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

North Lake Mechant Landbridge Restoration, Construction Unit 2
CWPPRA Priority Project List 10
State No. TE-44

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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 August 26, 2004.

ECOLOGICAL REVIEW

North Lake Mechant Landbridge Restoration, Construction Unit 2

In August 2000, the Louisiana Department of Natural Resources 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

The north Lake Mechant landbridge is located in the Terrebonne hydrologic basin and is comprised of an area delimited to the south by Lake Mechant, to the west by Lake Pagie, to the north by Bayou DeCade and to the east by the natural levee of Small Bayou LaPointe. The project is located in the *Coast 2050* Mechant/DeCade mapping unit, an area with high subsidence rates, estimated at 0.25-0.42 inches per year (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1999; Penland and Ramsey 1990). The North Lake Mechant Landbridge Restoration project encompasses approximately 7,572 acres of predominantly open water (>70%) and marsh, most of which is classified as intermediate, dominated by *Spartina patens* (marshhay cordgrass). The project is intended to protect the hydrologic barrier function, and maintain the integrity of the north Lake Mechant landbridge, by reducing interior marsh loss and shoreline erosion along lakes Mechant and Pagie. This land loss threatens the integrity of the landbridge that separates the intermediate and fresh marshes to the north from the marine and tidally dominated Lake Mechant system to the south (Figure 1). At the current shoreline erosion rate of 7.5 feet/year (Paille and Segura 2000), it is projected that a 500-1,000 foot section of Lake Mechant's northern shoreline will be breached within 10 years, thus compromising the hydrology and ecology of the adjacent intermediate marsh area. Additionally, the east Lake Pagie shoreline is eroding at a rate of 3.3 to 3.8 feet/year (Paille and Segura 2000), which also threatens the integrity of the landbridge.

The project design entails the use of the following features to preserve the landbridge: marsh creation north of Lake Mechant; vegetation plantings along eroding lakeshores; hard shoreline protection along containment dikes; plugging of several oil-field canals; and, the replacement of a fixed-crest weir with a sheet pile weir. It has been determined that construction of the project, as currently proposed, could impact a number of oyster leases identified within Lake Mechant. The difficulties and associated delays in dealing with oyster lease compensation/relocation issues have prompted the federal and local sponsors to divide the project into construction units (CU). This action will enable those project features that will not impact nearby oyster leases to proceed in a more timely fashion through design and construction phases. The vegetation-planting component of CU1 is covered in a previous Ecological Review, and entails the planting of 44,307 linear feet of *Spartina alterniflora* (smooth cordgrass). This Ecological Review focuses exclusively on CU2, which is composed of hard structures and marsh creation components.

