTING GRADE DERIVED FROM BATHYMETRY MAP, NEW CUT DUNE/MARSH RESTORATION, SHEET 1 OF 4 INCLUDED IN REPORT TITLED "HIGH RESOLUTION GEOPHYSICAL AND ARCHAEOLOGICAL SURVEY OF THE SOUTH PELTO AREA BLOCK 13 VICINITY OF SHIP SHOAL", C&C TECHNOLOGIES, 2003. (DRAWING FILENAME: 4037.DWG)
2. BORROW AREA CUT DEPTHS DERIVED FROM ISOPACH MAP INCLUDED IN REPORT TITLED "HIGH RESOLUTION GEOPHYSICAL AND ARCHAEOLOGICAL SURVEY OF THE SOUTH PELTO AREA BLOCK 13 VICINITY OF SHIP SHOAL", C&C TECHNOLOGIES, 2003.
3. VIBRACORE LOCATIONS AND SPECIFICS PREFIXED "BSS" & "SS" OBTAINED FROM REPORT TITLED "HIGH RESOLUTION GEOPHYSICAL AND ARCHAEOLOGICAL SURVEY OF THE SOUTH PELTO AREA BLOCK 13 VICINITY OF SHIP SHOAL", PAGE 11, C&C TECHNOLOGIES, 2003. VIBRACORE LOCATIONS AND SPECIFICS PREFIXED "CHVC" OBTAINED FROM REPORT TITLED "GEOTECHNICAL INVESTIGATION FOR EXPLORATION OF SAND RESOURCES IN THE LOWER MISSISSIPPI RIVER AND SOUTH PASS AND EXPLORATION FOR SAND VIA VIBRACORING IN SOUTH PELTO BLOCKS 12 & 13", COASTAL PLANNING AND ENGINEERING, 2005.
4. BORROW AREA SIDE SLOPES 1V:10H.

SCALE:
H: 1" = 20'
V: 1" = 2000'



6-A TO 6-A'



6-B TO 6-B'

LEGEND

EXISTING VIBRACORE

BORROW AREA CUT LIMITS

EXISTING GRADE (C&C TECHNOLOGIES, 2003b)

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FIGURE L5-11: SOUTH PELTO BORROW AREA 6 TYPICAL SECTIONS

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L5.10 Ship Shoal Borrow Area 7

L5.10.1 Description

Ship Shoal Borrow Area 7 is located approximately 10.1 miles south of Whiskey Island as depicted in Figure L5-3. The hydrographic conditions across most of the borrow site are relatively flat, with the controlling depths ranging from 17 to 23 ft NAVD 88.

Figures L5-12 and L5-13 present the Ship Shoal Borrow Area 7 plan and typical section.

L5.10.2 Geophysical Analysis

Substantial geophysical surveys were conducted including magnetic anomalies and side scan sonar contacts (C&C, 2003a). Two areas were recommended for avoidance based on archaeological potential as depicted in Figure L5-12.

L5.10.3 Geotechnical Analysis

Analyses including geotechnical data previously acquired by the Louisiana Geological Survey and the USGS were presented in a 2003 report from the EPA covering portions of Ship Shoal Blocks 87, 88, 89, 94, and 95 (C&C, 2003a).

C&C did not collect vibracore samples; however the above-referenced C&C report presented data from six previously-acquired vibracores from Ship Shoal. The cores varied in length: one at 34.8 ft and the remaining five averaged 15.1 ft. The surface stratum (10.8 ft) of the deepest core was sand, followed by two strata of clay, two of sand, and ending 9.9 ft into clay. The remaining five cores had from 12.2 to 14.4 ft of sand below the surface, with only two cores terminating in clay (C&C, 2003a.).

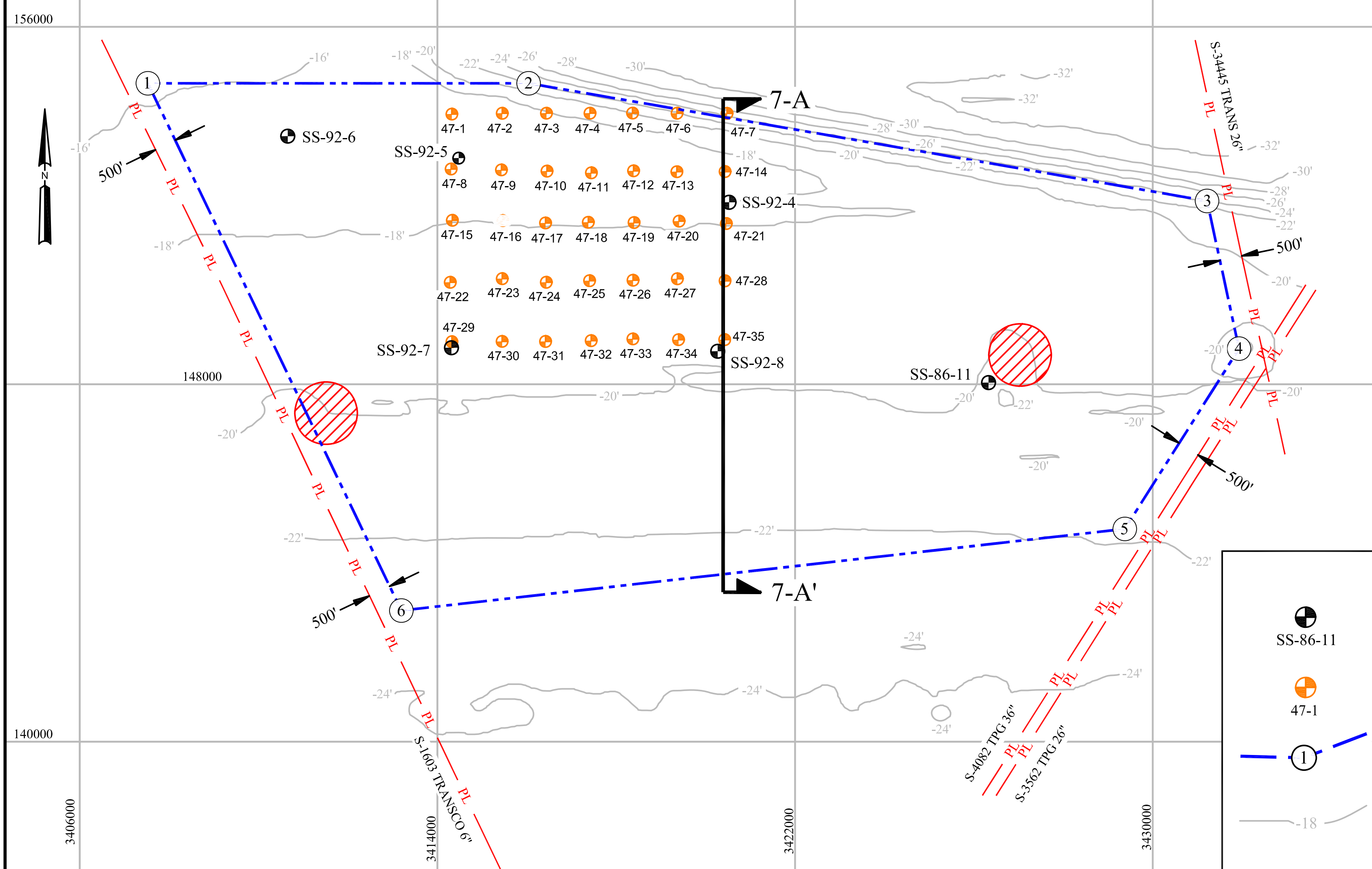
A subsequent geotechnical report for Ship Shoal included sampling data collected by Soil Testing Engineers (STE, 2004) at Ship Shoal Block 88 to characterize the borrow material for the TE-47 project. Composite statistics were developed for the upper sand layer for each vibracore taken within the vibracore sampling area. Thirty-five vibracores were performed across approximately 730 acres of Block 88 as depicted in Figure L5-12. The vibracores were spaced at approximately 1100 ft in the east-west direction and 1300 ft in the north-south direction. Detailed boring logs and grain size analysis for each sample were presented in STE (2004b). The thickness of the upper sand layer is generally greater than 10 ft over the majority of the sampling area, with some locations indicating sand to depths of 20 ft. The northeast comer of the sampling area was observed to contain less sand, with the minimum thickness there observed to be 4 ft. At the southern edge of the sampling area, two cores showed a minimum thickness of 8 ft.

L5.10.4 Volume and Summary

The Ship Shoal borrow area covering Blocks 88, 89, 94, and 95 ranges in thickness from 8 to 12 ft and has a mean grain size of 0.19 mm (C&C, 2003a). Assuming the average thickness of 10 ft, the estimated volume of sand within the Ship Shoal borrow area is approximately 64.8 mcy. Approximately 17.3 mcy of this volume were estimated by STE (2004) in an area within Block 88 surveyed for the TE-47 project, which yields a remaining potential available volume of approximately 47.5 mcy. The TE-47 project has not received funding, thus this volume was included in the borrow area evaluation.

Available cultural resources include seismic, sonar, and magnetic surveys conducted by C&C in 2003 (C&C, 2003a).

Stone et al. (2004) used the STWAVE model to examine to the impacts of Ship Shoal from sediment removal on waves propagation patterns for the range of representative wave conditions. In a numerical modeling effort, removal of the entire shoal was simulated and the impact on wave propagation and energy levels discussed suggesting that shoal removal will not have a significant impact on wave energy conditions along the Isles Dernieres.



BORROW AREA LIMITS		
PI NO.	EASTING - X	NORTHING - Y
1	3403522.40	154737.11
2	3412038.27	154736.95
3	3427212.51	152104.30
4	3427927.32	148798.56
5	3425373.67	144763.59
6	3409191.78	142936.56

COORDINATES ARE NAD83 , STATE PLANE, LOUISIANA SOUTH ZONE, US SURVEY FEET

LEGEND

- SS-86-11 — HISTORIC VIBRACORE
- 47-1 — TE-47 WHISKEY WEST FLANK VIBRACORE
- 1 — BORROW AREA LIMITS
- -18 — BATHYMETRIC CONTOUR (C&C TECHNOLOGIES, 2003a)
- PL — PIPELINE
- AVOIDANCE AREA

0' 1750' 3500' 7000'

DATA AND INFORMATION SOURCES:

1. BATHYMETRIC CONTOURS AND PIPELINE IDENTIFICATIONS DERIVED FROM BATHYMETRY MAP, WHISKEY ISLAND WEST FLANK RESTORATION SHEET 1 OF 4 INCLUDED IN REPORT TITLED "HIGH RESOLUTION GEOPHYSICAL AND ARCHAEOLOGICAL SURVEY OF PORTIONS OF BLOCKS 87, 88, 89, 94 AND 95 SHIP SHOAL AREA", C&C TECHNOLOGIES, 2003. (DRAWING FILENAME: 4036.DWG)
2. VIBRACORE LOCATIONS AND SPECIFICS PREFIXED "SS" OBTAINED FROM REPORT TITLED "HIGH RESOLUTION GEOPHYSICAL AND ARCHAEOLOGICAL SURVEY OF PORTIONS OF BLOCKS 87, 88, 89, 94 AND 95 SHIP SHOAL AREA", PAGE 13, C&C TECHNOLOGIES, 2003.VIBRACORE LOCATIONS AND SPECIFICS PREFIXED "04-SS88" OBTAINED FROM REPORT TITLED "SAND SOURVE INVESTIGATION, SHIP SHOAL - BLOCK 88, SHIP SHOAL - WHISKEY ISLAND WEST FLANK (TE-47) RESTORATION PROJECT, DMJM + HARRIS, 2005.

TE-47 WHISKEY WEST FLANK VIBRACORE INDEX

INDEX NO.	CORE NAME	INDEX NO.	CORE NAME	INDEX NO.	CORE NAME
47-1	04-SS88-01(P)	47-13	04-SS88-21(S)	47-25	04-SS88-09(S)
47-2	04-SS88-27(S)	47-14	04-SS88-20(S)	47-26	04-SS88-08(S)
47-3	04-SS88-28(S)	47-15	04-SS88-13(S)	47-27	04-SS88-07(S)
47-4	04-SS88-29(S)	47-16	04-SS88-14(S)	47-28	04-SS88-06(S)
47-5	04-SS88-30(S)	47-17	04-SS88-15(S)	47-29	04-SS88-04(P)
47-6	04-SS88-31(S)	47-18	04-SS88-16(S)	47-30	04-SS88-01(S)
47-7	04-SS88-02(P)	47-19	04-SS88-17(S)	47-31	04-SS88-02(S)
47-8	04-SS88-26(S)	47-20	04-SS88-18(S)	47-32	04-SS88-03(S)
47-9	04-SS88-25(S)	47-21	04-SS88-19(S)	47-33	04-SS88-04(S)
47-10	04-SS88-24(S)	47-22	04-SS88-12(S)	47-34	04-SS88-05(S)
47-11	04-SS88-23(S)	47-23	04-SS88-11(S)	47-35	04-SS88-03(P)
47-12	04-SS88-22(S)	47-24	04-SS88-10(S)		

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FIGURE L5-12: SHIP SHOAL BORROW AREA 7 PLAN VIEW

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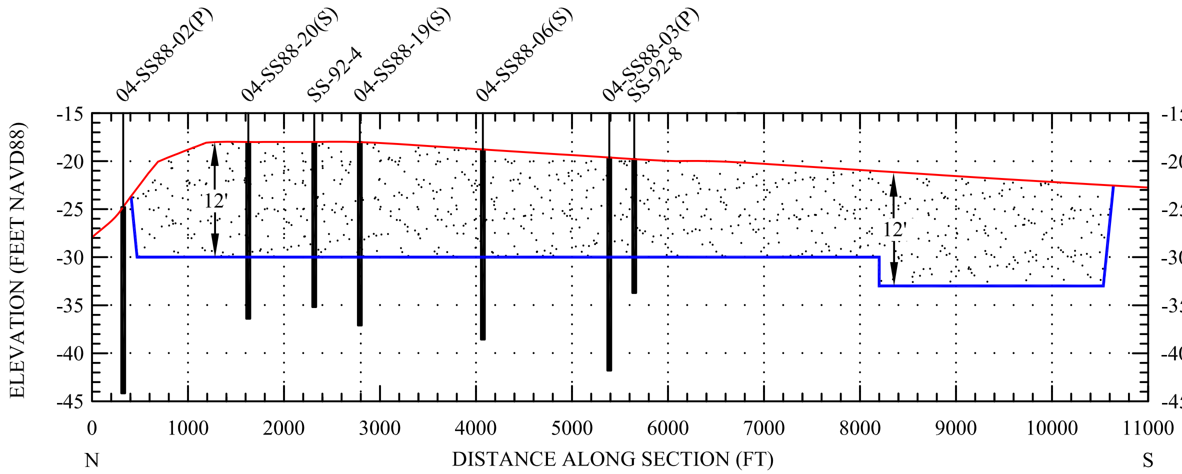
SCALE:
H: 1" = 20'
V: 1" = 2000'



7-A TO 7-A'

NOTES:

1. EXISTING GRADE DERIVED FROM BATHYMETRY MAP, WHISKEY ISLAND WEST FLANK RESTORATION SHEET 1 OF 4 INCLUDED IN REPORT TITLED "HIGH RESOLUTION GEOPHYSICAL AND ARCHAEOLOGICAL SURVEY OF PORTIONS OF BLOCKS 87, 88, 89, 94 AND 95 SHIP SHOAL AREA", C&C TECHNOLOGIES, 2003. (DRAWING FILENAME: 4036.DWG)
2. BORROW AREA CUT DEPTHS DERIVED FROM ISOPACH MAP INCLUDED IN REPORT TITLED "HIGH RESOLUTION GEOPHYSICAL AND ARCHAEOLOGICAL SURVEY OF PORTIONS OF BLOCKS 87, 88, 89, 94 AND 95 SHIP SHOAL AREA", C&C TECHNOLOGIES, 2003.
3. VIBRACORE LOCATIONS AND SPECIFICS OBTAINED FROM REPORT TITLED "HIGH RESOLUTION GEOPHYSICAL AND ARCHAEOLOGICAL SURVEY OF PORTIONS OF BLOCKS 87, 88, 89, 94 AND 95 SHIP SHOAL AREA", PAGE 13, C&C TECHNOLOGIES, 2003.
4. BORROW AREA SIDE SLOPES 1V:10H.

LEGEND

- EXISTING VIBRACORE
- BORROW AREA CUT LIMITS
- EXISTING GRADE (C&C TECHNOLOGIES, 2003a)

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FIGURE L5-13: SHIP SHOAL BORROW AREA 7
TYPICAL SECTION

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L5.11 Borrow Area Summary

Of the fifteen (15) identified potential borrow areas, four (4) were screened out due to location, *i.e.*, landward of depth of closure, five (5) were screened out due to lack of detailed geophysical survey data and clearance, and one (1) was screened out because it had been used for a previous project. Two (2) new ones were added but also screened out due to insufficient data or lack of clearance, leaving five (5) potential borrow areas. Of the five (5), three (3) contain beach compatible sand for beach and dune restoration, totaling over 71 mcy; two (2) contain mixed sediments compatible for marsh creation, totaling 10.37 mcy; and one (1) contains a layer of marsh material above a layer of beach/dune material, totaling 7.97 and 4.72 mcy, respectively.

L5.12 Back-Barrier Analyses

Back-barrier geotechnical investigations and analyses were performed to determine design criteria in support of the CWPPRA TE-48 project on Raccoon Island (NRCS, 2007) and the CWPPRA TE-50 project on Whiskey Island (LDNR, 2007). The extent of the investigations and analyses included the drilling of soil test borings to determine subsoil conditions and stratification, and to obtain samples of the various substrata. Soil mechanics laboratory tests, performed on samples obtained from the borings, were used to evaluate the physical properties of the subsoils. Engineering analyses, based on the soil borings and laboratory test results, were made to evaluate the stability of the foundation support for the proposed shoreline protection and marsh creation features. Analyses were performed to evaluate stability of the containment dike and retained marsh fill. Analyses were also made to estimate settlement of the dike and marsh area fill and the time-rate of settlement of these features.

Soil mechanics laboratory tests consisting of natural water content; unit weight; unconfined compression; and unconsolidated, un-drained compression were performed on undisturbed samples obtained from the soil test borings. Tests were performed on selected samples to classify the soils such as liquid limit, plastic limit, and plasticity index. Consolidation tests were performed on selected samples to determine their compressibility and stress history. Grain size analyses were performed on selected samples to determine their particle distribution curves.

The results of the laboratory analyses were applied to determine the time-rates of consolidation settlement for the containment dike and marsh fill designs. The time-rate calculations accounted for the foundation settlement of the subsoils due to the weight of the fill, and self-weight consolidation within the imported fill materials themselves. Settlement curves were developed for various dike and marsh platform elevations in varying bay bottom depths under varying water depths. It is noted that geologic subsidence needs to be factored in to compute the time-rates of total effective settlement. It was observed that fairly rapid settlement caused by the weight of the dike and the influence of the recently placed fill along with self-weight consolidation occurs within the first one to two years following construction. Following the initial two years, a steadier settling takes place which is dominated by the fairly constant geologic subsidence.

On Raccoon Island, design criteria for the breakwaters including bearing capacity, stability, and settlement were also developed.

These detailed analyses served as the design criteria for the island restoration measures described in Section L6.

L6. RESTORATION DESIGN PLANS

L6.1 GOAL STATEMENT

The LCA TBBSR Study was identified in the 2004 LCA Plan (USACE, 2004) and was recommended to the Congress in the Chief of Engineers report, dated January 31, 2005 (USACE, 2005). The report recommended a coordinated, feasible solution to the identified critical water resource problems and opportunities in Coastal Louisiana. The LCA TBBSR was included as one of the critical near-term restoration features throughout Coastal Louisiana. Title VII of the WRDA of 2007 authorizes the LCA program.

The Study goal defined in the 2004 LCA Plan and WRDA 2007 is to restore the geomorphologic form and ecologic function of the Terrebonne Basin barrier islands through simulating historical conditions by enlarging the barrier islands (width and dune crest) and reducing the current number of breaches.

L6.2 BARRIER ISLAND GEOMORPHOLOGIC FORM AND ECOLOGIC FUNCTION

The barrier islands in the Study Area are the remains of an abandoned Mississippi River Delta; and their degradation is the result of anthropogenic activities and episodic storm impacts, in combination with natural deltaic processes. The barrier islands are typically low lying and comprised of three physical features, the beach, dune, and back barrier marsh. They act as a buffer to reduce the full force and effects of wave action, saltwater intrusion, storm surge, and tidal currents on associated estuaries and wetlands. To restore their geomorphologic form and provide this buffer involves reinforcing the shoreline through beach and dune restoration. In addition, it includes providing a marsh platform to capture overwash sediments during episodic events; sediment that would otherwise be carried into back bay areas to form shoals or be lost into deeper waters. The marsh also serves as a roll over platform as the islands migrate landward.

Restoration of ecologic function of the barrier islands includes vegetating both the restored dunes and back barrier marsh platforms with native plants, to provide wetland habitat for a diverse number of plant and animal species and to help retain sediment. This approach is supported by the Wetland Value Assessment (WVA) methodology, which has been chosen as the model to evaluate the ecosystem restoration project benefits. The WVA methodology states that the key habitat components, dune, supratidal (beach), and intertidal (marsh), combine to provide the optimum metric by which the islands should be compared (CWPPRA, 2002). Below are the WVA model elevations that define dune, beach, and marsh:

- Dune elevation ≥ 5 ft NAVD 88;
- 2 ft NAVD 88 ≤ beach elevation ≤ 4.9 ft NAVD 88;
- 0.0 ft NAVD 88 ≤ marsh elevation ≤ 1.9 ft NAVD 88.

The marsh habitat has the highest weighting in the analysis used to compute the benefits, due to its ecologic function. The WVA criterion is to provide intertidal habitat for the longest duration physically practicable within the period of analysis, as determined by computing Average Annual Habitat Units.

L6.3 PLAN FORMULATION SUMMARY

L6.3.1 Introduction

The plan formulation process including the descriptions of the measures and the justification for selecting or rationale for screening each measure is summarized below and detailed in the Integrated Feasibility Study and Final Environmental Impact Statement Report, Section 3 Alternatives. The process included development of a range of hard-structural and soft-structural measures to address the specific problems, needs, and objectives of the Study and achieve the goal of restoring the geomorphologic form and ecologic function of the seven barrier islands within the Terrebonne Basin. The following steps were employed by the PDT in the process:

- Identify a wide range structural measures;
- Perform initial screening;
- Perform second level screening;
- Perform final screening;
- Create structural designs; and
- Compute construction component quantities.

L6.3.2 Summary of Measures

A wide variety of hard-structural and soft-structural measures was considered in the initial step including breakwaters, revetments, groins, terminal groins, sand fencing, barges/ships, sheet pile, pass closure, canal plugs, dune restoration, marsh creation, beach restoration, beach nourishment, subtidal sediment placement, addition of sediment into near-shore environment to supplement littoral drift, breach closure, small march island construction on bayside for bird habitat, vegetation planting, herbivore control, bio-engineered oyster reefs, spit creation, and canal backfilling.

L6.3.3 Initial Screening

The initial screening criteria were agreed upon by the PDT. The identified measures were selected and screened based upon experience with previous restoration efforts in the Study Area, knowledge of the Study Area, conventional scientific theory, best professional judgment, and consideration of the Study objectives.

Management measures were first screened based on their ability to meet the following five criteria:

- Consistency with Authorization and Purpose - measure is fully consistent with Project authorization and purpose;
- Achievement of Planning Objectives - measure is fully supportive of planning objective(s);

- Efficiency - measure directly influences the area(s) of greatest need;
- Environmental Impacts - measure presents no readily apparent potential for adverse environmental impacts; and
- Engineering Feasibility - measure directly supported by acceptable engineering and industry practices/physical plant.

Table L6-1 presents initial screening results by management measure.

Table L6-1. Initial Screening Results by Management Measure

Measure Code	Management Measure	Carried Forward? (Yes/No)
Hard-Structural		
HSM1	- Segmented Breakwaters (Specific Location)	Yes
HSM2	- Continuous Breakwaters (Specific Location)	No
HSM3	- Segmented Breakwaters (Entire Island)	No
HSM4	- Continuous Breakwaters (Entire Island)	No
HSM5	- Segmented Revetments (Specific Location)	No
HSM6	- Continuous Revetment (Specific Location)	Yes (Wine Island Only)*
HSM7	- Segmented Revetments (Entire Island)	No
HSM8	- Continuous Revetment (Entire Island)	No
HSM9	- Terminal Groins	Yes
HSM10	- Groins	No
HSM11	- Sand fencing	Yes
HSM12	- Sunken Barges/ships	No
HSM13	- Floating Barges/ships	No
HSM14	- Segmented Sheet pile (Specific Location)	No
HSM15	- Continuous Sheet pile (Specific Location)	No
HSM16	- Segmented Sheet pile (Entire Island)	No
HSM17	- Continuous Sheet pile (Entire Island)	No
HSM18	- Pass Closures	No
HSM19	- Canal Plugs	Yes
Soft-Structural		
SSM1	- Dune Restoration	Yes
SSM2	- Marsh Creation	Yes
SSM3	- Beach Restoration	Yes
SSM4	- Subtidal Sediment Placement	Yes
SSM5	- Addition of Sediment into Nearshore Environment	Yes
SSM6	- Breach Closure	Yes
SSM7	- Small Marsh Island Construction on Bayside	Yes
SSM8	- Vegetation Planting	Yes
SSM9	- Herbivory Control (Backbarrier Marsh)	Yes
SSM10	- Bio-engineered Oyster Reefs	No
SSM11	- Spit Creation (E&T Habitat)	Yes
SSM12	- Backfilling Canals	Yes
TOTAL MEASURES CARRIED FORWARD		**16**

HSM Denotes Hard-structural Measure, SSM Denotes Soft-structural Measure
*Continuous revetments placed at specific locations were eliminated because of potential environmental impacts with the exception of Wine Island. Wine Island is unique in that it was once surrounded by a boulder revetment to hold discharged material from dredging the HNC. The island is no longer contained within the revetment.

