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

Timbalier Island Dune/Marsh Restoration
CWPPRA Priority Project List 9
State No. TE-40
Federal No. XTE-45a

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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 February 17, 2003.

ECOLOGICAL REVIEW
Timbalier Island Dune/Marsh Restoration

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 monitoring 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

Timbalier Island is part of the Bayou Lafourche barrier island system and lies approximately 35 miles southeast of Houma in Terrebonne Parish, Louisiana. The Timbalier Island Dune/Marsh Restoration (TE-40) project was developed to restore the eastern part of Timbalier Island, which is rapidly migrating in a lateral direction (west/northwest) and decreasing in width and length (Figure 1). The project area is broken into two parts (Figure 2). Area A, which will be restored through direct creation of dunes and marsh, consists of 204 acres of open water and 239 acres of beach, vegetated dune, and marsh. Area B, which consists of 112 acres of land and 154 acres of open water, will be enhanced through the lateral migration of sediment from Area A.

During the last 100 years, Louisiana's barrier islands have naturally decreased in land mass by approximately 40% (Monteferrante and Mendelssohn 1982) with Timbalier Island having decreased by more than half (58%) its original size (Townson 1999). The decrease associated with Timbalier Island is due to a WNW migration of the island occurring through displacement of island sediment from the bayside of the eastern portion and placement on the gulfside of the western portion through longshore transfer. Gulf-side accretion rates for the western end of the island, from 1978-1988, were 40 feet/year while the bay-side erosion rates along the eastern end of the island were 42 feet/year [United States Environmental Protection Agency (USEPA) 1999]. With land loss rates of this nature, Timbalier Island is expected to disappear by the year 2050 (LCWCRTF & WCRA 1998) and migrate 5,249 feet WNW over the next 20 years (USEPA 1999). The lack of sand accumulation and a sustained sediment input source also contribute to the inability of barrier islands to cease migration, allowing a decrease in island size over time (Monteferrante and Mendelssohn 1982).

In addition to sediment shortage, offshore storms have exacerbated shoreline erosion which has contributed to barrier island breaching. Hurricane Andrew swept west of Isles Dernieres over south-central Louisiana on August 25, 1992 as a Category Four hurricane with winds between 141 and 155 miles per hour and a storm surge of 13-18 feet. The last time that a hurricane of this magnitude struck Louisiana was in 1893, when the Chenier Caminada hurricane struck the area. The Gulf-side erosion rate at the eastern end of Timbalier Island was documented at 137.1 feet/year during Hurricane Andrew, while the bay-side erosion rate at the eastern end was reported to be 28.5 feet/year (Penland et al. 1999). Through time, the western end of the island has begun to recover due to longshore sediment transport; however, the eastern end of the island continues to erode (Penland et al. 1999).