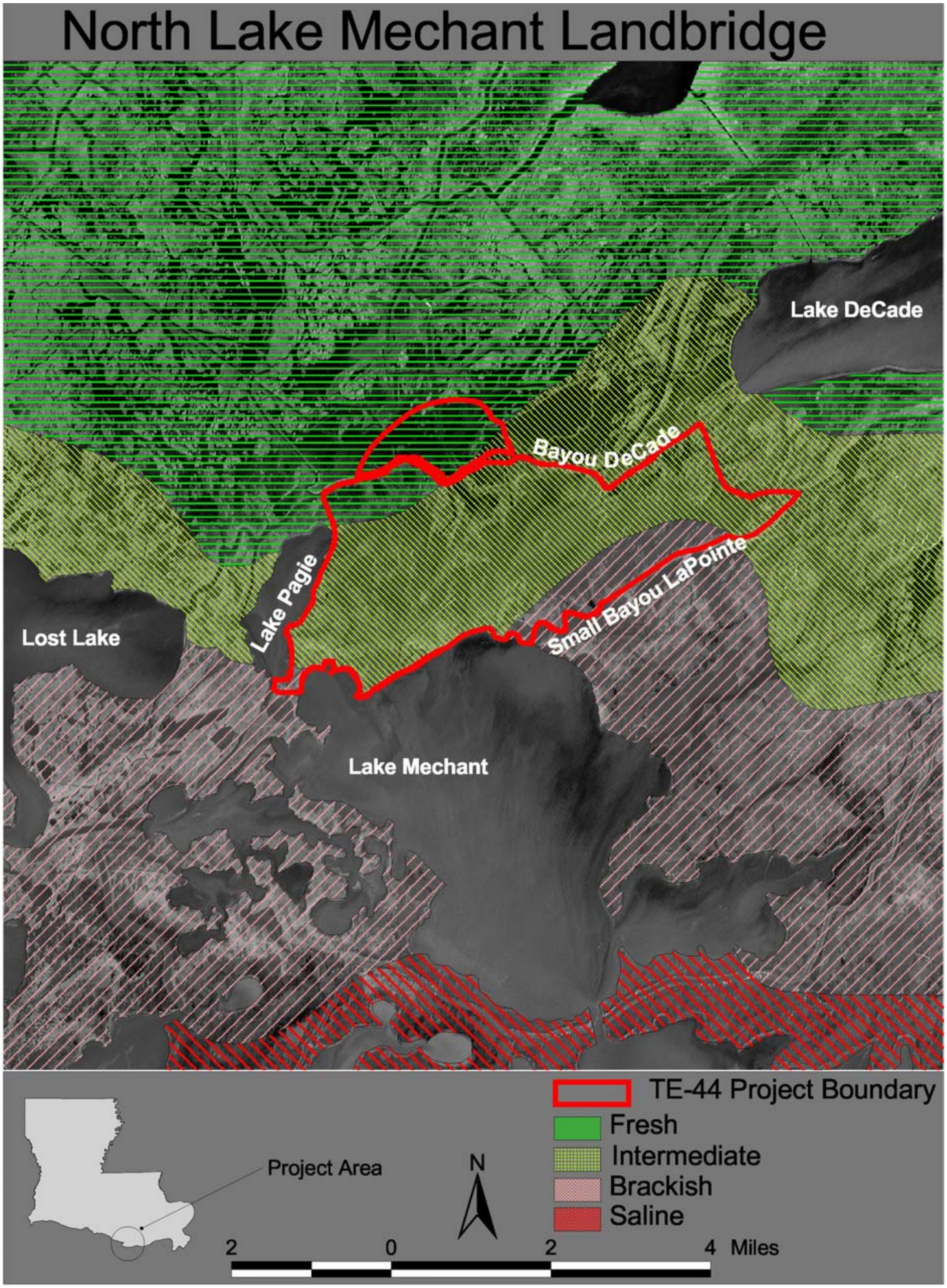

Figure 1. North Lake Mechant landbridge and marsh-vegetation types according to Chabreck and Linscombe (1997)

II. Goal Statement

- Create 790 acres of intertidal habitat suitable for intermediate marsh establishment at construction and nourish 40 acres of existing marsh.
- Maintain interior marsh vegetation type as intermediate for the duration of the project life of 20 years.

III. Strategy Statement

- The creation of 790 acres of intermediate marsh will be achieved through the confined placement of dredged material at an average elevation of 3.0 feet NAVD-88 and the nourishment of 40 acres of existing marsh will be achieved through the placement of 1 foot of dredged material.
- The interior marsh vegetation type will remain intermediate for the duration of the project life of 20 years through the construction of 2,362 linear feet of armored earthen dike, the placement of three earthen plugs, three sheet pile plugs, two rock plugs, and the replacement of a fixed crest weir with a sheet pile weir (Figure 2).