L6.3.4 Second Level Screening

The initial screening effort evaluated the measures as they applied to the Terrebonne Basin barrier island system in its totality, as a unit or "system." The second level process built on the initial screening, with emphasis on individual measures as they would apply to each island in the system. This screening process was undertaken during a three-day field trip to the islands (July 27-30, 2009), involving 20 members of the PDT, representing the responsible State and Federal agencies and their consultants. Results of the previous screenings were reviewed in situ, along with observations of the conditions of past CWPPRA and Coastal Impact Assistance Program (CIAP) projects. The days' observations were reviewed, reinforced, and recapitulated during evening discussions, to ensure this consensus. Based on these discussions, it was determined that no stand-alone measure would achieve project objectives. Furthermore, it was the consensus of the PDT that the primary island strategy should be a combination of beach, dune, and marsh restoration measures. These measures, when used in combination, were the only management measures capable of meeting the primary objective of restoring the geomorphologic form and ecologic function of the barrier islands. Table L6-2 presents second level screening results by individual island.

Table L6-2. Second Level Screening Results by Island

Island	Management Measure Code*
Raccoon	HSM1, HSM5, HSM9, HSM11, SSM1 through SSM12
Whiskey	HSM1, HSM5, HSM9, HSM11, SSM1 through SSM12
Trinity	HSM1, HSM5, HSM9, HSM11, HSM19, SSM1 through SSM12
East	HSM1, HSM5, HSM9, HSM11, SSM1 through SSM12
Wine	HSM6, HSM8, SSM2, SSM8, SSM9
Timbalier	HSM1, HSM5, HSM9, HSM11, SSM1 through SSM12
East Timbalier	HSM9, HSM11, SSM1 through SSM12

* see Table L6-1 for code descriptions

L6.3.5 Final Screening

At this point in the screening process, the PDT had concluded that the island strategies must include a beach, dune, and marsh component in order to achieve the objectives of the project. Therefore, the final screening effort, which built upon the second level screening process, evaluated the use of supplementary measures including sand fences, vegetative planning, herbivory control, breakwaters, terminal groins, and continuous revetments (for Wine Island Only). Table L6-3 presents final screening results by individual island.

Table L6-3. Final Screening Results by Island

Island	Management Measure Code*
Raccoon	HSM1, HSM9, and combination of SSM1, SSM2, SSM3, SSM8, and HSM11
Whiskey	HSM1 and combination of SSM1, SSM2, SSM3, SSM8, and HSM11
Trinity	Combination of SSM1, SSM2, SSM3, SSM8, and HSM11
East	Combination of SSM1, SSM2, SSM3, SSM8, and HSM11
Wine	HSM8 (repair of existing) and combination of SSM1, SSM2, SSM3, SSM8 and HSM11
Timbalier	SSM6, SSM12, and combination of SSM1, SSM2, SSM3, and HSM11
East Timbalier	SSM12, and combination of SSM1, SSM2, SSM3, and HSM11

* see Table L6-1 for code descriptions

L6.3.6 No Action Plan (Plan A)

The No-Action Plan, denoted as Plan A, is fully described in the Integrated Feasibility Study and Final Environmental Impact Statement Report, Section 3.4.1. Plan A serves as the basis of comparison for the Future Without Project (FWOP) conditions scenario. The FWOP conditions were compared to the proposed restoration measures, that is, Future With Project (FWP) conditions, in the plan formulation process to determine the net habitat benefits from construction.

L6.4 RESTORATION DESIGN STEPS

The design process included development of a range of restoration plans to enable the determination of the minimized restoration templates for each component. The following steps were used in the process:

- Determine historic erosion rates for each island;
- Determine design relative sea level change;
- Estimate fill compaction component for each island;
- Determine design storm events and storm-induced erosion;
- Calculate design acreage component for each island;
- Evaluate and, if applicable, account for existing CWPPRA and other related project plans;
- Create design fill templates for each island; and
- Compute design fill volumes and related construction component quantities.

L6.5 BARRIER ISLAND COMPONENTS

L6.5.1 Definition

The PDT defined the minimized restoration design template, denoted as Plan B, as the construction of the minimal barrier island dimensions that restore the barrier island's geomorphic form and ecologic function and retains this form and function after being subjected to the design storm events. The design storm events chosen included a hypothetical 50-year design storm, and historic storms, Hurricanes Katrina and Rita, which occurred in 2005, and Hurricanes Gustav and Ike, which occurred in 2008, as required by USACE guidance developed from recommendations initiated by the Interagency Performance Evaluation Task Force on Hurricane Katrina.

L6.5.2 Beach and Dune

Annex L-3 presents SBEACH (Storm-induced BEAch CHange) model simulations that were performed on an array of various restoration templates. The widths were increased / decreased by increments of 25 ft and elevations were increased or decreased by increments of 0.1 ft in order to derive the appropriate combination of beach berm and dune template superimposed on the beach berm. Based on the results of these simulations, the following minimal beach and dune island dimensions were derived for the Plan B design to meet the restoration template definition:

- Ggulf-side beach width = 250 ft;
- Beach elevation = 3.8 ft NAVD 88;
- Dune width = 100 ft;
- Dune elevation = 6.0 ft NAVD 88; and
- Bay-side beach width = 100 ft.

L6.5.3 Marsh

The marsh serves as a roll over platform as the islands migrate landward. Based on the post-storm observations from the recent historic storms, there is ample evidence that the back-barrier marsh width needs to be on the order of 1,000 ft to capture overwash sediments during episodic events; sediment that would otherwise be carried into back bay areas to form shoals or be lost into deeper waters. Cross-shore sediment transport models, e.g., SBEACH, tend to underestimate the extent of overwash; therefore a literature review was conducted to support the design criteria for the width of the marsh platform. Examination of vertical aerial photographs of the Texas coast, made following Hurricane Ike, show areas of overwash extending from 800 to 1,300 ft inland (Ewing, 2009). An extensive study of overwash on the Caminada-Moreau Headland by Ritchie and Penland found that, for much of the low shoreline, overwash penetrated from 700 to more than 1,000 ft beyond the beach (Ritchie and Penland, 1989). Examination of the aerial photographs in Williams, et al. (1992) show overwash areas extending to 1,300 ft on Timbalier Island and greater than 700 ft on East Island. Personal observations by various PDT members support planning for a minimum marsh width of 1,000 ft. Therefore, 1,000 ft was defined as the minimal marsh platform width for the Plan B design to meet the restoration template definition.

Based on similar Louisiana barrier island restoration plans, the average healthy marsh elevation, defined as the target elevation for the marsh platform, is typically within +/- 0.1 ft of MHW. MHW for the Study Area is approximately 1.6 ft NAVD 88 and was defined as the minimal marsh platform target elevation for the Plan B design to meet the restoration template definition.

L6.6 Design Criteria (Plan B)

L6.6.1 Bathymetric/Topographic Data

The island profiles used in the development of the design templates were produced from the BICM survey data set acquired in 2006 as described in Section L3. The survey data were utilized to develop representative profiles for each island. These profiles were also used in the SBEACH simulations described in Annex L-3 and served as the basis for calculating fill volumes required for the restoration design plans.

L6.6.2 Long-Term Erosion Rates

Because construction commencement is planned for 2012, designated as Target Year Zero (TY0), the designs had to account for erosion that would occur between 2006 and 2012. Design long-term erosion rates developed in Section L3.2 were used to calculate each barrier island's recession rate over the 6-year period. Fill templates were shifted landward of the 2006 shoreline positions to account for the projected erosion of the barrier shoreline by 2012.

L6.6.3 Relative Sea Level Change

Relative sea level change analysis was performed in accordance with the EC 1165-2-211 18-step guidance developed by USACE and presented in Section L2.7. According to this guidance, future subsidence rate remains constant, however, future eustatic SLR rate has three trends: historic (constant), intermediate (increase), and high (increase).

Based on the analysis, relative SLR derived from the intermediate trend (NRC Curve I) between 2006 and 2012 is equal to 0.2 ft. Therefore, the minimized restoration template design elevations were adjusted by a 0.2-ft vertical shift.

As demonstrated by the comparative analysis of the historic erosion rates adopted for the study and relative SLR induced erosion rates expressed in terms of the Bruun Rule (Sections L2.7 and L3.3), the uncertainties associated with future SLR and land loss subsidence are more than accounted for.

L6.6.4 Fill Compaction

The minimized restoration template was then analyzed to determine whether the beach/dune and marsh would require a vertical adjustment to account for compaction defined herein as the combined foundation settlement of the subsoils due to the weight of the fill and the self-weight consolidation within the imported fill materials themselves. The compaction value is a function of fill thickness and was derived for each island individually. The relationship between the fill thickness and compaction was developed based on data obtained from the CWPPRA project designs for Whiskey Island (LDNR, 2007) and Raccoon Island (NRCS, 2007) as described in Section L5.12.

Because the minimized template's beach/dune fill was sited above the mean low water line (MLW), the compaction value for the beach/dune portion of the fill was negligible. For Raccoon Island, the average beach/dune fill thickness below MLW was 2.2 ft, resultant compaction value was 0.2 ft, and its minimized restoration template design beach/dune elevations were shifted vertically accordingly.

Table L6-4 presents the average marsh fill thickness below MLW and the corresponding compaction value for each island. Based on the compaction analysis results, the minimized restoration template design marsh platform elevations were shifted vertically according to the compaction values.

Table L6-4. Marsh Thickness and Compaction Values

Island	Raccoon	Whiskey	Trinity	East	Wine	Timbalier	East Timbalier
Average Thickness (ft)	6.8	2.9	4.6	4.6	3.1	3.6	5.3
Compaction (ft)	0.7	0.3	0.5	0.5	0.3	0.4	0.5

L6.6.5 Existing CWPPRA Projects

The beach/dune and marsh design templates were reduced/adjusted to account for the CWPPRA TE-48 project on Raccoon Island (NRCS, 2007) and the CWPPRA TE-50 project on Whiskey Island (LDNR, 2007).

L6.6.6 Summary

Table L6-5 presents the summary of the dimensions of the TY0 (2012) Plan B restoration templates for each island. The restoration design plans and representative cross sections are presented in Annex L-2.

Table L6-5. Summary of TY0 Minimized Template Dimensions (Plan B)

Island	Raccoon	Whiskey	Trinity	East	Wine	Timbalier	East Timbalier
Gulf-side Beach Width (ft)	250	250	250	250	250	250	250
Dune Width (ft)	100	100	100	100	100	100	100
Bay-side Beach Width (ft)	100	100	100	100	100	100	100
Marsh Width (ft)	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Beach Elev. (ft, NAVD 88)	4.2	4.0	4.0	4.0	4.0	4.0	4.0
Dune Elev. (ft, NAVD 88)	6.4	6.2	6.2	6.2	6.2	6.2	6.2
Marsh Elev. (ft, NAVD 88)	2.5	2.1	2.3	2.3	2.1	2.2	2.3

L6.7 Restoration Designs for Various Design Periods (Plans C, D and E)

L6.7.1 Design Definition

In order to evaluate extending the longevity of the habitats created through the minimized restoration plan concept and enabling scaling, the PDT developed restoration plans for specific design periods. The definition of each plan was to ensure that the minimum restoration acreage would be retained at the end of the specified period. The PDT selected the 5-year (Plan C), 10-year (Plan D), and 25-year (Plan E) design periods, which were considered sufficient for developing a range of values for alternative plan formulation. The 50-year design period was screened out by the PDT because, in order to sustain itself for 50 years, the marsh platform would have to be elevated so high that it would not function as a marsh for the majority of the 50-year period of analysis. The marsh platform would not compact or subside to yield intertidal habitat for decades, thus this barrier island restoration template did not meet the definition of restoring geomorphologic form and ecologic function and was eliminated from further consideration.

L6.7.2 Design Components

L6.7.2.1 Long-Term Erosion Rates

Building upon the minimized restoration plans presented in Table L6-5 and long-term erosion rates developed in Section L3.2, the gulf-side beach width was increased for each island to account for design losses equivalent to the corresponding design period. For example, to create the Raccoon Island 10-year restoration plan, the Raccoon Island minimized gulf-side beach was extended landward by 28.6 ft/yr * 10 yrs = 286 ft. This typically resulted in the restoration template extending over existing island framework covering vegetated areas in both existing dunes and marsh.

L6.7.2.2 Design Storm Events

Using the results of the SBEACH modeling presented in Annex L-3, the beach width was increased for each island to account for the predicted value of shoreline recession in response to the specified design period storm event. The predicted values for the 5-year, 10-year, and 25-year design storms were 25 ft, 52 ft, and 77 ft, respectively. For example, for the Raccoon Island Plan D, in addition to the 286 ft of beach discussed in previous section, the Raccoon Island minimized gulf-side beach was extended further landward by 52 ft for a total of 338 ft.

L6.7.2.3 Short-Term Land Loss Rates

Building upon the minimized restoration templates, the marsh width was increased for each island to account for design marsh losses equivalent to the corresponding design period. The design short-term marsh land loss rates were developed in Section L3.3 based on the BICM (LDNR, 2008) and USGS (USGS, 2006) data sets and are summarized in Table L6-6.

Table L6-6. Short-Term Marsh Loss Rates

Island	Raccoon	Whiskey	Trinity/East	Timbalier	East Timbalier
Marsh Loss Rate (ac/yr)	8.4	14.4	3.1	10.9	23.8

For example, for the Raccoon Island Plan D, the Raccoon Island minimized marsh was extended landward by 84 acres which is equivalent to an average additional width of approximately 340 ft added on the bay side.

L6.7.2.4 Relative Sea Level Change

Relative sea level change analysis was performed in accordance with the EC 1165-2-211 18-step guidance developed by USACE and presented in Section L2.7. According to this guidance, future subsidence rate remains constant, however, future eustatic SLR rate has three trends: historic (constant), intermediate (increase), and high (increase).

Based on the analysis, relative SLR derived from the intermediate trend (NRC Curve I) between 2012 and 2017 is equal to 0.2 ft. Between 2012 and 2022, the SLR is equal to 0.4 ft and between 2012 and 2037 it is 0.9 ft. Therefore, the minimized restoration template design elevations were adjusted by a 0.2-ft, 0.4-ft and 0.9-ft vertical shifts for Plans C, D, and E, respectively..

As demonstrated by the comparative analysis of the historic erosion rates adopted for the study and relative SLR-induced erosion rates expressed in terms of the Bruun Rule (Sections L2.7 and L3.3), the uncertainties associated with future SLR and land loss subsidence are more than accounted for.

L6.7.2.5 Existing CWPPRA Projects

For Plans C and D, the beach/dune and marsh design templates were reduced/adjusted to account for the CWPPRA TE-48 project on Raccoon Island (NRCS, 2007) and the CWPPRA TE-50 project on Whiskey Island (LDNR, 2007). However, Plan E encompasses the footprints of these two projects because the CWPPRA projects' overall subsidence and settlement results in significant loss of geomorphologic form and ecologic function prior to TY25.

L6.8 HARD-STRUCTURAL MEASURE DESIGNS

L6.8.1 Hard-Structural Design Parameters

L6.8.1.1 Raccoon Island – Additional Breakwaters

As part of the TE-29 project, eight detached segmented breakwaters were constructed in 1997 at the eastern end of Raccoon Island to reduce shoreline erosion and promote accretion. These breakwaters are widely regarded as having fulfilled their intended function due to rapid salient development behind most of the breakwaters and a measurable decrease in the rate of shoreline retreat. In 2005, eight additional breakwaters were constructed immediately west of the original eight structures (TE-48 project).

Based on the performance of the TE-29 and TE-48 breakwaters and their parameters, a hard-structural design plan was developed, consisting of eight 300-ft long detached breakwaters spaced 300 ft apart along the remaining western part of Raccoon Island, in combination with placing beach, dune, and marsh fill. This structural measure was designed and evaluated based on the results of GENESIS modeling simulations of the existing breakwaters (Annex L-3) and their positive influence on the Raccoon Island shoreline. The modeling results yielded a negligible background erosion rate in the lee of the structures. The SBEACH modeling results were then used to predict the magnitude of shoreline erosion from episodic events within each design period to assess the performance of the breakwaters on the evolution of habitat acres over time. A 20-year design life was selected by the PDT based on the design criteria for compaction (Section L5.12) and relative SLR change. A typical design plan and section for the breakwaters are included with the restoration design plans in Annex L-2.

L6.8.1.2 Raccoon Island – Terminal Groin

This hard-structural design plan was aimed at capturing the net longshore sediment transport by constructing a 1,200-ft long terminal groin at the western end of Raccoon Island in combination with placing beach, dune, and marsh fill. This would result in retaining sediment on the beach updrift of the groin. This structural measure was evaluated by GENESIS modeling simulations (Annex L-3). The modeling results provided the background erosion rate used to assess the performance of the structure on the evolution of habitat acres over time. A 20-year design life was selected by the PDT based on the design criteria for compaction and relative SLR change. A typical design plan and section for the breakwaters are included with the restoration design plans in Annex L-2.

L6.8.1.3 Whiskey Island – Breakwaters

The design parameters for the breakwaters on Whiskey Island were based on the structural configuration of the TE-29 breakwaters on Raccoon Island. This hard-structural design plan consisted of constructing 300-ft long detached breakwaters spaced 300 ft apart along the entire length of Whiskey Island 300 ft gulfward of the shoreline, in combination with placing beach, dune, and marsh fill. The modeling results provided the background erosion rate used to assess the performance of the structure on the evolution of habitat acres over time. A 20-year design life was selected by the PDT based on the design criteria for compaction and relative SLR change. A typical design plan and section for the breakwaters are included with the restoration design plans in Annex L-2.

L6.8.2 Operation & Maintenance Measures

L6.8.2.1 Breakwaters and Terminal Groin

The purpose of Operation and Maintenance (O&M) is to allow a project to continue to function. For a structure such as a breakwater or a terminal groin, O&M is required to keep the structure functioning at a certain level to provide the benefits claimed in the analysis.

The breakwaters and terminal groin structural measures were evaluated based on a design life of 20 years. During this time, the structures will be maintained and repaired, if necessary. Based on information obtained through personal communication with NRCS, one of the sixteen TE-29 and TE-48 breakwaters on Raccoon Island had to be repaired because of structural settlement (Personal communication, Loland Broussard of NRCS, Dec, 02, 2009). Otherwise the existing breakwaters have performed and required little to no O&M. Costs for O&M are projected for the applicable measure and discussed in Section L9.

After 20 years, the effectiveness of the structural measures is projected to substantially diminish because of the sea level change, subsidence, and barrier island landward migration. Maintenance of the structures to the original design after 20 years will no longer result in the same level of function and benefits as the original structures once provided. In order to make the breakwaters and terminal groin functioning and beneficial after 20 years, the structures will have to be modified and rebuilt, which does not qualify as O&M.

L6.9 PROTECTION OF EXISTING HABITATS

As described in the design process, the templates for the conceptual design plans placed the fill over existing healthy vegetated habitats. During a field trip to the Study Area conducted in July 2009, concerns were expressed by various PDT members as they observed that existing healthy vegetated dunes and marsh areas would be covered by the proposed restoration plans on the majority of the seven islands as well as existing healthy mangroves on Raccoon and Whiskey Islands. These concerns were discussed through the plan formulation process and it was determined by the PDT that dune and marsh habitats could be recreated as part of the restoration plans. However, due to the challenges with recreating existing mangrove habitats, the PDT determined that covering existing healthy mangrove habitats was inconsistent with the Study goals and objectives, thus the fill templates for Raccoon and Whiskey Islands were redesigned by translating the beach and dune gulfward noting these plans increased the volume of sand required to achieve the design templates.

L6.10 HABITAT ACREAGES

The cross-shore forcing functions including storm impacts, overwash, island rollover and migration northward combined with the affects of relative SLR dominate the erosion processes on the islands compared to the alongshore forcing functions. Therefore, the historic shoreline change rates and land loss rates combined with the affects of relative SLR served as the design criteria for background erosion and determining habitat evolution over time versus the sediment budget.

Table L6-7 presents existing habitat acres (Plan A) and the habitat acres created by each restoration plan (Plans B, C, D, and E) based on the intermediate SLR trend (NRC Curve I). The total acres at key target years within the 50-year period of analysis were determined by applying the design criteria for shoreline erosion, compaction, relative SLR, land loss, and storm erosion. The weighted average was computed by taking the values at each key target year, averaging them, and then multiplying by the period. This process is fully described in Appendix K.

Table L6-7. Summary of Created Habitat Acres

Island	Plan	Beach/Dune Area at TY1* (ac)	Marsh Area at TY1 (ac)	Total Area at TY1 (ac)	Total Area at TY50 (ac)	Weighted Average Area over 50 years (ac)
Raccoon	Plan A	51	184	235	0	77
	Plan B	271	235	506	23	343
	Plan C	341	237	578	227	428
	Plan D	520	122	642	292	490
	Plan E	751	39	790	476	637
	Plan B w/ BW	271	237	508	38	368
	Plan C w/ BW	342	239	580	276	457
	Plan D w/ BW	521	122	643	341	521
	Plan E w/ BW	752	39	791	540	671
	Plan B w/ TG	271	237	508	34	364
	Plan C w/ TG	341	238	579	270	453
	Plan D w/ TG	520	122	642	337	515
	Plan E w/ TG	751	38	789	534	666
Whiskey	Plan A	377	443	820	0	290
	Plan B	670	509	1180	276	691
	Plan C	895	377	1271	363	801
	Plan D	986	376	1362	355	869
	Plan E	1402	250	1652	475	1163
Trinity	Plan A	238	326	564	0	131
	Plan B	464	569	1033	33	553
	Plan C	585	564	1149	199	667
	Plan D	1198	72	1270	298	789
	Plan E	1523	67	1589	625	1114

Island	Plan	Beach/Dune Area at TY1* (ac)	Marsh Area at TY1 (ac)	Total Area at TY1 (ac)	Total Area at TY50 (ac)	Weighted Average Area over 50 years (ac)
East	Plan A	199	59	258	0	68
	Plan B	318	362	680	46	359
	Plan C	385	372	756	122	432
	Plan D	802	33	835	192	512
	Plan E	1027	33	1060	397	733
Wine	Plan A	5	6	11	0	4
	Plan B	109	97	206	5	131
	Plan C	122	117	239	9	161
	Plan D	130	140	270	7	188
	Plan E	349	17	366	229	298
	Ring Only	26	3	29	1	8
Timbalier	Plan A	606	374	979	2	341
	Plan B	903	726	1629	175	890
	Plan C	1743	85	1828	373	1095
	Plan D	1952	83	2035	571	1304
	Plan E	2561	69	2630	1141	1898
East Timbalier	Plan A	75	133	208	4	87
	Plan B	376	452	828	7	538
	Plan C	1057	71	1128	496	765
	Plan D	1170	60	1230	726	983
	Plan E	1762	99	1861	1310	1576

* TY1 denotes Target Year 1 when construction is completed

L6.11 National Ecosystem Restoration (NER) Plan

The USACE objective in ecosystem restoration planning is to contribute to National Ecosystem Restoration (NER) Plan. Contributions to national ecosystem restoration (NER outputs) are increases in the net quantity and/or quality of desired ecosystem resources. Measurement of the NER Plan is based on changes in ecological resource quality as a function of improvement of habitat quality and/or quantity and expressed quantitatively in physical units or indexes (ER 1105-2-100).

As identified through three levels of screening, the measures carried forward into the alternatives development stage included at a minimum dune restoration, marsh creation, and beach restoration. During the plan formulation PDT meetings, the NER Plan was defined as the most cost effective plan that yielded the optimal habitat benefits from restoring the geomorphologic form and ecologic function of the beach, dune and marsh components on one or more of the islands.

Raccoon with Terminal Groin (Plan E) / Whiskey (Plan C) / Trinity (Plan C) / and Timbalier (Plan E) with the addition of renourishment was selected as the NER Plan The alternative restores the geomorphologic form and ecologic function of the four islands in the Terrebonne Basin barrier island system. Immediately after construction (TY1), the

NER Plan will add 3,283 acres of habitat (dune, intertidal, and supratidal) to the existing island footprints of Raccoon, Whiskey, Trinity, and Timbalier Islands, increasing the total size of the islands to 5,840 acres.

The renourishment quantity and sequencing was selected by determining the minimum amount needed to maintain the geomorphic form and ecologic function of the islands throughout the 50-year period of analysis (Appendix K). The resulting configurations are provided in Table L6-8. Marsh renourishment was not included since the initial restoration plan provides for significant intertidal habitat throughout the 50-year period of analysis.