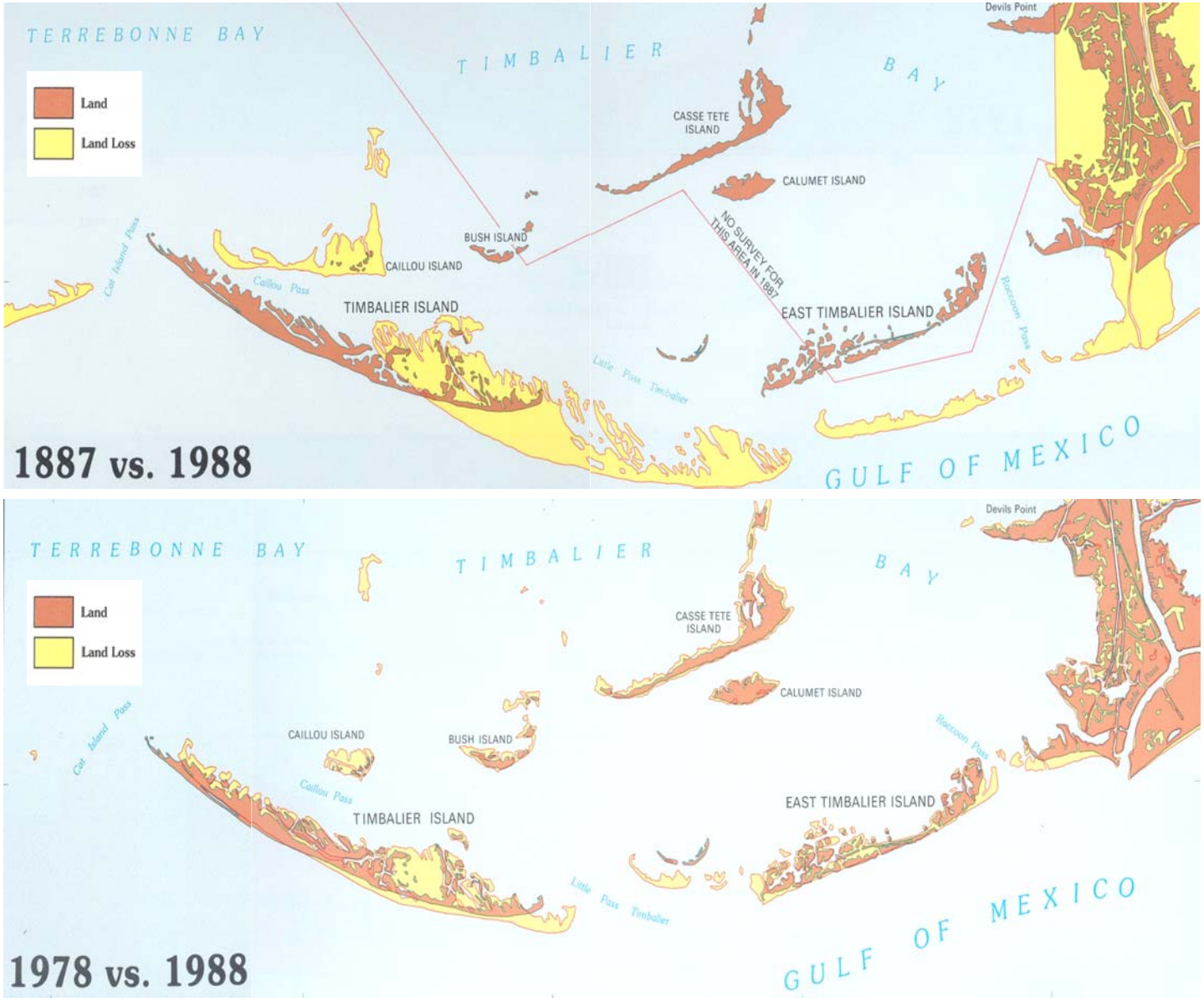

Figure 1. Timbalier Island shoreline change and land loss 1887 vs. 1988 and 1978 vs. 1988 (United States Geological Survey 1992)