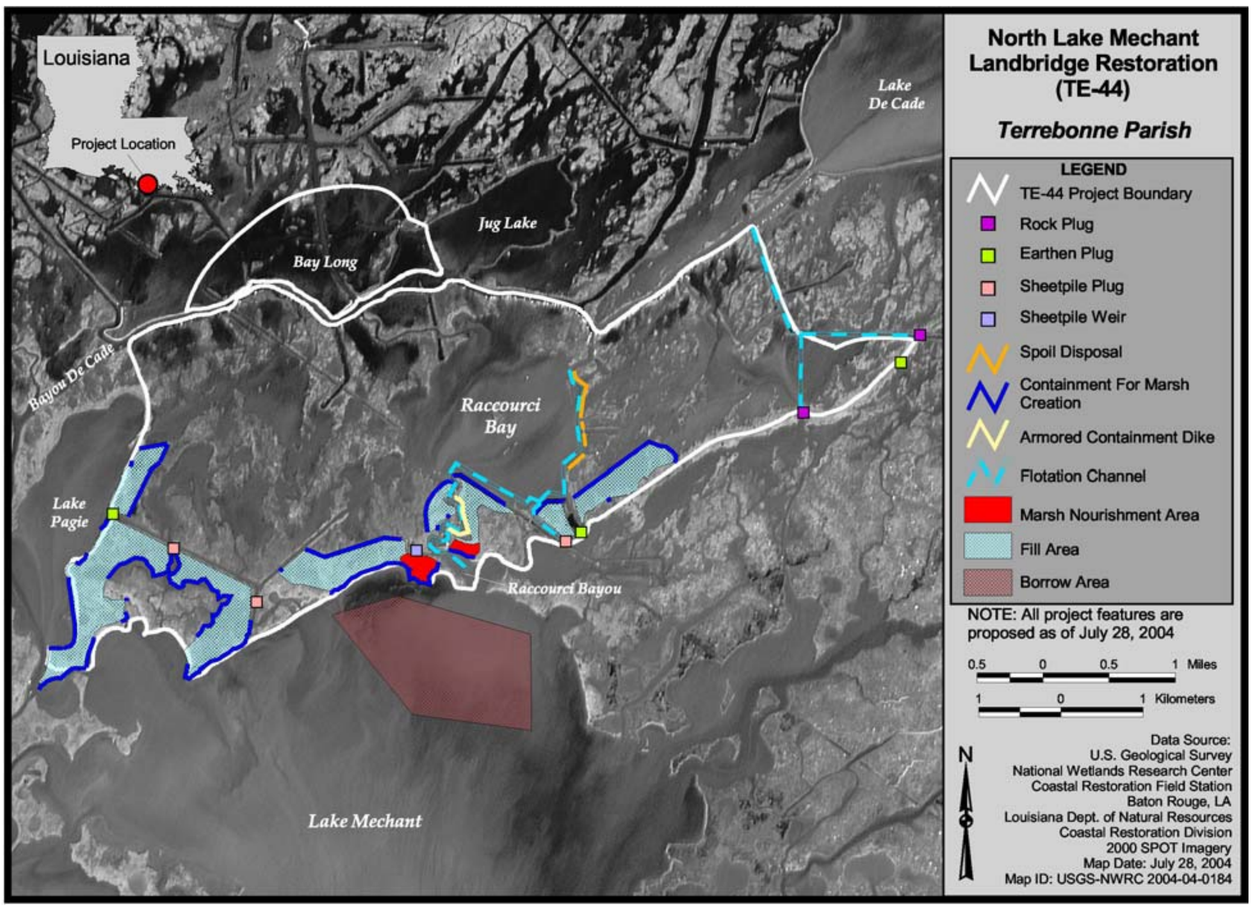

Figure 2. North Lake Mechant Landbridge Restoration project features

IV. Strategy-Goal Relationship

The placement of dredged material, and subsequent establishment of vegetation in open water areas of the project, will result in the direct creation of marsh habitat at an initial elevation of 3.0 feet NAVD-88, which will subside to intertidal elevation by year one post-construction.

The combination of all the features, plugs, armored earthen dike, weir replacement, and the placement of dredge material is expected to maintain the hydrologic barrier function of the North Lake Mechant landbridge. This will restrict the flow of higher salinity water from the southern portions of the project area into the fresher, northern portion of the project area, thereby maintaining the current marsh vegetation type as intermediate.

