Monitoring Series No. TE-27-MSPR-0800-1

MONITORING PROGRESS REPORT NO. 1
For the period February 14, 1998 to August 25, 1999

Coast 2050 Region 2

WHISKEY ISLAND RESTORATION
TE-27 (PTE-15b)

Third Priority List Barrier Island Restoration Project
of the Coastal Wetlands Planning, Protection, and Restoration Act
(Public Law 101-646)

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April 2001

INTRODUCTION

This manuscript is the first in a series of progress reports that presents monitoring data for the Whiskey Island Restoration (TE-27) project. This is a 20-year project designed to increase island elevation and width through dedicated dredging of local sediment sources and vegetative plantings as a sediment stabilization technique on Whiskey Island, Terrebonne Parish, Louisiana (**Figure 1**). The project is sponsored by the United States Environmental Protection Agency (EPA) and the Louisiana Department of Natural Resources/Coastal Restoration Division (LDNR/CRD) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III). The data encompass a two-year period beginning in the spring of 1998 (pre-construction) and ending in the Fall of 1999 (approximately 3-months after construction was completed). Results are presented and discussed within the context of the specific project goals and objectives outlined in the monitoring plan (Townson 1998) (http://www.savelawetlands.org/site/Reports/Monplans/TE27.pdf).

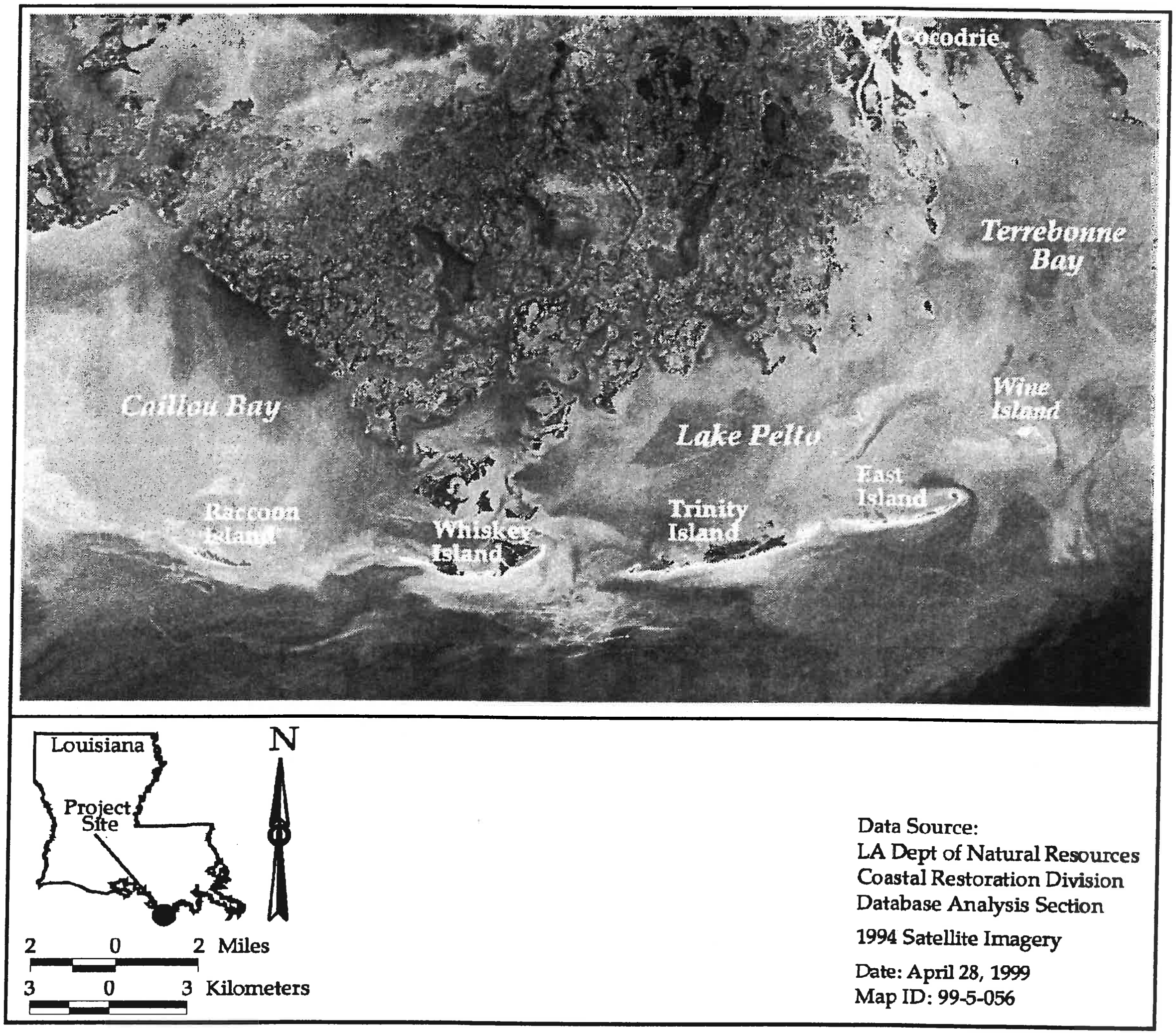

Figure 1. The Isles Dernieres barrier island chain, Terrebonne Parish, Louisiana.

Background: The Isle Dernieres barrier island chain, located along the Louisiana coast, is experiencing some of the highest rates of erosion of any coastal region in the world (Figure 1). Between 1887 and 1988 the average annual rate of land loss was 69.6 ac yr^{-1} (28.2 ha yr^{-1}), while the average rate of shoreline retreat was 36.4 ft yr^{-1} (11.1 m yr^{1}) (McBride et al. 1991). This condition has led to the landward migration (barrier island rollover) and rapid disintegration of the Isle Dernieres, as well as a decrease in its ability to protect the adjacent mainland marshes and wetlands from the effects of storm surge, salt water intrusion, an increased tidal prism, and energetic storm waves (McBride and Byrnes 1997). The Isles Dernieres began to form approximately 500 years ago when the Lafourche delta complex was abandoned by the Mississippi River (Frazier 1967). This shift in the point source of sediment supply deprived the Lafourche Delta complex of nourishment and initiated a phase of inundation, coastal retreat, and barrier arc formation (Penland et al. 1985). The modern Isle Dernieres is the product of hundreds of years of persistent inundation and shoreline transgression, which has led to the formation of five separate islands that include: Wine Island, East Island, Trinity Island, Whiskey Island, and Raccoon Island (Figure 1). A voluminous literature on the modern evolution of these islands attributes high rates of land loss in the region to the synergistic effects of global sea-level rise, subsidence, tropical and extra-tropical storm activity, inadequate sediment supply, and significant anthropogenic disturbances (Boyd and Penland 1981; Dingler and Reiss 1990; List et al. 1997; McBride et al. 1989; Penland et al. 1988; Penland and Ramsey 1990; Roberts et al. 1987).

In the early 1990's, the State of Louisiana proposed the implementation of a near-term strategy for large-scale restoration of its barrier islands through mining of offshore sand deposits (Wetland Conservation and Restoration Task Force 1992; 1993; van Heerden and DeRouen 1997). The impetus for this initiative was the specter of accelerated land loss along the fringing mainland marshes as well as a decline in fisheries productivity in the Terrebonne Estuary due to continued deterioration of the barrier islands. By the late 1990's, restoration projects had been completed on East Island, Trinity Island, Whiskey Island, and East Timbalier Island. This manuscript focuses on the restoration efforts undertaken on Whiskey Island (**Figure** 2).

Objectives and Goals: The primary objective of the project is to strengthen and stabilize Whiskey Island through sediment addition and vegetative growth which will maintain the protective barrier between the Gulf of Mexico and the lower Terrebonne Basin estuary system. The specific goals of the project are to 1) increase the height and width of the eastern and central section of Whiskey Island using dredged sediments; and 2) reduce the loss of dredged sediments through the growth of vegetation that will establish a protective canopy over the artificial fill surface. These goals will contribute to assessment and evaluation of the project objective.

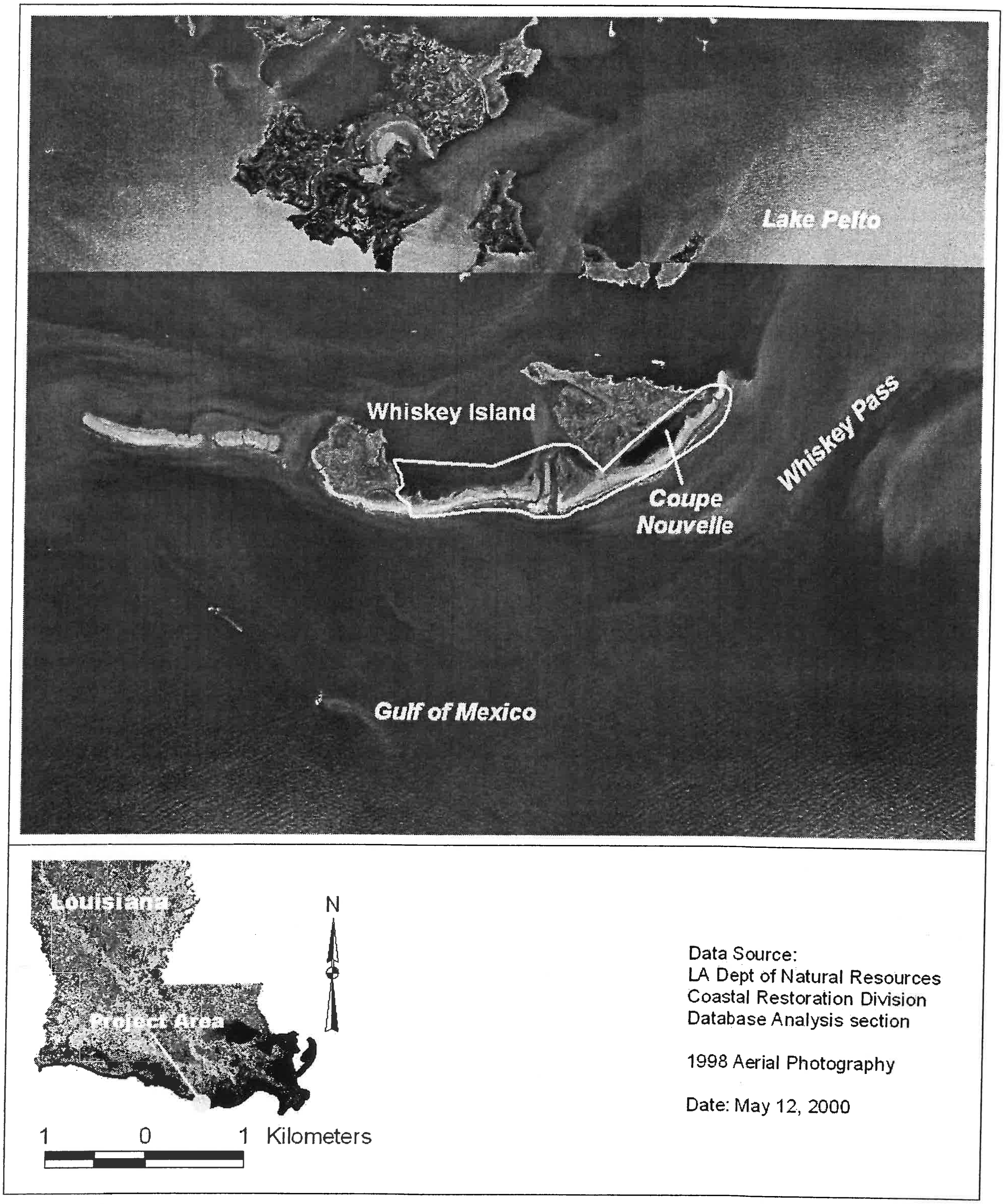

Figure 2. Location of the Whiskey Island Restoration (TE-27) project.