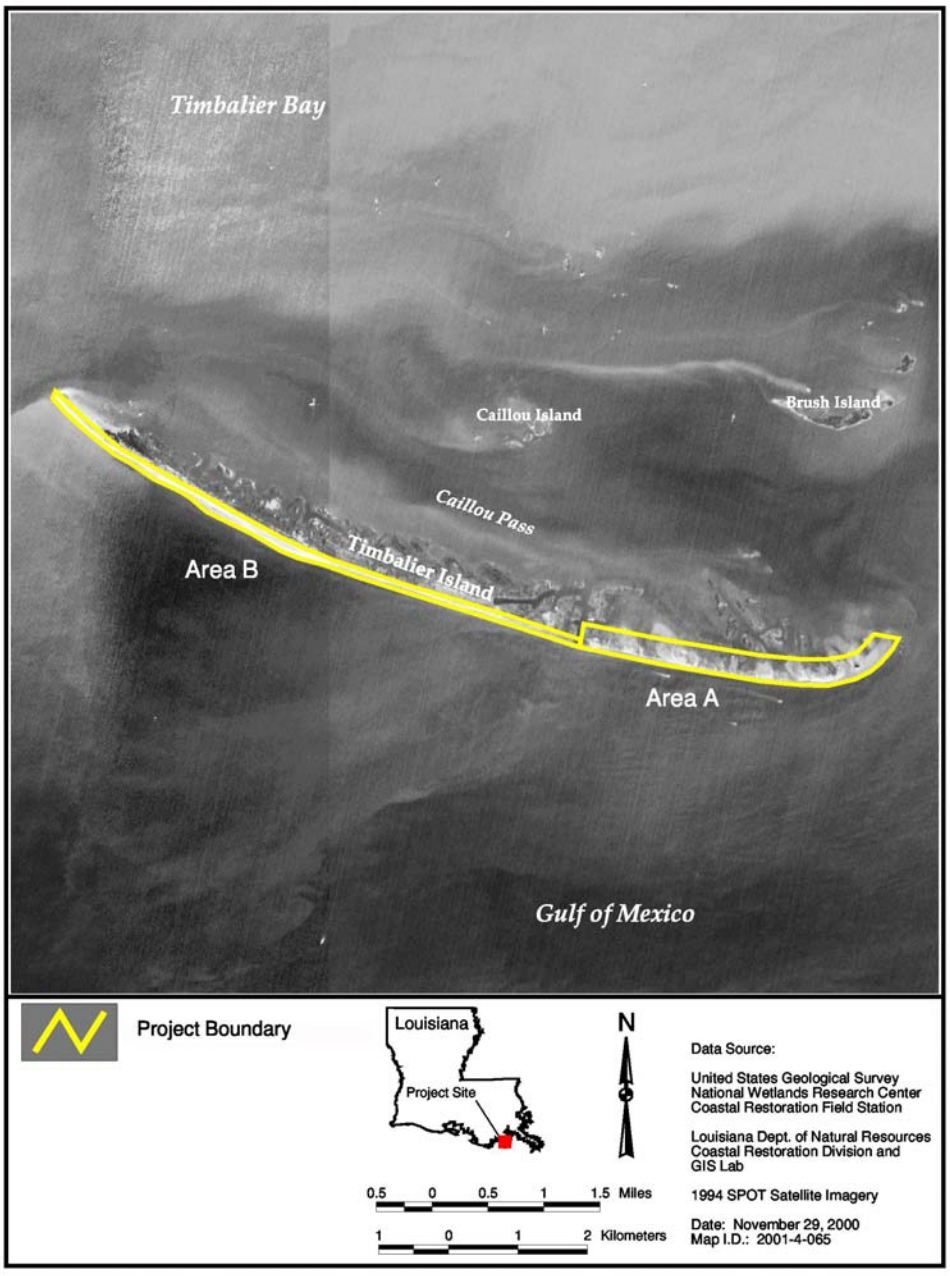

Figure 2. Timbalier Island Dune/Marsh Restoration (TE-40)

Coast 2050 identified the restoration and maintenance of barrier islands in Region 3 as an ecosystem strategy essential for returning the "island chains to a condition suitable for maintaining the integrity of the estuarine system" (LCWCRTF & WCRA 1998). Timbalier Island Dune/Marsh Restoration (TE-40) addresses a specific component of this broader ecosystem strategy.

II. Goal Statement

The goals of this project are to:

1. restore the eastern end of Timbalier Island
2. maintain the lateral migration of Timbalier Island

III. Strategy Statement

A dune and marsh platform will be constructed through deposition of dredged material, and will be stabilized by vegetation plantings and sand fencing.

IV. Strategy-Goal Relationship

The eastern end of Timbalier Island will be restored by directly creating dune and marsh in Area A. Sediment from Area A will drift into Area B through the natural process of lateral migration that barrier islands typically undergo. Constructing sand fencing and planting vegetation will aid in the reduction of wind-driven sand loss.

V. Project Feature Evaluation

Project Features

The following features were included in the 95% engineering design plan for the Timbalier Island Dune/Marsh Restoration project (T. Baker Smith & Son, Inc. 2002).

Borrow Site

Five borrow sources (Figure 3) were identified and analyzed using aerial photography, seismic data, hydrographic data, and geotechnical data (T. Baker Smith & Son, Inc. 2001). The geotechnical investigation showed that Borrow Areas 1, 2, and 4 have suitable sand. Area 2 was selected based on its cost effectiveness and proximity to the project area. Dredging for the proposed borrow site will not exceed 7.5 feet below the existing water bottom.

Dune and Overwash

The constructed dune will have an elevation of 8 feet NAVD with a top width of 400 feet and side slopes of 1:10. Dunes help maintain the integrity and strengthen barrier islands by providing protection from high intensity winds and waves caused by storms. Overwash events are extremely important in sediment transport, with the conservation of sediment being extremely important in longevity of the island. Overwash allows sediment to be deposited and stored on the back-barrier part of the island in overwash fans which may conserve sediment within the system and allow for it to be reworked (Armbruster et al. 2001).