V. Project Feature Evaluation

Geotechnical

The report of the geotechnical investigation of the project area indicates that the soils in the project area are predominantly soft peat, with some silty clays and sand in some locations (STE 2002). Based on settlement analyses, the report recommends that stage construction be required for the construction of the earthen containment, rock dikes and plug structures, and that those structures be underlain with geotextile fabric during construction. Long-term settlements of the structures are estimated to be on the order of 1.5 to 2.5 feet (STE 2002).

Plugs and Weir Replacement

Earthen, rock, and sheet pile plugs will be constructed to a maximum elevation of 4.0 feet NAVD-88 and underlain with a geotextile fabric. Mean low water is 0.27 feet NAVD-88 and mean high water is 1.45 feet NAVD-88 (LDNR 2004). The three earthen plugs will have a side slope of 4(H):1(V) with a crown of 50-60 feet. The rock plug will have a side slope of 3(H):1(V) with a 10 foot crown and will be constructed with 400 pound riprap. The three sheet pile plugs will include earthen wingwalls constructed to an elevation of 5.0 feet NAVD-88 and the steel sheet pile will be driven to a minimum depth of -23.0 feet NAVD-88. An existing fixed crest weir will be replaced with a sheet pile weir, with the bottom elevation of the weir set at 0.0 feet NAVD-88. The combination of sheet pile, rock and earth plugs was chosen for logistical and operational reasons and in response to a request by the landowner.

Armored Earthen Dike

Earthen dikes armored with concrete mat will be used to protect critical portions of the shoreline adjacent to Raccourci Bayou, to prevent further widening and straightening of the bayou. The armored earthen dike sections consist of earthen dikes placed on geotextile fabric and armored with concrete mat. The earthen dike will be constructed to an elevation of 4.0 feet NAVD-88, with 1.5(H):1(V) shore side slope and a 2(H):1(V) lake side slope, with a 4 foot crest minimum (Figure 3).

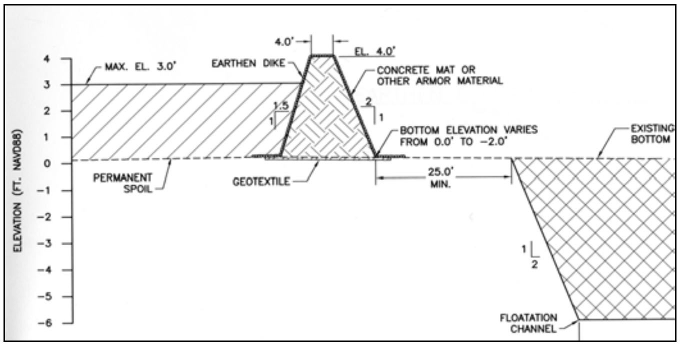

Figure 3. Detail of armored earthen dike (LDNR 2004).

Earthen Containment Dikes

A total of 54,551 linear feet of earthen containment dikes will be built to an elevation of +4.0 feet NAVD-88 with side slopes of 4(H):1(V) using *in situ* material to contain the dredged material (Figure 4). In order to keep the material as consolidated as possible, a bucket dredge will be used for construction. As the results of the geotechnical investigation estimate an anticipated structure settlement of 1.5-2.5 feet during the 20 year project life, Soil Testing Engineers, Inc (STE, Inc) (2002) recommended that the earthen dikes be constructed in two stages to allow for some consolidation of the sub-soils to occur, to further improve the stability and bearing capacity of the sub-soils and offset the initial settlement.