METHODS

Project Features

The Whiskey Island Restoration (TE-27) project includes the creation of approximately 355 ac (177 ha) of supratidal (beach, dune, barrier flat) and intertidal (beach, marsh) habitat using sediments dredged from Whiskey Pass (**Figure** 3). Target elevations range from +1 ft (0.3 m) to +4 ft (1.2 m) North American Vertical Datum of 1988 (NAVD) (**Figure** 4). The planting of vegetation along the artificial fill surface will be conducted to establish a protective canopy that will facilitate fill stabilization. Planted vegetation will include *Spartina alterniflora* (smooth cordgrass), *Spartina patens* (marshhay cordgrass), *Panicum amarum* (bitter panicum), and *Avicennia germinans* (black mangrove) (**Figure** 5).

Construction of the Whiskey Island Restoration project commenced in February 1998 and was completed in the Spring of 1999. The first phase of construction included hydraulic dredging of sediments from Whiskey Pass using a 37" Cutter Head Suction Dredge (7,200 hp) and a 30" Booster Pump Barge. This phase of construction was completed in late summer 1998. Approximately 2.9 million yds^3 (2.2 million m^3) of sediment were dredged from Whiskey Pass (borrow area) and deposited on Whiskey Island (Figure 3). A majority of the dredge material was deposited landward of the gulfside beach to restore the back-barrier portion of the island. Some material, however, was pumped onto the existing beach along the central portion of the island, in the vicinity of several breaches, as well as along the eastern section of the island near Coupe Nouvelle (Figure 2). The second phase of construction was conducted in the Spring of 1999 and included the planting of several native species of vegetation along the newly restored dune terrace and back-barrier beach. In total, 14,200 *Spartina alterniflora* (smooth cordgrass), 9,333 *Spartina patens* (marshhay

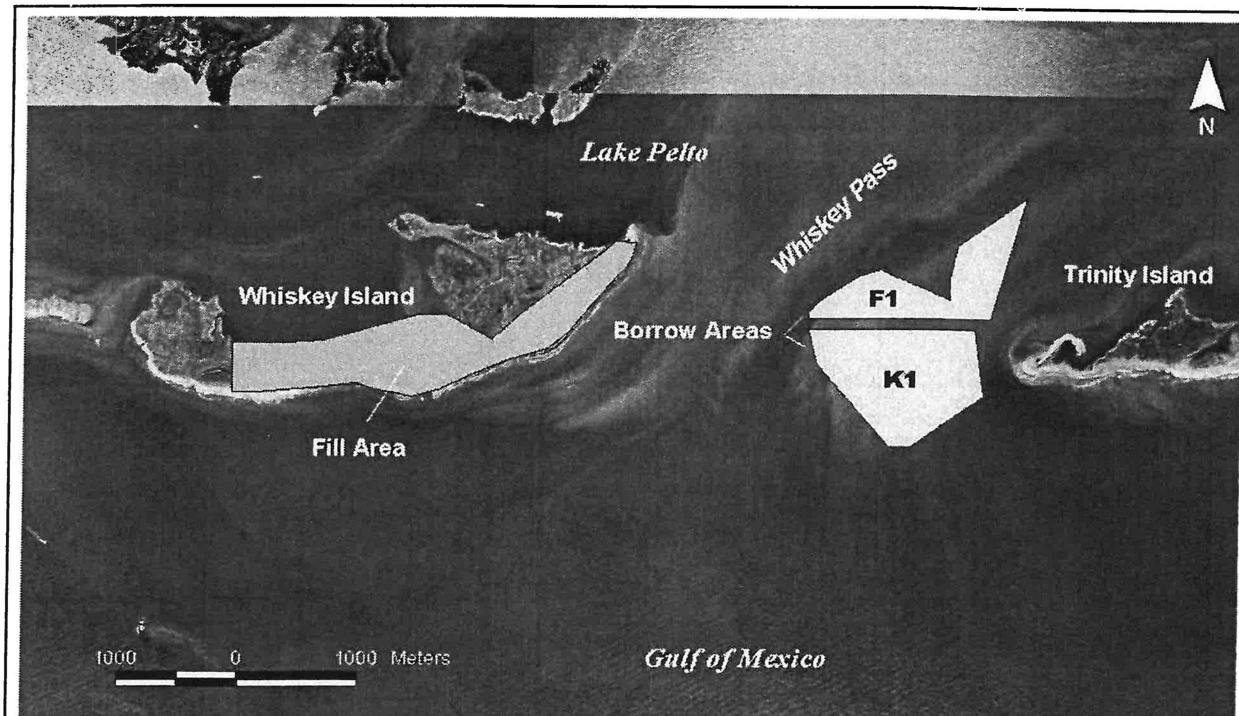

Figure 3. Locations of the borrow and fill areas at the Whiskey Island Restoration (TE-27) project.

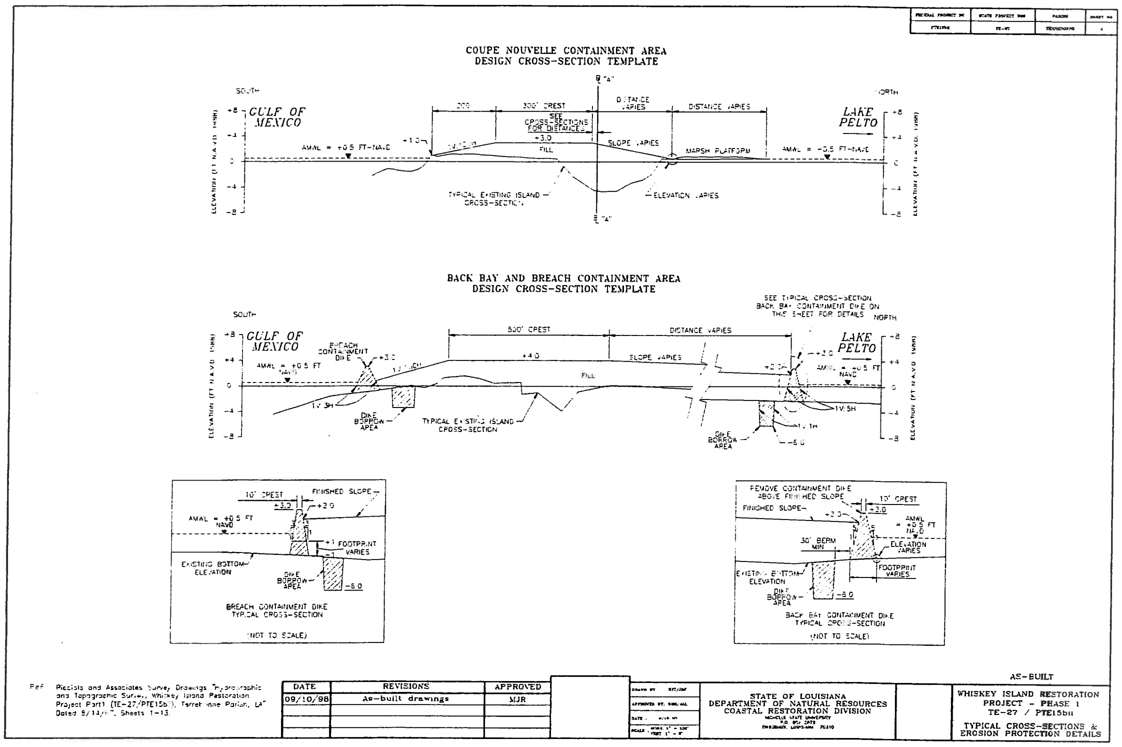

Figure 4. Typical design cross sections for the Whiskey Island Restoration (TE-27) project.

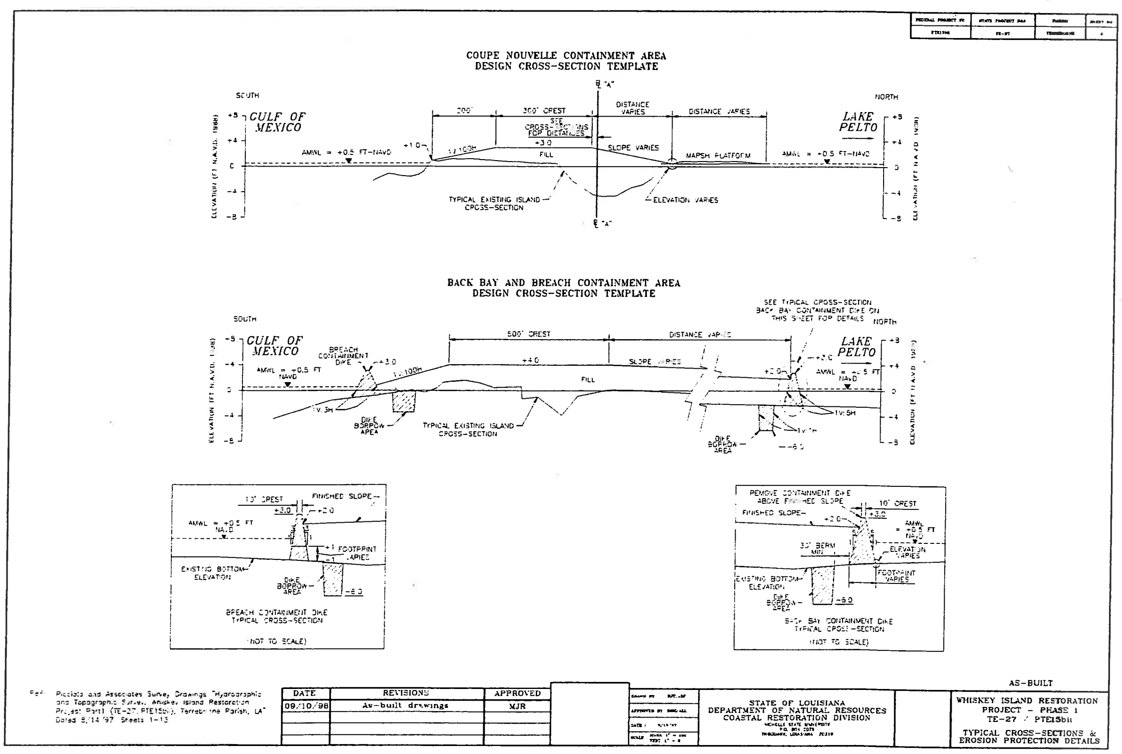

Figure 5. Typical planting design for the Whiskey Island Restoration (TE-27) project (note: not to scale).

cordgrass), 9,333 *Panicum amarum* (bitter panicum), and 1,625 *Avicennia germinans* (black mangrove) were planted.

Monitoring Design

This report presents topographic data collected before and after construction and vegetation data collected one growing season after vegetation was planted. The purpose of this report is to quantify the results of the dredging process with respect to volumetric changes and habitat restoration and assess the initial responses of the planted vegetation. Near-vertical aerial photography of the project area and regional wind data are presented to facilitate the assessment of project performance. A detailed description of the monitoring design can be found in Townson (1998).

Aerial Photography: In December 1997, the United States Geological Survey/National Wetlands Research Center (USGS/NWRC) acquired near-vertical, color-infrared, aerial photography of the project area at a scale of 1:12,000. Sub-meter accuracy was achieved by employing a differentially corrected global positioning system during data acquisition. The original film was checked for flight accuracy, color correctness, and clarity and was duplicated. Duplicate photography was subsequently indexed and scanned at 300 dots per inch (dpi). Individual frames of the photography were georectified using Erdas Imagine© (image processing and Geographic Information System (GIS) software) and then assembled to produce a mosaic encompassing the project area before construction.

Topographic Surveys: In August 1997 Morris P. Hebert, Inc. (MPH) established several transects on Whiskey Island and conducted a pre-construction topographic survey along the proposed restoration area (**Figure 6**). Conventional ground surveys were conducted with an electronic total station. Horizontal and vertical control were established using a static Global Positioning System (GPS) technique. The benchmark used during the survey was Dreux 2, which is a National Geodetic Survey (NOAA/NGS) benchmark (PID No.AU3293) that is part of the Louisiana High Accuracy Reference Network (HARN). Horizontal coordinates were referenced to the Louisiana Coordinate System (South Zone), North American Datum of 1983 (NAD 83). Elevations were referenced to the North American Vertical Datum of 1988 (NAVD). A fathometer was used to survey bathymetry along the subaqueous portions of the survey transects.