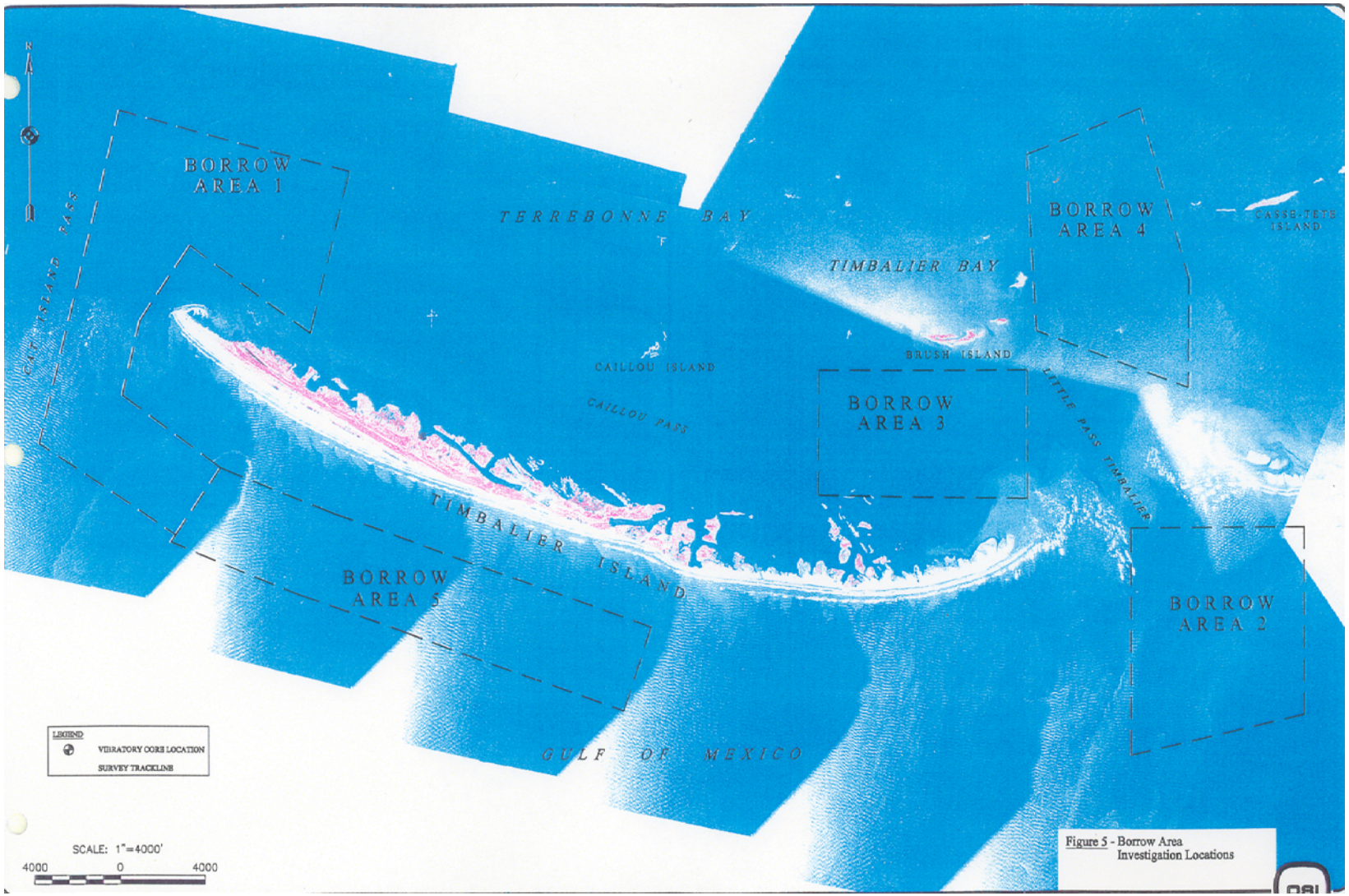

Figure 3. Borrow areas for Timbalier Island Dune/Marsh Restoration (TE-40) project (T. Baker Smith, & Son, Inc. 2002)

Back-Bay Berm

A 100-foot back-bay berm will be created with the same material as the dune, at an elevation of 4 feet NAVD. This feature will help to protect the dune on the bay side by retaining displaced dune sediments during washover events.

Marsh Platform

The target elevation range for construction of the marsh platform is 1.3 to 1.9 feet NAVD with an average elevation of about 1.4 feet NAVD and a width of 800 feet. The marsh platform will be constructed so that the entire range of elevation is represented. The platform will be low-lying and subjected to daily tidal exchanges and bay-generated waves, thus allowing natural channels and edge habitat to form from the hydraulic movement. The platform also provides valuable fisheries habitat and an additional area for over-wash material to settle during extreme storm events.

Vegetation Planting

Vegetation plantings will not be included in the initial construction phase of the project, but a separate contract will be issued for the work. The dune will be aerially seeded approximately 1 year after the initial construction phase to allow time for dewatering and proper planting season (to avoid winter weather). Louisiana native species, smooth cordgrass (*Spartina alterniflora*), marshhay cordgrass (*Spartina patens*), bitter panicum (*Panicum amarum* var. *amarum*), and sea oats (*Uniola paniculata*), will be planted. Vegetation is desirable for both its potential as wildlife habitat and dune stabilization properties. The plantings will bind the deposited sediments and assist in the accretion of wind-blown sand.