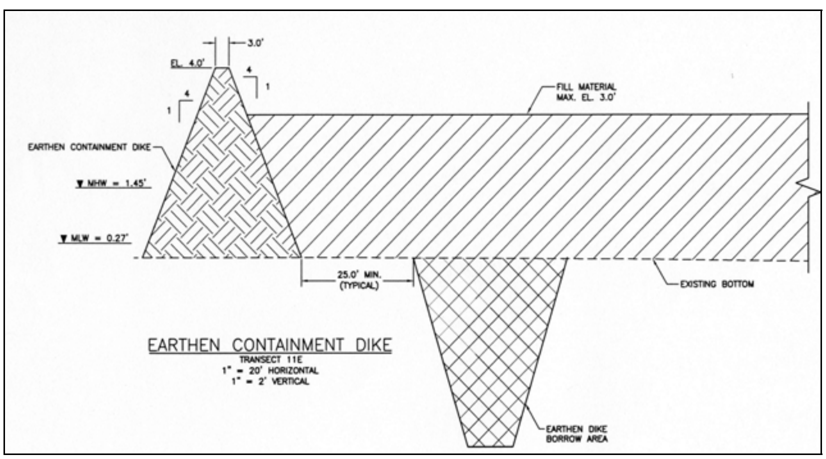

Figure 4. Details of earthen containment dike (LDNR 2004).

Created Marsh and Nourished Marsh

The dredged material will be placed in open water areas and, in some areas, on existing marsh. The material will be pumped into confined areas and filled to an elevation of 3.0 feet NAVD-88 in open water areas. Two small areas of deteriorated marsh in the project area totaling 40 acres will be nourished through the placement of a 12 inch layer of sediment atop the existing marsh, which ranges in elevation from 0.6 to 1.1 feet NAVD-88 (LDNR 2004) (Figure 2). This will mimic the natural processes of vertical sediment accretion, and will introduce nutrients and decrease problems associated with prolonged flooding. The placement of the dredged material will be accomplished in several lifts to accommodate for initial dewatering, and a small dredge (12-20 inch diameter) will be used. The created marsh platforms will initially be above mean marsh elevation. However, this elevation will decrease rapidly through volume loss brought on by settlement, shrinkage, and dewatering of the dredged material, as well as through a high rate of subsidence, estimated at 0.42 inches per year (Penland and Ramsey 1990). According to the geotechnical investigation (Soil Testing Engineers, Inc. 2002), it is expected that these factors will lead to the created marsh reaching the intertidal range by year 1 (mean low water is 0.27 feet NAVD-88 and mean high water is 1.45 feet NAVD-88) (Figure 5). The created marsh platform will remain in the intertidal range until approximately year 10, at which point according to the geotechnical report, the marsh platform will cease to be emergent (Table 1; Figure 5).

Table 1. Duration of created marsh platform in intertidal range for different target elevations (LDNR 2004)

Construction elevation (Feet NAVD-88)	Beginning and ending intertidal years	Total time within intertidal zone (years)
3.0	0.8 - 10	10.3
2.5	0.6 - 5.0	4.4
2.0	0.5 - 2.0	1.5
1.5	0.0 - 0.9	0.9

