E C O L O G I C A L   R E V I E W

Whiskey Island Back Barrier Marsh Creation
CWPPRA Priority Project List 13
State No. TE-50

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This document reflects the project design as of the 95% Design Review meeting, incorporates all comments and recommendations received following the meeting, and is current as of November 21, 2007.

Ecological Review
Whiskey Island Back Barrier Marsh Creation (TE-50)

In August 2000, the Louisiana Department of Natural Resources (LDNR) initiated the Ecological Review to improve the likelihood of restoration project success. This is a process whereby each restoration project's biotic benefits, goals, and strategies are evaluated prior to granting construction authorization. This evaluation utilizes environmental data and engineering information, as well as applicable scientific literature, to assess whether or not, and to what degree, the proposed project features will cause the desired ecological response.

I. Introduction

The proposed Whiskey Island Back Barrier Marsh Creation (TE-50) project is located in Terrebonne Basin on the southernmost boundaries of Lake Pelto and Caillou Bay, east of Coupe Colin and west of Whiskey Pass (Figure 1). The Caillou Boca channel lies immediately north of Whiskey Island (Figure 1). Whiskey Island is the second island from the western end of the Isle Dernieres barrier island chain, which stretches for 20 miles along the Louisiana coast. Whiskey Island is approximately 18 miles southwest of Cocodrie, Louisiana and 75 miles southwest of New Orleans, Louisiana.

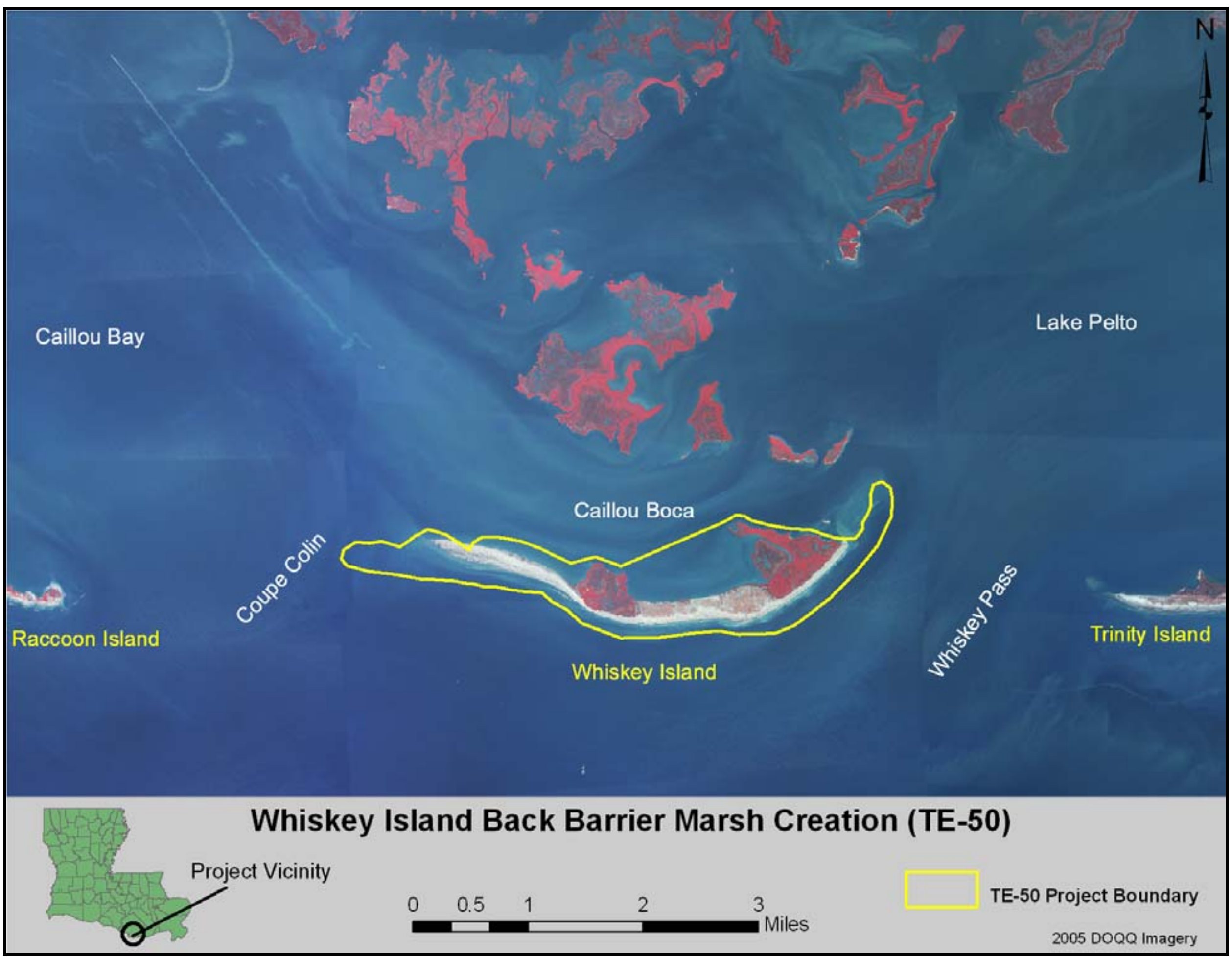

Figure 1. Whiskey Island Back Barrier Marsh Creation (TE-50) project boundary.

Louisiana's barrier islands have naturally decreased in land mass by approximately 40% over the last 100 years (Monteferrante and Mendelssohn 1982). The Isles Dernieres barrier island chain shoreline is one of the most rapidly deteriorating barrier shorelines in the United States (Williams et al. 1992). *Coast 2050* identified storm events as a major factor contributing to the rapid shoreline erosion along the Isle Dernieres island chain (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority [LCWCRTF & WCRA] 1999). Historically, tropical storms and hurricanes have caused beach erosion and overwash of these islands. In addition, winter storms and cold front passages contribute to the erosion of the islands, most notably the back barrier salt marsh shorelines (LCWCRTF & WCRA 1999).

Erosion of the gulf and bay shorelines is causing the islands to narrow. From the 1890's to 1988, the barrier island width had decreased approximately 2,612 feet (Williams et al. 1992). Historical landloss estimates in the area have averaged between 32.8 and 49.2 feet per year (LCWCRTF & WCRA 1999). According to Penland et al. (2004), the average rate of shoreline change for Whiskey Island from 1887-2002 was 56.0 feet per year and from 1988-2002 was 86.0 feet per year.

Future landloss projections estimate that if no restoration would occur, some of the islands would become subaqueous by 2007 and none of the Isles Dernieres chain will remain by 2050 (LCWCRTF & WCRA 1999). Other projections indicate that without restoration the islands may become subaqueous inner-shelf shoals by 2015 (Williams et al. 1992) or disappear by 2017 (McBride and Byrnes 1997).

A number of barrier island restoration projects have already been constructed throughout the Isles Dernieres barrier island chain, including a project on Whiskey Island. Completed in 1999, the Whiskey Island Restoration (TE-27) project (Figure 2) included the creation of back barrier marsh, closure of the Coupe Nouvelle breach, planting of vegetation, and construction of sand fencing. As a result, the area of Whiskey Island increased from 474.8 acres in 1996 to 642.9 acres in 2002, an increase of approximately 36% (Penland et al. 2003). However, due to the effects of Tropical Storm Isadore in September and Hurricane Lili in October of 2002, the area of Whiskey Island decreased to 529.4 acres by November of 2002 (Penland et al. 2003).