Sand Fencing

Approximately 29,000 feet of sand fencing will be installed immediately following construction to provide protection to dunes. This feature, designed to capture and accumulate fine-grained sand that is transported by the wind, is an integral part of dune restoration projects.

Geotube

Geotubes are proposed as an additive, alternate bid item to be constructed along the toe of the bayside containment dike. This feature would be used in place of the containment dike if it proves to be cost effective and could provide protection to the marsh platform sediment as it consolidates. The geotube would be placed with gaps at an elevation of 3 feet NAVD to promote active tidal exchange with the marsh platform. The gaps would channelize rainfall runoff and form tidal channels in the marsh platform.

Feature Analysis

T. Baker Smith & Son, Inc. (2002) developed three barrier island design alternatives to evaluate erosion performance and construction feasability (Table 1). The beach characteristics of the three alternatives were tested using a two dimensional model. This model, developed by the United States Army Corps of Engineers (USACE) Waterways Experiment Station, is called the

Storm Induced Beach Change (SBEACH) program. It simulates beach profile change under specified storm wave conditions and water levels. For this analysis, Category 1 and 2 hurricanes and Hurricane Andrew conditions were simulated. The primary inputs of this model are beach profile, storm conditions, and sediment data. Wave information and storm surge data were estimated for varying hurricanes using output from Sea, Lake and Overland Surge Hurricanes (SLOSH) developed by the National Weather Service and National Oceanic and Atmospheric Administration. Utilizing the SLOSH model, storm surge and wind speed were tracked as Hurricane Andrew passed over the project area in August 1992. This information was used in conjunction with Wave Information Study data from the USACE Waterways Experiment Station to develop a storm profile to input into SBEACH. After running the SBEACH model for the previously mentioned conditions, Alternative C displayed the least amount of erosion/recession of the +3 foot contour in all scenarios. Therefore, Alternative C was recommended based on the additional acreage of habitat that would be created combined with the capability of this design to withstand significant storm surge. The wider marsh platform of Alternative C also provides sand storage capacity during overwash conditions and creates a large runoff area to be used to naturally develop cuts and channels in the newly constructed marsh (T. Baker Smith & Son, Inc. 2002).

Table 1. Barrier island design alternatives for Timbalier Island Dune/Marsh Restoration (TE-40) (T. Baker Smith & Son, Inc. 2002)

Alternative	Gulfside Beach Width (ft)	Dune Height (ft NAVD)	Dune Width (feet)	Marsh Platform Width (ft)	Overall Footprint (ft)
A	100	5.0	100	300	500
B	100	6.0	200	500	800
C Recommended	200	8.0	400	800	1,400

The GENEralized model for SImulating Shoreline change (GENESIS) is a long-term shoreline change model developed by the USACE Waterways Experiment Station that calculates erosion and accretion of the shoreline based on temporal and spatial changes in the longshore transport rate due to breaking wave height and direction. This model confirmed that an east to west longshore current exists in the island system. It also indicated that there would be no measurable impact on the project area from excavating Borrow Area 2 for the horizontal and depth limits established (T. Baker Smith & Son, Inc. 2002).

VI. Assessment of Goal Attainability

The Assessment of Goal Attainability focused on the proposed project features (i.e., the dune and marsh platform, sand fencing, and vegetation plantings) and how each has been designed in order to achieve the project goals. Relevant monitoring data and scientific literature were utilized to assess the likelihood of project goal attainability.

Dune Building and Marsh Platform Building Through the Use of Dredged Material

Beach nourishment, or fill, generally can be defined as the artificial addition of suitable

quality sediment to a beach area that has a sediment deficiency in order to rebuild and maintain that beach at a width that provides storm protection and a recreation area (Campbell and Spadone 1982). In the past, the success and failure of beach nourishment projects were (and still remain) difficult to assess due to the lack of pre- and post-emplacement monitoring data to allow for objective project assessment and necessary adjustment of design (Davison et al. 1992). Dixon and Pilkey (2001) recently inventoried beach replenishment projects in the Gulf of Mexico and found very little data available for analysis. Because barrier islands and dunes provide protection against hurricanes (Stone and McBride 1998; Stone et al. 1997; vanHeerden and DeRouen 1997; List and Hansen 1992) and salt marshes offer opportunities as nurseries for many estuarine-dependent fishes (Beck et al. 2001; Halpin 2000; Williams and Zedler. 1999; Minello and Webb 1997; vanHeerden and DeRouen 1997; Baltz et al. 1993; Minello and Zimmerman 1992), it is important to restore these habitats. The following items are a summary of available information from constructed Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) projects and other scientific studies and numerical models performed on barrier islands located in coastal Louisiana.