Table L6-8. Renourishment Sequencing and Plans

Island Plan	Renourishment Year	Renourishment Plan
Raccoon Plan E w/ TG	TY30	Restore Plan B
Whiskey Plan C *	TY20	Add Plan C
	TY40	Add Plan B
Trinity Plan C	TY25	Add Plan C
Timbalier Plan E	TY30	Restore Plan B

* Whiskey would require two renourishments, one at TY20 and one at TY40

Raccoon Plan E will be renourished at TY30 by adding adequate sediment such that the dune and supratidal beach acres would be equivalent to that of a newly constructed Plan B template (i.e. restore a Plan B at TY30). No additional marsh material will be added.

Whiskey Plan C will require two renourishment intervals. The first will occur at TY20 and will include the addition of the same amount of dune and supratidal beach habitat that was originally created in TY1 (i.e. add a Plan C to the template at TY20). The second renourishment interval will occur at TY40 and will include the addition of the same amount of dune and supratidal beach habitat needed to construct a Plan B template. No additional marsh material will be added.

Trinity Plan C will be renourished at TY25 by adding the same amount of dune and supratidal beach habitat that was originally added in TY1 (i.e. add a Plan C to the template at TY20). No additional marsh material will be added.

Timbalier Plan E will be renourished at TY30 by adding adequate sediment such that the dune and supratidal beach habitat acres would be equivalent to the acres of a newly constructed Plan B template (i.e. restore a Plan B at TY30). No additional marsh material will be added.

The NER Plan is fully described in the Integrated Feasibility Study and Final Environmental Impact Statement Report, Section 3.6.

L6.12 First Component of Construction

A separate analysis was conducted on the individual islands of the NER Plan resulting in the selection of the first component of construction that could be constructed within the budget. The first component of construction consists of restoration of Whiskey Island to its minimal geomorphologic form and ecologic function along with five (5) years of advanced fill (Plan C) and two renourishment events, one at TY20 to add Plan C and the other one at TY40 to add Plan B.

The first component of construction is fully described in the Final Integrated Feasibility Study and Final Environmental Impact Statement Report, Section 3.7.

L7. CONSTRUCTION PROCEDURES AND ACCESS

L7.1 BEACH AND DUNE FILL

Based on professional experience and related CWPPRA project construction methods, it is anticipated that the contractor will use a hydraulic cutterhead dredge plant to excavate sand from the available sand borrow areas. Environmental laws protecting sea turtles could possibly require the cessation of work for a limited time if the allowable number of sea turtles killed is exceeded during dredging. The sand will then be pumped through a series of booster pumps to the beach/dune fill template via a submerged sediment pipeline.

During construction the contractor will be directed to maintain dedicated equipment loading/unloading areas, staging areas, and access corridors to minimize the impacts to the island. Existing mangrove habitats and prior restoration project areas shall be avoided by construction equipment and construction-related activities.

Once on the beach, the sediment pipeline will run parallel to the shoreline. Front-end loaders that are equipped with grapple arms will be utilized in the placement and relocation of the sediment pipeline. For segments of the fill template that have sufficient width, a Y-valve will be utilized to enable placement of multiple sediment pipelines along the template. The bifurcation of the discharge pipeline will facilitate lower discharge velocities and increased sediment retention within the fill template. In order to minimize the impact on piping plover, the beach will be constructed in sections to allow the birds to move to areas that are not currently under construction.

The sand will be worked on the beach by bulldozers to meet the specified template grades, slopes and widths. Construction methods may vary but it is anticipated that sand placement along the shoreline will be controlled by advancing a temporary sand dike several hundred feet parallel to shore ahead of the discharge terminus. This aids in reducing initial fill losses offshore and helps control temporary turbidity that may result from the fill placement operations. Typically water drainage and discharges will be directed offshore into the Gulf of Mexico or into existing marsh areas to nourish these habitats.

L7.2 BACK-BARRIER MARSH FILL

Based on professional experience and related CWPPRA project construction methods, it is anticipated that the contractor will use a hydraulic cutterhead dredge and booster pump(s) to excavate sediment from the available offshore marsh borrow area(s) and directly transport it via a submerged sediment pipeline to the marsh platform. As with the beach fill, environmental laws protecting sea turtles could possibly require the cessation of work for a limited time if the allowable number of sea turtles killed is exceeded during dredging. However, turtles are typically able to avoid cutterhead dredge intakes because the dredges move along the seabed at such a slow speed.

Sediment used to construct the marsh containment dikes will be dredged from existing material inside the marsh creation area rather than from offshore borrow areas. Therefore, dredging operations associated with the containment dikes are not expected to adversely impact sea turtles.

These operations will be done in a manner that will minimize turbidity. Discharge and dewatering from the marsh fill shall typically be directed towards the Gulf of Mexico including orienting discharge pipes such that the hydraulic flow moves in a gulfward direction and locating dewatering structures on the gulf side of the Study Area. The contractor may employ other methods such as building interior containment dikes and creating a drainage gradient towards the gulf. If excess turbidity occurs, the contractor will be directed to change the operating procedure to reduce the degree of turbidity.

L7.3 CONSTRUCTION ACCESS

The required land based equipment including but not limited to graders, loaders, dozers, and marsh buggy backhoes will be transported from the mainland to the islands via barge(s). The contractor will excavate access channels from the Gulf of Mexico or the back bays to the islands utilizing barge mounted clamshell dredges with temporary sidecast disposal. Exact access to the beach/dune and marsh fill templates will be determined and coordinated during the Planning, Engineering, and Design phase and will include the necessary easements. The contractor will be required to submit a construction access plan which shall contain provisions for restoring any damaged habitats.

Miscellaneous equipment to be stored on the beach may include sediment pipeline, graders, loaders, dozers, marsh buggy backhoes, weirs, grade stakes, light towers, fuel tanks with containment, welding machine, and temporary shanty for personnel. Further, the contractor will locate a quarters barge in an appropriate sheltered staging area to house the land based personnel and office facilities.

L8. ADAPTIVE MANAGEMENT PLAN (OPERATIONS AND MAINTENANCE)

The details for post-construction monitoring and adaptive management activities proposed for the Study along with estimates of cost and duration are presented in Appendix I. A description of O&M activities and estimates of cost for O&M are presented in Section L9.

L9. COST ESTIMATES

L9.1 CONCEPTUAL COST ESTIMATES

The conceptual cost estimates for each island restoration measure utilizing one or more of the sand and marsh borrow areas were determined by computing the costs based on equipment types and estimates of production rates, historical contract bids from projects of a similar nature, and professional experience. Conceptual costs were developed for individual islands in order to evaluate each measure on a level and consistent basis. Each island restoration estimate included a dredge plant for beach/dune fill and a dredge plant for marsh fill. Each dredge equipment cost estimate included pipeline, equipment mobilization/demobilization, and support plant. This method allowed for interchangeability of dredge type for beach/dune fill and marsh fill to evaluate the most efficient method of island restoration.

The costs derived were provided as inputs to the USACE Institute for Water Resources (IWR) Planning Suite which assists with formulation and comparison of alternative plans. The IWR analysis is fully described in Appendix K. The IWR model was employed to determine which island measure or combinations of island measures would be cost effective.

L9.1.1 Basis

The basis of the conceptual cost estimates were comprised of the following items:

<u>Mobilization / Demobilization</u>

The mobilization/demobilization costs included the anticipated plant and equipment to be used in the excavation, transportation, and placement of beach, dune and marsh fill. Separate mobilization/demobilization costs were developed for the beach/dune and marsh fill components in the event that independent dredge types would be used for the different fill elements. This provided the flexibility to use a hopper dredge or a cutterhead dredge for beach/dune fill and a cutterhead dredge for marsh fill construction. The derived costs were then compared to historic contract bids from the USACE and CWPPRA projects of a similar nature.

<u>Surveying</u>

Surveying costs included a daily rate for survey crew, survey vessel, and survey equipment, multiplied by the sum of the predicted sediment pumping duration, weather days, and mobilization days. Additional costs included a lump sum for survey crew travel and the installation and maintenance of marsh fill grade stakes.

Access Channel

Access channel costs were based on a unit cost per linear foot and derived from historical contract bids. The linear footage of the access channel for each island was estimated as the length of the northern containment dike.

Marsh Fill

Marsh fill volume was estimated using the BICM 2006 survey data, adjusted to account for background erosion and the effects of relative sea level rise between the date of the BICM survey and the anticipated start date of construction. Equipment costs were estimated by considering the daily rate for the cutterhead dredge and booster pump(s), fuel, per foot pipeline costs, and supporting equipment costs. The estimated equipment daily rates were then multiplied by the estimated construction duration, which was based on production rate, weather days, and mobilization/demobilization days. The unit cost per cubic yard for marsh fill was calculated by dividing the equipment total cost by the volume of marsh fill required.

Containment Dikes

Containment dikes are included in each island plan to provide sediment retention during marsh fill placement and to prevent sediment overflow into vegetative areas requiring protection from construction activities. The containment dikes are built with in-situ sediment. Containment dike linear footage is the sum of the northern and southern marsh retention dikes and, if required, the vegetative protection dikes. The containment dike unit cost per linear foot was derived from historical contract bids.

Beach / Dune Fill

Beach/dune fill volumes were estimated using the BICM 2006 surveys and adjusted to account for background erosion and the effects of relative sea level rise between the date of the BICM survey and the anticipated start date of construction. Equipment costs were estimated by considering the daily rate for the cutterhead or hopper dredge and booster pump(s), fuel, per foot pipeline costs, and supporting equipment costs. The estimated equipment daily costs were then multiplied by the estimated construction duration, which was based on production rate, weather days, and mobilization/demobilization days. The unit cost per cubic yard of beach/dune fill was calculated by dividing the equipment total cost by the volume of beach/dune fill required.

Breakwaters / Terminal Groin

Breakwater and terminal groin conceptual costs were developed following review of the contract bids for the CWPPRA breakwater extension project on Raccoon Island (TE-48) completed in 2008. Unit cost per ton for boulders; unit cost per square yard for geotextile; and lump sum costs for mobilization/demobilization, construction surveys, and quality control were developed and applied to the breakwater and terminal groin preliminary designs that incorporated these elements.

Sea Turtle Relocation

Sea turtle relocation trawling is used during hopper dredge operations in areas where turtles are known or suspected to be present. Relocation trawling is conducted using nets constructed to USACE specifications. The location of this Study Area is ideally suited for low cost mobilization/demobilization to due to the abundance of available trawlers in coastal Louisiana that could be contracted for this task. An approved National Marine Fisheries Service observer must be present during all relocation surveys. Sea turtle relocation costs were developed using historical contract bids.

Inspection / Construction Administration

The construction inspection costs were estimated by multiplying the inspector daily rate by the sediment pumping duration, weather days, and demobilization days. The construction inspector costs also included a lump sum cost for travel. The construction administration costs were estimated by multiplying the administration daily rate by the estimated construction duration along with a lump sum cost for travel.

L9.1.2 Assumptions

The following assumptions were used in the development of the conceptual cost estimates.

Dredge and Supporting Plant

The use of hopper and cutterhead suction dredges were evaluated as methods of sediment excavation. Consideration of both dredges allowed for the selection of the most cost effective method of island restoration. Following review of available hopper dredge fleet information, a 6,000 cubic yard (cy) hopper dredge was selected for use in the comparative costing analysis between island plans. A similar review was conducted for the cutterhead suction dredge, with the 30" dredge being selected. Supporting plant consist of booster pumps, support vessels, and other ancillary equipment. The following assumptions were used in the development of production rates and equipment cost for each dredge type and for each island:

Hopper Dredge

- Hopper dredge capacity: 6,000 cy (5,100 cy retained)
- Hopper dredge duration: 24 hours/day
- Hopper dredge pump horsepower: 4,500 Hp
- Hopper dredge propulsion horsepower: 5,000 Hp

Cutterhead Suction Dredge

- Cutterhead suction dredge size: 30"
- Cutterhead suction dredge duration: 20 hours/day
- Cutterhead suction dredge horsepower: 9,000 Hp

Booster Pumps

- Booster pump horsepower: 5,200 Hp

Support Plant

- Support plant horsepower: 1,000 Hp

Applying these assumptions, production rates were calculated using the *Cutter Suction Dredge Cost Estimating Program* (CSDCEP) developed by the Center for Dredging Studies, Zachry Department of Civil Engineering, Texas A&M University. Inputs for the production rate calculations for cutterhead suction dredge were average pipeline length from the borrow area to fill area, bank height, general sediment characteristics, and the dredge size. The hopper dredge inputs were the same as the cutterhead suction dredge with the exception of the pipeline length and the addition of vessel speed, sailing distance, and dredging depth. The offshore pipeline length for the hopper dredge was set at two miles, which is the average distance from the shoreline to water depths which would accommodate a loaded 6,000cy hopper dredge. Applying these inputs to the CSDCEP program yielded production rates for each dredge type. For the cutterhead suction dredge, the production rate and the number of booster pumps required were outputs. For the hopper dredge, the outputs included the estimated cycle time and volume per cycle.

General Construction

The following is a listing of the general conceptual construction assumptions applied in the development of the conceptual cost estimates:

- Mobilization time: 30 days
- Demobilization time: 30 days
- Beach and Dune fill dredge-to-fill ratio: 1.3:1
- Marsh fill dredge-to-fill ratio: 1.6:1

Dredge-to-fill ratios account for losses during excavation and transport of the material and overfill. Design fill quantities account for sea level rise, subsidence, and initial fill compaction.

L9.1.3 Contingencies

Based on professional experience, a 25% contingency was chosen for developing the conceptual cost estimates. This contingency was included to account for uncertainties in the development of the cost estimates including such things as fuel costs, contractor availability at the time of bidding, weather-related downtime during construction, and fill volume adjustments needed to construct the selected fill templates at time of construction. To reduce the uncertainties in the fill volume calculations, historical shoreline erosion rates, land loss rates, and the effects of relative sea level rise were applied to predict the background erosion that would be experienced from the date of the design survey to the actual construction period. These background erosion losses were applied to the island design templates as they were formulated.

L9.1.4 Refined Conceptual Cost Estimates

Following development of the conceptual cost estimates and initial IWR model results, combinations of island restorations were analyzed. As described in Section L9.1, the conceptual cost estimates were developed separately for individual islands and their associated beach/dune and marsh fill components. The initial conceptual cost estimates did not account for potential reductions due to shared mobilization and demobilization as well as other fixed costs. The conceptual cost estimates were re-evaluated and redundancies in cost components were eliminated. The reductions resulted in a single dredge mobilization/demobilization and associated mobilization/demobilization days for the combinations where the same dredge plant was selected for beach/dune and marsh fill. Redundant support plant cost was also eliminated and remaining support plant cost was shared between beach/dune and marsh fill components. Finally, redundant pipeline cost for beach/dune and marsh fill was eliminated, carrying forward only the longest pipeline length from borrow area to fill area that is required for each island in the combination. After removing redundant costs for the dredge plant and associated pipeline for each of the marsh and sand borrow areas, costs for relocating the pipeline from the sand borrow area to the marsh borrow area and from island to island were computed and included in the refined conceptual cost estimate.

L9.2 PRELIMINARY COST ESTIMATES

The preliminary cost estimates were developed for the island restoration alternatives in the Intermediate Array (Appendix K). These preliminary cost estimates built on the refined conceptual cost estimates with the inclusion of planning, engineering, and design; real estate easements; sand fencing; vegetative plantings; monitoring; and operation and maintenance.

L9.2.1 Basis

The basis of the preliminary cost estimates included the basis of the conceptual and refined conceptual cost estimates, defined in Section L9.1.1, along with the additional elements listed above.

<u>Planning, Engineering & Design</u>

The Planning, Engineering & Design Phase (PED) is the phase during which the design is finalized, plans and specifications are prepared and reviewed, and a construction contract is prepared for advertising consistent with USACE Engineering Regulation ER1110-2-1150 (USACE, 1999). The preliminary cost estimate for PED was based on professional experience.

Real Estate Easements

Easements and acquisitions were evaluated on a preliminary level for comparative purposes at this stage of alternative formulation. East Timbalier Island is the only island that contains oil and gas infrastructure that would be impractical to provide access to through canals. Acquisition of these structures was preliminarily estimated at 2% of the construction cost of this island. Access canals for Timbalier Island were relatively short and incorporated into the construction cost for containment dikes and access channels. All other islands did not possess oil and gas facilities or wells.

Sand Fencing

The design parameters for the sand fencing included a 4-foot high fence with 50% porosity (*i.e*., ratio of area of open space to total fence area) placed shore-parallel along the entire length of the dune to capture wind-blown sand and to help build and stabilize mounds. The sand fencing unit cost per linear foot was derived from historical contract bids

Vegetative Plantings

Vegetative planting cost estimates were derived from the analyses of historical contract bids and current recommendations for other LCA and CWPPRA projects in design. These cost estimates should be considered as preliminary only and should be amended as the site conditions warrant during PED. The design parameters for the vegetative planting plan are as follows.

Dune and Supratidal Platform

Based on professional experience, aerial dispersion of grass seed should be conducted on the dune and supratidal platform if construction completion occurs in the summer or fall months to provided ground cover during the winter, until vegetative plantings can be accomplished. As the time of completion of construction can not be determined at this time, aerial seeding was included in the preliminary cost estimate as a conservative measure.

Herbaceous plantings for the dune and supratidal platform included a mixture of species comprised of some or all of the following: bitter panicum (*Panicum amarum* var *amarum* 'Fourchon'), sea oats (*Uniola paniculata* 'Caminada'), marshhay cordgrass (*Spartina patens* 'Gulf Coast') and gulf cordgrass (*Spartina spartinae*). Species recommendations should be re-evaluated during PED when accurate soil properties, site conditions, salinity, and final elevations are determined. Herbaceous planting of the dune and supratidal areas would be conducted in the first year following construction.

Marsh Platform

Herbaceous planting for the marsh intertidal platform included smooth cordgrass (*Spartina alterniflora* 'Vermilion'). Planting of the marsh intertidal platform would be over 100% of the area on 8-foot centers. The herbaceous planting would be conducted in two phases. Phase one would plant 50% coverage of the marsh platform in second year following construction, with the remaining 50% coverage planted in third year following construction.

Woody Species

Woody species for the dune and supratidal swale areas included matrimony vine (*Lycium barbarum*), wax myrtle (*Morella cerifera*), iva (*Iva imbricata*), eastern baccharis (*Baccharis halimifolia*), and hercules club (*Zanthoxylum clava-herculis*). Species recommendations should be re-evaluated during PED when accurate soil properties, site conditions, salinity, and final elevations are determined. Woody species would be planted on the dune and supratidal swale areas 15% coverage in the second year following construction.

Aerial Seeding

Aerial seeding will be conducted over the dune / swale and marsh habitat areas with the appropriate seed species for the time of year following completion of construction activities.

Supervision and Inspection

Independent supervision and inspection during the construction phase is included to insure construction proceeds as scheduled, designed, and permitted. The preliminary cost estimates for supervision and inspection were based on professional experience.

Monitoring

An effective monitoring program will be required to determine if the outcomes are consistent with original goals and objectives. The monitoring plan consists of bathymetric and topographic surveys; aerial photography to define habitat classification and shoreline position; geotechnical sampling to determine sediment properties; and analysis of all data collected (Appendix I). The preliminary cost estimates for monitoring were based on professional experience.

Operations and Maintenance

The O&M elements included the measures outlined in the Adaptive Management Plan (Appendix I). The preliminary cost estimates for O&M were based on professional experience. O&M also included maintenance of the hard structural measures included in the Final Array, specifically the Raccoon Island breakwaters or terminal groin (Section L6). Based on the effects of relative sea level rise and performance of the TE-48 breakwaters, maintenance was projected at TY10. The maintenance costs included 25% of the initial rock volume along with mobilization/demobilization, quality control, and surveying.

L9.2.2 Assumptions

The assumptions made in the development of the preliminary cost estimates included the assumptions made for the conceptual and refined conceptual cost estimates, defined in Section L9.1.2.

L9.2.3 Contingencies

Based on professional experience, a 25% contingency was chosen for developing the preliminary cost estimates for all elements. This overall contingency was included to account for uncertainties in the development of the cost estimates including such things as fuel costs, contractor availability at the time of bidding, weather-related downtime during construction, and fill volume adjustments needed to construct the selected fill templates at time of construction. To reduce the uncertainties in the fill volume calculations, historical shoreline erosion rates, land loss rates, and the effects of relative sea level rise were applied to predict the background erosion that would be experienced from the date of the design survey to the actual construction period. These background erosion losses were applied to the island design templates as they were formulated.

L9.3 DETAILED COST ESTIMATE

Detailed cost estimates were developed for the NER Plan. The estimates include mobilization/demobilization; beach/dune fill placement; marsh fill placement; containment dikes; access channel; sand fencing; vegetative plantings; surveying; PED; construction management; adaptive management; and post-construction monitoring.

The NER Plan includes the following restorations and renourishments:

- Whiskey Island to its minimal geomorphologic form and ecologic function along with 5 years of advanced fill, followed by renourishment to the same plan in Target Year (TY) 20 and a second renourishment to the minimum geomorphologic form and ecological function only, in TY40;
- Trinity Island to its minimal geomorphologic form and ecologic function along with 5 years of advanced fill, followed by renourishment to the same plan in TY25;
- Raccoon Island to its minimal geomorphologic form and ecologic function along with25 years of advanced fill with the addition of a terminal groin on the western beach fill boundary, followed by renourishment in TY30 to the minimum geomorphologic form and ecological function only. O&M of the terminal groin would be accomplished in TY10; and
- Timbalier Island to its minimal geomorphologic form and ecologic function along with 25 years of advanced fill with renourishment to the minimum geomorphologic form and ecological function only in TY30.

The costs for the renourishment events include mobilization/demobilization; beach/dune fill placement; sand fencing; vegetation planting (dune/supratidal platform only); surveying; PED; and construction administration.

The NER Plan costs were subdivided into two contracts for initial restoration and individual contracts for renourishments or O&M. Contract No. 1 consists of the initial restoration of Whiskey Island, Trinity Island, and Raccoon Island with terminal groin. Contract No. 2 consists of initial restoration of Timbalier Island. The individual O&M and renourishment contracts are Raccoon Island terminal groin O&M (No. 3), Whiskey Island renourishment in TY20 (No. 4), Trinity Island renourishment in TY25 (No. 5), Raccoon Island and Timbalier Island renourishment in TY30 (No. 6), and Whiskey Island renourishment in TY40 (No. 7).

The first component of construction is a subset of the NER Plan consisting of initial restoration of Whiskey Island to its minimal geomorphologic form and ecologic function along with 5 years of advanced fill, followed by renourishment to the same plan in TY20 and a second renourishment to the minimum geomorphologic form and ecological function only, in TY40.

Unit costs for beach/dune and marsh fill were developed in the USACE Corps of Engineers Dredge Estimating Program (CEDEP) program. The dredge plant selected was a 30" cutterhead suction dredge and associated plant consisting of booster pumps, support vessels, and other ancillary equipment. The unit costs were added to the cost development in the MII software. Risk analyses were performed and provided the cost contingency at an 80% confidence level for the initial restoration of the NER Plans and the first component of construction. A fixed cost contingency percentage was applied to the renourishment events based on professional judgement. A construction schedule was developed and total costs were determined through escalation to mid-point of design, construction, and monitoring.

L9.3.1 Basis

Fill Material Sourcing

The NER Plan would utilize beach/dune and marsh material from a combination of Whiskey Island Restoration Borrow Area 3, New Cut Borrow Area 4, Raccoon Island Restoration Borrow Area 5, South Pelto Borrow Area 6, and Ship Shoal Borrow Area 7 (Section L1). Table L9-1 presents the required fill and cut volumes per borrow area for the NER Plan with renourishments.

The first component of construction would utilize beach/dune and marsh material from a combination of Whiskey Island Restoration Borrow Area 3 and Ship Shoal Borrow Area 7 (Section L1). Table L9-2 presents the required fill and cut volumes per borrow area for the first component of construction with renourishments

Table L9-1. NER Plan Borrow Areas and Cut Volumes

	Borrow Area	Beach/Dune Fill Volume (cy)	Marsh Fill Volume (cy)	Dredge-to-Fill Ratio	Beach/Dune Cut Volume (cy)	Marsh Cut Volume (cy)
Initial Restoration	Ship Shoal Borrow Area 7	17,500,000	2,760,000	1.13:1	19,800,000	3,120,000
	South Pelto Borrow Area 6	10,700,000	3,080,000	1.13:1	12,090,000	3,480,000
	Whiskey Island Restoration Borrow Area 3	–	4,790,000	1.6:1 upper layer	–	7,660,000
		–	3,630,000	1.3:1 lower layer	–	4,720,000
	New Cut Borrow Area 4	–	1,920,000	1.3:1	–	2,500,000
	Raccoon Island Restoration Borrow Area 5	–	1,850,000	1.3:1	–	2,400,000
Renourishment	Ship Shoal Borrow Area 7	20,400,000	–	1.13:1	23,100,000	–
	South Pelto Borrow Area 6	470,000	–	1.13:1	531,000	–

Table L9-2. First Component of Construction Borrow Areas and Cut Volumes

	Borrow Area	Beach/Dune Fill Volume (cy)	Marsh Fill Volume (cy)	Dredge-to-Fill Ratio	Beach/Dune Cut Volume (cy)	Marsh Cut Volume (cy)
Initial Restoration	Ship Shoal Borrow Area 7	8,330,000	–	1.13:1	9,410,000	–
	Whiskey Island Restoration Borrow Area 3	–	580,000	1.6:1 upper layer	–	928,000
Renourish-ment	Ship Shoal Borrow Area 7	14,700,000	–	1.13:1	16,600,000	–

Beach/Dune Fill Placement

For beach/dune construction the sand will be worked bulldozers to meet the specified template grades, slopes and widths. Construction methods may vary but it is anticipated that sand placement along the shoreline will be controlled by advancing a temporary sand dike several hundred feet parallel to shore ahead of the discharge terminus. This aids in reducing initial fill losses offshore and helps control temporary turbidity that may result from the fill placement operations. Typically water drainage and discharges will be directed offshore into the GOM or into existing marsh areas to nourish these habitats. The fill quantities for the beach/dune component of the initial restoration and renourishments of the NER Plan and first component of construction are listed in Table L9-3.