In addition to this TE-50 project, another project involving Whiskey Island is currently being evaluated as part of the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) program. The project, Ship Shoal: Whiskey West Flank Restoration (TE-47) (Figure 2), has completed Phase I (engineering and design) of the CWPPRA process; however, it was not recommended for Phase II (construction) funding when it competed in December 2006. The goals of the TE-47 project are to create a back barrier marsh platform and to rebuild dunes on the west flank of Whiskey Island in order to restore the integrity of the island. The material to construct these features would be obtained through the dredging and transportation of sediment mined from Ship Shoal, an offshore shoal approximately 8 to 10 miles from Whiskey Island.

This proposed TE-50 project (Figure 1) encompasses the mining of material to create a back barrier marsh platform, which will result in an increase in island width. An intention of this project is to facilitate the landward migration of the island as it washes over onto itself, thus allowing the island to respond naturally to sea level rise. However, it should be noted that due to the relatively deep Caillou Boca channel immediately north of the project area, there will be limitations inherent in this project (T. Baker Smith/Moffatt & Nichol [TBS/M&N] 2007). The location of this channel curtailed how far north the restoration project could be extended and will interfere with the natural tendency of the islands to roll over in response to storms and sea level rise (TBS/M&N 2007).

For this project, 316 acres of back barrier, intertidal marsh will be created through the dredging of material mined from a source near the island (approximately 2.8-4.5 miles southeast). Preserving Whiskey Island by creating a stable back barrier marsh platform will reduce storm surge and protect interior marsh and infrastructure (LCWCRTF & WCRA 1999). This project proposal is in accordance with *Coast 2050* Region 3 ecosystem strategies which include maintaining and restoring the Isles Dernieres barrier island chain (LCWCRTF & WCRA 1999).

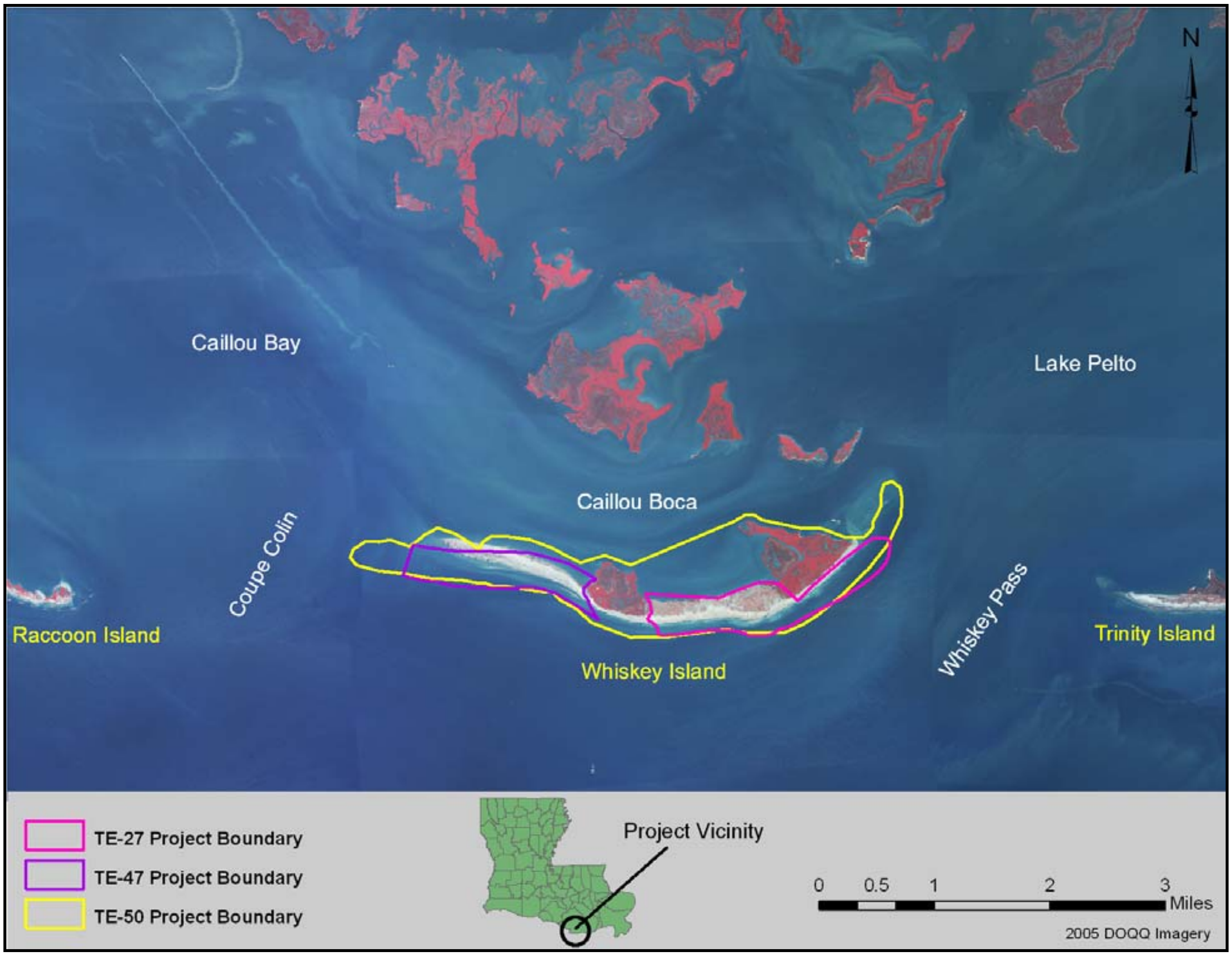

Figure 2. Project boundaries for TE-27, TE-47, and TE-50.

II. Goal Statement

- To create 316 acres of back barrier, intertidal marsh by the end of project construction.
- To establish tidal connectivity throughout the newly placed material with the construction of tidal creeks and ponds.
- To enhance the existing dune if a sufficient quantity of borrow material remains after the construction of the marsh platform.
- To increase the longevity of the natural and previously-restored portions of the island by increasing the width of the island to help retain sand volumes and maintain elevations.

III. Strategy Statement

- Construction of a back barrier marsh platform through the use of material dredged in the vicinity of Whiskey Island.
- Creation of approximately 5,800 feet of tidal creeks and 3, 1-acre tidal ponds to establish tidal connectivity.
- Placement of sand on top of the existing dune to increase the height and width.
- Planting of vegetation and construction of sand fencing to stabilize and conserve newly placed sediments.

IV. Strategy-Goal Relationship

Material will be dredged, hydraulically pumped, and placed on the bayside of the island to an elevation of +2.5 feet NAVD 88 (TBS/M&N 2007). The created marsh will extend from the northern vicinity of the existing island to the -3.5 foot NAVD 88 contour (United States Environmental Protection Agency [EPA] 2003) to create 316 acres of back barrier marsh. Sand will be placed on the existing dune to increase the elevation of the dune to +6.0 feet NAVD 88 (TBS/M&N 2007). Three, 1-acre tidal ponds and approximately 5,800 linear feet of tidal creeks will be constructed (TBS/M&N 2007) to establish tidal connectivity within the newly created marsh in order to provide habitat and maintain marsh. The created marsh will be planted to maximize the retention of sediment (EPA 2003). In order to increase the height and width of the dune, sand fencing will be placed 30 feet south of the centerline of the dune (TBS/M&N 2007), and vegetation will be planted on the dune.

IV. Project Feature Evaluation

<u>Modeling of Coastal Processes</u>

Understanding the effects of waves, winds, storm surge, currents, and tides on the barrier island system is crucial to designing a project that is structurally stable and capable of withstanding the natural processes to which the island will be subjected. Tropical storms, hurricanes, and cold fronts cause an increase in the force of these processes (e.g., increased wave heights, winds, storm surge, etc.) acting on the island. Longshore sediment transport in this project area also contributes to detrimental changes in island morphology by causing significant shoreline erosion. Although transport along the eastern end of the island is fairly low (~5,000 cubic meters per year [~6,540 cubic yards]), toward the center and western ends of the island, transport increases to ~80,000 cubic meters per year (~104,640 cubic yards) (TBS/M&N 2007).