In the Fall of 1998, T. Baker Smith and Sons, Inc. conducted a post-construction survey (Figure 6). Conventional ground surveys were conducted with an electronic total station. Horizontal and vertical control were established using the same techniques described above for the 1997 pre-construction survey. Survey data were referenced to the Louisiana Coordinate System (South Zone), North American Datum of 1983 (NAD 83) and NAVD. Since all the survey points were on land, a fathometer was not necessary for data acquisition. Differences in data coverage between the two surveys shown in Figure 6 are the result of project design changes made just prior to construction, which decreased the original size of the project area, and a lack of data collection along the western end of the fill, where the post-construction survey ends farther east than the pre-construction survey. Consequently, data comparisons could not be made in these areas.

In March 2000 John Chance Land Surveys, Inc. conducted an airborne LIDAR (Light Detection and Ranging) topographic survey of the Timbalier and Isle Dernieres barrier island chains. The survey

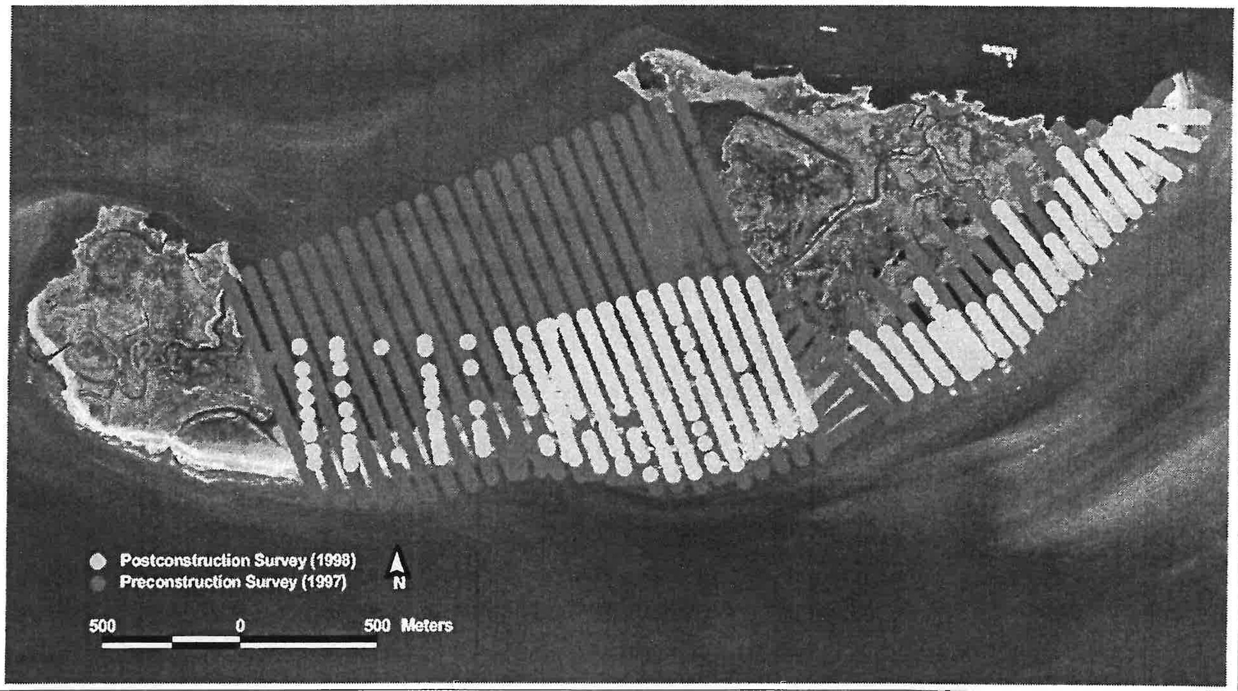

Figure 6. Pre-construction and post-construction topographic surveys at the Whiskey Island Restoration (TE-27) project.

acquired subaerial elevation data along East Timbalier Island, Timbalier Island, East Island, Trinity Island, Whiskey Island, and Raccoon Island (Figure 7). The helicopter-mounted LIDAR system (FLYMAP II®) was selected as a preferred method for topographic data collection over traditional ground surveys because it provides a cost-effective means for acquiring large amounts of data over relatively large areas and presently LDNR/CRD has seven barrier island restoration projects currently underway on the Timbalier and Isle Dernieres barrier islands (TE-18, TE-20, TE-24, TE-25, TE-27, TE-29, TE-30). A technical summary of the LIDAR flight data collection and data processing will be presented in the June 2002 Whiskey Island Restoration progress report.

Vegetation Plantings: Vegetation was sampled during August of 1999 to determine the percent survival, species composition, and percent cover approximately one growing season post-planting. Planted vegetation consisted of *P. amarum* and/or *S. patens* in the dune plots, *P. amarum* or *S. patens* in the spur plots, and *S. alterniflora* with interspersed *A. germinans* in the bay plots (Figure 5).

Plots to measure percent survival of planted vegetation were established in the 3 treatment types of dune, bay , and spur (Figure 8). Dune, bay and spur treatments contained 20, 12, and 12 plots, respectively. Percent survival plots were established randomly, by choosing a plant number and starting the plot at that location. Each randomly chosen percent survival plot was marked with a permanent stake and numbered with a numbered metal tag at the first plant in the rows (Figure 9).

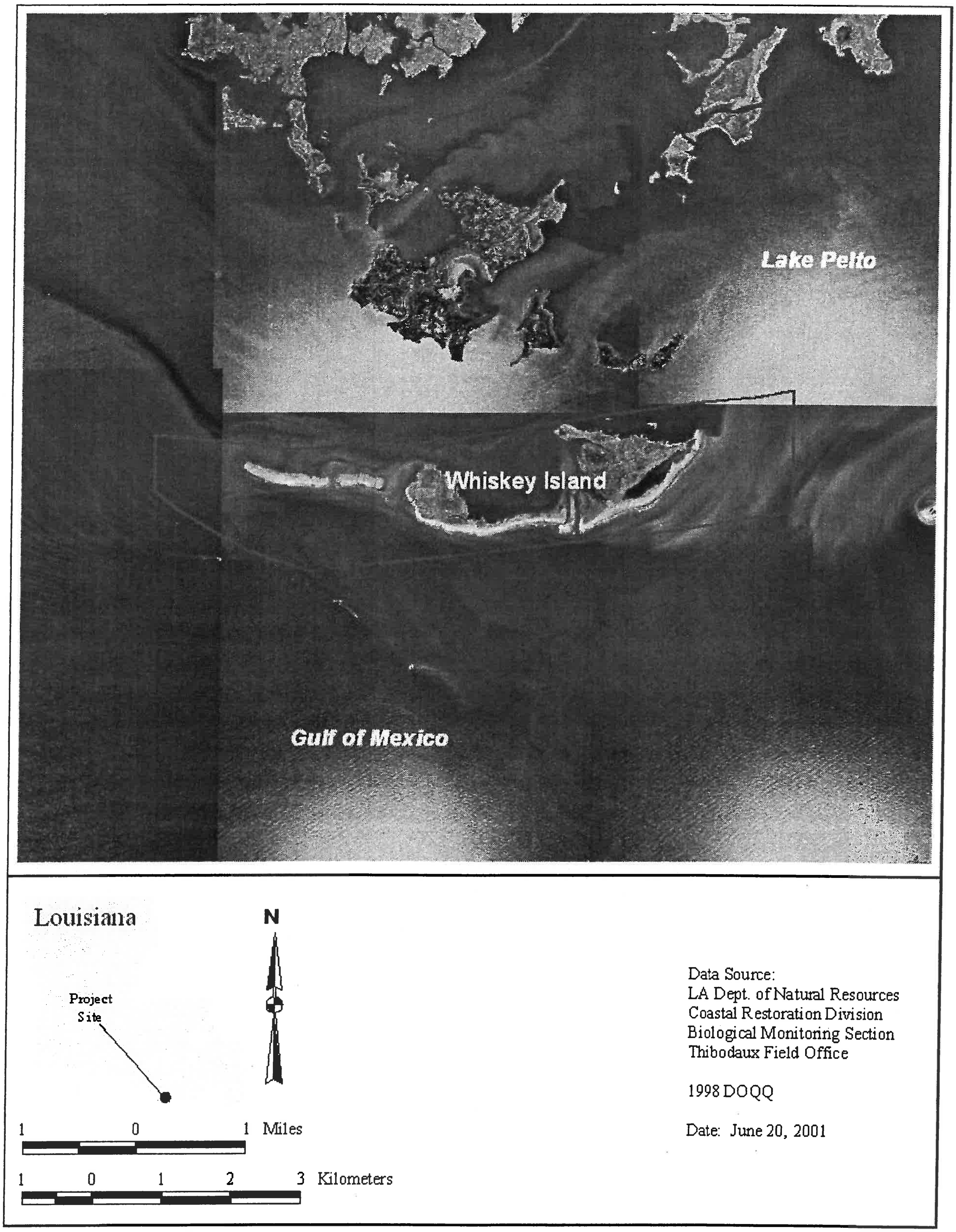

Figure 7. Approximate coverage of the March 2000 LiDAR survey for Whiskey Island Restoration (TE-27) project.

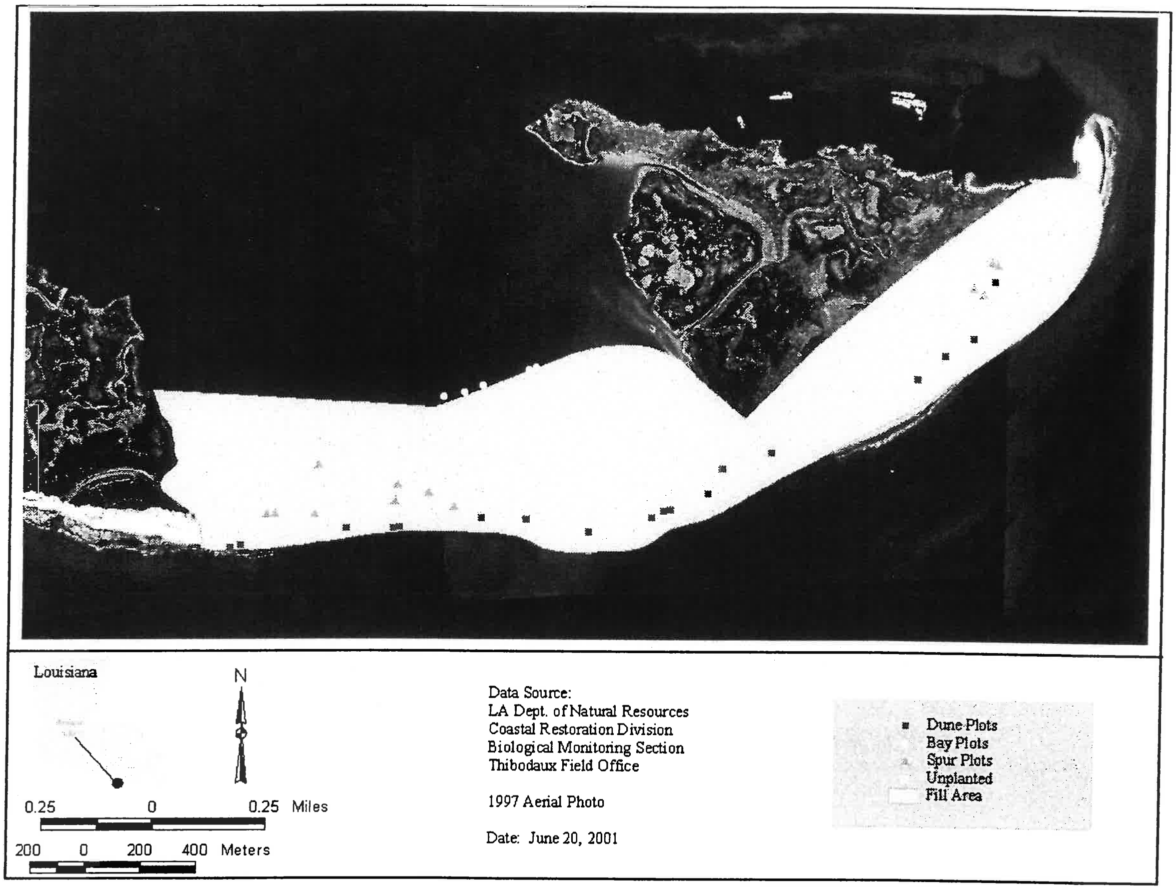

Figure 8. Location of vegetation stations for the Whiskey Island Restoration (TE-27) project.