Marsh Fill Placement

For marsh construction the fill material will be directed into the fill cells with the aid of a marsh backhoe directing the discharge pipeline. Discharge and dewatering from the marsh fill shall typically be directed towards the GOM including orienting discharge pipes such that the hydraulic flow moves in a gulfward direction and locating dewatering structures on the gulf side of the Study Area. The contractor may employ other methods such as building interior containment dikes and creating a drainage gradient towards the gulf. If excess turbidity occurs, the contractor will be directed to change the operating procedure to reduce the degree of turbidity. Fill quantities for the marsh component of the initial restoration of the NER Plan and first component of construction are listed in Table L9-3.

Table L9-3. NER Plan and First Component of Construction Required Fill Quantities Breakdown

NER Plan with Renourishments	Fill Area	Quantity (CY)
Whiskey Is. Initial Construction	Beach/Dune	8,330,215
	Marsh	579,724
Trinity Is. Initial Construction	Beach/Dune	3,813,885
	Marsh	3,772,925
Raccoon Is. Initial Construction	Beach/Dune	5,381,956
	Marsh	4,609,709
Timbalier Is. Initial Construction	Beach/Dune	10,702,818
	Marsh	9,073,317
Whiskey Is. Renourishment TY20	Beach/Dune	8,330,215
Trinity Is. Renourishment TY25	Beach/Dune	3,813,885
Raccoon Is. Renourishment TY30	Beach/Dune	1,946,212
Timbalier Is. Renourishment TY30	Beach/Dune	470,203
Whiskey Is. Renourishment TY40	Beach/Dune	6,359,650
First Component of Construction with Renourishments	Fill Area	Quantity (CY)
Whiskey Is. Initial Construction	Beach/Dune	8,330,215
	Marsh	579,724
Whiskey Is. Renourishment TY20	Beach/Dune	8,330,215
Whiskey Is. Renourishment TY40	Beach/Dune	6,359,650

Submerged and Shore Pipeline Relocations

Submerged pipeline relocations will be required during construction to facilitate the utilization of the different borrow areas for beach/dune and marsh restoration Relocations of the shore pipeline would be accomplished at the completion of the fill activities on each island. Costs were developed for the extraction and reinstallation of the submerged portions of the pipeline from one borrow area to another and the relocations of the shore pipeline segments These costs include equipment and crews to perform the work at an assumed rate of 1,500 feet per day.

Construction Access

The required land based equipment including but not limited to graders, loaders, dozers, and marsh buggy backhoes will be transported from the mainland to the islands via barge(s). The contractor will excavate access channels from the GOM to the islands utilizing barge mounted clamshell dredges with temporary sidecast disposal. Exact access to the beach/dune and marsh fill templates will be determined and coordinated during PED and will include the necessary easements. The contractor will be required to submit a construction access plan which shall contain provisions for restoring any damaged habitats.

Miscellaneous equipment to be stored on the beach may include sediment pipeline, graders, loaders, dozers, marsh buggy backhoes, weirs, grade stakes, light towers, fuel tanks with containment, welding machine, and temporary shanty for personnel. Further, the contractor will locate a quarters barge in an appropriate sheltered staging area to house the land based personnel and office facilities.

Sand Fencing and Vegetative Plantings

Following fill placement, sand fencing and vegetative plantings will be installed. The sand fences are porous barriers that reduce wind speed along the coast such that sand being transported by the wind accumulates on the downwind side of the fence. The sand fences will promote deposition of windblown sand, create dune features, reduce trampling of existing dunes by beach visitors, and protect vegetative plantings. Following construction, vegetative plants would commence as described in Section L9.2.1 for the dune and supratidal platform.

L9.3.2 Assumptions

Assumptions used during the development of the detailed cost include the following:

- Single dredge plant would be utilized per contract;
- Dredge: 30" cutterhead dredge of 9,200Hp operating at 16 hours per day;
- Boosters: 7,200Hp;
- Construction access would be constructed concurrent with the mobilization and preparation activities; and
- Marsh fill containment dikes would be constructed concurrent with beach/dune fill placement (Initial Restoration only).

L9.3.3 MCACES

The Tri-Services Automated Cost Engineering System (TRACES MII Version 3.01) was used to develop the baseline project cost for the NER Plan and first component of construction. MII is the second generation of the MCASES software used as a costing tool by the USACE. The MII English Cost Book 2008, National Labor 2008 - Preliminary Draft, and the MII Equipment Region 3r 2007 libraries were linked to the project library in the development of these costs. Elements of the restoration were assigned to feature codes following the Civil Works Work Breakdown Structure. The feature codes utilized in the project library include:

- [01] Lands and Damages;
- [06] Fish & Wildlife (Adaptive Management Plan);
- [10] Breakwaters & Seawalls (the NER Plan only);
- [17] Beach Replenishment;
- [30] Planning, Engineering & Design (PED); and
- [31] Construction Management.

A summary of the restoration elements is presented below and a detailed report of the MII cost estimate for the NER Plan and first component of construction can be found in Annex L-4.

Lands and Damages

Whiskey, Trinity, and Raccoon Islands are owned in entirety by the State of Louisiana. Timbalier Island is owned in majority by the State of Louisiana. Cost for Lands and Damages were obtained from the USACE Real Estate Division.

Fish & Wildlife (Adaptive Management Plan)

The Adaptive Management Plan is comprised of three elements. These included the Adaptive Management Plan program setup, Adaptive Management Plan implementation, and post construction monitoring. Program setup will commence and run concurrently with PED. Implementation and post construction monitoring will begin following initial restoration and continue for a period of up to 10 years. The Adaptive Management Plan is detailed in Appendix I.

Breakwaters and Seawalls

Breakwaters and Seawalls feature code is comprised of the elements of construction of the terminal groin on Raccoon Island for the NER Plan. Costs were developed for mobilization/demobilization, survey crews, quality control inspector, equipment, rip-rap rock, and geotextile underlayment.

Beach Replenishment

Beach replenishment encompasses the elements of construction including the mobilization/demobilization of the sediment delivery pipeline, installation and removal of shore and submerged pipeline, construction crews, water-borne and land-based equipment, dredge and plant, beach/dune and marsh fill and associated activities, relocations of the submerged pipeline from sand borrow area to marsh borrow area, sand fencing, and vegetative plantings.

Mobilization / Demobilization of Sediment Delivery Pipeline
The costs associated with mobilization and demobilization of the submerged pipeline was developed based on the required equipment and crews to handle the pipeline from its home base to the job site. The equipment element specified the number and horsepower of the tugs necessary for transporting the pipeline in floating rafts of 6,000 feet each. The mobilization/demobilization of the floating and shore pipeline was incorporated as part of the dredge and plant mobilization/demobilization costs.

Shore Pipeline Installation / Removal
The costs associated with the installation and removal of the shore segments of the pipeline was developed based on the required equipment and crews needed to work the pipeline within the fill templates. Stand-by times and costs associated with these activities were also incorporated in these costs.

Submerged Pipeline Installation / Removal
The costs associated with the installation and removal and/or relocation of the submerged pipeline were developed based on the required equipment and crews needed to work the

pipelines from the borrow areas to the fill templates. Stand-by times and costs associated with these activities were also incorporated in these costs.

Dredge Mobilization / Demobilization
The costs associated with mobilization and demobilization of the dredge, plant, and floating and shore pipeline were developed in the USACE CEDEP program and input to the MII cost analysis as a lump sum costs.

Beach / Dune Fill
A unit price for beach/dune fill was developed in the USACE CEDEP program and was based on the required fill material for the fill area, anticipated dredge-to-fill ratio losses, pumping distance, and dredge capacity. The unit price was entered into the MII cost estimate as in-place costs for fill and multiplied by the required volume to derive costs for the material only. Pay for fill material as in-place has been utilized on prior restoration projects as a means to promote "Best Management Practices" by the construction contractor.

Beach / Dune Construction
This category estimates the costs associated with the shore work required for shaping and grading the in-place fill material for the beach and dune. It included the costs for the required equipment and crews for the duration of constructing this feature.

Survey Crews
The costs for survey crews were developed in two phases, shore crew and offshore crew. The different equipment and crews required for the two distinctly different survey types lead to the development of these costs as separate entities. The shore based survey crew requires a survey chief and several rodmen to conduct the upland segments of the survey prior to, during, and following fill placement. The offshore crew required the inclusion of a survey vessel and operator for borrow area and nearshore bathymetric profile data collection.

Pipeline Crews
Similar to the survey crews, the pipeline crews require different personnel and equipment to maintain the sediment delivery pipeline. The shore crew is responsible for adding or removing pipeline as required by the alongshore advancement of the fill template. The equipment associated with these activities included bulldozers and pipeline segment handlers commonly called skidders. The offshore pipeline crews required additional personnel such as welders and crane operators. The offshore pipeline crews utilized equipment such as barges, cranes, welding machines, and air compressors to maintain the submerged sections of the sediment delivery pipeline

Marsh Fill (Initial Restoration Only)
A unit price for marsh fill was developed in the USACE CEDEP program and was based on the required fill material for the borrow area, anticipated dredge-to-fill ratio, pumping distance, and dredge capacity. The unit price was entered into the MII cost estimate as in-place costs for fill and multiplied by the required volume to derive a cost for the material only.

Marsh Fill Grade Stakes (Initial Restoration Only)
Marsh fill grade stakes are utilized to determine the elevations of fill in the marsh fill template prior to consolidation of the material to a point where egress is possible. The stakes are constructed with a graduation placard such that the elevation of the material can be measured through a sight glass and manually recorded in a survey book. The stakes are placed in the fill template prior to fill activities and conventionally placed on a grid of 150 feet by 250 feet. The unit cost for the grade stakes were based on prior marsh construction bids and inflated to 2009 dollars.

Marsh Fill Construction, Survey, and Pipeline Crews (Initial Restoration Only)
The marsh fill construction activities requirements for crews and equipment mimic that associated with beach/dune fill with minor differences in shore based equipment.

Access Channel
The unit cost for the access channel was derived from recent construction project bids and inflated to 2009 dollars. The channel length was developed from the feasibility level island design as the length of the northern marsh containment dike for the initial restoration and a fixed distance for renourishments since marsh containment would not be required. A more detailed estimate of access channel length will be determined following the final design survey in PED.

Containment Dikes
The unit cost per linear foot for containment dikes were derived from recently constructed project bids and inflated to 2009 dollars. The total length of the containment dikes was a summation of the island design lengths for the northern marsh containment dike and the beach/dune and marsh separation dike for initial restoration and only the beach/dune and marsh separation dike for renourishment events.

Sand Fencing
The sand fencing unit cost per linear foot was developed from recently constructed project bids and inflated to 2009 dollars. The required sand fencing length was derived from the island design length of the dune feature.

Vegetative Plantings
A detailed description of the vegetative planting scheme and species was presented in Section L.9.1 for initial restoration and are consistent with past and planned Louisiana barrier island restoration projects. The beach/dune fill segment is the only component selected for renourishment. Vegetative plantings of the dune and supratidal, woody species, and aerial seeding of the renourishment areas will follow the same methodology as the plantings schemes for initial restoration. The unit costs for the various plant species were developed from analyses of past project bids and planned restoration effort estimates and inflated to the cost year for this restoration.

Planning, Engineering & Design

Planning, Engineering & Design encompasses the final design and engineering during construction. The elements include project management, planning & environmental compliance, engineering & design, engineering technical review, contracting & reprographics, engineering during construction, planning during construction and project operations.

Construction Management

Construction Management is comprised of three elements; actual construction management, project operations administration, and overall project management.

L9.3.4 Risk Analysis

Risk analyses are required for any project whose cost exceeds $40 Million. The intent of a risk analysis was to determine the probability of various cost outcomes and schedule variances to quantify the required contingency needed in the cost estimate to achieve a level of cost confidence. The risk analysis process used the *Monte Carlo* technique to determine probabilities and contingencies for the project. This technique is incorporated into an add-on to Microsoft Excel and is commonly referred to as Crystal Ball. The resultant confidence levels express the probability that the corresponding contingency amount will cover the cost of the project being studied. The Cost Engineering Dx guidance for cost risk analysis focuses on risk and opportunity potential, all project features, and internal and external risks to the project. The standard confidence level recommended by the Cost Engineering Dx is 80%. The risk analysis was performed for the initial restoration of the NER Plan and the first component of construction. Details of the risk analyses for cost and schedule are presented in the Risk Analysis Reports found in Annex L-5.

The following are those elements analyzed in the cost and schedule risk models to determine the appropriate contingencies.

Beach/Dune and Marsh Fill Design Quantities

The island designs were developed utilizing survey data collected in 2006 as part of BICM (UNO and USGS, 2009). Through the use of shoreline erosion and landloss rates in the above referenced program, the fill volumes required in 2012 for beach/dune and marsh were calculated. A risk variance of +/-10% of the required volume was used to evaluate the risk associated with a decrease or increase in the erosional effects experienced by the island during this six year period. The variances in beach/dune and marsh required volumes were analyzed as separate risk elements so as to assess the risk if the beach/dune and marsh fill template experience differing erosional influences.

Geotechnical Issues with the Beach/Dune and Marsh Fill Borrow Areas

The sediment characteristics of the proposed borrow areas for beach/dune and marsh construction were analyzed from data collected within these borrow sources as part of designs for other restoration projects. Projected dredge-to-fill ratios were established and used in the production estimates for the dredge during construction of the beach/dune and marsh fill templates. To quantify variances induced by differing sediment characteristics that could be experienced within the borrow areas proposed for beach/dune fill and the marsh fill, differing ratios better than and worse than the most likely dredge-to-fill were evaluated for their affect on the construction costs. Sediment characteristics are one of three driving forces in determining production rates for the dredging equipment.

Sponsor's Ability to Fund Its Share

A delay of eighteen and six months in the procurement of funds to begin construction of the NER Plan and first component of construction, respectively were evaluated. The low risk was assumed to be the same as the most likely schedule for construction. The high risk was analyzed as a delay for the beginning of construction.

Fuel Prices

Overall affects of fuel prices on construction cost were analyzed. The most likely fuel price was derived from an average of fuel prices for 2009. A lower risk assumes the price of fuel would fall by as much as 25% from the 2009 average. A higher risk assumes that a volatile market could increase fuel prices by as much as 60% above the 2009 average price.

Severe Weather Downtime

The effects of dredging material in the open GOM on the dredge's effective operational hours per day were evaluated. A dredge may experience higher average operational time per day during periods of favorable weather and conversely experience lower than average operational time during periods of increases sea state such as during winter months. The most likely case, worst case, and best case operational times per day were established by review of USACE prior dredging projects. Operational time of the dredging equipment is one of three driving forces in determining production rates for the dredging equipment.

Delays due to Design Modifications

Following pre-construction surveys of the fill templates, design modification may be required to adjust the fill templates to maximize effectiveness of the island restoration. Through prior restoration project experience of the design team, a two month delay in beginning construction was considered as the high risk variance for the project schedule.

Long Pipeline to Island for Beach/Dune Fill

In development of the dredging production rates, it was determined that it was feasible to construct the beach/dune fill template using as few as two boosters from the borrow area to the fill template. The most likely number of boosters the contractor would use is three to maintain higher production rates. The number of booster pumps utilized in the delivery of sediment to the fill template is one of three driving forces in determining the production rates for the dredging equipment. Construction cost and schedule variances were calculated to evaluate the affects on project cost and schedule if the contractor chose to utilize only two booster pumps during the construction of the beach/dune fill template.

Bidder's Risk in a Volatile Market

The affects on construction costs of based on the risk assumed by the contractor were analyzed. These risks are those carried by the contractors that are not analyzed in other risk elements of this model. Those risks analyzed elsewhere include fuel prices, pipeline steel prices, weather delays, dredge acquisition, and additional mobilizations due to hurricanes. Examples of volatile market risk include, but are not limited to, other projects out for bid requiring the contractor's resources, labor force prices, and construction equipment availability. A low risk assumes the contractor is eager for the contract and would bid 10% less than the most likely and conversely a high risk indicates the contractor may be over extending his resources and submits a bid 25% higher than the most likely construction cost.

Pipeline Steel Prices

The risk associated with the changing price per pound of steel was analyzed to determine it's affect on the cost of the sediment delivery pipeline. Utilizing pricing from prior USACE projects, the assumed current cost per pound for steel was set a $0.60, the low price at $0.45, and the high price at $1.50. These prices were used in the determination of unit cost variances for beach/dune and marsh fill.

Dredge Acquisition

The risk associated with the availability of dredges for restoration construction at the time of notice to proceed for the contractor was considered. The delay to the construction schedule, while awaiting a dredge to become available from another project, was determined to be six months.

Hurricane Demobilization / Re-mobilization

For the possibility of a hurricane affecting the project during construction, an additional demobilization/re-mobilization of the crew, equipment, and dredge to safe harbor was evaluated.

Key Findings and Observations

The key cost risk drivers for the NER Plan identified through sensitivity analysis for the initial restoration component of Contract No. 1 (Whiskey, Trinity, and Raccoon Islands) are Internal Risks PED-11 (Geotechnical Issues Beach/Dune - Ship Shoal Borrow Area) in additional to External Risks PR-2 (Fuel Prices), PR-3 (Severe Weather/Downtime), PR-5 (Long Pipeline to Island for Beach Fill), PR-7 (Bidder's Risk in Volatile Market), and PR-8 (Pipeline Steel Prices) which together contribute 99.3% of the statistical cost variance.

The key cost risk drivers for the NER Plan identified through sensitivity analysis for the initial restoration component of Contract No. 2 (Timbalier Island) are Internal Risk PED-11 (Geotechnical Issues Beach/Dune - South Pelto Borrow Area) in addition to External Risks PR-2 (Fuel Prices), PR-3 (Severe Weather/Downtime), PR-5 (Long Pipeline to

Island for Beach Fill), PR-7 (Bidder's Risk in Volatile Market), and PR-8 (Pipeline Steel Prices) which together contribute 99.3% of the statistical cost variance.

The key schedule risk drivers identified through sensitivity analysis for the initial restoration component of the NER Plan are External Risks PR-1 (Sponsor's Ability to Fund its Share), PR-3 (Severe Weather/Downtime), PR-5 (Long Pipeline to Island for Beach Fill), PR-4 (Delays due to Design Modifications), and PR-10 (Dredge Acquisition), which together contribute 96.4% and 97.4% of the statistical schedule variance for Contracts No. 1 and No 2, respectively.

Following the execution of the simulations on the risk models, the key cost risk drivers identified through sensitivity analysis for the first component of construction are Internal Risk PED-11 Geotechnical Issues Beach/Dune Borrow Area) and External Risks PR-2 (Fuel Prices), PR-3 (Severe Weather/Downtime), PR-5 (Long Pipeline to Island for Beach Fill), PR-7 (Bidder's Risk in Volatile Market) which together contribute 96.4% of the statistical cost variance.

The key schedule risk drivers identified through sensitivity analysis for the first component of construction are External Risks PR-1 (Sponsor's Ability to Fund its Share), PR-3 (Severe Weather/Downtime), PR-5 (Long Pipeline to Island for Beach Fill), and PR-10 (Dredge Acquisition), which together contribute 91.8% of the statistical cost variance.

L9.4 TOTAL PROJECT COST SUMMARY

The Total Project Cost Summary (TPCS) is the culmination of the estimated project cost derived from the MII cost development, contingency percentage determined from the risk analyses, and the escalation to mid-point year quarter for the different elements of the initial restoration of the NER Plan and first component of construction. This summation provides a fully funded project cost estimate for initial restoration of the NER Plan and first component of construction. Each of the elements used in the development of the TPCS are described in the following sub-sections. The TPCS is presented in Annex L-6.

L9.4.1 Contingencies

National Ecosystem Restoration Plan

Since the NER Plan contained two separate contracts for the initial restorations, two independent risk analyses were performed. A cost contingency value of 27.4% and 29.4% was derived from the Crystal Ball analysis for the project costs at an 80% confidence level for Contracts No. 1 and No. 2, respectively. A schedule contingency value of 44.9% and 48.6% was derived from the analysis for the project schedule at an 80% confidence level for Contracts No. 1 and No. 2, respectively. The risk analyses focused on the risks and opportunities associated with all features of the NER Plan. Comparisons of the 50%, 80%, and 100% confidence levels for cost and schedule of the NER Plan's initial restoration are presented in Tables L9-4 through L9-7.

Table L9-4. Baseline Cost Estimate w/Contingency Summary (NER Plan Initial Restoration, Contract No. 1)

Contingency Level	MII Cost Estimate ($1,000)	Contingency Percentage	Total Contingency ($1,000) [1]	Baseline Cost Estimate ($1,000) [2]
50% Confidence Level - Initial Restoration Project Cost	$260,000	17.9%	$47,000	$307,000
80% Confidence Level - Initial Restoration Project Cost	$260,000	27.4%	$71,000	$331,000
100% Confidence Level - Initial Restoration Project Cost	$260,000	60.3%	$157,000	$417,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from Risk Analysis Forecast

Table L9-5. Baseline Schedule w/Contingency Summary (NER Plan Initial Restoration, Contract No. 1)

Risk Analysis Forecast	Crystal Ball Forecast Schedule	Total Contingency	Crystal Ball Forecast Schedule
50% Confidence Level - Initial Restoration Project Duration	64.5 months	34.7%	86.9 months
80% Confidence Level- Initial Restoration Project Duration	64.5 months	44.9%	93.5 months
100% Confidence Level - Initial Restoration Project Duration	64.5 months	75.3%	113.1 months

Table L9-6. Baseline Cost Estimate w/Contingency Summary (NER Plan Initial Restoration, Contract No. 2)

Contingency Level	MII Cost Estimate ($1,000)	Contingency Percentage	Total Contingency ($1,000) [1]	Baseline Cost Estimate ($1,000) [2]
50% Confidence Level - Initial Restoration Project Cost	$245,000	19.3%	$47,000	$292,000
80% Confidence Level - Initial Restoration Project Cost	$245,000	29.4%	$72,000	$317,000
100% Confidence Level - Initial Restoration Project Cost	$245,000	66.0%	$162,000	$407,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from Risk Analysis Forecast

Table L9-7. Baseline Schedule w/Contingency Summary (NER Plan Initial Restoration, Contract No. 2)

Risk Analysis Forecast	Crystal Ball Forecast Schedule	Total Contingency	Crystal Ball Forecast Schedule
50% Confidence Level - Initial Restoration Project Duration	55.8 months	37.3%	76.6 months
80% Confidence Level- Initial Restoration Project Duration	55.8 months	48.6%	82.9 months
100% Confidence Level - Initial Restoration Project Duration	55.8 months	83.7%	102.5 months

For the terminal groin O&M and renourishment events scheduled at TY10, TY20, TY25, TY30, and TY40, a cost contingency of 35% was selected based on professional judgment.

<u>First Component of Construction</u>

Contingencies for the initial restoration of the first component of construction were developed through the utilization of the Risk Register and Crystal Ball software as described in Section L9.4.4 Risk Analysis. A cost contingency value of 27.7% was derived from the Crystal Ball analysis for the project costs at an 80% confidence level. A schedule contingency value of 33.8% or 11.7 months was derived from the analysis for the project schedule at an 80% confidence level. The risk analysis focused on the risks and opportunities associated with all features of the first component of construction. Comparisons of the 50%, 80%, and 100% confidence levels for cost and schedule of the first component of construction initial restoration are presented in Tables L9-8 and L9-9, respectively.

Table L9-8. Baseline Cost Estimate w/Contingency Summary (First Component of Construction Initial Restoration)

Contingency Level	MII Cost Estimate ($1,000)	Contingency Percentage	Total Contingency ($1,000) [1]	Baseline Cost Estimate ($1,000) [2]
50% Confidence Level - Initial Restoration Project Cost	$90,100	18.4%	$16,600	$107,000
80% Confidence Level - Initial Restoration Project Cost	$90,100	27.7%	$24,990	$115,000
100% Confidence Level - Initial Restoration Project Cost	$90,100	59.2%	$53,320	$143,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from Risk Analysis Forecast

Table L9-9. Baseline Schedule w/Contingency Summary (First Component of Construction Initial Restoration)

Risk Analysis Forecast	Crystal Ball Forecast Schedule	Total Contingency	Crystal Ball Forecast Schedule
50% Confidence Level - Initial Restoration Project Duration	34.6 months	26.3%	43.7 months
80% Confidence Level- Initial Restoration Project Duration	34.6 months	33.8%	46.3 months
100% Confidence Level - Initial Restoration Project Duration	34.6 months	54.6%	53.5 months

For the renourishment events scheduled at TY20 and TY40, a cost contingency of 35% was selected based on professional judgment.

L9.4.2 Project Cost Estimate

The project cost for initial restoration and renourishment events of the NER Plan and first component of construction were developed in the MII software and escalated from the estimate price year to the program price year with contingencies added. Tables L9-10 and L9-11 presents the project cost for the program year of 2012 for each of the major project elements of the initial restoration with contingency for the NER Plan and first component of construction, respectively.