Numerical models were developed to examine hydrodynamic and morphological changes to Whiskey Island both under "future with project" and "future without project" scenarios. The Delft3D integrated surface modeling system (developed by WL | Delft Hydraulics in the Netherlands) was used to model these coastal processes. Some modeling results are presented in the following paragraphs to provide additional data used to evaluate the effectiveness of the project features.

<u>Geotechnical Analysis of Borrow Site</u>

The geological/geotechnical investigation consisted of compiling existing literature and data, conducting hydrographic and geophysical investigations, and analyzing vibracores to determine the availability and quality of material. The initial geotechnical investigation included the use of sounding, seismic/subbottom profiling, and magnetometry as well as push probe and grab samples to determine the areas with the highest probability of suitable sediment for this project.

It was determined that the marsh platform will be constructed of overburden (mixed sediments suitable for marsh creation), and the dune feature will be constructed of sand. Ocean Surveys, Inc. (OSI 2007) identified 3 offshore areas where data indicated the highest probability of suitable sediments: Area 1, Area 2, and Area 3. Subarea 2a was delineated from within Area 2, and Area 3 was further subdivided into subareas 3a, 3b, and 3c. A total of 48 vibracores were retrieved from the 3 study areas (5 from Area 1, 15 from Area 2, and 28 from Area 3; OSI 2007). Based on the analyses of vibracores, adequate quantities of overburden and sand were found in subareas 2a and 3a (TBS/M&N 2007). Area 1 was eliminated due to inadequate sand resources (TBS/M&N 2007).

In order to determine the location of possible obstructions and cultural resources, further investigations were initiated for subareas 2a and 3a and included hydrographic, seismic/subbottom profiling, magnetic, and side scan sonar imagery along track lines spaced 50 meters (164 feet) apart. Based on the data acquired, Archeological Resources, Inc. (ARI) recommended avoidance of several areas where magnetic anomalies were detected (Moffatt and Nichol [M&N] 2007). Estimated volumes of available sediment in subareas 2a and 3a, excluding the areas identified by ARI, are shown in Table 1.

Table 1. Estimated volume of material in subareas 2a and 3a (OSI 2007).

Subarea	Overburden volume (million yd^3)	Sand volume (million yd^3)	Total volume (million yd^3)
2a	3.05	1.15	4.2
3a	7.97	4.72	12.69

Estimates of volume necessary to construct this project are as follows: 2.76 million cubic yards of mixed sediment to construct the marsh platform and 360,000 cubic yards of sand to construct the dune (TBS/M&N 2007). A 1.2 cut to fill ratio will be used for the mixed sediment that will be dredged to create the marsh platform and a 1.6 cut to fill ratio will be used for the sand that will be dredged to increase the height and width of the existing dune (TBS/M&N 2007). Based on the estimated volume of material in the borrow sites, both subarea 2a and subarea 3a have sufficient material to successfully construct this project.

Borrow area 2a was selected for project construction based on the availability of sufficient material for project construction and the lower cost associated with using the borrow area that is nearer to the project area (TBS/M&N 2007). In addition, most or all of the usable material in borrow area 2a will be utilized for this project (TBS/M&N 2007). Had borrow area 3a been selected, only a portion of the available sand resources would have been required for project construction and contamination of the remaining sand resource with silts and clays would have occurred. Because sand is a limited resource, the selection of borrow area 2a leaves an intact borrow area (3a) for use on a future project. The borrow area will be mined using a hydraulic dredge, and a booster pump is not likely to be required. The approximate pumping distance from borrow area 2a is between 15,000 and 24,000 feet (2.8-4.5 miles) (TBS/M&N 2007).

Borrow Site Impacts

Borrow area 2a is located approximately 2.8-4.5 miles southeast of Whiskey Island and encompasses about 230 acres (TBS/M&N 2007). The bottom elevation ranges primarily from -15.0 to -16.0 feet NAVD 88 (TBS/M&N 2007). The thickness of the overburden ranges from 8 to 10 feet to as much as 30 feet or more, and the thickness of the sand layer ranges from 2.5 to 7.6 feet (TBS/M&N 2007). The thickness of the sand layer is typically less than 4 feet in 50% of the borrow area (TBS/M&N 2007). According to OSI (2007), approximately 3.05 million cubic yards of overburden and 1.15 million cubic yards of sand would be available for excavation if the entire borrow area, excluding the avoidance areas identified by ARI, is utilized for project construction. However, after laying out the borrow area excavation plan (and excluding avoidance areas), approximately 3.8 million cubic yards of overburden and approximately 600,000 cubic yards of sand (totaling approximately 4.4 million cubic yards of sediment) would be available for excavation with a flat cut to -30 feet NAVD 88 (TBS/M&N 2007).

The SWAN (Simulating WAves Nearshore) wave model (developed by Delft University of Technology in the Netherlands) was used to evaluate the impacts, at the -13 foot NAVD 88 contour (just behind borrow area) and the -10 foot NAVD 88 contour (nearest shoreline), to the wave climate resulting from dredging borrow area 2a (TBS/M&N 2007). The model indicates that dredging to the -30 foot NAVD 88 contour would not cause a significant change in local wave conditions and that the impacts decrease closer to the shore (TBS/M&N 2007).

Geotechnical Analysis of Whiskey Island East and West Flanks

The geotechnical investigation of the east and west flanks of Whiskey Island included 17 sample borings taken in the back bay and marsh areas behind the island and 3 auger borings taken on the foreshore of the beach (Eustis Engineering Company, Inc. [Eustis] 2007). The borings from the back bay and marsh areas indicated that the upper 65 feet of material was comprised of soft to very soft clays and silty clays each with both sand and silt lenses and with shell fragments (Eustis 2007).

Sediment Suitability Index

Sediments from the barrier island (above mean sea level), the back barrier (0 to -4 feet), and the east and west lobes of the island were assessed to determine if material dredged from the borrow site will be suitable for construction of the project features. The mean grain size of sampled sediments was 0.156 mm from the barrier island, 0.076 mm from the back barrier, 0.024 mm from the east lobe, and 0.014 mm from the west lobe (M&N 2007). Sediments taken from the barrier island were classified as 88% fine sand and 11% silt/clay, while sediments taken at the dune near the Gulf of Mexico were 98-99% fine sand (M&N 2007). Samples from the back barrier average 41% fine sand and 59% clay and silt combined. The east and west lobes contain approximately 35% clay, 58% silt, and 6% fine sand (M&N 2007).

Based on the comparison of native sediment on Whiskey Island to sediment in the borrow area, the overburden material is assumed to be suitable for the back barrier marsh creation and the underlying sand material will be suitable for the dune feature. Because the material will undergo a sorting process as a result of natural coastal conditions, it is important that the grain size of the borrow material be similar to the grain size of the native material. Sediment with similar characteristics to the native material will be more likely to support a newly created salt marsh habitat that is consistent with natural salt marsh habitat.

Settlement Curves

Settlement curves were computed for the marsh platform and the containment dikes. The curves show that a marsh platform constructed to +2.5 feet NAVD 88 will become intertidal between years 1 and 5 after construction and will continue to be intertidal for the remainder of the project life (TBS/M&N 2007). The containment dikes will be constructed to an elevation of +4.5 feet NAVD 88 thus allowing adequate freeboard (2 feet) for the newly placed sediment to dewater and consolidate (TBS/M&N 2007). Settlement curves for the containment dikes show that they would settle to an approximate elevation of +2.5 feet NAVD 88 if left intact until year 20 (this does not include an additional 3-6 inches of settlement that may occur due to desiccation of the fill) (Eustis 2007). It should be noted that the containment dikes will be lowered significantly before demobilization as described in the containment dike section below (TBS/M&N 2007). The amount of settlement predicted for the marsh platform and the containment dikes was combined with an estimated rate of sea level rise of 1.03 centimeters per year (0.4 inches per year), as determined by Penland and Ramsey (1990), to approximate marsh platform and containment dike elevations at various years after construction (TBS/M&N 2007).