General Findings

- A study by Minello and Webb (1997) concluded that marsh elevation and tidal flooding, both key characteristics affecting use of nekton and other aquatic organisms, should be considered
  in marsh creation projects. They found man-made marshes typically flood less than natural marshes do, and that fish densities within the vegetation of the created marshes were significantly lower than in the natural marshes. Similarly, Williams and Zedler (1999) recommended that projects be designed to more closely mimic natural marsh hydrogeomorphology.

- A longshore sediment transport model was developed for the Gulf of Mexico coastline from the Caminada Moreau headland west to Racoon Island, including Timbalier Island (Stone and Zhang 2001). These models are useful in predicting the redistribution of sediment used in restoration efforts and in quantifying longshore sediment transport by direction for a variety of fair weather and storm (non-hurricane) conditions. This model found that the net sediment transport along Timbalier Island is westward and that sand being eroded from the east flank is transported to the west where it is deposited along the west flank of the island and in Cat Island Pass (Stone and Zhang 2001).

- The *Barrier Shoreline Feasibility Study* (T. Baker Smith & Son, Inc. 1999) took a holistic approach to planning the restoration of the Louisiana barrier islands. This study recommended that Timbalier Island be rebuilt, Cat Island Pass and Little Pass remain open, East Timbalier be rebuilt and connected to Camanada-Moreau Headland, and Racoon Pass be closed. Specifically, two alternatives were identified and analyzed for Timblaier Island. Alternative 1 called for returning the island to its historic configuration of 1979, and Alternative 2 called for returning Timbalier Island to the pre-Hurricane Andrew configuration of 1988. Alternative 1 was preferred based on island stability and habitat benefits. Table 2 compares two restoration alternatives (Alternative A and Alternative B) to the final design specifications for Timbalier Island Dune/Marsh Restoration (TE-40) project, Alternative C (T. Baker Smith & Son, Inc. 2002).

CWPPRA Projects

- There are several recently constructed CWPPRA projects that have design features for dune and marsh platforms similar to those of Timbalier Island Dune/Marsh Restoration. Because all were constructed within the last three years, it remains difficult to compare results from project designs. Table 3 compares the design specifications for Timbalier Island Dune/Marsh Restoration (TE-40) to other barrier island restoration projects built and/or proposed within the Terrebonne Hydrologic Basin including Eastern Isles Dernieres Restoration, East Island (TE-20), Eastern Isles Dernieres, Trinity Island (TE-24), East Timbalier Island Restoration Phase 1 (TE-25), Whiskey Island Restoration (TE-27), East Timbalier Restoration Phase 2 (TE-30), and New Cut Dune/Marsh Restoration (TE-37). The table gives a general overview of the beach, dune, and marsh configurations for each of the CWPPRA projects.

- Preliminary results of pre- and post-construction surveys, represented by Digital Elevation Models for East Timbalier Island (TE-25; TE-30), indicate a shift from predominantly subtidal (<0.10 ft; beach, dune, and barrier flat) to supratidal (1.02 ft - 3.3 ft; beach and marsh) habitat for both projects with a general increase in dune height (LDNR 2001a; 2001b). The post-construction elevation increases are a result of dune building and will require extensive monitoring to determine project effectiveness (Krumrine and Brass 2003).

- The Whiskey Island Restoration (TE-27) project, completed in Spring of 1999, included the creation of approximately 355 acres of supratidal and intertidal habitat using sediment dredged from Whiskey Pass. Post-construction analysis of this project indicated the average elevation of the fill area was increased from -0.72 feet NAVD to 3.25 feet NAVD. Prior to construction, approximately 62% of the project area was subtidal habitat, 21% was intertidal habitat, and 17% was supratidal habitat. In contrast, after construction, 1% was intertidal habitat, and 99% was supratidal habitat. More than 186 acres of dune platform were created during construction, which was more than 53% of the entire fill area. The post-construction elevation data for this project indicated that 98.6 to 100% of the supratidal and dune habitats would be subjected to an overwash frequency of more than 15 events per year, on average. The project has immediately increased the height and width of the eastern and central section of Whiskey Island; however, it is too early to ascertain if the primary goal of strengthening and stabilizing the island has been met.