Table L9-10. NER Plan Initial Restoration Project Cost Summary Program Year (2012)

Project Element	Program Year Cost [2]	Contingency [1]	Program Year Total Cost [2]
Lands & Damages	$545,000	$164,000	$709,000
Fish & Wildlife (Adaptive Management Plan)	$5,820,000	Included	$5,820,000
Breakwaters & Seawalls	$1,830,000	508,000	2,330,000
Beach Replenishment	$463,000,000	$131,000,000	$593,000,000
Planning, Engineering & Design	$23,000,000	$6,590,000	$30,000,000
Construction Management	$23,000,000	$6,590,000	$30,000,000
NER Plan Initial Restoration Project Costs	$518,000,000	$144,000,000	$661,000,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS

Table L9-11. First Component of Construction Initial Restoration Project Cost Summary - Program Year (2012)

Project Element	Program Year Cost [2]	Contingency [1]	Program Year Total Cost [2]
Lands & Damages	$51,000	$15,000	$67,000
Fish & Wildlife (Adaptive Management Plan)	$5,820,000	Included	$5,820,000
Beach Replenishment	$78,000,000	$22,000,000	$100,000,000
Planning, Engineering & Design	$3,920,000	$1,090,000	$5,010,000
Construction Management	$3,920,000	$1,090,000	$5,010,000
First Component of Construction Initial Restoration Project Costs	$92,000,000	$23,920,000	$116,000,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS

L9.4.3 Project Schedule

Funding for this project is anticipated for October 2011 with the initial construction beginning in June 2012.

National Ecosystem Restoration Plan

Initial Restoration Contract No.1 - Whiskey, Trinity, and Raccoon Islands
PED is anticipated to begin on December 31, 2010 with the Adaptive Management Plan (AMP) program setup and initial monitoring beginning at the start of PED and continuing through construction. The implementation of the AMP and post construction monitoring for both contracts is anticipated to begin at the completion of construction for the initial restoration and run for 10 years. The following is a listing of the anticipated dates of construction elements for Contract No. 1.

- Mobilization: June 2012 to July 2012
- Beach/Dune Fill for Whiskey Island: July 2012 to July 2013
- Beach/Dune Fill for Trinity Island: July 2013 to April 2014
- Marsh Fill for Trinity Island: April 2014 to November 2014
- Marsh Fill for Whiskey Island: November 2014 to February 2015
- Beach/Dune Fill for Raccoon Island: February 2015 to October 2015
- Terminal Groin for Raccoon Island: October 2015 to November 2015
- Marsh Fill for Raccoon Island: October 2015 to May 2016
- Demobilization: May 2016 to June 2016

Vegetative Planting would commence in the Spring of 2017.

Initial Restoration Contract No. 2 - Timbalier Island
PED and AMP for Contract No. 2 would run concurrent with that of Contract No. 1. The following is a listing of the anticipated dates of construction elements for Contract No. 2.

- Mobilization: June 2012 to August 2012
- Beach/Dune Fill for Timbalier Island: August 2012 to June 2014
- Marsh Fill for Timbalier Island: June 2014 to August 2015
- Demobilization: August 2015 to October 2015

Vegetative Planting would commence in the Spring of 2016.

Operations & Maintenance and Renourishments
O&M and renourishment events are scheduled as follows:

- O&M of terminal groin at Raccoon Island at TY10
- Renourishment of Whiskey Island at TY20
- Renourishment of Trinity Island at TY25
- Renourishment of Raccoon and Timbalier Islands at TY30
- Renourishment of Whiskey Island at TY40

First Component of Construction

Mid-point of construction for the first component of construction would occur in February 2013 with construction being completed in October 2013. PED is anticipated to begin on December 31, 2010 with the AMP program setup and initial monitoring beginning at the start of PED and continuing through construction. The implementation of the AMP and post construction monitoring is anticipated to begin at the completion of construction for the initial restoration and run for 10 years. Renourishments would be conducted in TY20 and TY40.

Refer to Section L11 for additional schedule description details for the NER Plan and first component of construction.

L9.4.4 Fully Funded Project Cost

The fully funded project costs were developed in the TPCS spreadsheet for initial restoration of the NER Plan and first component of construction. The TPCS requires inputs on the baseline project cost, price level of estimate, project schedule, and project / schedule contingency. The TPCS formulates the fully funded cost through a summation of baseline cost and contingencies and escalates this to mid point of duration for each specific element. The elements of the TPCS for this project include the Lands & Damages, Adaptive Management Plan, Beach Replenishment, PED, and Construction Management. Tables L9-12 and L9-13 presents a summary of the results from the TPCS for the fully funded initial restoration of the NER Plan and first component of construction, respectively.

Table L9-12. Fully Funded Cost Summary for NER Plan Initial Restoration

Project Element	Program Year Cost [2]	All Contingencies & Escalations [1]	Fully Funded Total [2]
Lands & Damages	$545,000	$169,000	$715,000
Fish & Wildlife (Adaptive Management Plan)	$5,820,000	Included	$5,820,000
Breakwaters & Seawalls	$1,830,000	$661,000	$2,490,000
Beach Replenishment	$463,000,000	$156,000,000	$619,000,000
Planning, Engineering & Design	$23,000,000	$6,850,000	$30,000,000
Construction Management	$23,000,000	$7,800,000	$31,000,000
NER Plan Initial Restoration Fully Funded Costs	$518,000,000	$171,000,000	$689,000,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS

Table L9-13. Fully Funded Cost Summary for First Component of Construction Initial Restoration

Project Element	Program Year Cost [2]	All Contingencies & Escalations [1]	Fully Funded Total [2]
Lands & Damages	$51,000	$16,000	$67,000
Fish & Wildlife (Adaptive Management Plan)	$5,820,000	Included	$5,820,000
Beach Replenishment	$78,000,000	$25,000,000	$103,000,000
Planning, Engineering & Design	$3,920,000	$1,120,000	$5,040,000
Construction Management	$3,920,000	$1,240,000	$5,160,000
First Component of Construction Initial Restoration Fully Funded Costs	$92,000,000	$27,000,000	$119,000,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS

The base cost for the renourishment efforts developed in the MII were escalated to the mid points of construction through the use and expansion of the cost index trends available in the Civil Works Construction Cost Index System (EM 1110-2-1304, March 30, 2010). The fully funded cost for O&M and renourishments are presented in Tables L9-14 through L9-18. Renourishment events for the first component of construction are a subset of those for the NER Plan and include the Whiskey Island TY20 and TY40.

Table L9-14. Fully Funded Cost Summary for TY10 Terminal Groin O&M

Project Element	Program Year Cost [2]	All Contingencies & Escalations [1]	Fully Funded Total [2]
Lands & Damages	$51,000	$33,000	$84,000
Breakwaters & Seawalls	$627,000	$443,000	$1,070,000
Planning, Engineering & Design	$63,000	$41,000	$104,000
Construction Management	$64,000	$45,000	$109,000
TY10 Terminal Groin O&M Fully Funded Costs	$805,000	$565,000	$1,370,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS Simulation

Table L9-15. Fully Funded Cost Summary for Whiskey Is. TY20 Renourishment

Project Element	Program Year Cost [2]	All Contingencies & Escalations [1]	Fully Funded Total [2]
Lands & Damages	$51,000	$45,000	$96,000
Beach Replenishment	$73,000,000	$70,000,000	$143,000,000
Planning, Engineering & Design	$3,650,000	$3,360,000	$7,010,000
Construction Management	$3,650,000	$3,510,000	$7,160,000
TY20 Renourishment Fully Funded Costs	$80,000,000	$77,000,000	$157,000,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS Simulation

Table L9-16. Fully Funded Cost Summary for Trinity Is. TY25 Renourishment

Project Element	Program Year Cost [2]	All Contingencies & Escalations [1]	Fully Funded Total [2]
Lands & Damages	$51,000	$54,000	$105,000
Beach Replenishment	$50,000,000	$56,000,000	$106,000,000
Planning, Engineering & Design	$2,490,000	$2,760,000	$5,250,000
Construction Management	$2,480,000	$2,860,000	$5,340,000
TY25 Renourishment Fully Funded Costs	$55,000,000	$62,000,000	$117,000,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS Simulation

Table L9-17. Fully Funded Cost Summary for Raccoon and Timbalier Is. TY30 Renourishment

Project Element	Program Year Cost [2]	All Contingencies & Escalations [1]	Fully Funded Total [2]
Lands & Damages	$443,000	$567,000	$1,000,000
Beach Replenishment	$37,000,000	$51,000,000	$88,000,000
Planning, Engineering & Design	$1,840,000	$2,460,000	$4,300,000
Construction Management	$1,840,000	$2,550,000	$4,390,000
TY30 Renourishment Fully Funded Costs	$41,000,000	$56,000,000	$97,000,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS Simulation

Table L9-18. Fully Funded Cost Summary for Whiskey Is. TY40 Renourishment

Project Element	Program Year Cost [2]	All Contingencies & Escalations [1]	Fully Funded Total [2]
Lands & Damages	$51,000	$91,000	$142,000
Beach Replenishment	$58,000,000	$110,000,000	$167,000,000
Planning, Engineering & Design	$2,880,000	$5,350,000	$8,190,000
Construction Management	$2,880,000	$5,480,000	$8,350,000
TY40 Renourishment Fully Funded Costs	$63,000,000	$121,000,000	$184,000,000

Notes: 1. Adaptive Management Plan cost includes prior escalation & contingency and is subjected to the Total Contingency and Escalation.
2. Costs taken from TPCS Simulation

The fully funded cost developed for the NER Plan with renourishments is estimated at $1,246,000,000. Using the same methods for costing as that used for the NER Plan, the fully funded cost for the first component of construction with renourishments is estimated at $461,000,000.

L10. RELOCATIONS

Whiskey, Trinity, and Raccoon Islands are owned in entirety by the State of Louisiana. Timbalier Island is owned in majority by the State of Louisiana. There are no oil/gas infrastructure or facilities that would require relocation for the restorations of the NER Plan or first component of construction.

L11. SCHEDULE

L11.1 DESIGN SCHEDULE

The design schedule follows the elements of the PED outlined in Engineering Regulation ER1110-2-1150 (USACE, 1999) which include: project reformulation; documentation of design; technical review conference; design documentation reports; permit applications; value engineering; hazardous, toxic, and radioactive waste assessments; relocations; physical model studies; preparation of the project cooperation agreement; preparation of plans and specifications; independent government estimates; review of NEPA document; and independent technical review.

On a project following the full normal authorization process, the PED phase begins when the Major Subordinate Command Commander issues the public notice for the feasibility report and PED funds are allocated to the district. PED generally requires a period of up to two years, depending on the complexity of the project, and ends with completion of the plans and specifications for the first construction contract or as otherwise defined in the PED cost-sharing agreement. Engineering functions shall be prepared to begin an intensive effort immediately upon notification that PED funds are available.

For the LCA TBBSR Study, it is estimated this phase will last approximately 17 months. Time should be saved because the alternatives analysis, fill template designs, and borrow area identification were completed as part of the engineering feasibility study. Surveys, volume calculations, and cost estimate will have to be updated at the design level prior to completing final plans and specifications. PED is anticipated to begin on December 31, 2010.

L11.2 CONSTRUCTION SCHEDULE

L11.2.1 NER Plan Initial Restoration Schedule

Construction funds authorization is anticipated in October 2011 with construction beginning in June 2012. The construction schedule consists of project mobilization / demobilization and construction access, beach / dune and marsh fill placement, and pipeline relocation for each island. Restoration activities for the NER Plan are anticipated to begin in June 2012 and be concluded in July 2016. A construction element and duration summary for ach contract are listed below.

<u>Contract No. 1 - Whiskey Island, Trinity Island, and Raccoon Island with Terminal Groin</u>

- Mobilization:
    - Mobilize Pipeline: The sediment delivery pipeline shall take approximately 14 days to mobilize from home port to the project site (June 2012).

- Mobilize Equipment and Crew: This involves moving all shore based crew and equipment to the project site and would take approximately 8 days (July 2012)
- Mobilize Dredge: Mobilization of the cutterhead dredge is anticipated to require 14 days. (July 2012)

- Pre-lay of Pipeline
  - Pre-lay Shore Pipeline: The anticipated duration to pre-lay 5,656 feet of shore pipeline on Whiskey Island is 11 days. Shore pipeline will be installed prior to beach/dune fill construction in July 2012.
  - Pre-lay of Submerged Pipeline: The anticipated duration to pre-lay 62,908 feet of submerged pipeline from Ship Shoal to Whiskey Island is 42 days. Submerged pipeline will be installed prior to beach/dune fill construction in June - July 2012.

- Access Channel - Whiskey Island: Construction of the access channel is estimated to progress at 500 feet per day based on review of prior projects. There is estimated to be 5,000 feet of access channel required for the mobilization of shore equipment to begin construction of the containment dike south with construction duration of 10 days. Access channel on Whiskey Island will commence in June 2012 in order to have the equipment and crews on site for the completion of pre-laying shore pipeline to be commensurate with the completion of the installation of the submerged pipeline in July 2012.

- Containment Dike South (CDS) - Whiskey Island: The CDS separates the beach/dune fill from the marsh fill and will be constructed concurrently with the installation of the sediment pipelines and beach/dune fill. Construction of the CDS is estimated to progress at 400 feet per day based on review of prior projects. There is estimated to be 17,918 feet of CDS required for Whiskey Island requiring 45 days for construction (June - August 2012).

- Beach/Dune Fill - Whiskey Island: Dredge and fill activities for Whiskey Island beach/dune would require the excavation and placement of 8,330,215 cubic yards (in-place) of sands from Ship Shoal. This is calculated to take 325 days. (July 2012 to June 2013)

- Sand Fencing - Whiskey Island: Sand fencing along the dune of Whiskey Island is estimated to require 18,075 feet of materials and be installed at 900 feet/day. Sand fencing installation would commence following beach/dune construction and be completed in 20 days (June - July 2013).

- Pipeline Relocation (Ship Shoal-Whiskey Is. to Ship Shoal-Trinity Is.)
  - Pickup Shore Pipeline: Following beach/dune construction on Whiskey Island, the shore pipeline would be removed for relocation to Trinity Island. This involves the removal of 11,071 feet of shore pipe requiring 22 days (June - July 2013).

- Pickup Submerged Pipeline: Following beach/dune construction on Whiskey Island, the submerged pipeline must be relocated from the orientation of Ship Shoal-Whiskey Island to Ship Shoal-Trinity Island. This requires the removal of 62,908 feet of submerged pipeline at a pace of 1,500 feet per day and is anticipated to take 42 days (June - July 2013).
- Pre-lay Shore Pipeline: The anticipated duration to pre-lay 13,088 feet of shore pipeline on Trinity Island is 26 days. Shore pipeline will be installed prior to beach/dune fill construction on during the period of August - September 2013.
- Pre-lay Submerged Pipeline: Installation of 77,280 feet of submerged pipeline from Ship Shoal to Trinity Island is anticipated to take 52 days. Submerged pipeline will be installed prior to beach/dune fill construction during the period of July - September 2013.

- Access Channel - Trinity Island: There is estimated to be 5,000 feet of access channel required for the mobilization of shore equipment to begin construction of the CDS with construction duration of 10 days. Access channel on Trinity Island will commence on August 14, 2013 in order to have the equipment and crews on site for the completion of pre-laying shore pipeline to be commensurate with the completion of the relocation of the submerged pipeline in September 2013.

- Containment Dike South - Trinity Island: The CDS separates the beach/dune fill from the marsh fill and will be constructed concurrently with the relocation of the sediment pipelines and beach/dune fill. There is estimated to be 17,918 feet of CDS required for Trinity Island requiring 56 days for construction (August - October 2013).

- Beach/Dune Fill - Trinity Island: Dredge and fill activities for Trinity Island beach/dune would require the excavation and placement of 3,813,885 cubic yards (in-place) of sands from Ship Shoal. This is calculated to take 163 days (September 2013 - March 2014).

- Sand Fencing - Trinity Island: Sand fencing along the dune of Trinity Island is estimated to require 22,434 feet of materials and installation would commence following beach/dune construction and be completed in 25 days (March 2014).

- Containment Dike North (CDN) - Trinity Island: The CDN separates the marsh fill from the back bay and will be constructed concurrently with the relocation of the sediment pipelines. There is estimated to be 22,237 feet of CDN required for Trinity Island requiring 56 days for construction (March - May 2014).

- Pipeline Relocation (Ship Shoal-Trinity Is. to Whiskey 3A-Trinity Is.)
  - Pickup Submerged Pipeline: Following beach/dune construction on Trinity Island, the submerged pipeline must be relocated from the orientation of Ship Shoal-Trinity Island to Whiskey 3A borrow area-Trinity Island. This requires the removal of 77,280 feet of submerged pipeline and is anticipated to take 52 days (March 6 - April 27, 2014).

  - Pre-lay Submerged Pipeline: Installation of 15,889 feet of submerged pipeline from Whiskey 3A to Trinity Island is anticipated to take 11 days. Submerged pipeline will be installed prior to marsh fill construction during the period of April - May 2014.

- Marsh Fill - Trinity Island: Dredge and fill activities for Trinity Island marsh would require the excavation and placement of 3,772,925 cubic yards (in-place) of mud/silt from Whiskey Island 3A borrow area. This is estimated to take 190 days (May - November 2014).

- Containment Dike North - Whiskey Island: The CDN separates the marsh fill from the back bay and will be constructed concurrently with the relocation of the sediment pipelines. There is estimated to be 7,370 feet of CDN required for Whiskey Island requiring 19 days for construction (November - December 2015).

- Pipeline Relocation (Whiskey 3A-Trinity Is. to Whiskey 3A-Whiskey Is.)
  - Pickup Shore Pipeline: Following marsh construction on Trinity Island, the shore pipeline would be removed for relocation to Whiskey Island. This involves the removal of 24,315 feet of shore pipe requiring 49 days (November 2014 - January 2015).
  - Pickup Submerged Pipeline: Following marsh construction on Trinity Island, the submerged pipeline must be relocated from the orientation of Whiskey 3A-Trinity Island to Whiskey 3A-Whiskey Island. This requires the removal of 15,889 feet of submerged pipeline and is anticipated to take 11 days (November 2014).
  - Pre-lay Shore Pipeline: The anticipated duration to pre-lay 5,656 feet of shore pipeline on Whiskey Island is 11 days. Shore pipeline will be installed prior to marsh fill construction in January 2015.
  - Pre-lay Submerged Pipeline: Installation of 34,288 feet of submerged pipeline from Whiskey 3A to Whiskey Island is anticipated to take 23 days. Submerged pipeline will be installed prior to marsh fill construction during the period of November - December 2015.

- Marsh Fill - Whiskey Island: Dredge and fill activities for Whiskey Island marsh would require the excavation and placement of 579,724 cubic yards (in-place) of mud/silt from Whiskey Island 3A borrow area. This is estimated to take 23 days (January - February 2015).

- Access Channel - Raccoon Island: There is estimated to be 5,000 feet of access channel required for the mobilization of shore equipment to begin construction of the CDS with construction duration of 10 days. Access channel on Raccoon Island will commence in February 2015 in order to have the equipment and crews on site for the completion of pre-laying shore pipeline to be commensurate with the completion of the relocation of the submerged pipeline in April 2015.

- Containment Dike South - Raccoon Island: The CDS separates the beach/dune fill from the marsh fill and will be constructed concurrently with the relocation of the sediment pipelines. There is estimated to be 20,609 feet of CDS required for Raccoon Island requiring 52 days for construction (February - April 2015).

- Pipeline Relocation (Whiskey 3A-Whiskey Is. to Ship Shoal-Raccoon Is.)
    - Pickup Shore Pipeline: Following marsh construction on Whiskey Island, the shore pipeline would be removed for relocation to Raccoon Island. This involves the removal of 11,071 feet of shore pipe requiring 22 days (February - March 2015).
    - Pickup Submerged Pipeline: Following marsh construction on Whiskey Island, the submerged pipeline must be relocated from the orientation of Whiskey 3A-Whiskey Island to Ship Shoal-Raccoon Island. This requires the removal of 34,288 feet of submerged pipeline and is anticipated to take 23 days (February - March 2015).
    - Pre-lay Shore Pipeline: The anticipated duration to pre-lay 10,183 feet of shore pipeline on Raccoon Island is 20 days. Shore pipeline will be installed prior to beach/dune fill construction in March 2015.
    - Pre-lay Submerged Pipeline: Installation of 56,721 feet of submerged pipeline from Ship Shoal to Raccoon Island is anticipated to take 38 days. Submerged pipeline will be installed prior to beach/dune fill construction during the period of March - April 2015.

- Beach/Dune Fill - Raccoon Island: Dredge and fill activities for Raccoon Island beach/dune would require the excavation and placement of 5,381,956 cubic yards (in-place) of sands from Ship Shoal. This is calculated to take 204 days (April - October 2015).

- Sand Fencing - Raccoon Island: Sand fencing along the dune of Raccoon Island is estimated to require 12,186 feet of materials and installation would commence following beach/dune construction and be completed in 14 days (October - November 2015).

- Raccoon Island Terminal Groin: Mobilization/demobilization and construction is estimated to take 48 days and commence with the completion of the beach/dune fill on Raccoon Island (October - December 2015)

- Containment Dike North - Raccoon Island: The CDN separates the marsh fill from the back bay and will be constructed concurrently with the beach/dune fill for Raccoon Island. There is estimated to be 12,505 feet of CDN required for Raccoon Island requiring 31 days for construction (September - October 2015).

- Marsh Fill - Raccoon Island Component 1: Dredge and fill activities for Raccoon Island marsh component 1 would require the excavation and placement of 2,763,555 cubic yards (in-place) of sand from Ship Shoal borrow area. This is estimated to take 109 days (October 2015 - February 2016).

- Pipeline Relocation (Ship Shoal-Raccoon Is. to Raccoon BA-Raccoon Is.)
  - Pickup Submerged Pipeline: Following beach/dune and marsh component 1 construction on Raccoon Island, the submerged pipeline must be relocated from the orientation of Ship Shoal-Raccoon Island to Raccoon borrow area-Raccoon Island. This requires the removal of 56,721 feet of submerged pipeline and is anticipated to take 38 days (February - March 2016).
  - Pre-lay Submerged Pipeline: Installation of 26,503 feet of submerged pipeline from Raccoon BA to Raccoon Island is anticipated to take 18 days. Submerged pipeline will be installed during the period of March - April 2016.

- Marsh Fill - Raccoon Island Component 2: Dredge and fill activities for Raccoon Island marsh component 2 would require the excavation and placement of 1,846,154 cubic yards (in-place) of mud/silt from Raccoon borrow area. This is estimated to take 48 days (April - May 2016).

- Pickup of Pipeline
  - Pickup Shore Pipeline: Following fill activities on the island 13,675 feet of shore pipeline will be broken down and readied for transport from Raccoon Island. These activities are anticipated to require 27 days. (May - June 2016)
  - Pickup Submerged Pipeline: Following fill activities on Raccoon Island; 26,503 feet of submerged pipeline will be broken down and readied for transport. These activities are anticipated to require 18 days. (May - June 2016)

- Demobilization:
  - Demobilize Pipeline: Demobilization of the sediment pipeline is anticipated to take 14 days. (June - July 2016)
  - Demobilize Equipment and Crews: Demobilization of the shore equipment and crews is anticipated to take 8 days. (June - July 2016)
  - Demobilize Dredge: Demobilization of the dredge is anticipated to take 14 days. (May - June 2016)

- Vegetative Plantings:
  - Plantings - TY1: Aerial Seeding and Dune/Swale planting will take place during the appropriate season in Target Year 1.
    - Whiskey Island: Anticipated April - May 2014
    - Trinity Island: Anticipated April - May 2015
    - Raccoon Island: Anticipated April - May 2016
  - Plantings - TY2: Woody Species and 50% Marsh Fill plantings will take place during the appropriate season in Target Year 2.
    - Whiskey Island: Anticipated April - May 2015
    - Trinity Island: Anticipated April - May 2016
    - Raccoon Island: Anticipated April - May 2017

- Plantings - TY3: Remaining 50% Marsh Fill plantings will take place during the appropriate season in Target Year 3.
  - Whiskey Island: Anticipated April - May 2016
  - Trinity Island: Anticipated April - May 2017
  - Raccoon Island: Anticipated April - May 2018

Contact No. 2 (Timbalier Island)

- Mobilization:
  - Mobilize Pipeline: The sediment delivery pipeline shall take approximately 14 days to mobilize from home port to the project site (June 2012).
  - Mobilize Equipment and Crew: This involves moving all shore based crew and equipment to the project site and would take approximately 8 days (July 2012)
  - Mobilize Dredge: Mobilization of the cutterhead dredge is anticipated to require 14 days. (June 2012)

- Pre-lay of Pipeline
  - Pre-lay Shore Pipeline: The anticipated duration to pre-lay 12,068 feet of shore pipeline on Timbalier Island is 24 days. Shore pipeline will be installed prior to beach/dune fill construction during the period of July - August 2012.
  - Pre-lay of Submerged Pipeline: The anticipated duration to pre-lay 85,206 feet of submerged pipeline from South Pelto to Timbalier Island is 57 days. Submerged pipeline will be installed prior to beach/dune fill construction during the period of June - August 2012.