Back Barrier Marsh Creation

Material from the borrow area and the marsh fill area was analyzed to determine the amount of fill consolidation and foundation settlement, respectively, that would occur over the 20-year life of this project. Elevation of the marsh platform was calculated for 0.2 years, 1 year, 5 years, and 20 years post-construction based on the settlement analysis and an initial construction elevation of either +2.0, +3.0, or +4.0 feet NAVD 88 (TBS/M&N 2007). Tidal data for Whiskey Island indicate a mean low water (MLW) level of 0.0 feet NAVD 88, a mean sea level (MSL) of +0.86 feet NAVD 88, and a mean high water (MHW) level of +1.6 feet NAVD 88 (M&N 2007). Because one of the intentions of this project is to create intertidal marsh, a marsh fill construction elevation of +2.5 feet NAVD 88 was selected (Figures 3 and 4). Based on the settlement analysis, marsh created to this elevation will become intertidal 1 to 5 years post-construction and will remain intertidal for the full project life (Table 2) (TBS/M&N 2007).

Table 2. Marsh height (feet, MLW) for initial fill height of +2.5 feet NAVD 88 (TBS/M&N 2007). *MLW is roughly equal to NAVD 88 at construction and rises afterward to a maximum of +0.68 feet NAVD 88 at year 20 (TBS/M&N 2007).

Bottom elevation (feet, NAVD 88)	Time in years			
	0.2	**1**	**5**	**20**
	Marsh Height (feet, MLW*)			
0.0	2.28	2.12	1.79	1.16
-1.0	2.27	2.01	1.62	0.97
-2.0	2.18	1.90	1.45	0.80
-3.0	2.12	1.76	1.28	0.60
-4.0	2.04	1.58	1.06	0.36

The current back barrier marsh platform design encompasses the creation of 316 acres of marsh (TBS/M&N 2007). The marsh platform will be constructed from the northern boundary of the island, which is currently +2.0 feet NAVD 88, to the -3.5 foot NAVD 88 contour (EPA 2003). Approximately 2.76 million cubic yards of mixed sediment will be necessary to increase the elevation of this area to +2.5 feet NAVD 88 (TBS/M&N 2007). A survey of the existing east and west marsh lobes was conducted to identify an average target marsh elevation for the marsh creation. Elevation of the marsh lobes averaged +1.48 feet NAVD 88 (TBS 2006). Initial construction elevation of the newly created marsh will be approximately 1 foot higher than the existing marsh lobes, but due to consolidation and dewatering of the material (which will occur during the first few months after construction) that will be pumped onto the island, the created marsh platform will reach an intertidal elevation within 1 to 5 years after construction (TBS/M&N 2007).

Numerical modeling was performed to determine the expected wave conditions that will occur in the vicinity of the back barrier marsh creation area. The model generated significant wave heights of 1.25 to 1.5 feet with the waves moving from northwest to north for the passage of a typical cold front (36 mph wind speeds) and wave heights of 3.5 to 4 feet with waves moving from northwest to north for the passage of Hurricane Katrina (76 mph wind speeds) (TBS/M&N 2007).

Containment Dikes

Containment dikes will be constructed around the perimeter of the marsh creation area to an elevation of +4.5 feet NAVD 88 with 1(V):5(H) side slopes (Figures 3 and 4) (TBS/M&N 2007). In order to reduce the impacts of waves and currents, the northern containment dike will be constructed with a crest width of 20 feet (TBS/M&N 2007). This dike will be breached at the location of the 2 proposed tidal creeks (TBS/M&N 2007) in order to allow for increased tidal exchange. The east, west, and south containment dikes will not be exposed to direct action from winds and waves and will be built with a 10 foot crest width (TBS/M&N 2007). The east and west dikes will be constructed such that some of the existing tidal creeks on the east and west lobes of the island will remain connected to open water (TBS/M&N 2007). Upon completion of construction, each of the dikes will be lowered to marsh elevation, or to the extent practicable (based on the settlement and consolidation of the marsh platform), so that the integrity of the platform will not be compromised.

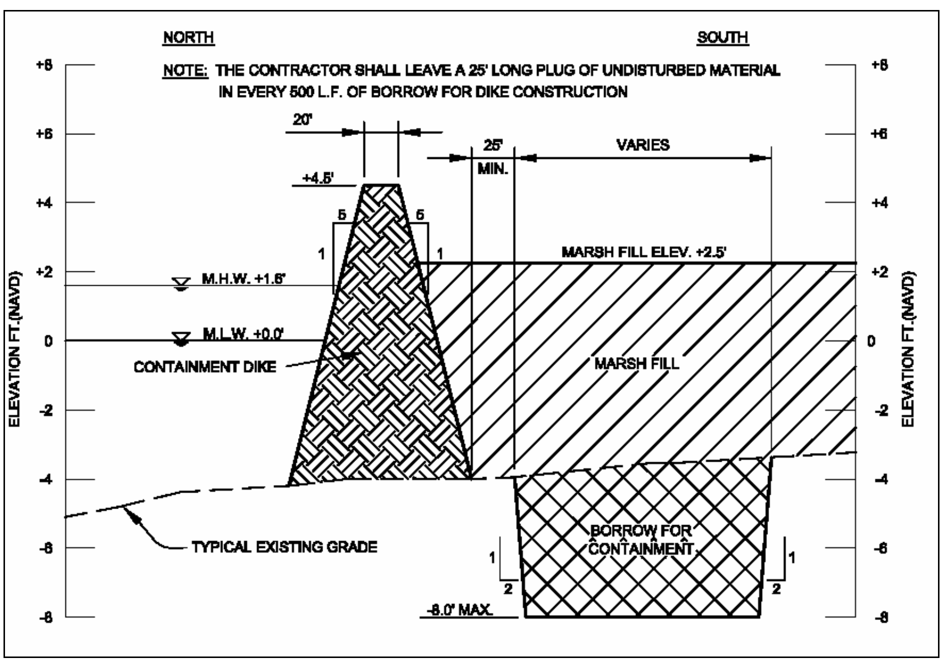

Figure 3. Typical northern containment dike with marsh fill (TBS/M&N 2007).

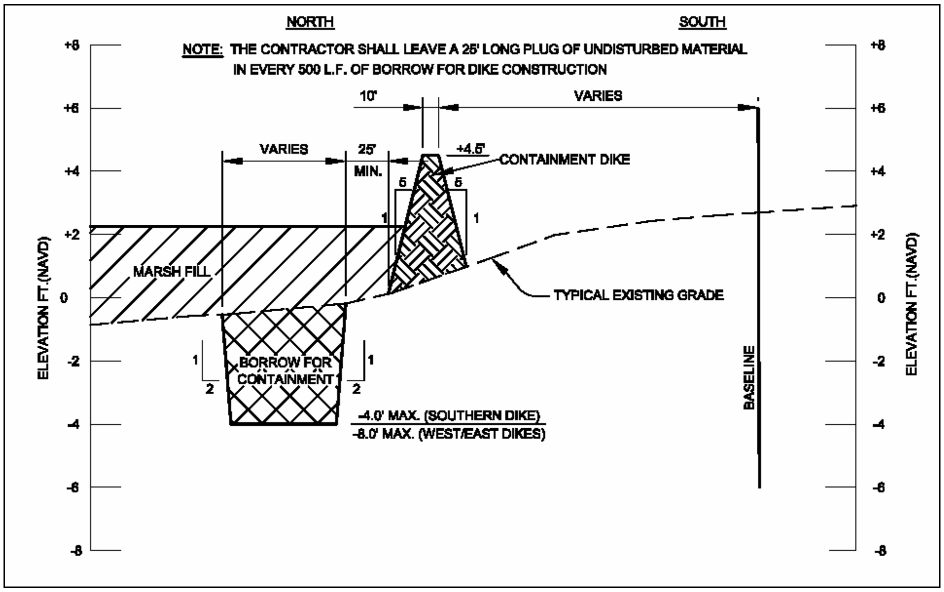

Figure 4. Typical southern, western, and eastern containment dike with marsh fill (TBS/M&N 2007).