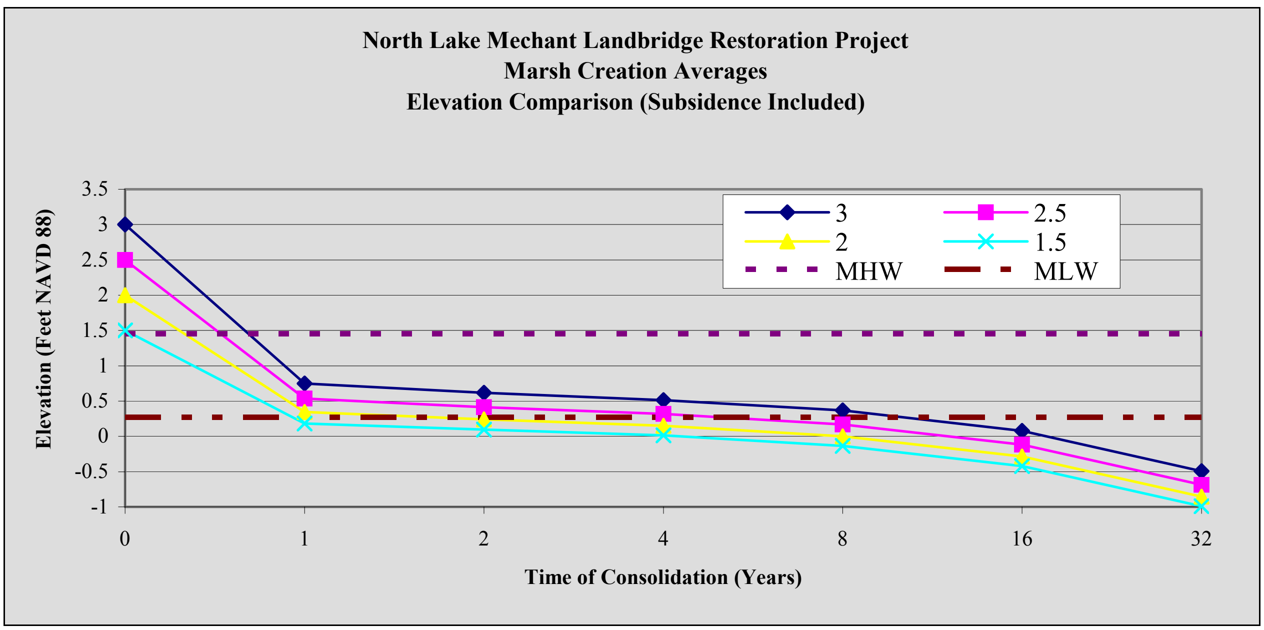

Figure 5. Estimated elevation change of the created marsh over the 32 years

VI. Assessment of Goal Attainability

The project is designed to protect the hydrologic barrier function and maintain the integrity of the north Lake Mechant landbridge. This can only be achieved if all the components of the project perform as desired.

Plugs

The purpose of the plugs is to restrict the flow of water of different salinities between the northern and southern portions of the project area. This hydrological restriction is likely achievable under the present proposal, as long as the structures, and the adjacent shorelines, remain intact.

Created Marsh

Marsh creation through the use of dredged material has been practiced in the U.S. for decades. Despite years of experience with this technique, there is still ongoing debate in the scientific literature on the "success" of the created marsh, and whether created marshes are functionally equivalent to natural marshes (Streever 2000; Moy and Levin 1991). Research conducted in Galveston Bay, Texas comparing natural and created *Spartina alterniflora* marshes indicates that there are significant differences in physical parameters such as marsh-water edge ratios, area perimeter ratio, marsh edge angle of exposure and elevation (Delaney et al. 2000).

Another study conducted in Galveston Bay indicates that densities of both fishes and decapod crustaceans are also lower in created marsh 3-15 years in age (Minello and Webb 1997). In a study conducted in a tidal marsh in Virginia, a 12 year old constructed marsh showed significant differences in habitat function in 3 areas: sediment organic carbon at depth, saltbush density, and bird utilization (Havens et al. 2002).

Some research indicates that as marshes age, they progress to a general level of habitat function similar to that of natural marshes. A study conducted in North Carolina suggests that after 20-25 years constructed marshes are similar to natural marshes in vegetation productivity, benthic infaunal density and organic carbon accumulation, but that soil nutrient reservoirs are lower in constructed *Spartina* marshes (Craft et al. 1999).

In addition to the United States Army Corps of Engineers dredge material beneficial use program (U.S. Army Corps of Engineers 1995) and the Louisiana Department of Natural Resources Dedicated Dredging program (LA-01) (LDNR 2000), several marsh creation projects have been constructed in coastal Louisiana.

- The Bayou Labranche Wetland Creation (PO-17) project was designed to create approximately 305 acres of marsh at a ratio of 70% emergent marsh to 30% open water in 5 years. The target elevation for the created marsh was estimated at +0.65 to +1.62 feet NAVD-88. The target elevation was generally met during construction; however, most of the project area was constructed at an elevation in the upper range, which was not a suitable elevation for the establishment of marsh. In addition, one of the water control structures had been tampered with, which affected the dewatering of the dredged material. It is expected that with time the constructed marsh will achieve the desired marsh-water ratio and that as the sediments continue to consolidate, the present upland vegetation will be supplanted by more wetland species (Troutman 1998). The results of vegetation surveys conducted in 1996, 1997, 1998, 2001, and 2002 indicate that the dominant vegetation in the project area is in fact changing from upland to wetland types (Boshart 2003).