- Access Channel - Timbalier Island: Construction of the access channel is estimated to progress at 500 feet per day based on review of prior projects. There is estimated to be 5,000 feet of access channel required for the mobilization of shore equipment to begin construction of the CDS with construction duration of 10 days. Access channel on Timbalier Island will commence in July 2012 in order to have the equipment and crews on site for the completion of pre-laying shore pipeline to be commensurate with the completion of the installation of the submerged pipeline in August 2012.

- Containment Dike South - Timbalier Island: The CDS separates the beach/dune fill from the marsh fill and will be constructed concurrently with the installation of the sediment pipelines and beach/dune fill. Construction of the CDS is estimated to progress at 400 feet per day based on review of prior projects. There is estimated to be 35,455 feet of CDS required for Whiskey Island requiring 89 days for construction (July - October 2012).

- Beach/Dune Fill - Timbalier Island: Dredge and fill activities for Timbalier Island beach/dune would require the excavation and placement of 10,702,818 cubic yards (in-place) of sands from South Pelto. This is calculated to take 469 days. (August 2012 - November 2013)

- Sand Fencing - Timbalier Island: Sand fencing along the dune of Timbalier Island is estimated to require 35,425 feet of materials and be installed at 900 feet/day. Sand fencing installation would commence following beach/dune construction and be completed in 39 days (November 2013 - January 2014).

- Containment Dike North - Timbalier Island: The CDN separates the marsh fill from the back bay and will be constructed concurrently with the beach/dune fill for Timbalier Island. There is estimated to be 42,580 feet of CDN required for Timbalier Island requiring 107 days for construction (August - November 2013).

- Marsh Fill - Timbalier Island Component 1: Dredge and fill activities for Timbalier Island marsh component 1 would require the excavation and placement of 3,083,736 cubic yards (in-place) of sand from South Pelto borrow area. This is estimated to take 130 days (November 2013 - April 2014).

- Pipeline Relocation (South Pelto-Timbalier Is. to Whiskey 3A-Timbalier Is.)
    - Pickup Submerged Pipeline: Following beach/dune and marsh component 1 construction on Timbalier Island, the submerged pipeline must be relocated from the orientation of South Pelto-Timbalier Island to Whiskey 3A-Timbalier Island. This requires the removal of 85,206 feet of submerged pipeline and is anticipated to take 57 days (April - June 2014).
    - Pre-lay Submerged Pipeline: Installation of 82,796 feet of submerged pipeline from Whiskey 3A to Timbalier Island is anticipated to take 55 days. Submerged pipeline will be installed during the period of June - July 2014.

- Marsh Fill - Timbalier Island Component 2: Dredge and fill activities for Timbalier Island marsh component 2 would require the excavation and placement of 4,066,504 cubic yards (in-place) of mud/silt and sand from Whiskey 3A borrow area. This is estimated to take 237 days (July 2014 - March 2015).

- Pipeline Relocation (Whiskey 3A-Timbalier Is. to New Cut-Timbalier Is.)
    - Pickup Submerged Pipeline: Following marsh component 2 construction on Timbalier Island, the submerged pipeline must be relocated from the orientation of Whiskey 3A-Timbalier Island to New Cut borrow area-Timbalier Island. This requires the removal of 82,796 feet of submerged pipeline and is anticipated to take 55 days (March - May 2015).
    - Pre-lay Submerged Pipeline: Installation of 38,881 feet of submerged pipeline from New Cut to Timbalier Island is anticipated to take 26 days. Submerged pipeline will be installed during the period of May - June 2015.

- Marsh Fill - Timbalier Island Component 3: Dredge and fill activities for Timbalier Island marsh component 3 would require the excavation and placement of 1,923,077 cubic yards (in-place) of mud/silt and sand from New Cut borrow area. This is estimated to take 61 days (June - August 2015).

- Pickup of Pipeline
    - Pickup Shore Pipeline: Following fill activities on the island 21,925 feet of shore pipeline will be broken down and readied for transport from Timbalier Island. These activities are anticipated to require 44 days. (August - September 2015)
    - Pickup Submerged Pipeline: Following fill activities on Timbalier Island; 38,881 feet of submerged pipeline will be broken down and readied for transport. These activities are anticipated to require 26 days. (August - September 2015)

- Demobilization:
    - Demobilize Pipeline: Demobilization of the sediment pipeline is anticipated to take 14 days. (September 2015)
    - Demobilize Equipment and Crews: Demobilization of the shore equipment and crews is anticipated to take 8 days. (September - October 2015)
    - Demobilize Dredge: Demobilization of the dredge is anticipated to take 14 days. (August 2015)

- Vegetative Plantings:
    - Plantings - TY1: Aerial Seeding and Dune/Swale planting will take place during the appropriate season in Target Year 1. Anticipated April - May 2016
    - Plantings - TY2: Woody Species and 50% Marsh Fill plantings will take place during the appropriate season in Target Year 2. Anticipated April - May 2017
    - Plantings - TY3: Remaining 50% Marsh Fill plantings will take place during the appropriate season in Target Year 3. Anticipated April - May 2018

L11.2.2 NER Plan O&M and Renourishment Construction Schedule

The PED process for the O&M and renourishments shall begin prior to the designated TYs for the beginning of construction activities.

NER Plan - Terminal Groin O&M at TY10

O&M activities for the terminal groin at TY10 will follow the same schedule as the initial construction. The require amount of rock to be placed in the O&M would be 25% of the initial construction required volume.

NER Plan - Whiskey Island Renourishment at TY20

Renourishment of Whiskey Island at TY20 will follow the same schedule as the initial construction with the exceptions that it will not involve marsh fill construction or marsh fill vegetative planting. Dune/swale aerial seeding and planting should occur in TY21 and TY22. The volume of sediment required will be that needed to restore the geomorphologic form and ecological function, plus accounting for five years of background erosion/land loss.

NER Plan - Trinity Island Renourishment at TY25

Renourishment of Trinity Island at TY25 will follow the same schedule as the initial construction with the exceptions that it will not involve marsh fill construction or marsh fill vegetative planting. Dune/swale aerial seeding and planting should occur in TY26 and TY27. The volume of sediment required will be that needed to restore the geomorphologic form and ecological function, plus accounting for five years of background erosion/land loss.

NER Plan - Raccoon and Timbalier Island Renourishment at TY30

Renourishment of Raccoon and Timbalier Islands at TY30 will follow the same schedule as the initial construction with the exceptions that it will not involve marsh fill construction or marsh fill vegetative planting. Dune/swale aerial seeding and planting should occur in TY31 and TY32. The volume of sediment required will be that needed to restore the geomorphologic form and ecological function.

NER Plan - Whiskey Island Renourishment at TY40

Renourishment at TY40 will follow the same schedule as the initial construction with the exceptions that it will not involve marsh fill construction or marsh fill vegetative planting. Dune/swale aerial seeding and planting should occur in TY41 and TY42. The volume of sediment required will be that needed to restore the geomorphologic form and ecological function, plus accounting for five years of background erosion/land loss.

L11.2.3 First Component of Construction Initial Restoration Schedule

Construction funds authorization is anticipated in October 2011 with construction beginning in June 2012. The construction schedule consists of project mobilization / demobilization and construction access, beach / dune and marsh fill placement, and pipeline relocation for each island. Restoration activities for the first component of construction are anticipated to begin in June 2012 and be concluded on October 2013. A construction element and duration summary is as follows:

- Mobilization:
  - Mobilize Pipeline: 62,908 feet of the sediment delivery pipeline shall take approximately 14 days. This duration is to move the pipe to the site near Whiskey Island. (June 2012)

    - Mobilize Equipment and Crew: This involved moving all shore based crew and equipment to the island. Mobilization of crew and shore equipment would take approximately 8 days and begin with the completion of the Access Channel. (July 2012)
    - Mobilize Dredge: Mobilization of the cutterhead dredge is anticipated to require 14 days. (July 2012)

- Access Channel is estimated to progress at 400 feet per day based on review of prior projects. There is estimated to be 10,000 feet of access channel required with construction duration of 25 days. Access channel will commence on June 13, 2012 in order to have the equipment and crews on site for the completion of pre-laying shore pipeline to be commensurate with the completion of the installation of the submerged pipeline. (June - July 2012)

- Pre-lay of Pipeline
    - Pre-Lay Shore Pipeline: The anticipated duration to pre-lay 5,656 feet of shore pipeline is 11 days. Shore pipeline will be installed prior to beach/dune fill construction in July 2012.
    - Pre-Lay of Submerged Pipeline: The anticipated duration to pre-lay 62,908 feet of submerged pipeline from Ship Shoal to Whiskey Island is 42 days. Submerged pipeline will be installed prior to beach/dune fill construction during the period of June - July 2012.

- Containment Dike South (CDS) - Whiskey Island: The CDS separates the beach/dune fill from the marsh fill and will be constructed concurrently with the installation of the sediment pipelines and beach/dune fill. Construction of the CDS is estimated to progress at 400 feet per day based on review of prior projects. There is estimated to be 17,918 feet of CDS required for Whiskey Island requiring 45 days for construction (June - August 2012).

- Beach/Dune Fill: Dredge and fill activities for Whiskey Island beach/dune would require the excavation and placement of 8,330,215 cubic yards (in-place) of sands from Ship Shoal. This is calculated to take 10.7 months or 325 days. (July 2012 - June 2013)

- Sand Fencing - Whiskey Island: Sand fencing along the dune of Whiskey Island is estimated to require 18,075 feet of materials and be installed at 900 feet/day. Sand fencing installation would commence following beach/dune construction and be completed in 20 days (June - July 2013).

- Containment Dike North - Whiskey Island: The CDN separates the marsh fill from the backbay and will be constructed concurrently with the relocation of the sediment pipelines. There is estimated to be 7,370 feet of CDN required for Whiskey Island requiring 19 days for construction (March - May 2013).

- Pipeline Relocations
  - Pickup Submerged Pipeline: Following beach/dune construction the submerged pipeline must be relocated from Ship Shoal borrow area to Whiskey Island TE-50 borrow area 3A. This requires the removal of 62,908 feet of submerged pipeline from Ship Shoal to Whiskey Island. At a pace of 1,500 feet per day, it is anticipated to take 42 days to relocate the submerged pipeline. (June - July 2013)
  - Pre-lay Submerged Pipeline: Installation of 34,288 feet of submerged pipeline from Whiskey Island TE-50 borrow area 3A to Whiskey Island. At a pace of 1,500 feet per day, it is anticipated to take 23 days to re-install the submerged pipeline. (July - August 2013)

- Marsh Fill: Dredge and fill activities for Whiskey Island marsh would require the excavation and placement of 579,724 cubic yards (in-place) of mud/silt from Whiskey Island TE-50 borrow area 3A. This is calculated to take 0.8 months or 23 days. (August - September 2013)

- Pickup of Pipeline
  - Pickup Shore Pipeline: Following fill activities on the island 11,071 feet of shore pipeline will be broken down and readied for transport. These activities are anticipated to require 22 days. (September - October 2013)
  - Pickup Submerged Pipeline: Following fill activities on the island 34,288 feet of shore pipeline will be broken down and readied for transport. These activities are anticipated to require 23 days. (September - October 2013)

- Demobilization:
  - Demobilize Pipeline: Demobilization of the sediment pipeline is anticipated to take 14 days. (October 2013)
  - Demobilize Equipment and Crews: Demobilization of the shore equipment and crews is anticipated to take 8 days. (October 2013)
  - Demobilize Dredge: Demobilization of the dredge is anticipated to take 14 days. (October 2013)

- Vegetative Plantings:
  - Plantings - TY1: Aerial Seeding and Dune/Swale planting will take place during the appropriate season in Target Year 1. (Anticipated time April - May 2014)
  - Plantings - TY2: Woody Species and 50% Marsh Fill plantings will take place during the appropriate season in Target Year 2. (Anticipated time April - May 2015)
  - Plantings - TY3: Remaining 50% Marsh Fill plantings will take place during the appropriate season in Target Year 3. (Anticipated time April - May 2016)

L11.2.4 First Component of Construction Renourishment Construction Schedule

The PED process for the renourishments shall begin prior to the designated TYs (TY20 and TY40) for renourishment.

First Component of Construction - Renourishment at TY20

Renourishment at TY20 will follow the same schedule as the initial construction with the exceptions that it will not involve marsh fill construction or marsh fill vegetative planting. Dune/swale aerial seeding and planting should occur in TY21 and TY22. The volume of sediment required will be that needed to restore the geomorphologic form and ecological function, plus accounting for five years of background erosion/land loss.

First Component of Construction - Renourishment at TY40

Renourishment at TY40 will follow the same schedule as the initial construction with the exceptions that it will not involve marsh fill construction or marsh fill vegetative planting. Dune/swale aerial seeding and planting should occur in TY41 and TY42. The volume of sediment required will be that needed to restore the geomorphologic form and ecological function of Whiskey Island.

See Section L11.3 for details of AMP full schedule durations.

L11.3 Adaptive Management and Monitoring Plan Schedule

The AMP program setup and initial monitoring is anticipated to begin at the start of PED in December 2010 and continue through the end of construction for the initial restorations. The implementation of the AMP and post construction monitoring is anticipated to begin at the completion of the initial restorations and run for ten (10) years if required.

L12. VALUE ENGINEERING REPORT

L12.1 INTRODUCTION

This section is a summary of and excerpts from the Value Engineering Study (VE) Report as it pertains to the LCA Terrebonne Basin Barrier Shoreline Restoration Study. Complete details can be found in the final report titled *Value Engineering Study Report, Terrebonne Basin Barrier Shoreline Restoration, Multipurpose Operation of Houma Navigation Lock, Convey Atchafalaya River Water to Northern Terrebonne Marshes* prepared by Value Management Strategies, Inc (VMS, 2009).

The VE study report summarized the events of the VE workshop conducted May 5 – 8, 2009 for the U.S. Army Corps of Engineers (USACE), New Orleans District, by VMS. The subject of the study were the LCA TBBSR, Houma Navigation Lock Operations, and Convey Atchafalaya River Water to Northern Terrebonne Marshes Studies.

This study was conducted at the Feasibility Scoping Report/Preliminary Draft EIS, an early stage of Study development, and as such was at the beginning of plan formulation.

L12.2 VALUE ENGINEERING PROCESS

VE is a strictly adhered to process that follows specific steps and procedures. The specific steps in the VE process are as follows:

Step 1: Preparation – Developing a basic understanding of the client/user needs and requirements, specific goals, and current costs, with an agreement on the scope of the study.

Step 2: Information – Information is gathered prior to and during the study, and is reviewed and discussed with the team. A summary of Study constraints, critical issues, and observations from field inspection can be found in the *Study Analysis* section**.**

Step 3: Function Analysis – Defines the functions of the Study through an organized use of the Function Analysis System Technique (FAST) diagram that shows how the functions are related to one another.

Step 4: Speculation – Also known as creativity, it is the application of brainstorming techniques to develop a large quantity of ideas rather than focusing on the quality of ideas. A complete list of workshop ideas can be found in the *Idea Evaluation* section.

Step 5: Evaluation – Reduces the large quantity of ideas to a few high quality ideas.

Step 6: Development – The concepts identified in the evaluation phase are developed into specific VE alternatives that have been technically validated and quantified as much as possible.

Step 7: Report – Containing the VE team's recommendations and a presentation to the project stakeholders to receive their approval of these recommendations.

Step 8: Implement and Audit – Tracking the implementation of alternatives and auditing the results measures the effectiveness of the VE effort.

L12.3 VALUE ENGINEERING ALTERNATIVE CONCEPTS

The table that follows summarizes all of the alternative concepts developed by the VE team. The items in **bold** text were identified by the VE team as items of particular note and key recommended strategies for the PDT to consider.

Table L12-1. Summary of Value Engineering Alternative Concepts (Terrebonne Basin and General/Plan Formulation Only)

Number	Description
	LCA Terrebonne Basin Barrier Shoreline Restoration Study
T-1	**Install inverted breakwaters and use excavated material to construct or replenish back marsh**
T-2	**Obtain a clear definition of the Study objectives regarding sustainability**
T-3	**Establish permanent trust fund for renourishment costs**
T-4	**Construct a permanent pipeline from Ship Shoal to the east end of East Timbalier Island**
T-5	Conduct offshore sediment analysis to identify alternative sources of barrier island renourishment sediment
T-6	Consider wind-powered fixed dredged sediment supply
T-7	**Use Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) to regulate Ship Shoal quantities to various projects needing sediment**
T-8	**Consider coastal geomorphic processes for sediment placement**
T-9	**Utilize sand recycling/backpassing for barrier island nourishment**
T-10	**Fix barrier islands in their current location, eliminating/minimizing island rollover, by incorporating a "hard" core (e.g., buried sand - filled Geotubes, revetments) or allow surface armoring (e.g., revetments, rock, concrete)**
T-11	Construct groins and/or breakwaters with pre-filled sediment
T-12	**Construct new barrier island chain closer to new shoreline**
T-13	Establish an environmental dredging fleet
T-14	Prioritize Study components based on marsh loss factors
T-15	Add Plan Strategy that addresses habitat needs in excess of budgetary limitations
T-16	Implement oil/gas industry outreach program regarding future sediment management
T-17	Change the term "non-structural" in Study documents to "soft structural"
General / Plan Formulation	

Number	Description
G-1	**Develop Plan Strategies that account for higher levels of global sea level rise**
G-2	**Develop a seasonal freshwater management plan**
G-3	Create a Federal advisory committee
G-4	Identify and incorporate the effects of subsidence from fluid withdrawal in the Study analysis and design; utilize water injection to minimize the impacts of fluid withdrawal-induced subsidence
G-5	Consider alternate procurement methods for construction

L12.3.1 Alternative Concept Descriptions - LCA Terrebonne Basin Barrier Shoreline Restoration

T-1 Install Inverted Breakwaters and Use Excavated Material to Construct or Replenish Back Marsh

This Study Area faces a severe shortage of suitable material for island/dune construction as well as the back marsh. A potential good source of back marsh material may exist just offshore of the barrier islands on the GOM side. This material can easily be dredged and placed on the land side of the island as the base for the back marsh. With this excavation comes another advantage, the construction of an inverted breakwater on the GOM side in front of the island.

The construction of inverted breakwaters parallel to the beach is a simple concept that could prove to be very cost effective as well as physically effective for normal wave activity. They could even be constructed in tandem with offshore shoals. The concept is depicted in Figure L21-1.

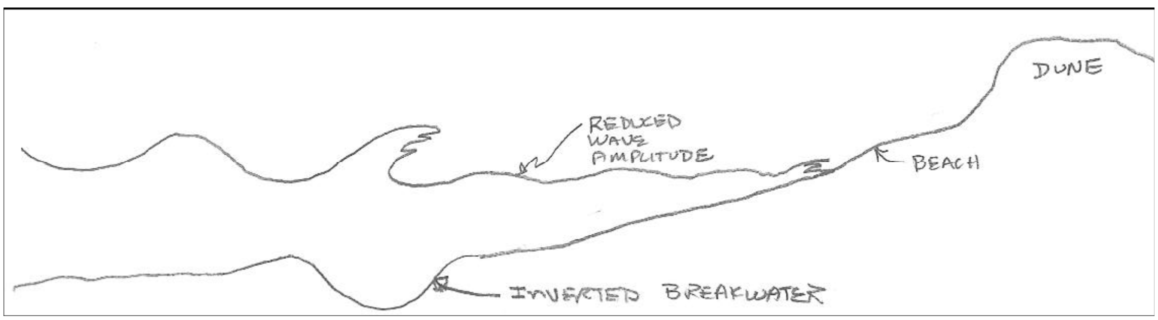


Figure L12-1. Inverted Breakwater Concept

The argument against inverted breakwaters is that the inverted breakwaters may trap some of the sand eroding from the beach, and thus negatively impact the littoral drift. However, the current littoral drift carries minimal sediment so the effect downdrift should also be minimal.

The advantage of this approach is the potential for obtaining sediment close to points of placement at a lower cost to the restoration. In addition, the initial wave heights will be diminished by the inverted breakwater, reducing impact energy along the shoreline and allowing more time for stabilization of plantings. Over time it is probable that movement of sediment will fill in the inverted breakwater because, at this location, there is a decrease in wave energy and the trench acts as a sediment trap. But this could be seen as a benefit as these trenches would become excellent locations for material needed in future maintenance dredging to renourish and sustain the program.

A paper published in the *Journal of Waterway, Port, Coastal, and Ocean Engineering* (January/February 1996) entitled *Multi - Pit Breakwaters* by William G. McDougal, A. Neil Williams, and Keizo Furukawa assessed the benefits of a submarine depression used as a breakwater. They found that the appropriate selection of depression (pit) dimensions and placement may lead to a significant reduction in wave height behind these structures. The shadow region behind the pits can reduce the wave heights by 10% to 20% of the incident wave height. This paper provides guidance on the selection of pit (inverted breakwater) geometries and placement for optimal breakwater performance. These features would not be very effective in reducing significant storm surges, in the same manner that offshore rock breakwaters would not be effective either. Further modeling and/or test reaches are recommended to assess their applicability to the Study.

T-2 Obtain a Clear Definition of the Study Objectives Regarding Sustainability

The first environmental operating principle of the USACE states that the USACE should, "Strive to achieve environmental sustainability, and recognize that an environment maintained in a healthy, diverse, and sustainable condition is necessary to support life." The sixth item listed in the "12 Actions for Change" indicates that the USACE should "focus on sustainability." It is clear from these principles and actions that sustainability is important to the USACE and, consequently, should be incorporated into USACE activities. However, the April 2009 Feasibility Scoping Meeting Report (FSMR) does not contain any mention of how sustainability will be considered in plan formulation. Moreover, there is no definition of sustainability provided in the FSMR. A clear definition of sustainability is needed in order to make sustainability a meaningful Study objective.

Such an objective may be established as follows:

- Sustainable with resources within the LCA up to the Year 2100 based on a range in relative sea level rise (e.g., extrapolation of historical rates of sea level rise, accelerated rate of sea level rise per NRC-low I, and accelerated rate of sea level rise per NRC-high III) no matter what the cost.

T-3 Establish Permanent Trust Fund for Renourishment Costs

Eustatic SLR at the highest rates combined with subsidence could be a net rise of nearly 6 feet by Year 2100 and thus inundating the Study Area. If the LCA program is not cancelled by Congress for these reasons, then an alternative concept requires repeated fill and restoration efforts to keep pace with both Eustatic SLR rise and subsidence. This is not a sustainable condition, but demands continuous repeated beach renourishment and marsh platform fill in perpetuity. Placing fill at the rate that equals the combined faster rate of Eustatic SLR rate based on this current science, and the known subsidence rates, in perpetuity will be vital for restoration success. Consequently, episodic (e.g., every five years) marsh platform fill and barrier island sand nourishment is essential for ecological restoration success. Renourishment needs based on just the NER process using cost effective incremental cost analysis justification cannot provide for perpetual ecological needs.

Congress typically chooses not to undertake financial obligations requiring future funding for perpetual costs. But Congress may appropriate funds to establish a permanent trust fund and the interest accrued would provide for perpetual costs. While such costs may be included as O&M costs provided by State, not Federal, funding, then only State assets, not national assets, are accessible. However, support is growing in Congress for certain permanent trust funds, for residential housing for example, which would build on successful trust fund models by States and tribes. By far the largest is the $26 billion Alaska Permanent Fund.

A possible example for a beach renourishment permanent trust fund: A multi-variant analysis of the costs to assure dredging and placement of sand from Ship Shoal to the Terrebonne Basin barrier islands based on the above various rates of Eustatic SLR rise is performed to determine the projected range of perpetual funding needed. If, for example, an annual beach renourishment cost of $5 million is required to keep pace with the accelerated rate of Eustatic SLR, then a permanent beach renourishment trust fund of $166 million yielding 3% annually would be needed. *(Should this trust fund yield exceed renourishment requirements, the trust fund may grow or alternatively annual net excess can be returned to the U.S. Treasury.)*

References:

NOAA, Sea Levels Online.
http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml

T-4 Construct a Permanent Pipeline from Ship Shoal to the East End of East Timbalier Island

One of the potential methods for barrier island construction and renourishment being considered by the PDT is to create “feeder beaches” that may erode into the littoral drift transferring sand to be deposited on barrier islands to the west. The primary location for such a “feeder beach” would be the east end of East Timbalier Island. Typically, this would involve periodically bringing in a dredge to Ship Shoal, laying a pipeline, and transferring sand to the “feeder beach”.

If the PDT determines that there is benefit to identifying a permanent location for deposition of renourishment sand at East Timbalier Island, it may be possible to lay a permanent pipeline for the dredge to hook up to. The pipeline could terminate on land, though this may create an issue with excessive accumulation of sand in a small area that might plug the pipe and prevent full deposition of the desired volume of sand. It may be preferable to terminate the sand within the littoral drift current itself rather than on dry land so that the sand begins its journey to the west immediately after it exits the pipe. A key concern would be locating the pipeline to avoid or minimize impacts to existing oil and gas facilities located between Ship Shoal and East Timbalier Island.

A further refinement of this idea would be to construct a permanent dredging plant at Ship Shoal to feed this pipeline. This dredge could be powered by "green" technologies (wind, solar) as discussed in another proposal.

T-5 Conduct Offshore Sediment Analysis to Identify Alternative Sources of Barrier Island Renourishment Sediment

The PDT has indicated that a major constraint in achieving the Study objectives is the availability of suitable sediment to restore and maintain the barrier islands. Although Ship Shoal was identified as a sediment source with known reserves of sand, there are numerous projects in the LCA program that are planning to utilize these sediment resources. In addition, Ship Shoal is between 50 and 100 miles from the barrier islands depending on the exact location within Ship Shoal and the island that is being restored with sand from this sediment source. Consequently, the cost of restoring the islands could be reduced significantly if alternative sediment sources closer to the islands were utilized for restoration activities. These sources may consist of sand layers located beneath the top sections of near-shore bottoms.