Dune Creation

When this project was originally authorized, it did not include a dune feature (TBS/M&N 2007). However, at the initiation of the engineering and design phase for this project, a decision was made to include a dune in the design in order to increase the elevation of the island near the Gulf of Mexico. Because a dune system can increase the structural stability of the island as well as provide protection against overwash and breaching, a robust dune system is a critical component of a healthy barrier island ecosystem (TBS/M&N 2007).

Designs with dune crest elevations of +4.0, +5.0, +6.0, +7.0, and +8.0 feet NAVD 88 were analyzed to determine which would provide the required protection against wave overtopping (TBS/M&N 2007). Overtopping was calculated for 3 storm scenarios: small storm conditions (5-year storm), design storm conditions (30-year storm), and large storm conditions (100-year storm) (TBS/M&N 2007). Based on these calculations, the minimum suggested elevation for the dune was determined to be +6.0 feet NAVD 88 (TBS/M&N 2007).

The dune will be constructed to an elevation of +6.0 feet NAVD 88 with side slopes of 1(V):30(H) and a 100 foot crest width (TBS/M&N 2007). The dune will extend for approximately 13,000 linear feet near the island shoreline and will require approximately 360,000 cubic yards of sand to construct (TBS/M&N 2007).

Tidal Creeks

In order to establish tidal connectivity as soon as possible after project construction is completed, the design of this project includes the construction of a network of tidal creeks and ponds. Two techniques were considered for the construction of tidal creeks and ponds in the back barrier marsh (TBS/M&N 2007):

1. *Pre-excavation of creeks and ponds* – This technique involves the excavation of the tidal creeks and ponds before the marsh is constructed (TBS/M&N 2007). As dredged material is placed, the thicker layer of sediment over the excavated areas will settle more quickly, creating creeks with a lower elevation than the surrounding

marsh and allowing accelerated tidal exchange in the back barrier marsh (TBS/M&N 2007). In addition, the northern containment dike will be breached at the confluence of each tidal creek after project construction is complete to allow tidal exchange to occur (TBS/M&N 2007).

2. *Pre-excavation of creeks and ponds with controlled marsh fill placement* – This technique is similar to the previous technique but includes a buffer area around the excavated features in which direct placement of material would not be allowed (TBS/M&N 2007). This would result in a thinner layer of marsh fill in the creek beds and a lower elevation of the creek beds in relation to the surrounding marsh (TBS/M&N 2007).

As a result of the increased cost associated with the second technique, and due to the inherent complexities involved in directing the discharge of fill material around buffered areas, the first technique was selected as the preferred alternative.

Originally, the tidal creek design included the pre-excavation of creeks to a depth of -6.0 feet NAVD 88, with the bottom width of the creeks varying depending on the location of the creek within the marsh platform (TBS/M&N 2007). The planned width of the creeks was 50 feet at the northern extent of the marsh platform decreasing to 20 feet at the southern end (TBS/M&N 2007). The creeks were to be constructed with side slopes of 1(V):3(H) (TBS/M&N 2007). Three separate branching tidal creek systems were planned, each with 2 ponds located at the intersection of the creek branches (TBS/M&N 2007). Round tidal ponds were to be excavated to -6.0 feet NAVD 88 with a constructed diameter of 235 feet (TBS/M&N 2007). The original design included over 12,500 linear feet of tidal creeks and 6, 1-acre tidal ponds (TBS/M&N 2007).

However, as a result of further deliberation by the project team and discussions at the 30% Design Review Conference, the tidal creek and pond design was modified. It was decided that 2 tidal creek and pond scenarios would be tested for the purpose of collecting data to determine whether tidal creeks need to be pre-excavated in future projects or whether tidal creeks will develop naturally (Figure 5). Lessons learned from observations and analysis of monitoring data from the 2 tidal creek and pond scenarios will provide guidance for the design of future marsh creation projects. The 2 tidal creek and pond scenarios are as follows:

1. *With tidal features* - At the eastern end of the marsh platform, a tidal creek system consisting of primary, secondary, and tertiary creeks and 2 tidal ponds will be pre-excavated. Near the center of the platform, the pre-excavated creek system will consist of a primary creek, secondary creeks, and a tidal pond.

2. *Without tidal features* - At the western end of the marsh platform, no tidal features will be constructed. This area will provide an opportunity to observe whether tidal creeks will form naturally.

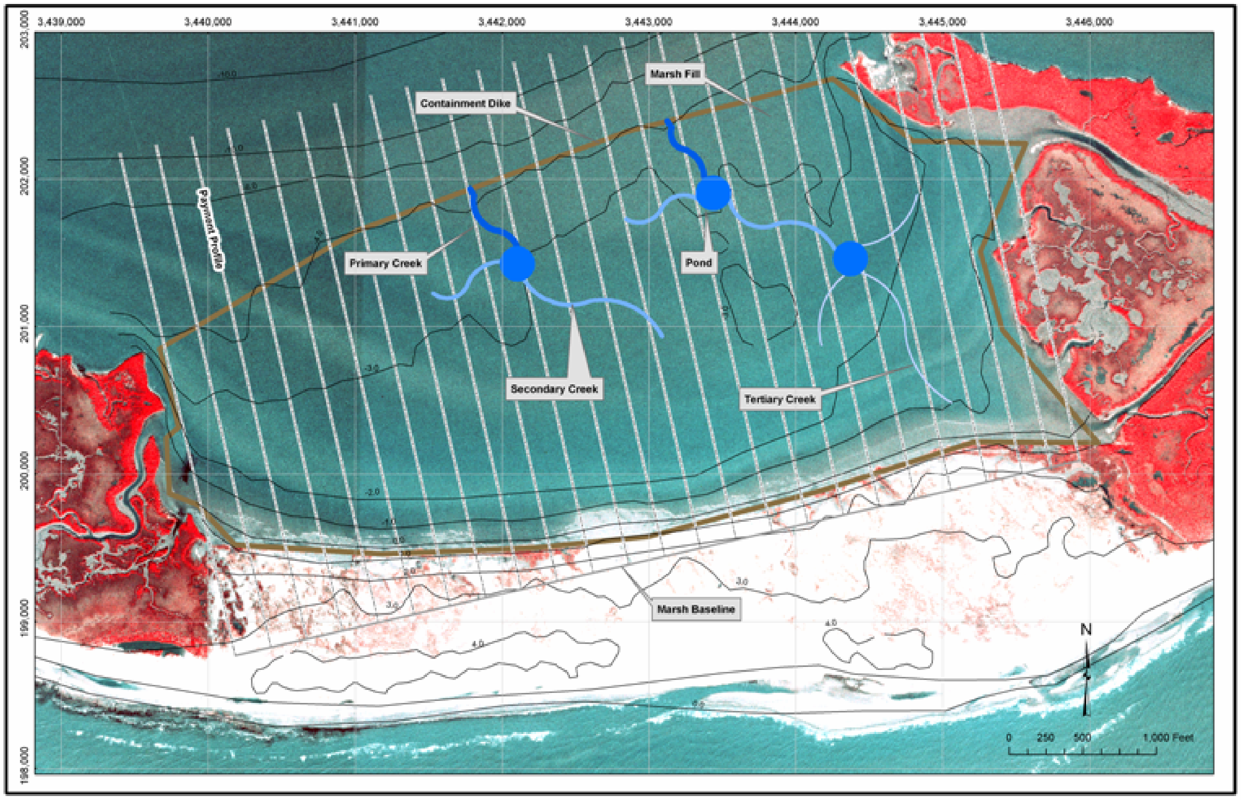

Figure 5. Tidal creek and pond design (Tucker Mahoney, M&N, personal communication, September 24, 2007).