Table 2. Comparison of alternative Timbalier Island design configurations from the Barrier Shoreline Feasibility Study (1999) and the T. Baker Smith & Son, Inc. Final Engineering Report (2002)

Alternative Design Configurations	Timbalier Island Design Specifications				
	Gulfside Beach Width (ft)	Dune Height (ft NGVD or NAVD)	Dune Width (ft)	Marsh Platform Width (ft)	Overall Footprint (ft)
Barrier Shoreline Feasibility Study (1999)					
Alternative 1: Historic Configuration (1978)	300	7.0 - 9.0 NGVD	50	~1,600	1,970
Alternative 2: Pre-Hurricane Andrew Configuration (1988)	300	6.6 NGVD	50	~800	1,230
T. Baker Smith & Son, Inc. Final Engineering Report (2002)					
Alternative A	100	5.0 NAVD	100	300	500
Alternative B	100	6.0 NAVD	200	500	800
Alternative C	200	8.0 NAVD	400	800	1,400

= Recommended Alternatives

Table 3. Comparison of barrier island design specifications for seven CWPPRA projects in the Terrebonne Hydrologic Basin

Project Name	Project Number	Construction Date	Barrier Island Design Specifications				
			Gulfside Beach Width (ft)	Dune Height (ft NGVD or NAVD)	Dune Width (ft)	Marsh Platform Width (ft)	Overall Footprint (ft)
Eastern Isles Dernieres Restoration, East Island	TE-20	July 1999	200 - 250	8.0 NGVD	300	100 - 350	600 - 1,100
Eastern Isles Dernieres, Trinity Island	TE-24	July 1999	200 - 250	8.0 NGVD	300	100 - 350	600 - 1,100
East Timbalier Island Restoration Phase 1	TE-25	May 2001	N/A	5.0 NGVD	200	350 - 700	550 - 900
Whiskey Island Restoration	TE-27	July 1999	200	3.0 NAVD	300	800 - 1,500	1,300 - 2,000
East Timbalier Island Restoration Phase 2	TE-30	Partially Constructed	N/A	5.0 NGVD	200	350 - 700	550 - 900
New Cut Dune/Marsh Restoration	TE-37	Not Constructed	340	8.0 NAVD	300	740	1,500
Timbalier Island Dune/Marsh Restoration	TE-40	Not Constructed	200	8.0 NAVD	400	800	1,400

= Final Engineering Report Recommendation (T. Baker Smith & Son, Inc. 2002)

Vegetation Plantings and Sand Fencing

Factors that may affect vegetation planting projects include soil characteristics, wave fetch, herbivore threats, and many other site specific conditions (Bahlinger 1995). The following studies support the use of vegetation plantings in barrier island restoration projects, when used in combination with sand fencing. The United States Department of Agriculture (USDA) recommended the use of both marshhay cordgrass and bitter panicum in dune restoration projects (USDA 1992).

- Mendelssohn et al. (1991) demonstrated the success of effectively building dunes in low sediment supply systems such as Timbalier Island by combining vegetation plantings with sand fencing to decrease wind velocity along the dune. The three species of plants used in the study were bitter panicum, sea oats, and seashore paspalum (*Paspalum vaginatum*). After 15 months, bitter panicum had the highest survival at 73%, sea oats had 23% survival, and seashore paspalum had only 3% survival. The low survival of seashore paspalum was probably due to sand burial. Overall plant cover was good, up to 60% cover in some areas. Marshhay cordgrass, though not planted at the study site, accounting for approximately 20% of additional cover.

- In 1992, the LDNR performed a restoration study which incorporated the use of marshhay cordgrass on 1-foot centers at Trinity Island, one of the four islands within Isles Dernieres. By 1994, this and other native vegetation such as salicornia (*Salicornia virginica*), baccharis (*Baccharis halimifolia*), black mangrove (*Avicennia germinans*), and seaside goldenrod (*Solidago sempervirens*) spread to assist in stabilizing the island (Bahlinger 1995).

- Louisiana Department of Natural Resources conducted a five-year project, Timbalier Island Planting Demonstration (TE-18), which incorporated the use of both sand fencing and vegetation planting. Vegetation was planted on 1-foot centers. Marshhay cordgrass and bitter panicum were planted on the bay side of the fences between the perpendicular fence spurs. Both species displayed excellent transplant survival and growth when sand fences remained intact (Townson et al. 1999). Sand fencing and vegetation plantings were proven to be a success, particularly in the first year of the study; however, after three to four years, the beach was found to be narrowing, and unable to dissipate wave energies.