DGPS coordinates were also collected at each stake to facilitate re-establishment of stations in the future. Due to inconsistency in planting design within treatments, such as varying numbers of plant rows from 1 to 6, station sizes varied both within and among treatment types. However, all percent survival plots contained 16 plants.

Within the three planted treatments as well as unplanted areas, species composition and percent cover of vegetation was determined using the Braun-Blanquet method (Mueller-Dombois and Ellenbert 1974) as described in Steyer et al. (1995). Species in 4 m^2 plots were recorded, and ocular estimates of percent cover for the total plot and individual species were made. Cover classes used were: solitary, <1%, 1-5%, 6-25%, 26-50%, 51-75%, and 76 to 100%. Cover plots were established within the planted treatments using the randomly chosen plants for the percent survival sampling. Each cover plot was established using the percent survival plot's marker stake as it's southeast corner, and the cover plot was oriented in a North-South direction. Unplanted treatment cover plots were established between the spurs, using a randomly chosen distance from the dune plots and marked as mentioned above. Dune, bay, and spur treatments contained the same number of cover plots as percent survival plots mentioned earlier, and 12 additional cover plots were established in the unplanted treatment.

<u>Wind Data</u>: Five years of hourly wind data from the mid-1980's to early 1990's were acquired from the C-MAN station on Grande Isle, LA to estimate potential wind-induced (eolian) sediment transport along the newly restored fill surface. Hourly wind data were also obtained from the 1998 tropical season (June through November) to quantify wind speed and wind direction during four tropical cyclones that impacted the project area in September and October 1998.

Figure 9. Placing a permanent 2x2 in wooden stake in the southeast corner of a vegetation plot at Whiskey Island Restoration (TE-27) project (photo taken August 1999).

Wave-Current-Surge Information System Data: Near real-time sea-state and meteorological information, including wave height and spectral characteristics, wave period, direction of propagation, water level, surge, and current velocity profile, are available through the Coastal Studies Institute's WAVCIS (Wave-Current-Surge Information System) monitoring program (http://erin.csi.lsu.edu) at Louisiana State University. **Figure 10** illustrates the locations of existing and proposed WAVCIS data collection stations along coastal Louisiana. Several of these stations, including CSI0 and CSI5 through CSI8, will provide local process information along the Isle Dernieres and Timbalier barrier island chains that will compliment current data collection efforts and enable LDNR/CRD to quantify environmental processes that initiate sediment transport and drive barrier shoreline change. Specifically, the WAVCIS data will provide both oceanographic and meteorologic parameters during the passage of cold fronts, tropical storms, and hurricanes and information critical for assessment of and input to hydrodynamic models. It is anticipated that the WAVCIS database will play an important role in future monitoring of the Whiskey Island Restoration (TE-27) project.

Data Processing and Analyses

Topographic Data: Analysis of the topographic survey data was accomplished using ArcView® Geographic Information System software (GIS). A triangulation-based (TIN) surface generation

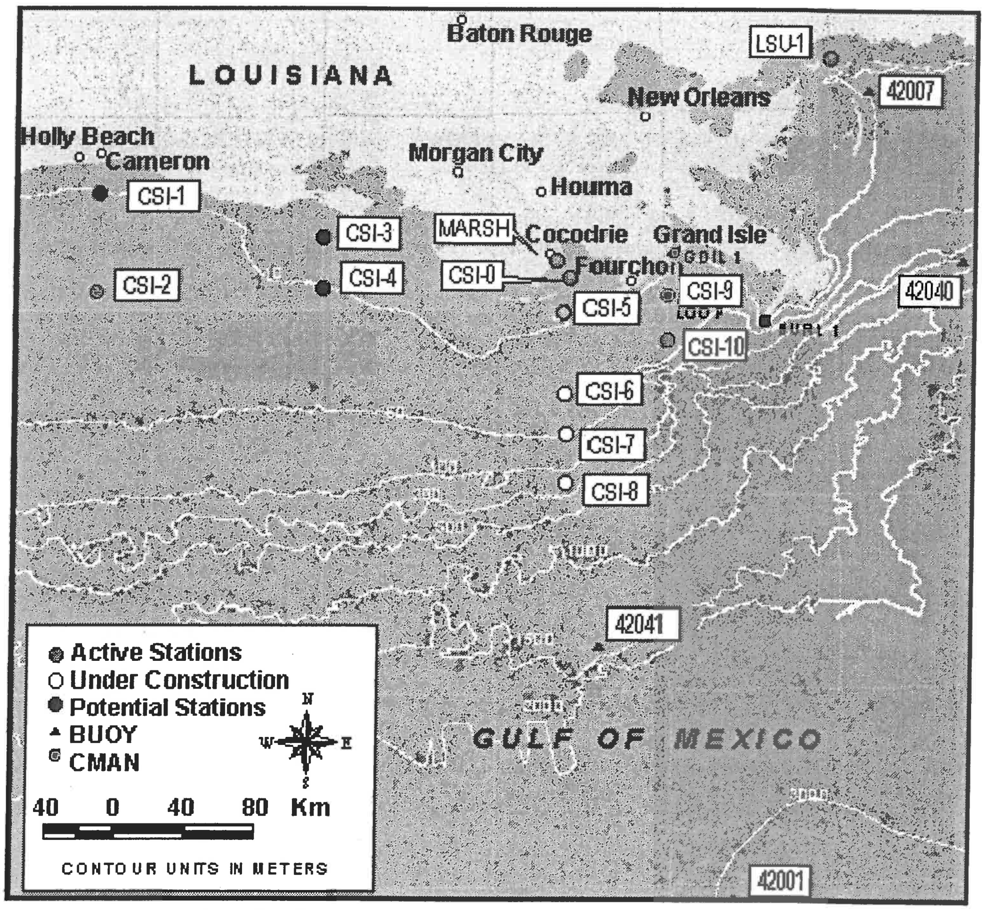

Figure 10. Location of active and proposed WAVCIS stations along coastal Louisiana.

routine in ArcView's Spatial Analyst® extension was used to generate digital terrain models from the pre-construction and post-construction survey data in order to quantify area and volume changes achieved during the dredging phase of construction. Since a Universal Transverse Mercator (UTM) projection is required for surface interpolation, survey coordinates were converted from the Louisiana State Plane coordinate System (NAD 83) to the Universal Transverse Mercator coordinate system (NAD 83) using Corpscon (USACE , version 5.11.05). Converted survey data were then imported to ArcView® for surface interpolation. Grid models were computed from the TIN surfaces and clipped using a customized routine in ArcView® to produce modeled topographic surfaces of equal size. Surfaces were then classified by elevation into three discrete classes that represent subtidal, intertidal, and supratidal habitats. A dune habitat was also classified as a subset of the supratidal class. The subtidal class comprises that portion of the project area that lies below mean lower low water (MLLW). Normally this habitat is subaqueous during all stages of the tide. The intertidal class comprises that portion of the project area that lies between MLLW and mean higher high water (MHHW). This habitat is normally subaerial at low water when the tide is in ebb, but submerged at high water when the tide is in flood. Maximum innundation of this habitat usually occurs during Tropic tides, but can also occur during the passage of cold fronts and tropical cyclones (Boyd and Penland 1981). The supratidal class comprises that portion of the project area that lies above MHHW. This habitat is subaerial during all stages of the tide and is only inundated during intense extra-tropical storms and tropical cyclones (Ritchie and Penland 1988).

Information from the tidal benchmark located at Bayou Rigaud, Grand Isle, Louisiana (#876 1724) was acquired from the National Oceanic and Atmospheric Administration (NOAA) in order to reference local tidal datums to NAVD and classify the surface models. Since the tidal datums at this station are only referenced to the National Geodetic Vertical Datum of 1929 (NGVD), the difference between NAVD and NGVD had to be estimated. The difference in orthometric heights between the two datums was estimated from the Littler RM 1 benchmark located in Cocodrie, LA (PID# AU1325) and verified with Corpscon. The benchmark information indicated that NGVD is approximately 0.15 ft (0.05 m) higher than NAVD. The Corpscon output indicated that the difference between the two datums at Whiskey Island is about 0.07 ft (0.02 m). Since the differences between the two are similar, the Corpscon output (0.07 ft) was used to reference NGVD to NAVD. Table 1 lists the elevations of the tidal datums and NGVD relative to NAVD. The subtidal class comprises those areas below -0.1 ft (-0.03 m) NAVD. The intertidal class comprises those areas between -0.1 ft (-0.03 m) and +1.02 ft (+0.31 m) NAVD. The supratidal class comprises those areas above +1.02 ft (+0.31 m). The supratidal class also comprises the dune subclass which includes the portion of the project area that lies above +3.3 ft (+1 m) NAVD.

The area of each habitat class was determined using a routine in ArcView® that computes area of designated elevation classes based on grid-cell size (2 m) and frequency. A similar routine was used to compute pre-construction and post-construction volumes in the project area. Volumes were calculated to a base contour of -10.0 m NAVD and a grid-cell size of 2.0 m was used because this was the grid cell resolution of the interpolated surfaces.

<u>Vegetation Data</u>: Due to availability of only one sampling period, as well as treatment variability mentioned earlier, data was analyzed to show general trends in planting survival as well as percent cover 1 growing season post planting. Additionally, data from 2 other CWPPRA barrier island

restoration project were combined with the Whiskey Island data for analysis and will be presented to strengthen interpretations of barrier island planting data. Isle Dernieres Restoration, Phase 1 (TE-20) project and Isle Dernieres Restoration, Phase 0 (TE-24) project were similar barrier island restoration efforts, and were planted using the same approximate design as the Whiskey Island

Table 1. Elevation of tidal datums referenced to the North American Vertical Datum of 1988.

Vertical Datum	NAVD Elevation (m)
Mean Higher High Water (MHHW)	+0.31
Mean High Water (MHW)	+0.29
Mean Sea Level (MSL)	+0.14
National Geodetic Vertical Datum (NGVD)	+0.02
North American Vertical Datum (NAVD)	0.0
Mean Low Water (MLW)	-0.02
Mean Lower Low Water (MLLW)	-0.03

Restoration (TE-27) project. Analysis was conducted of percent survival of planted species as a total of the plot. Percent survival of each species planted could not be tracked, again due to the variability of the plantings.

Comparison are made within the data set using an unbalanced block design. The assumptions of parametric analysis were tested using Statistical Analysis System (SAS) univariate procedure. When the univariate procedure indicated that data was not normally distributed, square root transformation ($y^{1/2}$) of the data was conducted which resulted in a near-normal distribution. Data were analyzed with SAS Analysis of Variance (ANOVA) procedure and the least significant difference (LSD) procedure and tested at the 95% confidence level to determine differences among treatments (SAS Institute Inc. 1996). Based on the small p-values produced by the ANOVA, the effect of transforming non-normal data should not diminish the overall conclusions drawn from the analyses. Data were detransformed for presentation.