Creeks will be pre-excavated to a depth of -6.0 feet NAVD 88 and will be constructed with side slopes of 1(V):3(H) (TBS/M&N 2007). Primary, secondary, and tertiary creeks will be constructed with a bottom width of 50 feet, 30 feet, and 20 feet, respectively (TBS/M&N 2007). Three, round tidal ponds will be built at the intersections of the creeks and will be excavated to -6.0 feet NAVD 88, with a constructed diameter of 240 feet (TBS/M&N 2007). The current design includes 5,800 feet of tidal creeks and 3, 1-acre tidal ponds (TBS/M&N 2007). The tidal creek layout is comprised of 1,040 feet of primary creeks, 2,560 feet of secondary creeks, and 2,200 feet of tertiary creeks (Tucker Mahoney, M&N, personal communication, September 24, 2007). The northern containment dike will be breached at the location of the 2 pre-excavated tidal creeks (TBS/M&N 2007).

<u>Sand Fencing</u>

Sand fencing aides in the formation of dunes and traps sand that otherwise would be lost from the system (Khalil and Lee 2004). The United States Department of Agriculture ([USDA] 1992) recommends installing sand fencing 4 feet high with 50% porosity (i.e., ratio of area of open space to total projected area), placed parallel to shore along the entire length of the dune. The purpose of the sand fencing design is to slow wind velocity, capture wind-blown sand, and build and stabilize dunes. Approximately 13,000 linear feet of sand fencing will be placed, in a single row, 30 feet south of the centerline of the created dune (TBS/M&N 2007).

Vegetation

In order to stabilize the created back barrier marsh platform, the created marsh will be planted with smooth cordgrass (*Spartina alterniflora*) (EPA 2003) and black mangrove (*Avicennia germinans*) (Keith Lovell, LDNR, personal communication, August 6, 2007). Smooth cordgrass (*Spartina alterniflora*) is a native marsh plant that is able to colonize and protect marsh soils (M&N 2007), and it has been used in previous Isles Dernieres back barrier marsh creation projects (West and Dearmond 2007a, 2007b, 2007c). Although the optimal planting density for newly created back barrier has not yet been defined, planting vegetation is necessary to restore island habitat as well as to stabilize the marsh platform. The preliminary vegetation planting schedule for the marsh and dune is provided below (Figure 6):

WHISKEY ISLAND BACK BARRIER MARSH CREATION (TE-50)
VEGETATIVE PLANTINGS
August 6, 2007

Preliminary Planting Schedule

Marsh Planting: Based on 300 acres of created marsh with tidal features.

Smooth Cordgrass	250,000*	plugs, rows 10' apart, plants 5' on center
Black Mangrove	5,000*	4" containers, planted on higher elevation

Dune Planting: Based on 13,000 linear feet of dune, planting area approximately 160 feet wide.

Bitter Panicum	10,400	4" containers, 4 rows, 5' spacing
Seacoast Bluestem	5,200	4" containers, 2 rows, 5' spacing
Seashore Dropseed	5,200	4" containers, 2 rows, 5' spacing
Marshhay Cordgrass	5,200	4" containers, 2 rows, 5' spacing
Sea Oats	5,200	gallons, 2 rows, 5' spacing

* Planting of marsh will likely occur in phases or at a different time from dune planting depending upon settlement of marsh creation area.

Figure 6. Preliminary planting schedule with plant varieties that will be used to vegetate the marsh and dune platforms (Keith Lovell, LDNR, personal communication, August 6, 2007).

V. Assessment of Goal Attainability

When addressing the likelihood that the proposed project features will provide the desired ecological response, it is important to evaluate the lessons learned from scientific research and past projects that are similar in scope to the Whiskey Island Back Barrier Marsh Creation (TE-50) project. The findings of this review are detailed below.

Barrier Island Restoration

There are several constructed CWPPRA barrier island projects that have included the design and implementation of marsh and dune platforms. The Barrier Island Comprehensive Monitoring (BICM) Program, currently being initiated through the Louisiana Coastal Area (LCA) Science and Technology (S&T) Program, will provide long-term monitoring of the barrier island shorelines and the resulting changes in habitat (Green 2006). Analysis of the data acquired by this program will provide useful information for further evaluation of these constructed barrier island restoration projects as well as information to plan and design future projects.

Five constructed barrier island projects along the Isle Dernieres and Timbalier barrier island chains and their respective design parameters are listed below:

Isles Dernieres Restoration East Island (TE-20) - construction completed in July 1999

- Marsh platform constructed to an elevation of +4.0 feet NGVD 29 and 800 feet wide
- Dune elevation of +8.0 feet NAVD 88 with a dune width of 300 to 500 feet

Isles Dernieres Restoration Trinity Island (TE-24) - construction completed in July 1999

- Marsh platform constructed to an elevation of +4.0 feet NGVD 29 and 800 feet wide
- Dune elevation of +8.0 feet NAVD 88 with a dune width of 300 feet

East Timbalier Island Sediment Restoration – Phase 1 (TE-25) - construction completed in May 2001

- Marsh platform constructed to an elevation of +3.0 feet NGVD 29 and 500 feet wide
- Dune elevation of +5.0 feet NAVD 88 and dune width of 200 feet

Whiskey Island Restoration (TE-27) - construction completed in July 1999

- Marsh and Dune elevations ranging from +3.0 to +4.0 feet NAVD 88 with a width of 300-500 feet

Timbalier Island Dune and Marsh Creation (TE-40) - construction completed in 2004

- Marsh platform constructed to an elevation of +1.4 feet NAVD 88 and 800 feet wide
- Dune elevation of +8.0 feet NAVD 88 and a dune width of 400 feet

Although the previously listed projects differ in design, the general objectives of creating marsh and dune habitat, preventing breaching and overwashing, and establishing vegetation are similar. Restoration of marsh on East, Trinity, Whiskey, and Timbalier islands increased both the width and the elevation of the islands, thereby extending their longevity. However, due to tropical storms and hurricanes, as well as erosion and landward migration, additional restoration will be necessary for the islands to continue to serve their role as protective barriers. Future performance evaluations are needed for each of these projects to determine an optimal design for island and marsh restoration in the barrier island systems.

<u>Back Barrier Marsh Creation</u>

The 3 Isles Dernieres barrier island restoration projects mentioned above (TE-20, TE-24, and TE-27) included the construction of a back barrier marsh platform. Preliminary observations suggest that these restoration projects were able to reduce the erosion of the barrier island (West and Dearmond 2007a, 2007b, and 2007c). Inspection of these projects indicated an increase in the area and elevation of the barrier island, thus increasing the projected longevity of the islands (Penland et al. 2003). However, the elevation at which the marsh platforms were constructed for each project was too high to establish back barrier marsh (Penland et al. 2003). Penland et al. (2003) states that back barrier marsh platforms should not be constructed to an elevation greater

than +2.0 feet NAVD 88. The types of vegetation that grew post-construction, from natural colonization, on the restored back barrier marshes were more indicative of habitats found at the higher barrier island elevations rather than habitats found at natural back barrier marsh elevations (Fearnley 2004).