- The Barataria Bay Waterway Wetland Restoration (BA-19) project was intended to create 9 acres of vegetated wetlands and increase the marsh surface elevation on Queen Bess Island through the deposition of dredged material. The target marsh surface elevation in the design of the project was +1.22 feet NGVD-29. Three years post construction, the average surface elevation in the project area was +0.79 feet

NGVD-29, well below the target elevation, and no appreciable vegetation growth had occurred (Curole 2001).

- The Lake Chapeau Sediment Input and Hydrologic Restoration, Point Au Fer Island (TE-26) project was designed for an elevation at construction of +1.5 feet NGVD-29. This would result in a final elevation of +0.5 feet NGVD-29 after dewatering and consolidation, which is the average marsh elevation as determined by cross section surveys of the fill area. The dredged material was planted with *S. alterniflora* plugs, though some natural recruitment of *S. alterniflora* and *S. patens* had already occurred. Some areas in the project area were filled below the target elevation, and there were construction problems with containment levees and the dredge discharge pipeline corridor. The project was originally intended to create 260 acres of marsh; however, the dredged material was deposited on only 168 acres at construction (Raynie and Visser 2002).

<u>Nourished Marsh</u>

Marsh nourishment is a new restoration concept that has not been employed in any Breaux Act funded projects to date. The concept behind marsh nourishment is that the increase in elevation provided by the addition of sediment would increase plant growth by improving the conditions within the growing environment. Interest in marsh nourishment as a costal restoration technique began with studies evaluating the environmental effect of thin layer disposal of dredged material in marshes, as an alternative to bucket dredging (Cahoon and Cowan 1988; Wilber 1992). These early studies concluded that dredged material disposed in thin layers in existing healthy marshes did not negatively impact healthy marshes, though they also did not provide any benefits. Immediately post disposal there was some plant die-off; however, revegetation occurred within a few years. The model for marsh recovery varies according to the thickness of sediment placement and extent of soil modification, and will occur either through the new shoots from the surviving rhizomes, or through reseeding (Wilber 1993).

Several other studies have been conducted to determine the effects of sediment additions on marsh health. *S. alterniflora* transplanted in dieback areas of Caminada Bay, Louisiana at higher elevations had more than twice the above ground and belowground biomass (Wilsey et al 1992). Ford et al. (1999) found that increased elevation through the deposition of one-inch layer of dredged material increased percent cover in a deteriorated *S. alterniflora* marsh in Louisiana three-fold. Another study conducted in a deteriorated *S. alterniflora* marsh near Venice, Louisiana evaluated the effect of varying thicknesses of sediment addition from minimal to more than twelve inches. Plant biomass was 30-50% greater in the areas that received the most addition (greater than 6 inches), and cover increased by 50% in the nourished areas, compared to the reference areas (Kuhn and Mendelssohn 1999). A study conducted in North Carolina evaluated the effect of the addition of a 0-4-inch layer of sediment to deteriorated and non-deteriorated *S. alterniflora* marshes. The study concluded that the non-deteriorated marshes did not benefit from the soil addition, but a two-fold increase in vascular plant stem density was observed in the deteriorated marsh (Leonard 2002). Although the correlation between increased stem density and total thickness of sediment added was not statistically significant, there was a strong positive relationship between the amounts of sediment received and stem density in the deteriorated sites.

Armored Earthen Dike

Several projects using hard shoreline stabilization materials have been implemented in the Louisiana coastal zone to stabilize lake and bay shorelines and navigation canal banks. Results from restoration projects indicate that shoreline protection measures have been effective in protecting lake shorelines from erosion.

- The Boston Canal/Vermilion Bay Bank Protection (TV-09) project was designed to reduce wind-driven wave erosion along Vermilion Bay and at the mouth of Boston Canal. Rock breakwaters and vegetation plantings were constructed in 1995 to accomplish that goal. Initial post-construction data indicate that 1.4 to 4.5 feet of sediment was deposited between the breakwater and the shoreline in less than one year. The rock breakwater at the mouth of Boston Canal was successful in stabilizing the shoreline (Thibodeaux 1998).