Wind Data: The potential for wind-induced sediment transport along the fill surface was estimated by calculating the percentage of wind observations that exceeded the threshold shear velocity for sediment transport. The threshold shear velocity at the bed (fill surface) was determined from wind measurements collected 17.6 m above the bed by calculating the shear velocity for a given grain size, relating that to a drag coefficient established in field studies in the area, and then relating that to a 17.6 m height using a logarithmic wind profile equation. The threshold shear velocity is given by:

$$U_{*t} = A\ [((p_s\text{-}p)\ g\ D_m / p)^{1/2}]$$

where U_{*t} is the threshold shear velocity for transport, p_s is the particle density (2.65 g/cm^3), p is the density of air (0.001225 g/cm^3), g is the acceleration of gravity (980 cm s^{-1}), D_m is the mean grain size (0.015 cm) and A is a constant equal to 0.1 in air. Therefore, for dry beach sand, assuming a mean grain diameter of 0.15 mm (Hsu and Blanchard 1991), the threshold shear velocity U_{*t} is 0.18 m s^{-1}. Shear velocity can be related to wind velocity at any height z by:

$$U_z^2 = U_*^2 / C_z,$$

where C_z is a drag coefficient at an elevation of 2 m above the bed for a flat beach environment (from Hsu 1987). Therefore, the threshold shear velocity at 2 m above the bed (U_{2mt}) is 4.1 m s^{-1}. From the logarithmic wind profile,

$$U_z = U_* / k\ [\ln(Z/Z_0)],$$

where U_z is the mean horizontal wind velocity at height Z above the bed, Z_0 is the aerodynamic roughness length and k is von Karman's constant (0.4), the threshold velocity at 17.6 m above the bed is given by:

$$U_{17.6mt} = U_{2mt} + U_{*t}\ [\ln(Z/Z_0)] / k$$

$$U_{17.6mt} = 4.1 + (0.18)\ [\ln(17.6/2)] / 0.4$$

$$U_{17.6mt} = 5.1 \text{ m s}^{-1}$$

The percentage of hourly wind observations exceeding 5.1 m s^{-1} was then calculated from the 5-year wind record and the results were plotted.

RESULTS

Topographic Data: A digital elevation model showing habitat classes along the fill area before and after construction is presented in **Figure 11**. The average elevation of the fill area was increased from -0.72 ft (-0.22 m) NAVD to 3.25 ft (0.99 m) NAVD during the dredging process. The fill width along the western section of the project area ranged between 1300 ft (396 m) and 2100 ft (640 m) and along the eastern section between 800 ft (244 m) and 1200 ft (366 m). Prior to construction approximately 62% of the project area was subtidal habitat, 21% was intertidal habitat, and 17% was supratidal habitat. After construction 0% of the project area was subtidal habitat, 1% was intertidal habitat, and 99% was supratidal habitat. Area changes by habitat class are shown in **Table 2**. Approximately, 346.4 ac (140.1 ha) of supratidal and dune habitat were restored along the project area during the dredging phase of construction. Subtidal and intertidal habitats were reduced by 217.5 ac (88.0 ha) and 68.0 ac (27.5 ha), respectively. Although dunes were not physically created on the island during construction, the areas restored to > 3.3 ft (1 m) NAVD are defined as the dune platform, where planted vegetation will potentially promote dune formation. More than 186 ac (75.4 ha) of dune platform were created during construction, which is more than 53.2% of the entire fill area.

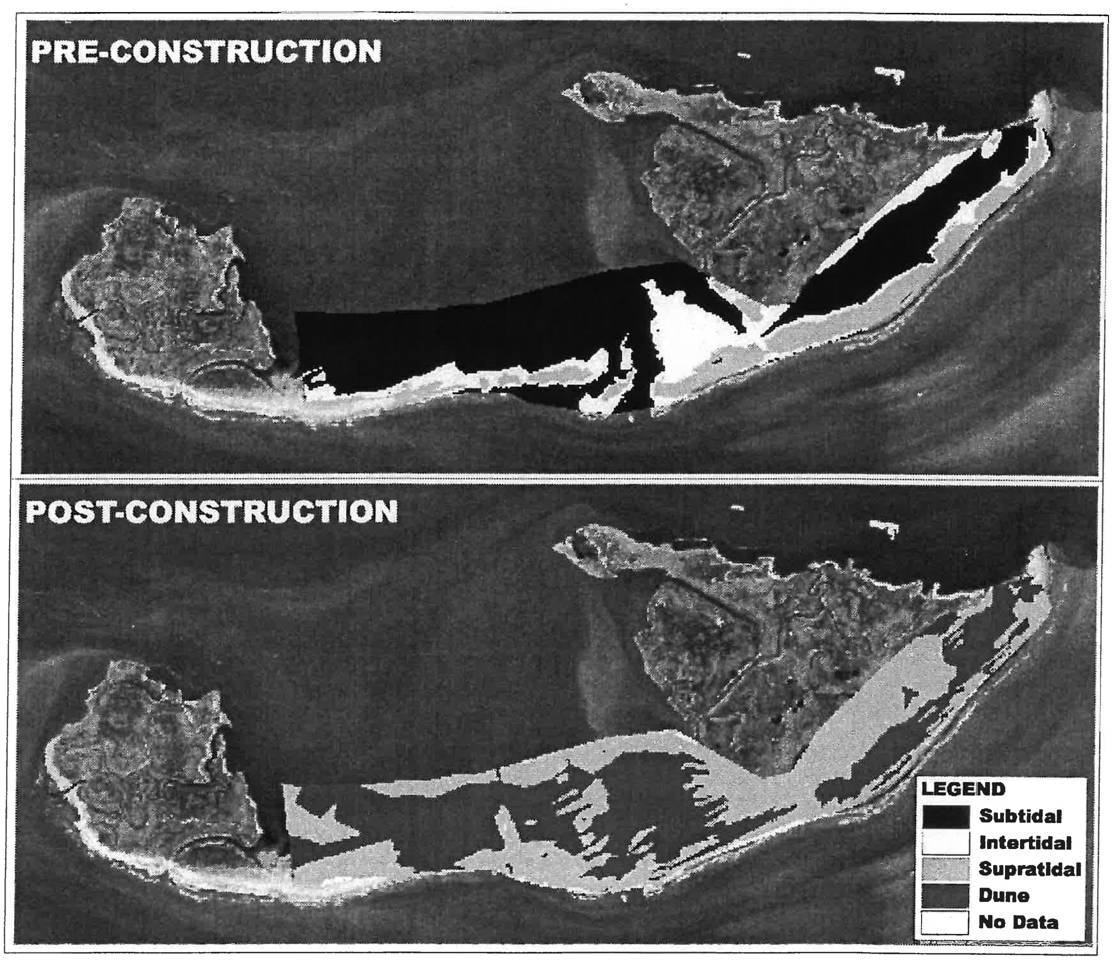

Figure 11. Digital elevation models showing habitat classes before and after construction of the Whiskey Island Restoration (TE-27) project.

Table 2. Area changes by habitat class before and after dredging at the Whiskey Island Restoration (TE-27) project.

Description		Area (ha)		
Habitat Class	NAVD Elevation (m)	Pre-	Post-	Change
Subtidal	< -0.03	88.0	0.0	-88.0
Intertidal	-0.03 to +0.31	29.0	1.5	-27.5
Supratidal	+0.31 to +1.00	24.6	64.8	40.2
Dune	> +1.00	0.1	75.4	75.3
Total	-----	141.7	141.7	----

The quantity of dredge material deposited along the fill area was estimated by the dredging contractors and LDNR/CRD engineers to be 2.9 million yd^3 (2.2 million m^3). The fill volume calculated from the digital elevation model was 2.2 million yd^3 (1.7 million m^3), which is 78% of the volume estimated by the contractors. Two factors that may have contributed to the 22% discrepancy are 1) the pre-construction survey was conducted 6 months prior to the commencement of dredging and any erosion during this time period would not be reflected in the survey data; and more importantly 2) the post-construction survey did not cover the entire fill area making digital elevation models less accurate (Figure 6).

Vegetation Data: Percent survival of planted vegetation on Whiskey Island Restoration (TE-27) project averaged 28% for all treatment types (Figure 12). Dune, bay, and spur treatments each had very low survival rates of 30, 29, and 25%, respectively. Comparisons with other CWPPRA Isle Dernieres barrier island projects 1 growing season post-construction indicated Whiskey Island Restoration (TE-27) project had significantly lower percent survival rates ($p = 0.001$) than those projects within all treatment types (Figure 12).

Mean cover on the dredged material 1 growing season post-construction, as expected, was low (Table 3). A total of 15 species were recorded within all treatments at Whiskey Island Restoration (TE-27) project, including those 3 species planted. The dune, bay, spur, and unplanted treatments had 8, 1, 2, and 5 species besides those planted, respectively (Table 4). However, the spur treatment had the highest mean percent cover when compared to any other treatment, including the unplanted reference plots.

When looking at an individual species impact on cover values within the treatments, the planted species had the highest percent cover values within all 3 planted treatments as expected. However, cover of all unplanted species was greater than all planted species in the dune treatment as well as the unplanted reference plots (Figure 13). This seems to indicate that naturally occurring vegetation remained within or colonized these area better than the other treatments.

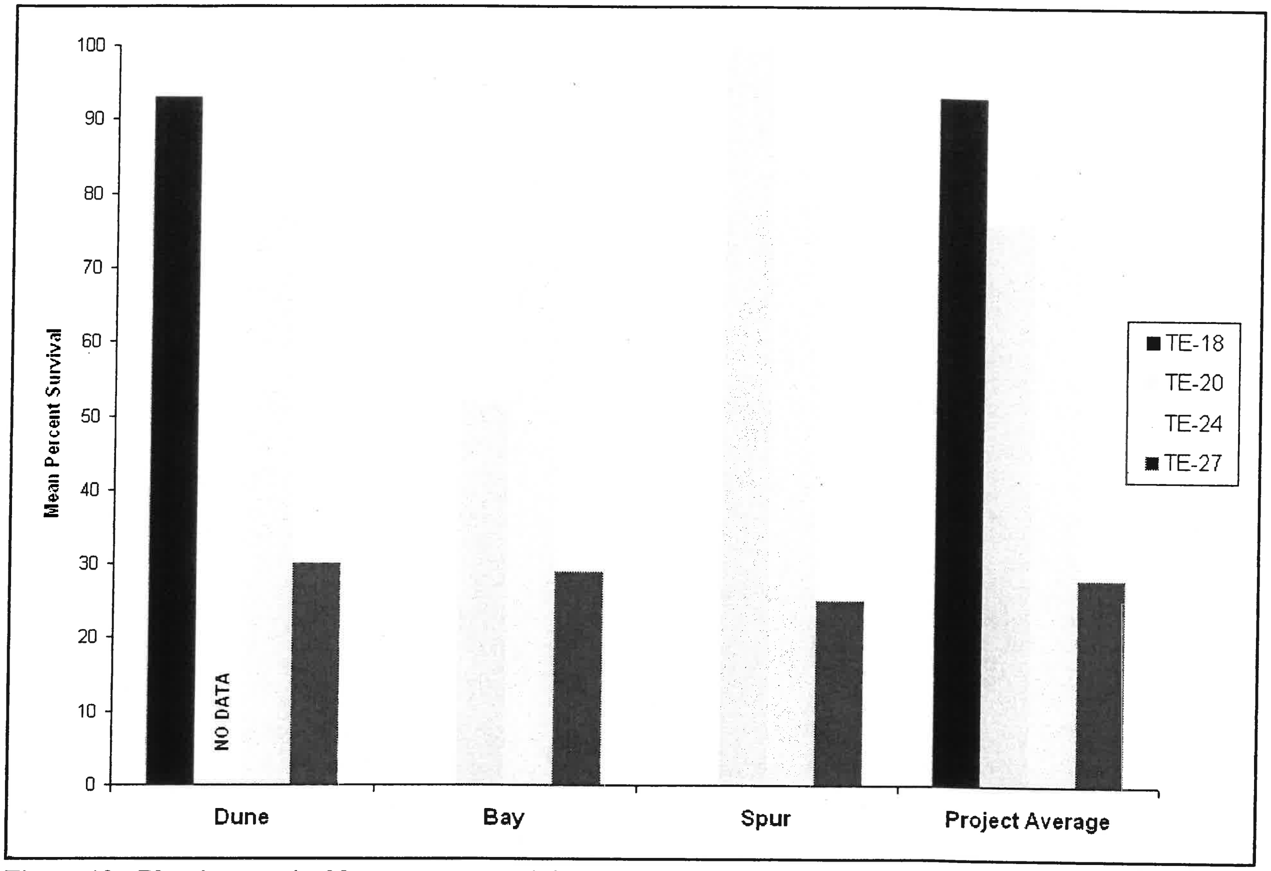

Figure 12. Planting survival by treatment at 4 CWPPRA barrier island restoration projects.