Fearnley (2004) indicates that back barrier salt marsh habitat created through previous restoration projects on the Isles Dernieres barrier island chain has not been equivalent to natural salt marsh habitat, in part because the sediment that has been used for restoration is coarser than the native material and cannot adequately support a natural salt marsh habitat. Differences in other soil properties (bulk density, conductivity, total carbon, etc.) and in elevation also result in restored marsh habitats being dissimilar to those in natural marshes (Fearnley 2004). A geotechnical investigation of the natural back barrier sediment was conducted for this proposed project. The sediment that will be used to create the back barrier marsh platform on Whiskey Island is anticipated to be compatible with the natural sediment of the back barrier area. Therefore, for this project, the habitat provided by the created marsh should, over time, become comparable to that of the natural marsh habitat.

Tidal Creeks

In order for the created back barrier marsh to be sustainable, the marsh needs to accrete at a level that is equal to or greater than the rate of relative sea level rise. Tidal creek construction will facilitate periods of inundation, allowing for the transport of nutrients, sediment, and organisms into the marsh and the removal of detritus and other by-products from the marsh (Weishar et al. 2005). Through these natural processes, marsh building can occur by the deposition of sediment. Maintaining low velocities in the tidal waters is a key component in the design of the creek network (Weishar et al. 2005), in that low velocities will allow for the settling of sediment out of suspension as well as the movement of small organisms through the system. The relative elevation of the area, the particle size of the sediment, and the presence of vegetation will affect how the tidal creek system evolves over time (Wallace et al. 2005).

Wallace et al. (2005) found that constructing tidal creeks in a salt marsh restoration site allowed the site to develop geomorphic characteristics (including drainage density, tidal prism, and creek dimensions) that were comparable to the reference area after 5 years. The restoration site was constructed to have 3 areas with tidal creeks and 3 areas without tidal creeks (Wallace et al. 2005). After 4 years, new (volunteer) creeks that formed in the areas without constructed tidal creeks were, at most, one fourth the area of the constructed creeks (Wallace et al. 2005). Construction of tidal features may be necessary if restoration goals include short timelines or if low sediment inputs are expected (Wallace et al. 2005).

Dune Building

There are varying opinions in the scientific community concerning the construction of dunes in restoration projects. Penland et al. (2003) recommends building dunes at an elevation that mimics natural barrier island conditions to facilitate an increase in biodiversity. Others suggest that dune height should be significantly higher than natural dunes to protect infrastructure and prevent overwashing during storm events (Campbell and Benedet 2004). Therefore, dune height should be a function of specific project goals. If a desired response of the project is to prevent overwashing and breaching, it may be preferable to construct higher dunes. If a desired outcome of the project is to maximize island and marsh footprints while maintaining the island area and its environment, then lower and wider dunes may serve this purpose. Based on the overtopping calculations completed for this project, the minimum suggested elevation for the dune was +6.0 feet NAVD 88 (TBS/M&N 2007).

Vegetation and Sand Fencing

The following studies provide additional information related to the use of vegetation plantings, sand fencing, or a combination of the two, as well as another consideration that may affect vegetative plantings for barrier island restoration projects.

Vegetation Plantings combined with Sand Fencing

- Mendelssohn et al. (1991) demonstrated the success of effectively building dunes in low sediment supply systems such as Pass La Mer to Chaland Pass and Pelican Island by combining vegetation plantings with sand fencing to decrease wind velocity along the dune. The 3 species of plants used in the study were bitter panicum (*Panicum amarum*), sea oats (*Uniola paniculata*), and seashore paspalum (*Paspalum vaginatum).* Straight fences with spurs were initially more successful at accumulating sand and promoting dune height. Additionally, straight fences arranged parallel to the shoreline were more effective overall when compared to those angled perpendicularly to the shoreline.

- The Timbalier Island Planting Demonstration (TE-18) project was a 5-year demonstration of sediment trapping fences used in conjunction with vegetative plantings to build dunes along the gulf shoreline of Timbalier Island (Townson et al. 2000). Over 7,390 linear feet of sand fencing was constructed parallel to the Gulf of Mexico shoreline and each fence site had perpendicular spurs added every 50 feet that extended 25 feet from the fence bayward (Townson et al. 2000). Marshhay cordgrass (*Spartina patens)* and Atlantic panicgrass (*Panicum amarum* var. *amarulum)* were planted on the bay side of the fences (Townson et al. 2000). Both Atlantic panicgrass (*Panicum amarum* var. *amarulum*) and marshhay cordgrass (*Spartina patens*) displayed excellent transplant survival when sand fences remained intact, approximately 93% and 53% respectively (Townson et al. 2000). Fenced and planted sections of the project area experienced a 0.8 foot per year increase in average dune height between 1995 and 1999, while the reference areas experienced a 0.5 foot per year increase (Townson et al. 2000). Sand fencing along with vegetative plantings appeared to be successful in trapping sediment and increasing overall dune height, particularly in the first 1 to 2 years after construction (Townson et al. 2000).

- Success of marshhay cordgrass (*Spartina patens*) has been demonstrated in many studies but high mortality rates occurred in plantings for the East Timbalier Island Sediment Restoration, Phase 1 (TE-25) and Phase 2 (TE-30) projects. The drought conditions of 2001 could have negatively affected the vegetation in these projects. A site visit in 2001 revealed that bitter panicum (*Panicum amarum*), bermudagrass (*Cynodon dactylon*), and sea-blite [*Suaeda linearis* (Ell.) Moq.] were present in 36% of vegetation plots (West et al. 2007). The majority of marshhay cordgrass (*Spartina patens*) plantings were found to be dead or barely alive, and those that were alive appeared to be stressed (West et al. 2007). The advantages of bitter panicum (*Panicum amarum*) as stabilizing vegetation far outweigh those of marshhay cordgrass (*Spartina patens*), thus bitter panicum (*Panicum amarum*) is planted more often (Keith Lovell, LDNR, personal communication, October 2003). Plant survival was found to be greater north of the dune fence (West et al. 2007). In addition, plant survival was significantly greater behind fences that were configured in a "V" pattern (which provided a buffer to the vegetation behind the fence) as compared to fences configured in an "A" pattern (which focused overwash through the fence causing scour) (West et al. 2007).

- The Whiskey Island Restoration (TE-27) project demonstrated the importance of installing sand fences. This project, planted in 1999, did not initially include sand fencing, and rapid loss of newly placed sediment occurred as a result of aeolian transport and wave overwash (West and Dearmond 2007c). The monitoring results from 1 growing season after planting indicated that vegetation survival was low (<30%), possibly due to drought conditions (West and Dearmond 2007c). More recent monitoring results suggested a decline in species richness and an increase in bare ground between 2001 and 2003. (West and Dearmond 2007c).

Vegetation Plantings

The plant communities present on barrier islands improve the stability of the island and provide essential habitat for animals (Hester et al. 2005). Furthermore, barrier island vegetation works to trap and stabilize sand and other sediments that are transported through aeolian processes (Hester et al. 2005). The role of barrier island vegetation is therefore critical in maintaining and improving the stability and functionality of the barrier island and in providing some defense against the effects of storm events. Factors that may have an effect on vegetative planting projects include soil characteristics, wave fetch, herbivore threats, and many other site-specific conditions (Bahlinger 1995). Campbell et al. (2005) found that delaying the planting of marsh vegetation from 6 months to 1 year following construction (to allow for dewatering and consolidation of newly placed material) increased the success of the planting.