It is suggested that an offshore sediment source investigation be conducted to identify alternative sources of barrier island restoration and nourishment sediment. The investigation would focus on the area in the immediate vicinity of the islands and on the side towards the GOM. It might be possible to tap into the oil/gas industry for geological information (e.g., seismic recordings, geological logs, and sediment borings) to assist in conducting this investigation, thereby reducing the costs of the investigation. In addition, this recommendation could be used to suggest funding for the BOEMRE to conduct this investigation for the purpose of mapping the sediment resources in the area since BOEMRE is the Federal agency responsible for managing these offshore resources.

T-6 Consider Wind-Powered Fixed Dredged Sediment Supply

This alternative concept involves the permanent placement of a cutter head pipeline dredge at Ship Shoal with the pipeline terminus on East Timbalier Island. Sand deposited here sub-tidally is expected to accrete to the barrier islands by longshore displacement. Two booster pumps (either kinetic or positive displacement) are needed to supplement the dredge pump due to the distance the sand slurry can be pumped without pipe sedimentation. Two booster pumps would be installed to form a series spaced equidistant from the dredge site to the disposal site. A displacement booster pump used in combination with a centrifugal dredge pump would require a booster pump holding facility because it is difficult to match positive displacement pumping rates to centrifugal pumping rates.

Offshore Louisiana has potential for wind energy development according to two reports prepared for the Department of Energy in 1979. Offshore areas west of the Mississippi River offer a high Class 3/low Class 4 wind energy resource. (Class 7 being the maximum and Class 3 is the threshold for feasible wind power development.) In 2005, the Louisiana legislature approved authority for the State Mineral Board to lease State lands and water bottoms (i.e., areas within three miles of shore) for the production of wind energy.

To power these slurry pumps, three 1.5 MW capacity wind turbines and towers would be installed: one at the Ship Shoal cutterhead and two others to power the booster pumps. Wind power supply is interruptible. Cut in wind speed, when power is produced, begins at 3.5 m/s (8.4 mph). Because the wind-powered electric pumps would shut down when the wind is below the cut in speed, a flap valve at each booster station would be installed to drain the slurry to prevent sediment build up in the pipe.

The installed price for each 1.5 MW wind turbine and tower is estimated at $17.5 million according to the Danish Wind Industry Association. General Electric produced over 10,000 1.5 MW capacity wind turbines successfully operating since 1996 and are manufactured at GE's Pensacola, Florida plant.

T-7 Use BOEMRE to Regulate Ship Shoal Quantities to Various Projects Needing Sediment

The proposed concept is to use the BOEMRE to regulate the use of Ship Shoal sediments for use by various projects, in particular coastal barrier island restoration. Included in the idea is the thought to have BOEMRE evaluate the actual quantities of available sediment at Ship Shoal and determine appropriate locations for its use.

Background

Following a request by the USACE to be a Cooperating Agency in the LCA Barataria Basin Barrier Shoreline Restoration, the BOEMRE has been working with the USACE and other Federal and State natural resource agencies regarding the use of Ship Shoal and other sand bodies under their jurisdiction for use as sand sources for coastal restoration projects. Working as a Cooperating Agency for the LCA Barataria Basin Barrier Shoreline Restoration, the BOEMRE determined the need for intensive coordination and management of offshore sand resources for use in coastal Louisiana restoration projects. In May 2003, Mr. Barry Drucker with the BOEMRE established the Louisiana Sand Management Working Group (LA-SMWG) with the intent and purpose of bringing together various Federal and State natural resource agencies, as well as potential sand resource users. S. Jeffress Williams, USGS (Coastal and Marine Geology Program, 384 Woods Hole Rd., Woods Hole, MA 02543, email: jwilliams@usgs.gov) provided a compelling summary of the problems and opportunities at the meeting:

- Need for long-term sand requirements: Use of offshore sand for nourishment and coastal restoration in Louisiana, as well as many other regions, has longer term implications than just 20 to 30 years. The USACE projects are typically authorized for 50 years. For several projects suitable and economical sand resources have not been identified for 50 years of initial fill and periodic O&M fills. In my judgment, we need longer term planning for compiling sand needs. At minimum 50 years, 100 years is best.

- Need for sediment database/Seafloor maps: For Louisiana in particular, a great deal of data and information is available from very disparate sources on sand body location, sand quality, and quantity. What is needed is a comprehensive computer-based sediment database. The usSEABEDsystem is one start in this direction, but it needs further development to incorporate subbottom data, i.e., cores, borings, and seismic. Also, at least for premier sand bodies like Ship Shoal, Tiger Shoal, etc., we need complete map coverage of the seafloor using digital mosaic side-scan and multi-beam technologies that have recently become available. Such base maps are critical for not only accurately delineating the sand bodies, but also important for mapping essential fish habitats and infrastructure to avoid, such as pipelines.

- Permit streamlining: Plans for large scale barrier nourishment are well advanced in Louisiana, potentially requiring ~100 CY meters of sand. An efficient permitting process by the USACE and BOEMRE needs to be in place.

- Science studies/monitoring: Important questions arise on sediment transport processes associated with dredging and nourishment, such as: What is the traditional engineering "close-out depth" for a particular coast and how close to shore can you dredge without exacerbating erosion of the adjacent coast? What is the importance of ebb-tide shoal sediments for the Louisiana sediment budget and can they be mined without causing downdrift erosion? What is the optimum spatial and temporal design for dredging so as to minimize environmental harm? How long do dredge holes remain open? What are their short and long-term effects on marine habitats, wave refraction, etc.?

In May 2003, the BOEMRE provided in the Federal Register a notice to prepare a multi-project environmental assessment to evaluate the potential environmental impacts associated with the removal of sand resources from Ship Shoal. Meetings were conducted over the ensuing years with BOEMRE funding scientific efforts to investigate the potential impacts associated with removal of sand resources from Ship Shoal.

Implications for Creative Idea:

The BOEMRE is the regulatory agency with jurisdiction to manage the Ship Shoal and other offshore Federal sand bodies. They have been conducting investigations over the past several years. There have been several studies funded by the BOEMRE that have determined the extent of sand and other mineral resources on Ship Shoal. The BOEMRE has funded and will likely continue to fund studies regarding potential impacts of removing these sand resources from Ship Shoal on aquatic organisms, as well as on wave dynamics. However, BOEMRE does have authority to make decisions on suitability or priority of sand use.

VE Alternative follow-up:
In June 2007, BOEMRE sent a letter to all stakeholders (Federal, State, and other) requesting information on potential projects using outer continental shelf (OCS) sand and gravel resources in the next five years. Based upon BOEMRE resources and stakeholders' responses regarding project timelines, a maximum of two projects per quarter were scheduled.

Most recently, BOEMRE sent another request in April 2009 to update the calendar; responses were due June 1, 2009. Their intent is to publish the responses in the Federal Register in the third quarter of 2009. It is anticipated that BOEMRE will continue to schedule a maximum of two projects per quarter.

T-8 Consider Coastal Geomorphic Processes for Sediment Placement

The configuration and manner in which sediment will be placed on the barrier islands was not presented in the April 2009 FSMR. It appears that the PDT is leaning towards placement of most sediment (sand on the GOM side and mud on the bay side) on the downcoast side of the islands, which is the western end of each island. This preliminary decision is apparently based on the fact that the longshore transport moves sediment from east to west. Likewise, from a cross-shore standpoint it does not appear that much consideration has been given yet to how the sediment would be placed from the beach across the dune and into the back-bay marsh. It might be possible to increase the longevity of the placed sediment by considering the coastal geomorphic processes in developing and/or refining the configuration and manner of sediment placement.

Instead of placing sand in equal amounts along the entire length of the island or in larger volumes at the western end of each island, the PDT should consider constructing the east end of each island wider than the west end. Utilizing this configuration for the beach restoration and nourishment activities would allow the eastern beach area to serve as a feeder beach providing a sediment source to nourish downcoast (western) beaches as the longshore transport moves the sand from east to west. Prior to implementation, a coastal processes analysis should be conducted to determine the maximum beach width in each area to avoid overbuilding the beach in the eastern portions of each island. An overbuilt beach could push the sand into deeper waters and/or result in overly steep beach slopes, both of which could increase the rate of erosion.

Another consideration in the placement of sediment for island restoration is the aspect ratio of each barrier island. The aspect ratio is the length of each island divided by the width and it can be calculated as a mean or at regular intervals (e.g., every quarter mile) along the entire length of each island. There has been some research conducted to estimate the optimum aspect ratio for the barrier islands and this information should be considered in the development of sediment placement configurations (volumes and locations).

T-9 Utilize Sand Recycling/Backpassing for Barrier Island Nourishment

Beach restoration and beach nourishment are presented in the April 2009 FSMR as two management measures that will be carried forward for future consideration in the formulation of Study alternatives. Beach restoration is defined in the FSMR as the (initial) placement of beach-suitable sediment (sand) within the beach profile from the dune out to the depth of closure, while beach nourishment is defined as the periodic placement of sand in the same location. Beach restoration basically restores the shoreline and beach to historical conditions, while beach nourishment keeps pace with future erosion to maintain the restored condition. Ongoing beach nourishment activities will require the identification and dredging of additional sources of sand in the future. Based on existing information and data, sand is already limited in availability and there is a lot of demand for that sand for this Study as well as other projects in the LCA program. Therefore, the retention and efficient use of existing and future sand resources will be an important factor in cost-effectively meeting Study objectives.

One way to make more efficient use of existing and future sand resources is to utilize sand recycling/backpassing to replace and/or augment beach nourishment activities. In the Terrebonne Basin barrier islands, the net longshore transport is from east to west, meaning that sand is driven by the waves from east to west. Sand recycling would consist of dredging sand at the western end of the barrier islands and placing it on the eastern end. This would help reduce the quantity of new sand needed for future nourishment activities. The effectiveness of sand recycling can be improved through the construction of terminal groins or breakwaters at the downcoast end of the barrier islands to capture as much sand as possible before it is lost to the bay area and/or GOM. Prior to implementation, coastal processes analyses should be conducted to make sure that sand from an upcoast island (i.e., to the east) is not providing a substantial source of sand to a downcoast island, otherwise the sand recycling program might result in increased erosion to the downcoast barrier island. Sand recycling has been used with success along Peninsula Beach, which is located in Long Beach, California.

T-10 Fix Barrier Islands in Their Current Location, Eliminating/Minimizing Island Rollover, By Incorporating a "Hard" Core (e.g., Buried Sand-Filled Geotubes, Revetments) or Allow Surface Armoring (e.g., Revetments, Rock, Concrete)

The natural geomorphic development of barrier islands is to allow them to rollover where the dune field progresses landward overriding the back marsh as the beach face erodes. This is currently the preferred design as presented by the PDT. In order for this approach to be successful, periodic renourishment (typically every five years) is required over the 50-year period of analysis to maintain both the barrier island and the back marsh. However, the current Study plan and budget only allows for a single renourishment after about five years, which means the sustainability of the Study is in doubt.

An alternative approach is to fix the islands in place and minimize the amount of renourishment required. This is not a "natural" geomorphic process for barrier islands as it limits rollover and migration of the barrier island landward. However, there are agencies in the State, as well as members of the general public, who would prefer this approach as a more positive means of providing storm surge and salinity intrusion protection. Fixing the location of the islands with a corresponding reduction of renourishment needs may improve sustainability within the available budget for the Study. It would also reduce the amount of material needed, which is a considerable general Study concern.

One alternative installs a buried “hardscape” that draws a “line-in-the-sand” on the shoreline. The sand-filled Geotube (using sand already earmarked for beach and dune restoration) would resist erosion of sand along with storm surge-related breaches in a more cost-effective manner than, say, offshore breakwaters. In most cases these Geotubes can replace the offshore breakwaters, or be used in tandem with the breakwaters (such as inverted breakwaters proposed above) in critical areas.

Since the Geotubes are not exposed most of the time, they will not experience deterioration from sunlight or vandalism. If damage to the Geotubes occurs from storm surge activity, they can be replaced or repaired. Erosion of the sand in front of the Geotubes and on top will likely occur over time requiring renourishment of the dunes approximately every ten years. A sketch of this concept is shown in Figure L12-2:

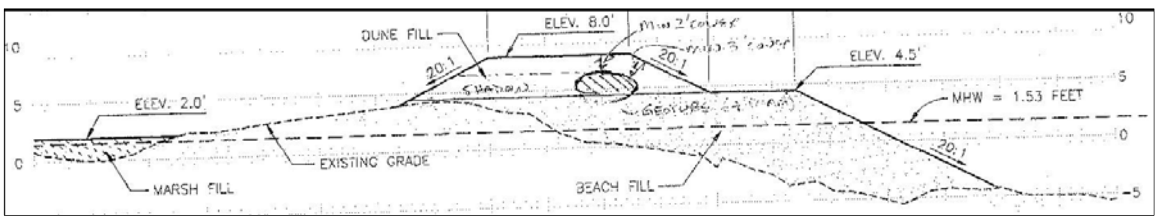


Figure L12-2. Geotube Incorporation in Beach Design Concept

In lieu of Geotubes, other hardened materials such as revetments or rock can be buried in the core to increase the “hardness” of the island. Further, surface hardening can be considered through the use of surface revetments, concrete, or rock; however, this approach may not be preferred over the “hardened” core concept as it would take away from the sand beach surface that may be preferred nesting areas for birds. In addition, surface hardening would be considered to be less aesthetic than exposed sand surfaces, and would be less capable of supporting stabilizing vegetation.

<u>T-11 Construct Groins and/or Breakwaters with Pre-filled Sediment</u>

The use of groins and breakwaters to trap sand on the barrier islands were identified as potential management measures to be carried forward through the plan formulation phase. Based on the information presented in the April 2009 FSMR, it appears that groins and breakwaters would be implemented without the use of pre-fill. The implementation of groins and breakwaters without pre-fill can lead to erosion of adjacent shorelines and beaches as indicated in the FSMR. This erosion is caused by the trapping (or retention) of sand in the fillet of the groins, as well as the salient (or tombolo if the salient touches the shoreline) of the breakwaters.

The addition of pre-fill should be considered to address the potential impact of erosion attributed to the implementation of groins and breakwaters. For groins, the use of pre-fill would entail estimating the volume of sand that would be trapped in the fillet and then placing this volume of sand in the fillet as part of the initial groin construction project. In the case of the breakwaters, the use of pre-fill would consist of estimating the volume of sand that would be trapped in the salient and then placing that volume of sand in the salient as part of the initial breakwater construction project. The use of pre-fill mitigates for impacts to adjacent beaches while the retention structure (i.e., groin or breakwater) provides a wider, more stable beach. Prior to implementation of pre-fill for a breakwater, a coastal processes analysis should be conducted to assess the potential impact of the salient itself on longshore transport.

T-12 Construct New Barrier Island Chain Closer to New Shoreline

There is high probability that maintaining the existing barrier islands beyond the 50-year period of anaylsis will not be possible due primarily to increasing rates of sea level rise, future subsidence, and resources constraints (e.g., sediment supply and funding). Given the value of the habitat on the islands, as well as the important role these islands play in protecting bayside resources, it still makes sense to expend resources in restoring and maintaining the islands from now and into the immediate future (e.g., 50 years). However, it also makes sense to begin thinking now about the long-term sustainability of the entire ecosystem in the LCA.

It is suggested that consideration be given to the design and construction of a new barrier island chain. This would include the identification of a new “fallback” shoreline that would be used to guide the location of the new barrier island chain. This new shoreline and barrier island chain would form the second line of defense, with the first line of defense being the restoration and protection of the existing barrier islands. The new barrier island chain could be constructed in areas of the existing LCA that are relatively high in elevation and free of oil and gas wells and pipelines to minimize construction costs associated with fill placement and construction access. In addition, this strategy could be implemented through an adaptive management framework such that lessons learned from restoration and maintenance of the existing barrier islands could be used to improve the design, construction, and maintenance of the new barrier island chain.

T-13 Establish an Environmental Dredging Fleet

The amount of sediment needed to renourish the barrier island system will far exceed the available dredge fleet in and beyond the region. While private industry will respond to this need by manufacturing additional dredges as projects progress, it is likely that such plant development will severely lag demand. Private industry will not likely produce more than is needed at any given period, as they will perceive a risk of over supplying intermediate need. Such projected constant shortages will likely limit bid completion and raise prices substantially.

A possible means of avoiding this problem may be government partnerships with private industry to fabricate new dredges in advance of individual project need. For example, the government could build the needed fleet and lease the equipment to industry; the government could finance industry to build their fleet; or industry could build the fleet on their own and lease equipment to the government. There are a number of “lease/purchase” and other innovative procurement options that balance risk and optimize financial advantages between the government and industry. In general, the government can secure capital at relatively low cost and industry can take tax advantages of ownership via depreciation deduction. Such advance fabrication of dredges could help in achieving adequate resource supply to meet projected demand.

T-14 Prioritize Study Components Based on Marsh Loss Factors

The PDT indicated that some type of system would be needed to prioritize restoration activities. However, it does not appear that such a system was developed or applied during preparation of the information contained in the FSMR. The PDT was asked if an estimate had been developed that represents the percentage of marsh loss due to the various causes of erosion. For example, how much of every 100 acres of marsh loss is attributed to sea level rise, fluid withdrawal-induced subsidence, sediment compaction-induced subsidence, wind-wave erosion, storm-induced erosion, vegetation loss attributed to salinity changes, and herbivore activity. Note that a cursory review of the figure in Attachment F of the April 2009 FSMR suggests a relationship between oil and gas extraction (as represented by oil and gas wells) and marsh loss (as represented by open water areas). It is important to develop an estimate of the importance of these various loss factors because a primary stated objective of the barrier island restoration is to protect and preserve the marsh to the north of the islands. If sea level rise and fluid-induced subsidence are of equal or greater importance than wind-wave erosion and storm-induced erosion, then restoration of the barrier islands may not achieve this objective.

One way to address this issue would be to conduct an analysis to determine the amount of marsh loss attributed to sea level rise, fluid withdrawal-induced subsidence, sediment compaction-induced subsidence, wind-wave erosion, storm-induced erosion, vegetation loss attributed to salinity changes, and herbivore activity. The results of this analysis could then be used to prioritize Study components, thereby giving the PDT a planning tool for the prioritization task that they will have to undertake. The results might also suggest that it is not possible to meet some of the Study objectives or that the objectives themselves need to be prioritized in order to select the appropriate restoration activities. Concern about the possible findings of this analysis should not be used as a reason not to conduct it since the results will merely inform the decision making process. For example, even if the results indicate that sea level and/or subsidence are primary contributors to marsh loss, it does not mean that barrier island restoration should not be implemented, rather, it means that barrier island restoration would probably not be effective in meeting the Study objective related to marsh protection from wind-wave erosion and storm-induced erosion.

T-15 Add Plan Strategy That Addresses Habitat Needs in Excess of Budgetary Limitations

The Plan Strategies identified for the Study are intended to produce a full spectrum of alternative plans as required by National Environmental Policy Act (NEPA) and USACE planning guidance in ER 1105-2-100. Alternative Plan Strategies were designed to be significantly different from one another and to represent the entire range of solutions to identified problems within the Study Area. This VE alternative concept is intended as a check to the PDT that Plan Strategy E, increase of current configuration and functional geomorphology, be the Plan Strategy that addresses habitat needs above and beyond the budgetary limitations set by the Study authorization. During the NEPA alternative evaluation process, this consideration is needed regardless if the funds will be available to ever make the alternative feasible. If Plan Strategy E is not intended to satisfy this part of the alternative evaluation, suggest developing an additional Plan Strategy that does address the "best case" scenario regarding habitat creation and sustainment.

T-16 Implement Oil/Gas Industry Outreach Program Regarding Future Sediment Management

The PDT indicated that the oil/gas industry (industry) might redistribute sediment placed on the islands following restoration activities. The industry has a longstanding practice of redistributing sediment to protect oil/gas infrastructure. For example, the industry redistributes sediment via dredging to bury pipelines that have become exposed following storm and hurricane activity. Consequently, the PDT expressed concern that the industry would utilize the newly placed sediment for this purpose upon completion of restoration activities, thereby decreasing the effectiveness of restoration activities and undermining Study success.

An outreach program could be implemented to proactively address this issue. The outreach program would explain the various restoration components to the industry. It would include a description of the natural sediment processes and how those processes would benefit the natural habitat and resources, as well as how those processes would benefit the industry. A description of acceptable sediment management practices would be included in the outreach program to minimize negative practices and maximize positive practices since it might be possible to work with the industry to help maintain and/or improve the islands upon completion of restoration activities. Finally, the outreach program would have to be developed in careful consideration of the target group that is to receive the information to make sure the right people in the industry are getting the message and that it is tailored to those people. This will help ensure that the right message is getting to the right people.

T-17 Change the Term "Non-Structural" in Study Documents to "Soft Structural"

The Study documents uses the following definition of terms: "*A management measure is a feature (a structural element that requires construction or assembly on-site) or an activity (a non-structural action) that can be combined with other management measures* *to form alternative plans."* The term "non-structural" is commonly used in USACE flood control and hurricane protection projects. It has a very specific meaning that includes options such as flood proofing property, raising buildings above flood elevations, purchasing property and/or relocating or removing the property from the area of risk, and prohibition of further development in areas of risk. However, for this Study, the term is to refer to restoration activities that include:

- Dune restoration;
- Marsh creation;
- Beach restoration;
- Beach nourishment;
- Subtidal sediment placement;
- Addition of sediment into near-shore environment to supplement littoral drift;
- Beach closure;
- Small marsh island construction on bayside for bird habitat;
- Vegetative planting;
- Herbivory control;
- Biological bio-engineered oyster reefs;
- Spit creation; and
- Canal backfilling.

In order to avoid confusion with a generally accepted definition, the VE team recommends that the term "nonstructural", as used in the Study documents, be changed to "soft structural".

L12.3.2 Alternative Concept Descriptions - General / Plan Formulation

G-1 Develop Plan Strategies that Account for Much Higher Levels of Sea Rise

The purpose of this ecological restoration is to achieve a sustainable solution, but the Study must respond to Relative SLR as the combined rates of subsidence and SLR. SLR consists of two factors: 1) Eustatic rise due to density warming and 2) land-based glacial melt rise. Eustatic sea level rise during the next 50 years is expected to be approximately 4 inches (IPCC 4th Assessment Report, 2007). The IPCC has not yet projected the portion of SLR due to land-based glacial melt. Under the 2007 IPCC "business as usual" scenario, Eustatic SLR is projected to be 0.75 feet to 1.5 feet by 2100. At that time, no significant acceleration of SLR rise had been detected. New research published this year indicates that SLR could be 3 to 4 feet by 2100, which is much higher than IPCC 2007 predictions (Niels Bohr Institute, published in the journal *Climate Dynamics*). The great uncertainty in the rate of SLR regards how quickly the ice sheets on land will melt.

The subsidence rate in the Mississippi River delta planning area range from 1.0 to 3.5 feet by the year 2100. The Relative SLR (i.e., the Eustatic SLR rise and the delta's subsidence rates) used for the LCA Program for the next 50 years are 1.3 to 2.6 feet, or 2.6 to 5.2 feet by the end of the century. Twentieth century rise in sea level from observed data was about 1.8 mm/year as result of long-term response to the end of the last ice age. Since 1992, however, satellite data have recorded an accelerated rate of SLR of 3.0 mm/year, but this is not sufficiently long to determine if this rate will be prolonged or is a short-term change.

Benefits depend upon habitats maintained above sea level. Consequently, benefits beyond the 50-year period of analysis will be lost due to subsidence, SLR, and storm-induced habitat loss. Long-term melting of the Greenland ice sheet during subsequent centuries of warming could result in complete melting over several thousand years, eventually resulting in a SLR of 22 feet (7 meters).

As the rate of SLR in the future is unknown, the Study should develop specific Plan Strategies that consider the range of possible future SLR rates, and check to see how sensitive the Study design is to those different scenarios. Those future scenarios include:

- A low level that is based on an extrapolation of the historic rate assumes SLR will be linear in the future and will not accelerate;

- A medium level that assumes SLR of 0.5 meters by 2100; and

- A high level that assumes a greater future acceleration of SLR of 1.5 meters by 2100.

However, as noted above, current science projecting an accelerated rate of land-based glacial melt has huge ramifications for Study viability or perpetual cost obligations. Future SLR rate based on this science must wait on future work by the IPCC and U.S. agencies to be completed by late 2009. This work is based on recent, and increased, rates of observed SLR using satellite data, previous historic rates of sea level rise during past glacial melt. Currently, work is underway by the USACE, NOAA, and USGS to investigate the glacial melt contribution to future SLR.

G-2 Develop a Seasonal Freshwater Management Plan

Wetlands in the Study Area are deteriorating as a result of subsidence, lack of sediment and nutrient deposition, saltwater intrusion and erosion. Deterioration will continue unless action is taken to resolve the causative factors. Sustainable protection and enhancement of the wetlands in the Study Area is dependent on providing a hydrologic regime that minimizes the physiological stress to wetland vegetation.