Comparison with the other 2 CWPPRA Isle Dernieres barrier island restoration projects discussed earlier indicated no significant differences of mean cover by project (p = 0.0658) (Table 3). Additionally, when all projects were combined to test for treatment differences, no significant differences were detected (p = 0.1554). Possibly indicating that plantings, as well as their survival, have little effect on percent cover within 1 growing season, when utilizing this planting design.

Mean canopy heights were also measured in all plots. The average canopy height on Whiskey Island was 7.1 in (18 cm), with dune bay, spur, and unplanted plots having 8.3, 8.7, 9.1, and 1.6 in (21, 22, 23, and 4 cm), respectively (Table 3). Again, when combined with Isle Dernieres Restoration, Phase 1 (TE-20) and Isle Dernieres Restoration, Phase 0 (TE-24) projects, there were significant differences in mean canopy heights between projects (p = 0.024) as well as among treatments (p = 0.001). As expected the planted treatments had higher canopies than the unplanted, and Whiskey Island Restoration (TE-27) projects had a lower average canopy height than the other projects (Table 3).

Wind Data: The percentage of winds exceeding the threshold shear velocity for sediment transport is presented by month in Figure 14. During the months of October through April, when cold front passages are most frequent (Roberts et al. 1987), winds velocities exceed the threshold velocity for sediment transport more than 50% of the time. Between May and September percentages decrease and reach a minimum of 20% during June and July. This general pattern of higher potential

Table 3. **Mean percent cover and mean canopy height for August 1999 (one growing season post-planting) vegetative sampling for the 3 CWPPRA Isle Dernieres barrier island restoration projects.**

Project	Treatment	Mean Percent Cover	Mean Canopy Height (cm)
TE-20 [1]	Bay	7 (n=10)	43 (n=10)
	Spur	11 (n=10)	77 (n=7)
	Unplanted	15 (n=6)	5 (n=4)
TE-24	Dune	28 (n=12)	58 (n=12)
	Bay	25 (n=12)	78 (n=12)
	Spur	18 (n=12)	51 (n=12)
	Unplanted	3 (n=12)	8 (n=11)
TE-27	Dune	7 (n=20)	21 (n=16)
	Bay	3 (n=12)	22 (n=11)
	Spur	14 (n=11)	23 (n=9)
	Unplanted	6 (n=12)	4 (n=12)
All Projects	**Dune**	**18**	**40**
	Bay	**12**	**47**
	Spur	**14**	**50**
	Unplanted	**8**	**6**

[1] - No Dune treatment plots were sampled at project TE-20.

Table 4. **Percent of stations and mean percent cover for all vegetation species recorded in the Braun-Blanquet sampling plots for all treatment types at the Whiskey Island Restoration (TE-27) project.**

	Dune		Bay		Spur		Unplanted	
Species	**% Station**	**Mean Cover (%)**	**% Station**	**Mean Cover (%)**	**% Station**	**Mean Cover (%)**	**% Station**	**Mean Cover (%)**
Bare Ground	100.00	93.10	100.00	97.00	100.00	86.75	100.00	93.50
Panicum amarum	20.00	14.00			25.00	36.76		
Spartina alterniflora			66.67	3.50				
Spartina patens	30.00	3.02			8.33	20.00		
Distichlis spicata	5.00	5.00					8.33	1.00
Sesuvium portulacastrum	25.00	0.62	33.33	2.00	50.00	4.33	33.33	18.00
Batis maritima							8.33	0.50
Heliotropium curassavicum					8.33	4.00		
Cakile constricta	5.00	5.00						
Salicornia bigelovii							8.33	6.00
Ipomoea imperati	45.00	4.44						
Ipomoea pes-caprae	5.00	5.00						
Croton punctatus	10.00	10.05						
Vigna luteola	5.00	0.50						
Phytolaca americana	5.00	3.00						
Fimbristylis sp.							8.33	0.50

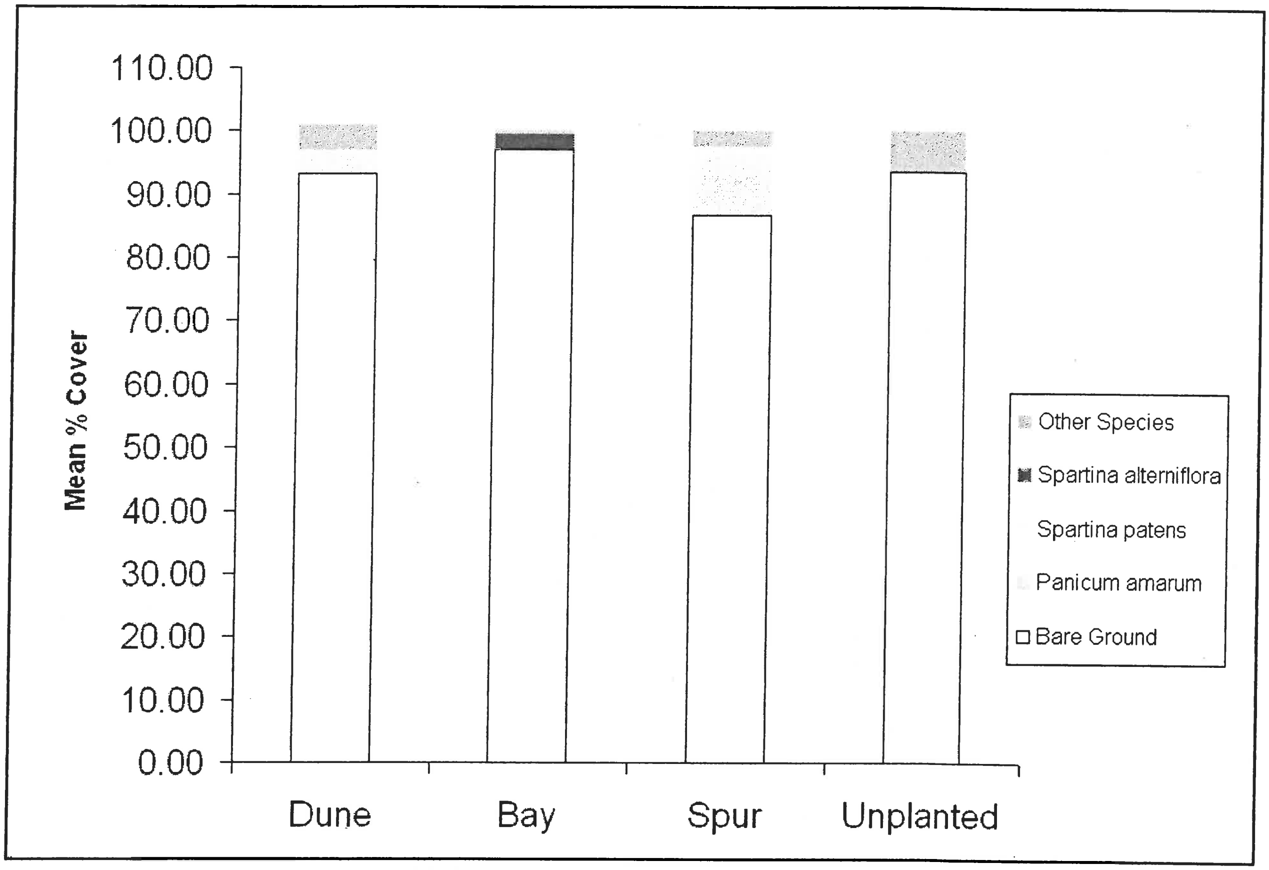

Figure 13. **Mean percent cover of individual species by treatment type 1 growing season post-planting at Whiskey Island Restoration (TE-27) project.**

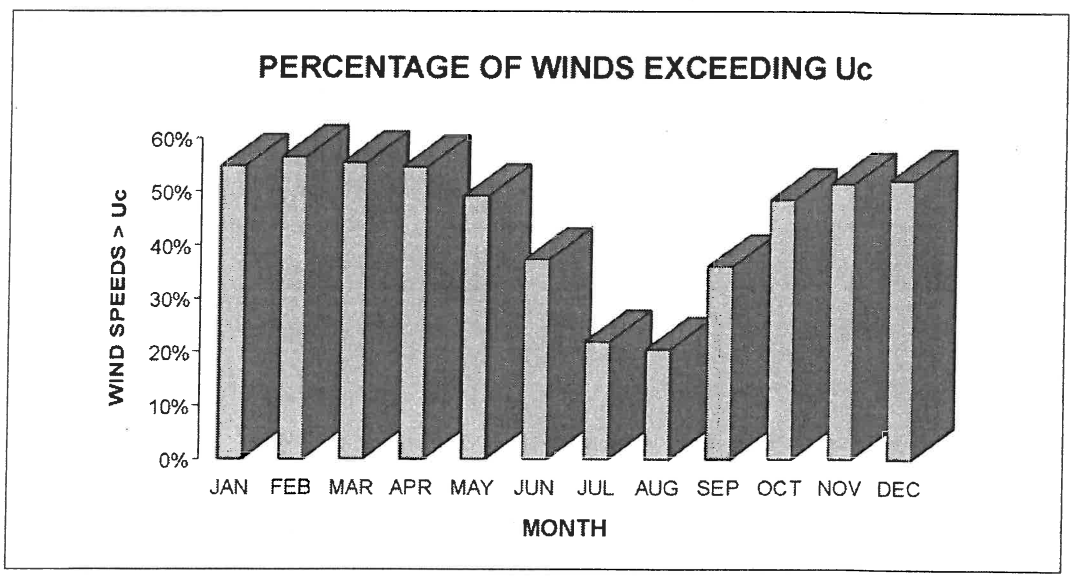

Figure 14. **Percentage of wind observations by month that exceeded the critical threshold velocity for particle entrainment and transport at the NOAA C-MAN station on Grand Isle, LA.**

sediment transport rates during the winter months is directly related to higher wind velocities that prevail during this period. Anecdotal evidence of wind-induced erosion along the fill surface during the first six months following construction is exemplified in photographs taken on East and Trinity Islands in the Spring of 1999. Figure 15 shows dunes 4 (1.2 m) to 6 ft (1.8 m) in elevation that formed adjacent to sand fencing that was constructed on East Island (Figure 1) shortly after dredging was completed in July 1998. During the same period, similar dune development was not observed at Whiskey Island (TE-27), where sand fencing was not constructed after dredging. Additionally, areas of eroded sediments were documented on Whiskey Island, indicating wind and rain removal of sediments (Figure 16).

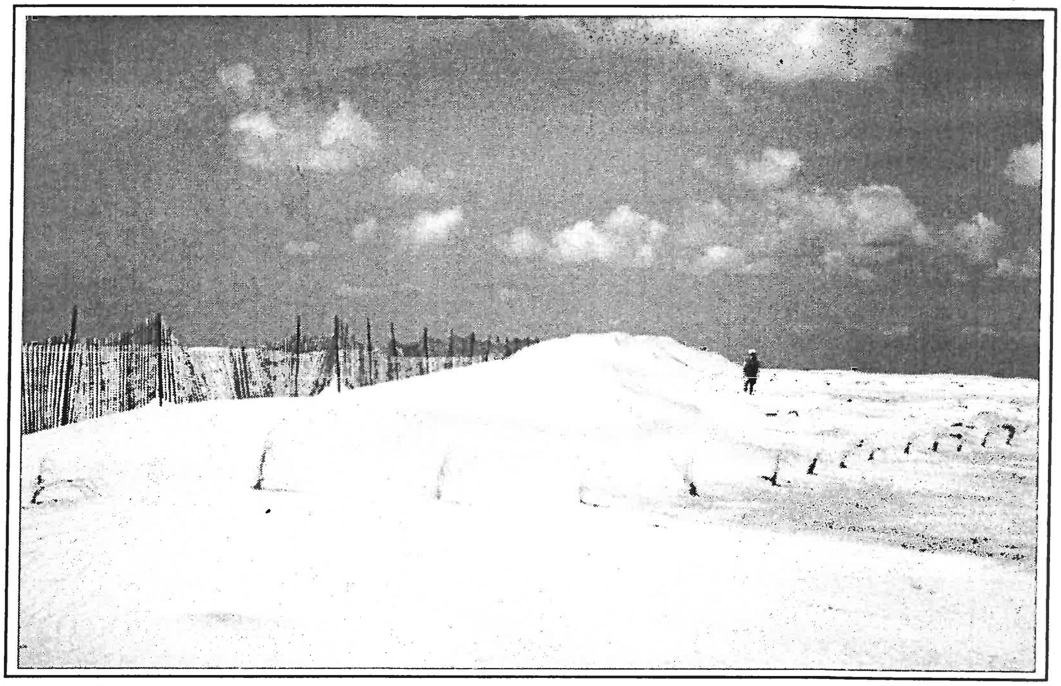

Figure 15. Dunes in the vicinity of sand fencing on East Island that formed during the 10-month period following construction (photograph taken in June 1999).