- Preliminary analyses of data from two similar CWPPRA barrier island projects showed only a slight increase in vegetation cover two years following construction. At Eastern Isles Dernieres Restoration, East Island (TE-20), there was a slight increase in vegetation from 1999 (immediate post-construction) to 2001 (2 year post-construction) for bay, spur, and areas left unplanted. Data for Eastern Isles Dernieres, Trinity Island (TE-24) showed that vegetation slightly increased in cover between 1999 (immediate post-construction) and 2001 (2 year post-construction) for unplanted areas, and for bay, dune, and spur.

- Success of marshhay cordgrass has been demonstrated in many studies but high mortality rates occurred in planting for TE-25 and TE-30 on East Timbalier Island. The drought

- conditions of 2001 could have negatively affected the vegetation in these projects. A site visit in 2001 revealed that bitter panicum was vigorous in most areas. The advantages of bitter panicum as a stabilizing vegetation far outweigh those of marshhay cordgrass, thus bitter panicum is planted more often (Personal Communication with Keith Lovell).

- Mendelssohn et al. (1991) concluded that 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 arranged angled (perpendicularly) to the shoreline.

- 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. Monitoring results from 2001indicated that vegetation survival and cover was low (28% and <14%, respectively), and that the area exhibited severe wind-induced erosion (Armbruster et al. 2001). However, the drought conditions of 2001 may have also affected vegetation growth for this project.

- A study conducted in 1984 by Hester et al. (1994) on Timbalier Island evaluated the effect of herbivory on bitter panicum plantings. The study consisted of planting bitter panicum in protected and unprotected plots. One year later, vegetative cover of bitter panicum in the protected plots increased 33%, along with an increase of 67% in stem density. No plants survived in the unprotected plot and field observations suggested that 0% vegetative cover of bitter panicum was likely due to nutria (*Myocastor coypei*) herbivory. The study suggested that herbivory could be an important cause of transplant failure on barrier islands in Louisiana; however, Keith Lovell and Kenneth Bahlinger (personal communication) of the LDNR, Coastal Restoration Division, indicated that the effects of herbivory on vegetation of nearby barrier islands have not been significant.

Summary and Conclusions

Multiple research projects concluded that beach nourishment via dune building and marsh creation are viable means of rebuilding and maintaining barrier islands. These dunes and marsh areas act as hurricane and storm abatement modules thus prolonging island existence. Models designed to evaluate project design alternatives and mimic the surrounding hydrology of the islands have also been effective in depicting the effects of proposed project features. Analysis of the models provide a conduit to make well-educated decisions on which alternatives to place under further purview and how to proceed after the best alternative has been selected. Literature reviews of past projects similar in nature and design to the Timbalier Island project have shown that sandfences and vegetation plantings are a major component of successfully restoring barrier island environments. Both sandfences and vegetation plantings help sustain dune integrity and strength while providing habitat for wildlife. The findings as presented in the assessment of goal attainability section show the potential of this project and the need for action if Timbalier Island is desired for future generations.

VII. Recommendations

30% Ecological Review Recommendations and Outcome:

1. The target width of the marsh platform, based on the T. Baker Smith & Son, Inc. Preliminary Engineering Report is 800 feet. If the goal of the project is to restore eastern Timbalier Island, it may be more appropriate to construct the marsh platform to its historic (1978) width of 1,600 feet. This was the recommendation of the *Barrier Shoreline Feasibility Study* which was finalized in 1999 (Table 2). The marsh platform serves as stop-over habitats for migrating songbirds, and the initial nursery for marine fish and macroinvertibrates.
   This issue was discussed at the 30% Engineering and Design Meeting. Due to cost constraints, the marsh platform will remain at 800 feet. Compared to similar, recently constructed barrier island restoration projects, this is the widest marsh platform designed, thus far.

2. Timing of sand fencing is crucial. Recent studies showed that sand fencing should be constructed immediately after project construction.
   This point was recognized and well received at 30% Engineering and Design Meeting.

3. Because there are studies that show both the success and the failure of marshhay cordgrass and bitter panicum, it remains difficult to determine the most preferable species for TE-40.
   This was simply a summary of findings.

4. The target width of the gulfside beach, based on the T. Baker Smith & Son, Inc. Preliminary Engineering Report is 200 feet. Due to the high energy wave environment, this feature would be more susceptible to erosion. Should the gulfside beach be widened to prolonge beach life? *This was simply a question for the 30% meeting.*

95% Ecological Review Recommendations:

Based on the evaluation of the project's biotic benefits, goals, and strategies, the final design for the Timbalier Island Dune/Marsh Restoration (TE-40) is acceptable, and the project should proceed to Phase II.

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