Seasonal differences in the need for freshwater and nutrients, and the locations from which freshwater can be recruited and distributed, should be optimized. For example, the quantity of water that can be diverted from the Atchafalaya River to the Gulf Intracoastal Waterway (GIWW) is somewhat limited due to infrastructure restrictions: traffic tunnel in Houma and the Houma twin bridge abutments are two examples. Freshwater could also be diverted into the GIWW system at the Harvey Lock and Algiers Lock. In addition, freshwater is being diverted into Bayou Lafourche and Davis Pond. Each of these is an individual site at which important resources can be introduced into the wetlands; however, quality and quantity of freshwater could be enhanced with coordination and planning treating these sources as a supply network.

Opportunities exist to naturalize the distribution of freshwater and, to a limited extent, the deltaic forming sediments, improve distribution of freshwater, and to reduce the negative impacts of GOM storm events. Seasonal GOM events have an intensive impact on the remaining marsh areas. Opportunities exist through freshwater supply and distribution to create a healthier marsh which will be more resistant to the normal range of events.

Cost to develop a management plan is minimal. Implementing the management plan would likely require instrumentation and communication equipment.

G-3 Create Federal Advisory Committee

Public participation will be achieved through the NEPA process involving Federal and State cooperating agencies, public review, and public and legislative hearings. This can be augmented by developing a formal multi-State committee. A Federal advisory committee can be comprised of both government and nongovernmental stakeholders along the Mississippi flyway, including Canada. The Federal Advisory Committee Act (FACA, PL 42-463) governs the establishment and behavior of Federal advisory committees. There are now approximately 1,000 such committees. FACA was an attempt by Congress to curtail the "locker-room discussion" that had become prevalent in administrative decisions and obligates transparency in the process.

For example, a Federal advisory committee may include the Missouri and Mississippi State River Basin Commissions, and national and Canadian environmental organizations. This would expand national interests to support Congressional intent, but will add additional administrative burden to the USACE.

Example FACA Committee: The National Park Service, Georgia, Big Cypress National Preserve Off-Road Vehicle (ORV) Advisory Committee.

G-4 Identify and Incorporate the Effects of Subsidence from Fluid Withdrawal in the Study Analysis and Design; Utilize Water Injection to Minimize the Impacts of Fluid Withdrawal-Induced Subsidence

The Principal of Effective Stress is a well known geotechnical engineering principal applied to the consolidation of sediments and rock when there is a net change in interstitial pressure in the system. Principally, this can be described as an increase in stress between particles resulting from a reduction of pore fluid pressure that causes the solid particles in the mass to move closer together. Once this consolidation of mass occurs, it cannot be reversed. The reduction in fluid pressure happens when the fluids are permanently removed from the system (that is, through the pumping or mining of groundwater, oil, and gas). The consolidation of the solids produces general settlement (or subsidence) of the ground surface.

Significant ground surface subsidence (sometime associated with fault development) as a direct result of fluid withdrawal has been documented worldwide. Well known cases exist in Houston, south central Arizona, North Las Vegas, and central California. In the Long Beach, California area, from about 1920 to 1960, 29 feet of surface subsidence occurred that was directly related to the removal of oil and gas.

The current documents do not fully address time-dependent subsidence in the Study Area due to oil and gas withdrawal, a process which is ongoing in the area. The amount of such subsidence has not reportedly been documented to date. It is recommended that surface subsidence due to fluid withdrawal in the Study Area, and its future impacts on Study sustainability, be assessed and included in the Study design and documents.

There may be some visual evidence of a correlation of open water in the Study Area with the concentrated location of oil wells. It could be interpreted that some of this open water resulted, in part, from subsidence associated with the withdrawal of oil and gas from these concentrated well areas. This visual comparison can be seen in the two maps below (Figure L12-3, L12-4).

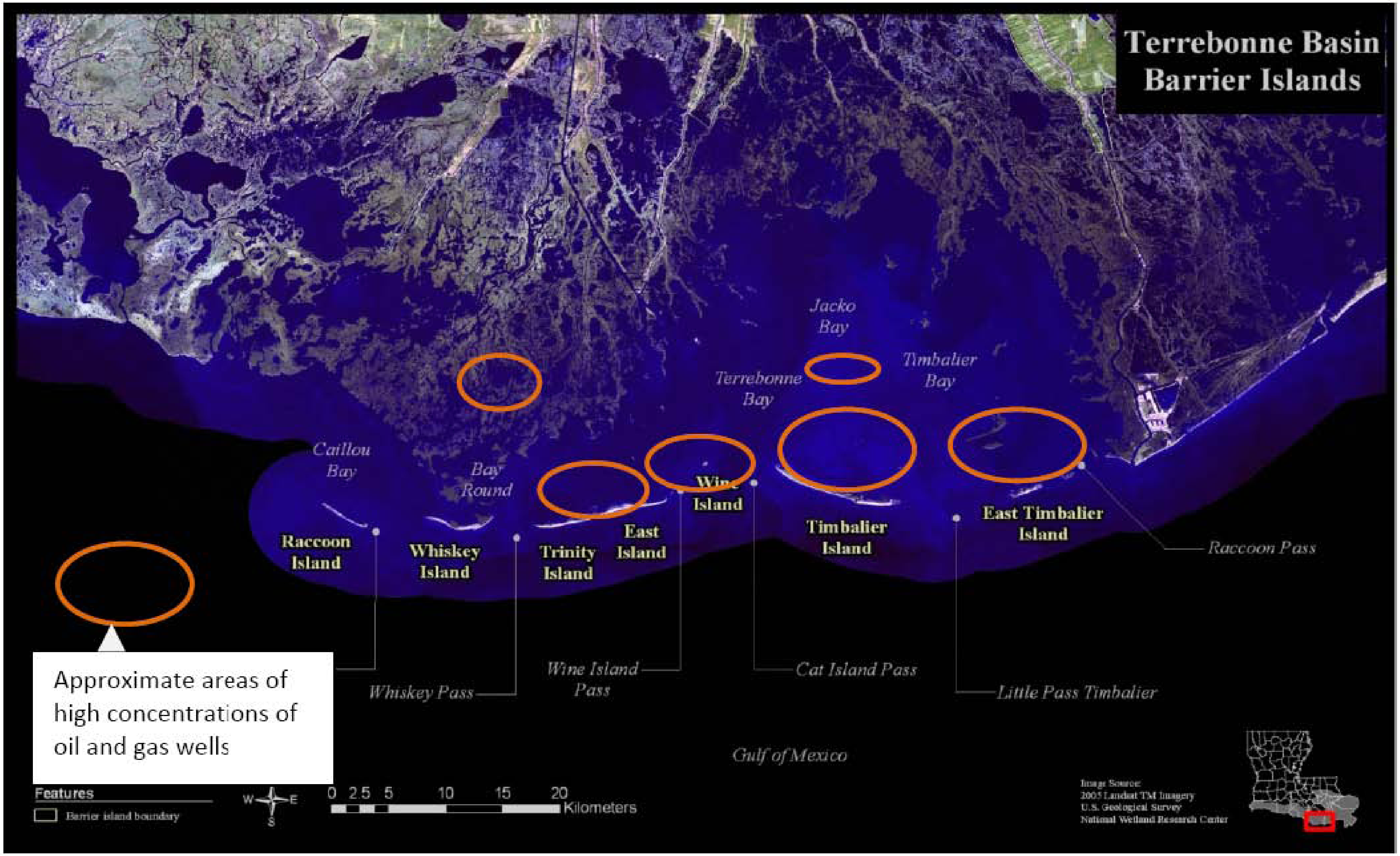


Figure L12-3. Approximate Areas of High Concentration of Oil & Gas Wells

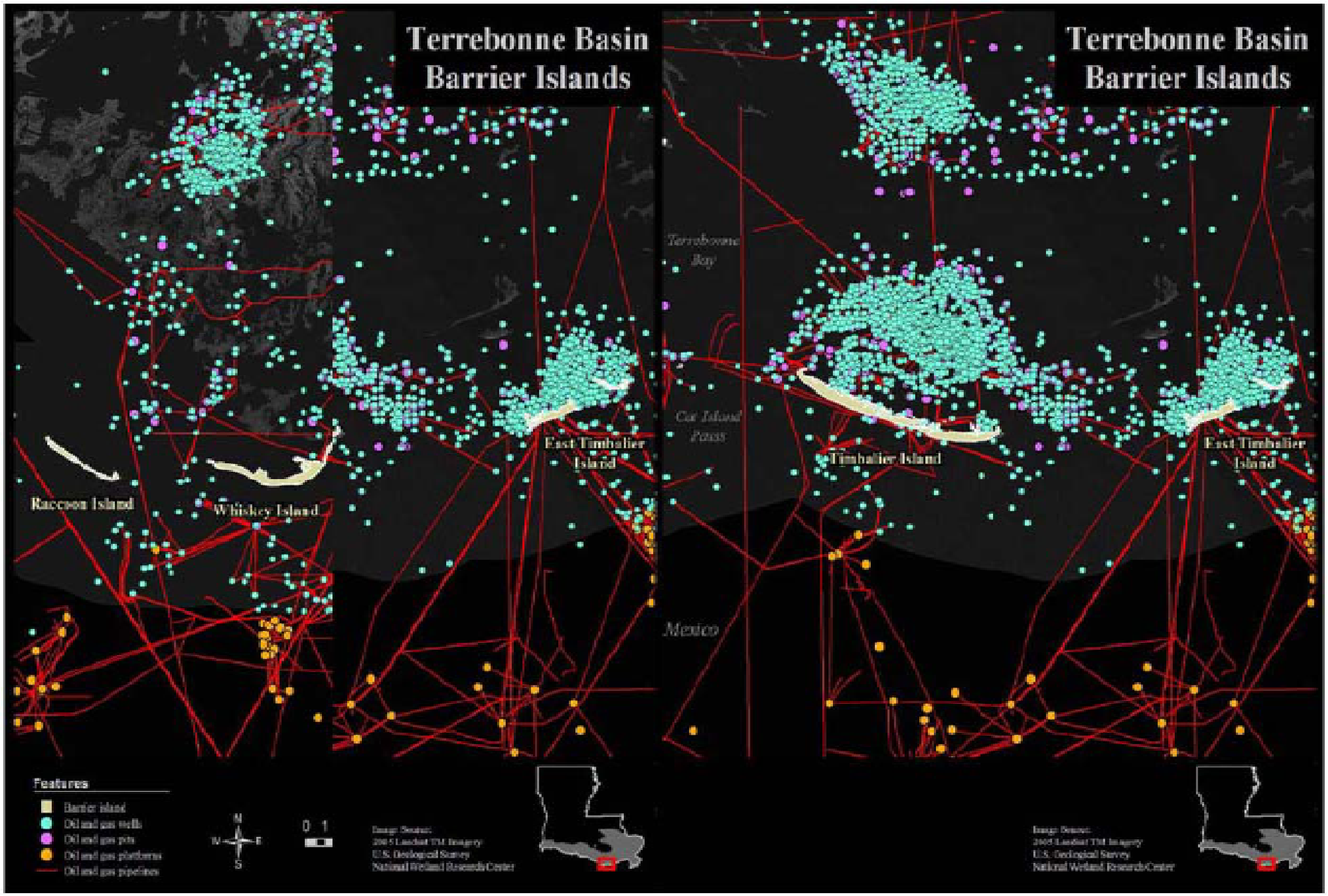


Figure L12-4. Oil & Gas Infrastructure

As was mentioned above, from about 1920 to 1960 in the Long Beach, California area, 29 feet of surface subsidence occurred that was directly related to the removal of oil and gas. Once this problem was identified, the petroleum industry elected to inject saltwater into the subsurface to replace the withdrawn oil and gas as a mechanism of recharge that would maintain the internal pressures, thus minimizing the change in effective stress. As a result of this effort, additional subsidence has been limited to about 1 foot to date.

An added benefit of saltwater recharge has been the ability to increase the extraction of petroleum from the reserve. Such recharge has become a standard practice in the industry. If this is not already being done within the Study Area, the USACE is encouraged to open discussions with the oil industry to see if the technique can be implemented. This would reduce the amount of future subsidence due to fluid withdrawal, extending the life of the Study and its sustainability.

G-5 Consider Alternate Procurement Methods for Construction

Given the complexities associated with identifying sources of material for renourishment of the barrier islands, transport and placement of the material, and preservation of the material, as well as limited specialized contractor availability, use of alternate procurement methods should be considered. Examples of some of these methods include CM-at-Risk and using Habitat Units as the pay items.

CM-at-Risk procurement, also known as Integrated Design-Bid-Build or Earlier Contractor Involvement, involves selecting a contractor and separate designer during the design phase. Both parties work together under separate contracts with the government with the objective of developing a design that is most efficient. The government then negotiates and awards construction packages to the contractor. If negotiations are not successful, the government reserves the option to bid the work on the construction open market.

The process calls for the selection of a construction contractor (based on qualifications only) early in the design phase. This contractor and the designer collaborate in developing a design most suitable for the specific contractor while meeting all performance requirements (such as maximizing the number of Habitat Units created). In this arrangement, the government has the option to either negotiate a subsequent construction price with the previously selected contractor or bid the job on the open market. Such a procurement plan would help assure a constructible design that meets the relatively complex requirements of this Study.

L12.4 Study Analysis

Key Study Factors

The first day of the study included meetings with the Study stakeholders. The following summarizes key Study issues and concerns identified during these sessions.

Project Issues

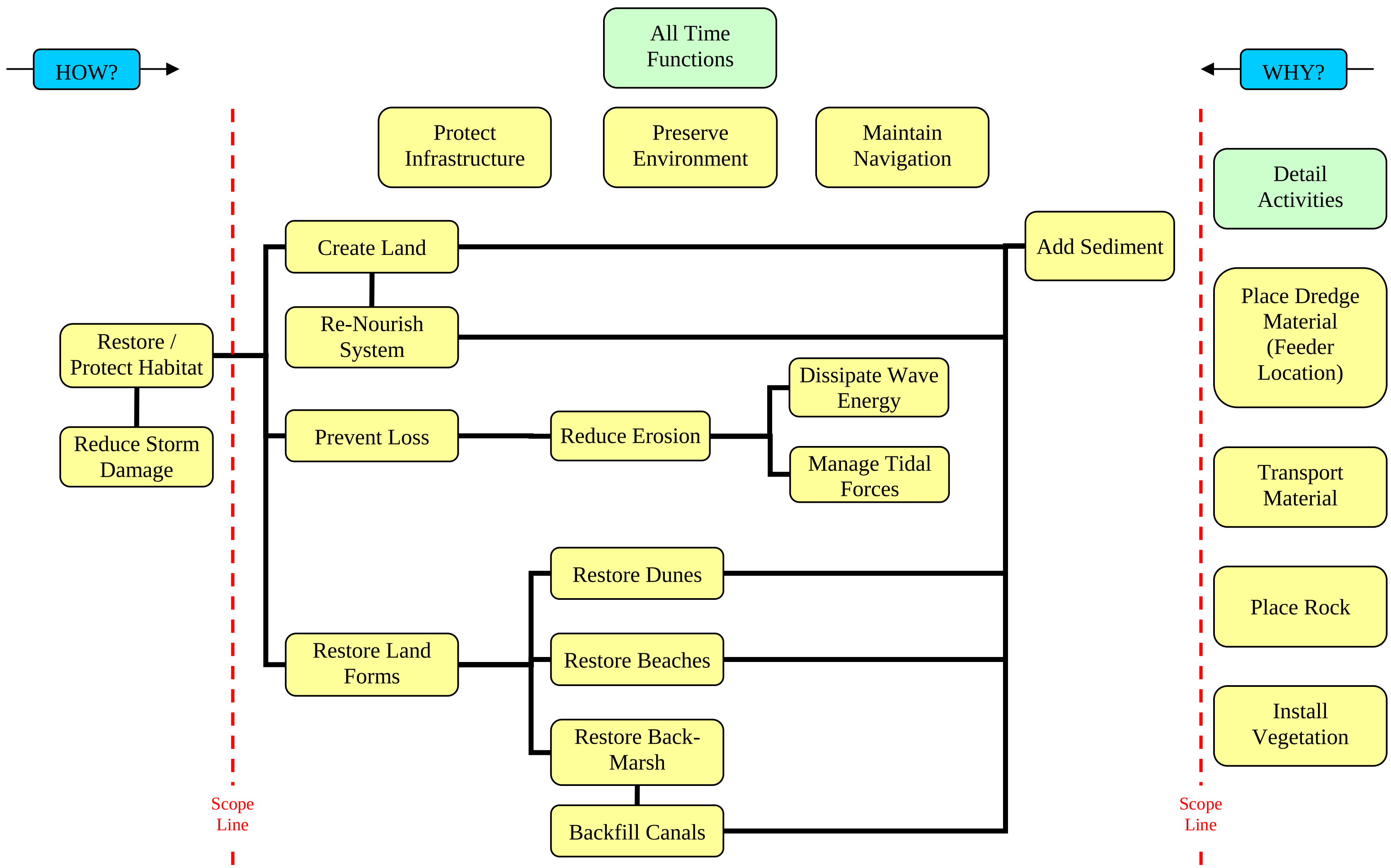
The following are some of the issues and concerns associated with the LCA TBBSR Study:

- Lack of sediment for barrier island renourishment. The demand for sediment from various projects exceeds the supply at Ship Shoal;
- Study authorization requires signed Chief's Report by December 2010;
- There is a limit to the number of dredges available to supply sediment for barrier island renourishment;
- Absolute sea level rise threatens the restoration's justification and sustainment;
- Key navigation routes through the Study Area limits must be maintained; and
- Authorized funds do not provide for future renourishment requirements;

Function Analysis / Fast Diagram

Function analysis was performed and a FAST Diagram was produced, which revealed the key functional relationships for the Study. This analysis provided a greater understanding and how the Study objectives and specific activities are related.

LCA Terrebonne Basin Barrier Shoreline Study FAST Diagram
(Adapted from VMS, 2009)



L12.5 IDEA EVALUATION

L12.5.1 Introduction

All of the ideas generated by the VE team were recorded and evaluated with Study-specific attributes applied to each idea to ensure an objective evaluation.

L12.5.2 Performance Attributes

Performance attributes represent those aspects of a Study's scope and schedule that may possess a range of potential values (as opposed to performance requirements which represent essential, non-discretionary aspects). The VE team developed the following list of performance attributes to act as criteria for considering the value potential of the creative ideas:

- Coordination with natural/coastal processes. Includes sustainability of barrier island system;
- Functionality of habitat. Includes acres of habitat and quality of habitat;
- Degree of protection to interior marsh; and
- Schedule.

L12.5.3 Evaluation Process

The VE team, as a group, generated and evaluated ideas on how to best perform the various major components or functions of the Study. The goal of the evaluation was to select the best ideas that would produce a high level of performance at an acceptable level of cost. The evaluation used the key criteria listed above and the function analysis performed by the VE team. Given the relatively early level of Study development at the time of the VE study (i.e., no original design), the team evaluated each of the ideas with respect to each of the key evaluative criteria to determine whether it was better than, equal to, or worse than the other feasible alternatives. The team then reached a consensus on the idea's development status. Readers are encouraged to reconsider all ideas generated by the VE team, as previously rejected ideas may prove to be feasible as the Study development proceeds beyond the scope of the VE study.

L12.5.4 Idea Evaluation

All of the ideas that were generated during the creative phase were recorded and each idea was discussed individually and the advantages and disadvantages of each were discussed. The Idea Evaluation Summary Table containing all of the ideas, and the rating applied to each idea, is presented on the following pages. The ideas were assigned a recommendation for development as follows:

Develop	=	Develop into VE Alternative Concept
ABD	=	Being Done or Part of Original Scope
Eliminate	=	Idea Rejected or Outside Study Scope
Comb w/ No.	=	Idea Combined with Another Idea

Table 12-2. Idea Evaluation Summary

No.	Idea Description	Development Status
LCA Terrebonne Basin Barrier Shoreline Restoration Study		
T-1	Install inverted breakwaters and use fill for replenishing back-marsh	Develop
T-2	Calculate renourishment rates required to sustain barrier islands accounting for absolute sea level rise	Develop
T-3	Use a given planning horizon (i.e., 50-year) for renourishment requirements based on a range of sea level rise	Comb w/ T-2
T-4	Obtain a clear definition of the sustainability Study objective	Develop
T-5	Include renourishment costs in construction costs	Develop
T-6	Establish Federal trust fund for renourishment costs	Develop
T-7	Construct new barrier island reach closer to new shoreline	Develop
T-8	Relocate Timbalier Islands to the north using existing islands as sediment source	Eliminate
T-9	Incorporate a hard core into barrier islands	Comb w/ T-10
T-10	Fix barrier islands in current location; Harden islands to reduce rate of roll over	Develop
T-11	Divert Mississippi River to provide sediment for littoral drift ("Feed the Beast")	ABD
T-12	Prioritize which barrier islands should be saved	ABD
T-13	Use East Timbalier as a feeder island for other islands	Eliminate
T-14	Utilize sand recycling/back-passing for barrier island renourishment	Develop
T-15	Allow revetments	Comb w/ T-10
T-16	Use buried revetments	Comb w/ T-10
T-17	Use Geotubes for dune core	Comb w/ T-10
T-18	Utilize concrete armor units in lieu of rock	Comb w/ T-10
T-19	Procure environmental dredging fleet	Develop
T-20	Use C-rock for barrier island hardening and relocate as necessary to allow roll over	Eliminate
T-21	Evaluate a retreating strategy for relocating barrier islands closer to marshes	Comb w/ T-7
T-22	Utilize congressional action to allocate Ship Shoal sands	Eliminate
T-23	Evaluate actual quantities of available sediment at Ship Shoal and determine appropriate locations	Comb w/ T-42
T-24	Design alternatives for future tidal prism	ABD
T-25	Close Wine Island Pass; connect East Island to Wine Island	Eliminate
T-26	Construct east end of each island wider than west end to act as sediment source; ensure islands have sufficient aspect ratio for coastal geomorphic processes	Develop
T-27	Change the term "non-structural" in Study documents to "soft structural"	Develop

No.	Idea Description	Development Status
T-28	Utilize water injection to minimize impacts from fluid withdrawal-induced subsidence	Comb w/ G-6
T-29	Connect the two pieces of East Timbalier Island and close the pass in between	Eliminate
T-30	Prioritize project components based on habitat loss factors	Develop
T-31	Investigate additional Mississippi River diversions to provide sediment for barrier islands	ABD
T-32	Implement oil/gas industry outreach program regarding future sediment management practices	Develop
T-33	Conduct offshore sediment analysis to identify alternative sources of barrier island renourishment sediment; provide BOEMRE sufficient funds to map sediment sources	Develop
T-34	Consider variable habitat types on barrier islands	ABD
T-35	Construct permanent pipeline from Ship Shoal to the east end of Timbalier Island	Develop
T-36	Consider alternate procurement methods for construction	Develop
T-37	Construct groins and/or breakwaters with pre-filled sediment	Develop
T-38	Run dredges using green technologies in lieu of diesel	Comb w/ T-35
T-39	Add Plan Strategy that addresses habitat needs in excess of budgetary limitations	Develop
T-40	Develop Plan Strategies to evaluate differing renourishment requirements and island hardening alternatives	ABD
T-41	Use birth control agents to control nutria	Develop
T-42	Use BOEMRE to regulate Ship Shoal quantities to various projects needing sediment	Develop
T-43	Relocate pipelines crossing Ship Shoal to increase sediment capacities available	Eliminate
T-44	Use abandoned pipelines at Ship Shoal for sediment transport	Eliminate
T-45	Utilize back-bay material for renourishment of barrier islands	Eliminate
General / Plan Formulation		
G-1	Use upwelling ram pumps to bring cold water to ocean surface to reduce hurricane intensities	Eliminate
G-2	Use ram pumps to power sediment transport piping	Eliminate
G-3	Develop a seasonal freshwater management plan	Develop
G-4	Create Federal advisory committee to represent the migratory bird interest (FACA)	Develop
G-5	Perform parametric analysis of Study alternatives accounting for the three levels of sea level rise	Develop
G-6	Identify and incorporate effects of subsidence from fluid withdrawal into Study analysis	Develop

L12.6 Value Engineering Study Results

The natural processes of subsidence and erosion have combined with human-caused effects leading to significant shoreline retreat and land loss along the Terrebonne Basin barrier island reach. As such, the system is in a continuous need of sediment. The current Study plans and budget only allow for a single renourishment after about five years, which means the sustainability of the islands are in doubt. Furthermore, the availability of suitable sediment from Ship Shoal to restore and maintain the barrier islands may be limited. Finally, the barrier islands form a complex system of ecological, physical, chemical, and social processes, which interact in a highly involved and, at times, dynamic fashion.

Key VE alternatives identified to address these issues are as follows:

- Sustain Barrier Island System
  - Obtain a clear definition of the Study objectives regarding sustainability; and
  - Establish permanent trust fund for renourishment costs.

- Provide Sediment for Renourishment
  - Use Bureau of Ocean Energy Management, Regulation, and Enforcement to regulate Ship Shoal quantities to various projects needing sediment;
  - Construct a permanent pipeline from Ship Shoal to the east end of East Timbalier Island;
  - Utilize Dynamic Coastal Systems;
  - Utilize sand recycling/backpassing for barrier island nourishment;
  - Consider coastal geomorphic processes for sediment placement; and
  - Construct new barrier island chain closer to new shoreline.

- Protect Sediment
  - Install inverted breakwaters and use excavated material to construct/replenish back marsh; and
  - Fix barrier islands in their current location, eliminating or minimizing island roll over, by incorporating a “hard” core or allow surface armoring.

L13. REFERENCES

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