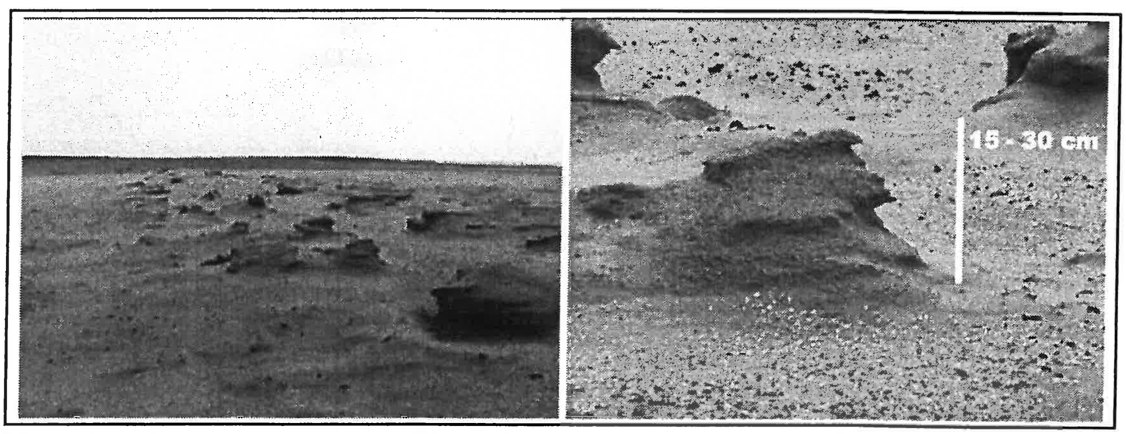

Figure 16. The typical formation of clay lag deposits along the fill surface during the first 9 months after construction as seen on Isle Dernieres Restoration, Phase 1 (TE24) project, suggests that vertical erosion caused by eolian processes was significant and occurred rapidly without a protective vegetative canopy (photograph taken in May 1999).

DISCUSSION

Immediate post-construction evaluation of the fill area at Whiskey Island Restoration (TE-27) project illustrates significant changes in island morphology and habitats. Pre-construction habitats, with more than 82.6% being classified as inter-tidal or lower elevations, when compared with the post-construction change to 98.9% of the habitat classified as supratidal or higher, shows significant increases to the project areas height and width (Table 2). This is important in relating the projects impacts to island overwash threshold regimes.

Pre-construction morphology indicates that the majority of the project area was inundated on a regular basis. However, post-construction project profiles now provide sufficient subaerial elevations to move the island into a collision to overwash regime. It should be noted that project models show elevations are still well below the 5.12 ft NAVD (1.56 m) regional overwash threshold delineated by Ritchie and Penland (1988). The post-construction elevations would indicate 98.6 to 100% of the Supratidal and Dune habitats would be subjected to an overwash frequency, on average, of more than 15 events per year. This condition would place the project area in the washover flat morphological category described by Ritchie and Penland (1985).

Overwash events are extremely important in sediment transport during the transgressive barrier island arc stage of the abandoned delta evolution (**Figure 17**). The overall sediment budget deficit during this phase, makes conservation of sediment extremely important in longevity of the island.

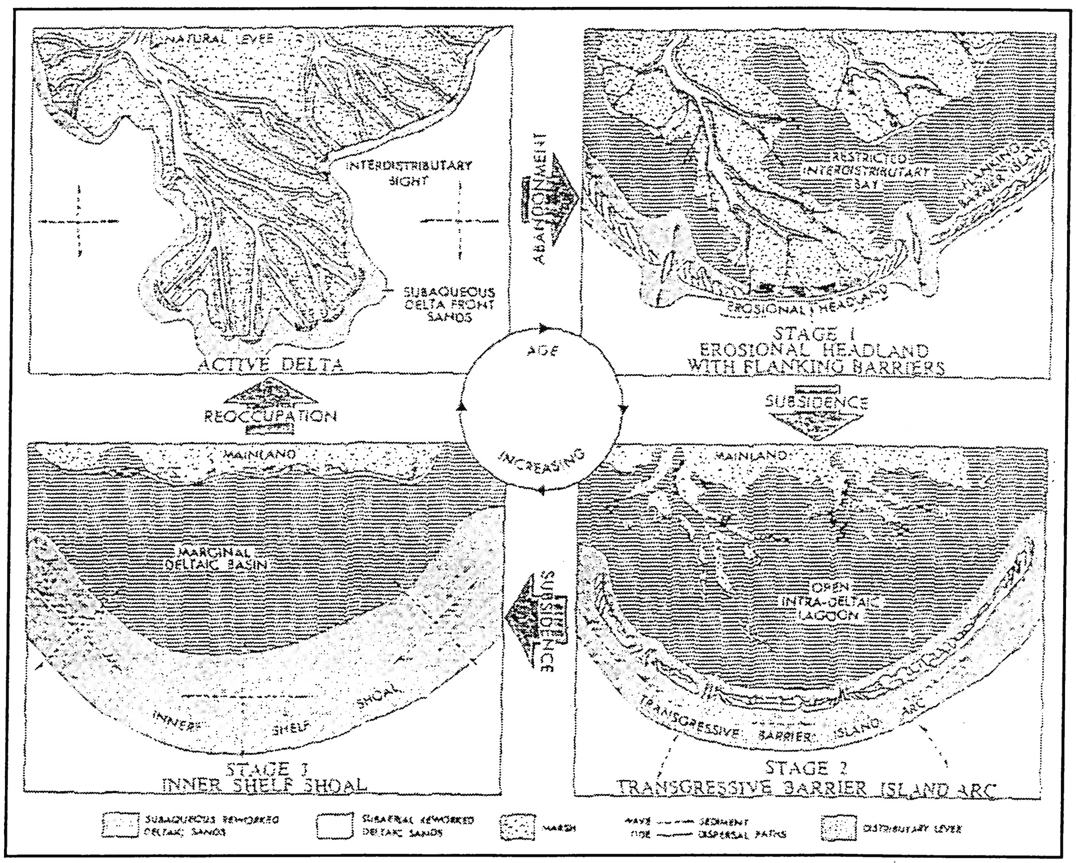

Figure 17. Model of delta evolution from Penland and Boyd (1981).

Repeated collision of storm generated waves will move sediment offshore into the inner shelf zone (Figure 18). Removal of sediments below the 16.4 ft (5 m) isobath make them unlikely to be available for recovery during fair weather conditions (Krawiec 1966, Murray 1970, Murray 1972, Penland and Boyd 1982). Overwash allows sediment to be deposited and stored on the back-barrier in overwash fans which may conserve sediments within in the system and allow for it to be reworked by an advancing shoreface. However, overwash does not capture all of the sediments removed from the near and foreshore environments. Additionally the sediment captured in the overwash fan is removed from the current nearshore environment, thereby allowing no immediate return to the shoreline during fair weather wave conditions.

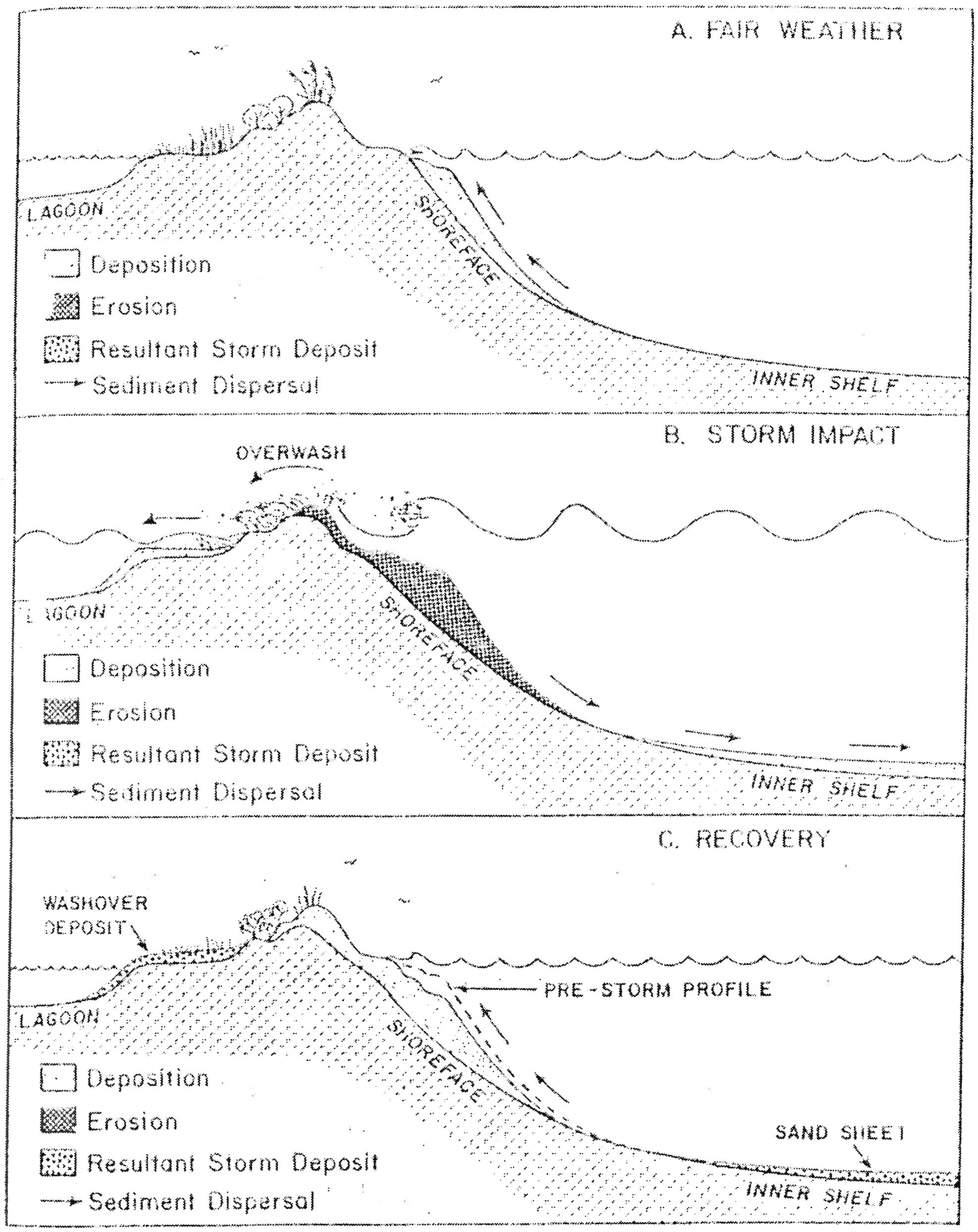

Figure 18. Typical model of collision and overwash of Louisiana barrier islands from Penland et. al. (1985).