The USDA recommends the use of both *Spartina patens* (marshhay cordgrass) and *Panicum amarum* (bitter panicum) in dune restoration projects (USDA 1992). The presence of vegetation and the type of vegetation on a dune is one component that determines, to an extent, the stability and height of the dune (Hester et al. 2005). According to Hester et al. (2005), dunes with *Panicum amarum* (bitter panicum), *Uniola paniculata* (sea oats), or *Crotons punctatus* (beach tea) can reach a height of 5 meters (16.4 feet), while dunes with *Spartina patens* (marshhay cordgrass) generally form dunes less than a meter (less than 3.2 feet) high.

- In 1992, the LDNR performed a restoration study which incorporated the use of marshhay cordgrass (*Spartina patens*) planted on 6-foot centers at Trinity Island, 1 of the 4 islands within Isles Dernieres. This planting project was completed after the passage of Hurricane Andrew in 1992. By 1994, marshhay cordgrass (*Spartina patens*) and other native vegetation such as salicornia (*Salicornia virginica*), baccharis (*Baccharis halimifolia*), black mangrove (*Avicennia germinans*), and seaside goldenrod (*Solidago sempervirens*) had propagated and assisted in stabilizing the island (Bahlinger 1995).

- Analyses of data from two similar CWPPRA barrier island projects, the Isles Dernieres Restoration East Island (TE-20) project and the Isles Dernieres Restoration Trinity Island (TE-24) project, indicate an increase in number of species (except in dune plots) and vegetation cover (West and Dearmond 2007a, 2007b). Sampling in 2001 revealed the dominance of bermudagrass (*Cynodon dactylon),* which was aerially seeded and marshhay cordgrass *(Spartina patens)*, smooth cordgrass (*Spartina alterniflora*), and bitter panicum

(*Panicum amarum),* which were planted, in the vegetative cover (West and Dearmond 2007a, 2007b). Data for the TE-20 project indicated a decrease in bare ground with each successive year of sampling for both unplanted and spur plots (West and Dearmond 2007a). Data for the TE-24 project demonstrated that vegetation slightly increased in cover between 1999 (immediate post-construction) and 2001 (2 years post-construction) for unplanted areas and spur areas but decreased in cover for the same areas from 2001 to 2003 (West and Dearmond 2007b). More recent data indicated an increase in species richness with each consecutive year, as well as colonization by natural means. More species are colonizing the island and replacing the species that were planted or aerially seeded during construction (West and Dearmond 2007a, 2007b).

Herbivory

- A study conducted in 1984 by Hester et al. (1994) on Timbalier Island evaluated the effect of herbivory on bitter panicum (*Panicum amarum*) plantings. The study consisted of planting bitter panicum in protected and unprotected plots. The study suggested that herbivory could be an important cause of transplant failure on barrier islands in Louisiana; however, Keith Lovell of the LDNR, Coastal Restoration Division (personal communication, October 2003) indicated that the effects of herbivory on vegetation of nearby barrier islands have not been significant.

Summary/Conclusions

Storm events, subsidence, and gulf and bay erosion have all contributed to the current deteriorated state of Whiskey Island. A goal of the Whiskey Island Back Barrier Marsh Creation (TE-50) project is to create 316 acres of back barrier, intertidal marsh and to increase the width of the island to help retain sand volumes and maintain elevations through the use of material mined from a source near the island. Creation of a back barrier marsh platform will permit the island to migrate landward as it washes over onto itself, and will thereby allow the island to naturally respond to sea level rise.

The numerical models developed for this project were used to determine the existing hydrodynamic conditions around Whiskey Island, as well as the hydrodynamic conditions that will result from construction of the project as proposed. Among the processes the modeling evaluated were the effects of waves on the newly created back barrier marsh, the effects of dredging of the borrow area on the wave climate, and the elevation of dune necessary to provide some protection for the island against overwash and breaching. Modeling of dune heights ranging from +4.0 to +8.0 feet NAVD 88 indicated that the creation of a dune at +6.0 feet NAVD 88 will provide some protection for the island against the overwash and breaching that could result from the passage of a design storm (30-year) (TBS/M&N 2007).

A thin layer of sand will be exposed in the borrow area after the overburden material is removed and used to build the back barrier marsh platform. The addition of this sand will increase the height and width of the dune which will initially protect the newly created marsh platform. The dune feature will extend the longevity of the barrier island by allowing the island to migrate landward through the rollover process that will take place due to the occurrence of storms and sea level rise. The restored dune will provide increased protection against potential overwash and breaching that can occur as a result of storms or other high water events. As storm events take place and due to the increased width of the barrier island that will result from this proposed restoration project, the additional material placed on the dune will remain in this barrier island system as it is transported landward and deposited on the bayside of the island. According to Hester et al. (2005), a dune provides protection from wind and wave energy to the landward side of the barrier island. This allows for the establishment of vegetation zones on the landward side of the island, thus increasing the biodiversity of the barrier island ecosystem (Hester et al. 2005). In addition to the stabilizing effect of the dune and the ecological benefits that it will provide, restoration of the dune will allow maximum utilization of the sand resource identified in borrow area 2a. If the sand resource is not utilized for this project, it will not be usable for future restoration projects because the sand with become contaminated with silts and clays as a result of the removal of the overburden.

The elevation to which the marsh platform is constructed plays a crucial role in determining the type of habitat that will be created on the newly constructed back barrier marsh. According to Penland et al. (2003), the elevation of a back barrier marsh should not be greater than +2.0 NAVD 88. While initial construction of the back barrier marsh platform for this project will be above this recommended elevation, due to dewatering and consolidation of these sediments, the elevation of the entire marsh platform will be below +2.0 NAVD 88 by 5 years after construction.

Based on a review of monitoring reports and relevant literature, it appears that vegetative plantings and sand fencing improve the stability of barrier islands by slowing wind velocities, trapping sediment that would otherwise be lost through aeolian processes, and promoting dune formation and stability. Various strategies can be employed to improve the success of barrier island restoration projects. One of these strategies includes the construction of sand fences as soon as possible after dredged sediment placement is completed in order to minimize loss of sediment (West and Dearmond 2007a). Sand fencing should be constructed parallel to the shore and perpendicular to the predominant wind direction in order to build and stabilize the dune (West and Dearmond 2007a). Another strategy that can be employed is the construction of continuous dunes of sufficient height and width to minimize the overwash and breaching that result from storm events (West and Dearmond 2007a). These strategies will be considered and implemented as necessary in the construction of this project.

Previously constructed barrier island restoration projects on the Isles Dernieres barrier island chain have been successful at increasing the width and elevation of the islands. However, the islands have continued to deteriorate due to the impacts of tropical storms and hurricanes, the natural erosive forces acting on the island on both the bay and gulf sides, and the natural landward migration of these barrier islands. This TE-50 restoration effort will help to maintain the integrity of Whiskey Island and to preserve the functions that it provides.

In order to address the uncertainty related to whether or not tidal creeks and ponds will form naturally on a newly created marsh platform, this proposed project includes a marsh platform design that should provide data that may be used to help resolve this issue. In order to test the hypothesis that tidal features will develop naturally over time, the eastern portion of the platform will contain pre-excavated tidal features while the western portion of the platform will be left unaltered. Observations and analysis of monitoring data will provide valuable information regarding whether the construction of tidal features is necessary to ultimately achieve tidal exchange within this created back barrier marsh. Should this experimental effort yield a conclusion that tidal creeks and ponds will develop naturally, the result of this effort may be the opportunity to affect the design of future marsh creation projects.

VII. 95% Design Review Recommendations

Based on the evaluation of available ecological, geological, and engineering information, as well as scientific literature and environmental data, and a review of similar restoration projects, the proposed strategies of the Whiskey Island Back Barrier Marsh Creation (TE-50) project will likely achieve the desired ecological goals. Therefore, it is recommended that this project progress towards Phase 2 authorization.

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