Two additional sediment transport processes to be considered during monitoring of this project are eolian transport and wave-induced longshore transport. Longshore transport moves sediments down drift of the source area. This process is important in reworking sediments in the inner shelf zone along the shoreface as well as movement of sediment into tidal inlets. The borrow site for this project was located in Whiskey Pass between Whiskey and Trinity Islands (Figure 3). Longshore sediment transport moves sediments along the shoreface and tidal inlet between Whiskey Island and Trinity Island (the location of another large CWPPRA barrier island sediment deposition project). The location of a large "sediment sink" between the islands may act to sequester sediments in the longshore transport system, functionally removing them from the already limited sediment budget. This may affect longevity of not only the Whiskey Island Restoration (TE-27) project but the other Isle Dernieres restoration projects and needs to be better evaluated in future monitoring efforts. For example, a project is under consideration to fill Whiskey Pass and reestablish a barrier island habitat. This could require filling the Whiskey Island Restoration (TE-27) project borrow pit from which sediment was just removed (Figure 3).

Ample evidence also exists of significant wind-induced erosion along the fill areas on Whiskey Island, Trinity Island and East Island restoration projects (TE27, TE-24, and TE-20, respectively). Figure 8 illustrates the percentage of winds that exceeded the threshold shear velocity for eolian sediment transport during a five year period in the early 1990's. The greatest potential for sediment transport exists during the months from September through May. This period coincides with the months that cold fronts and extra-tropical cyclones are most frequent along the northern Gulf of Mexico. The vulnerability of the fill to wind-induced erosion is demonstrated in Figure 16, which shows clay lag deposits along the fill area on Trinity Island after nearly nine months of winter storms. In some locations more than 0.15 m (0.5 ft) of vertical erosion occurred during this period along the fill surface (Figure 16). On Trinity and East Island, where sand fencing was constructed immediately after dredging was completed, dunes developed to elevations of greater than 1 m (3 ft) in some locations (Figure 15). Since sand fencing was not constructed on Whiskey Island and dunes were not present during Spring 1999 inspections, it can be inferred that a substantial amount of dredge material was probably transported off the island into the Gulf of Mexico and Lake Pelto. Especially with the winds associated with tropical activity documented immediately post-dredging (**Figure** 19). Again, potentially reducing the amount of sediment available within an already sediment limited system.

In addition to the lack of sediment fences, the vegetation plantings 1 growing season post construction showed little impact on cover of the newly deposited sediment. As reported, mean cover values for the project area averaged <14% in planted areas and averaged 6% in unplanted areas. No detailed data exists on the aerial extent of plantings, however the majority of the project acreage appears unplanted. In addition to the small extent of the plantings, the poor survivorship of plantings added to the lack of coverage (Figure 12). Addition sampling of the vegetation in fall 2001 may provide better indication of the effect of plantings on eolian sediment transport. However, it should be noted that survivorship on the other CWPPRA Isle Dernieres barrier island projects was much higher (Figure 12) while mean cover values even in planted treatments remained below 30%.

Significant deflation may occur prior to colonization and maturation of vegetation on the newly deposited sediments and sediment fences appear to have made significant contributions to

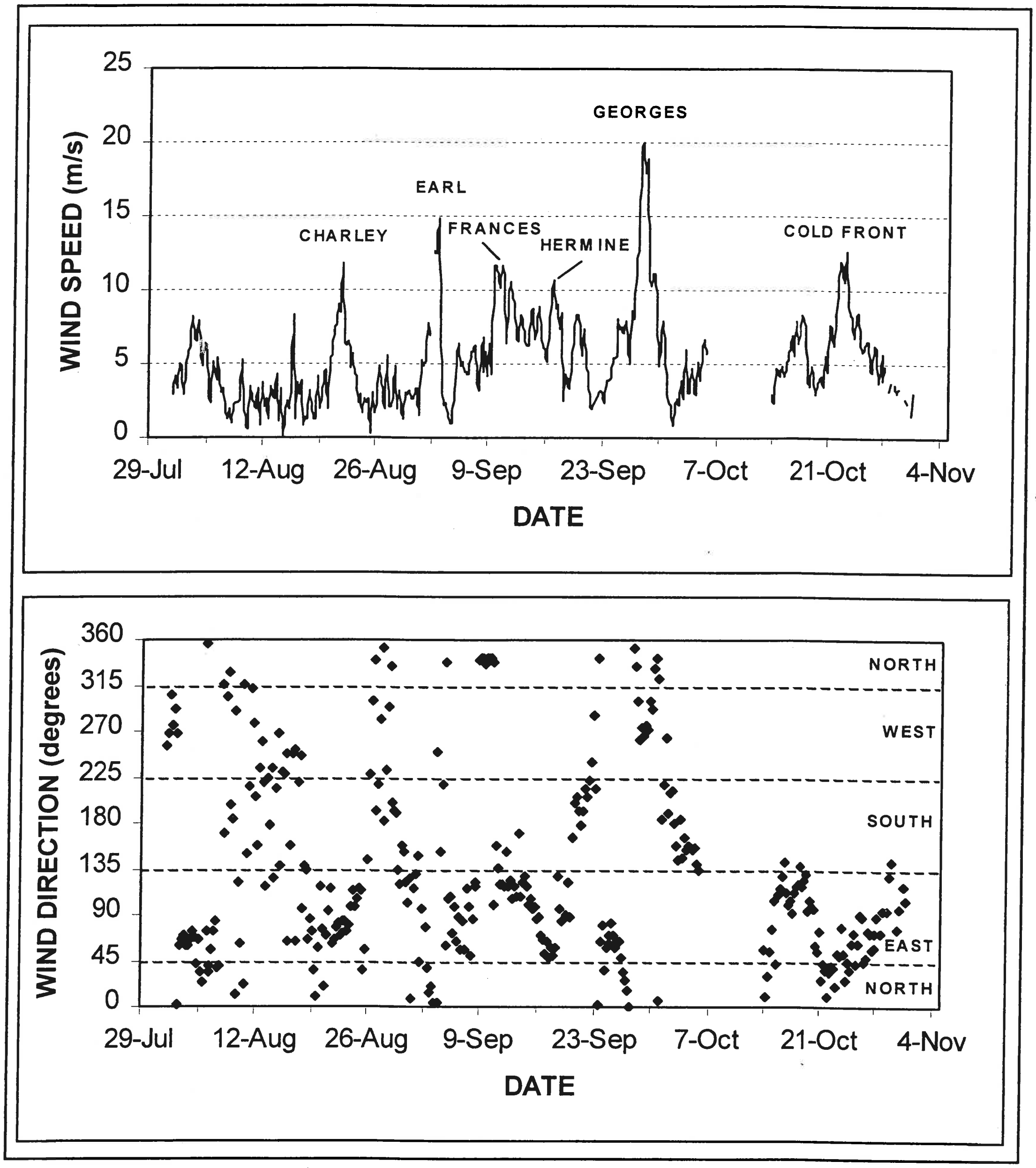

Figure 19. **A time series of wind speed and wind direction showing signatures associated with five tropical cyclones and one cold front that impacted the coast between August and October 1998. The data were obtained from the C-Man station at Grande Isle, LA, which is located approximately 50 miles east of the project area.**

maintenance of sediments within other project areas during an important post-construction morphologic adjustment period (Figure 20). The lack of sediment fences on this project may have been costly from a sand budget/project longevity perspective because post-construction adjustment through eolian deflation may reduce the barrier's elevation and increase the frequency of overwash events.

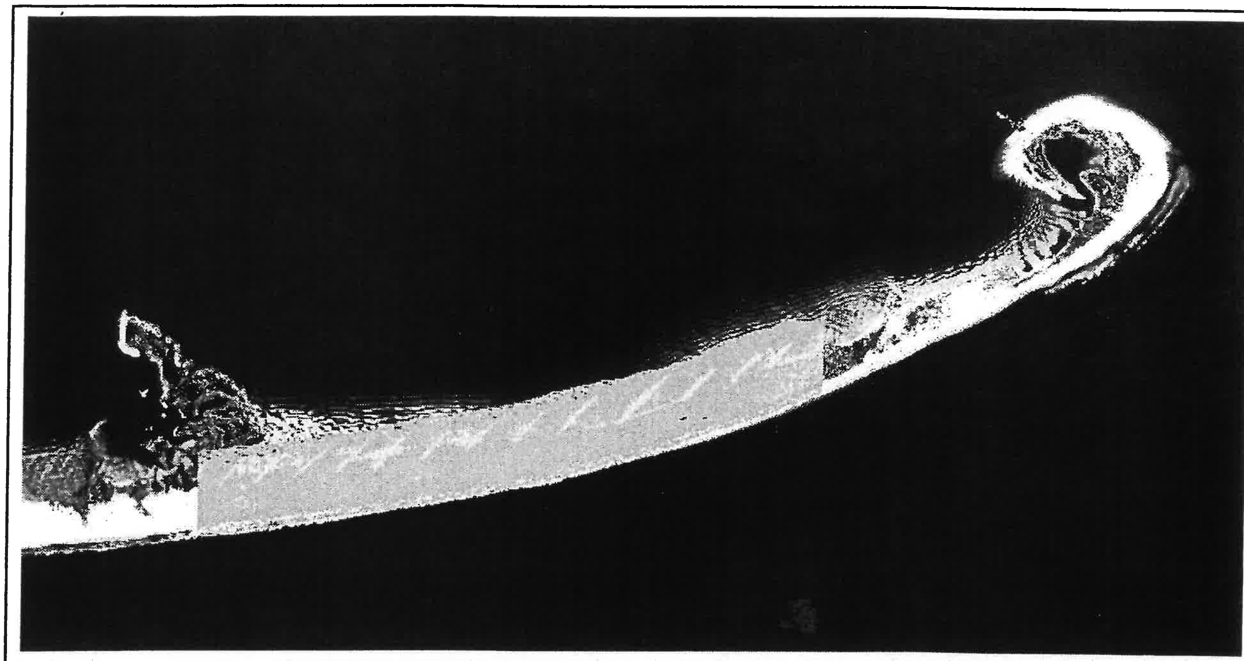

Figure 20. A portion of unfiltered LIDAR data form the March 2000 flight at Isle Derniers Restoration, Phase 0 (TE-20) project showing all elevations above the 2.44 m design elevation in green. Note the elevations above the as-built design are located in areas believed to be adjacent to the sediment fences (no data was provided to DNR monitoring as to the exact location of the fences).

All of these factors need to be balanced to determine the best height and width of islands within these barrier systems. Further analysis of survey information, wave height, and sea levels should allow comparisons of this project to other similar projects through time to determine the best designs to maintain project benefits for the longest time period. Future reports should evaluate sediment removal through eolian and overwash transport, as well as sediment capture by fences as well as vegetation. Additionally, shoreface erosion needs to be evaluated. This important component of the beach profile is currently unknown, and until it is evaluated, current designs are difficult to evaluate within a conservation of mass perspective.

CONCLUSIONS

The project has immediately met the first management goal of increasing the height and width of the eastern and central section of Whiskey Island using dredged sediments. The pre- and post-construction model show definite increases in width as well as height of the island to elevation above the MHHW elevation creating Supratidal habitats. However, it is to early to tell if the primary project objective of strengthening and stabilizing Whiskey Island through sediment addition and vegetative growth which will maintain the protective barrier between the Gulf of Mexico and the lower Terrebonne Basin estuary system has been met.

Another conclusion is that sediment fencing erected immediately after construction can capture a significant amount of newly emplaced dredge material, thereby reducing wind-induced sediment transport rates and the quantity of sediment transport into the surf. Added analysis on the direct impact of sediment fences to sediment conservation will be address in future reports by comparing volumes of sediment captured by fences compared to sediments removed from other areas.

As discussed future monitoring efforts must determine if the vegetation plantings have had an impact on sediment stabilization and whether project designs have produced an island capable of a sufficient longevity to last the 20 year project life. Certainly it appears that current vegetation planting designs do not immediately impact coverage of the sediemnt. Future sampling will help determine the ability and timeliness of planting designs to provide sufficient coverage for island stabilization.

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Note: The LDNR/CRD reference for naming plant species is:

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