- The Turtle Cove (PO-10) shoreline protection project was initiated in 1993 to protect a narrow strip of land in the Manchac Wildlife Management Area which separates Lake Pontchartrain from an area known as "the Prairie" (O'Neil and Snedden 1999). Wind induced waves contributed to a shoreline erosion rate of 12.5 feet per year. A 1,642 foot rock filled gabion was constructed 300 feet from shore at an elevation of 3 feet above mean water level with the goal of reducing erosion and increasing sediment accretion behind the structure. Post construction surveys conducted during the period of October 1994 to December 1997 revealed that the shoreline had prograded at a rate of 3.47 feet in the project area. The rate of sediment accretion, as determined from elevation surveys conducted in January 1996 and January 1997, was 0.26 feet per year. The soils in The Prairie and Turtle Cove area consist of Allemands-Carlin peat, which is described as highly erodible organic peat and muck soils (USDA 1972). Due to the weak and compressible nature of the subsurface soils, the gabions settled 0.59 feet in just over two years (October 1994 to January 1997). Also, five years after construction, the rock filled gabion structure exhibited numerous breaches and required extensive maintenance in August 2000 (John Hodnet, LDNR, Personal Communications, August 2003).

- The Lake Salvador Shore Protection Demonstration (BA-15) project evaluated a series of shoreline protection measures at Lake Salvador, St. Charles Parish, and Louisiana. Phase two of this project was conducted in 1998 and evaluated the effectiveness of a rock berm to protect the lake shoreline from higher energy wave erosion. Shoreline surveys conducted behind the berm five months after construction indicated that the shoreline was still eroding. Subsequent surveys were not conducted due to poor weather conditions (Lee et. al 2000). The rock structure itself appears to be holding up well, showing little sign of deterioration and subsidence. The structure was designed with a crest elevation of 4.0 feet NAVD-88; however the structure average height in 2002 was 2.51 feet NAVD-88. The average settlement of the structure, as measured from 1998 to 2002, was 0.29 feet (Raynie and Visser 2002), which indicates that the settlement may have only been built to an elevation of 2.75 feet NAVD-88 (Darin Lee, LDNR, Personal Communications, July 19, 2002).

There are also several examples of projects involving the use of shoreline protection to stop erosion along navigation canal banks.

- The Cameron Prairie National Wildlife Refuge Shoreline Protection (ME-09) is an example of such a project. This project located in north-central Cameron Parish consisted of constructing a 12,200 foot rock breakwater 0-50 feet from the northern bank of the Gulf Intracoastal Waterway to prevent waves caused from boat traffic from eroding the remaining spoil bank. Since project construction in 1994, shoreline erosion in the project area has ceased, and from 1994 to 2000, the shoreline has prograded at an average rate of 9.8 feet/year (Barilleaux and Clark 2002).

- Another canal bank stabilization project, Freshwater Bayou Shoreline Protection Dike (TV-11), was constructed in 1994. Data collection on this project was halted due to manpower and budgetary constraints, but one year following construction completion, rocks in segments of the dike were washed away by boat wakes, thus compromising its structural integrity and leaving the underlying geotextile fabric exposed (LDNR 1996).

- The Freshwater Bayou Wetland Protection, Phase 1 (ME-04) project, constructed in 1995, has not only reversed wave-induced bank erosion, but also initial monitoring efforts have indicated that the bank has prograded at a rate of 2.34 feet/yr over a 12-month period (LDNR 1998).

Summary/Conclusions

A review of the results from the restoration projects referenced above demonstrates the importance of identifying the optimal dredge material elevation for the establishment of marsh vegetation and the importance in achieving that targeted elevation. The results of the geotechnical investigation can then be utilized to forecast and predict the rate of settlement of the dredged material to further refine that target elevation. In view of the predicted high rate of settlement and historical high rate of subsidence in the North Lake Mechant Landbridge Restoration project area, the created marsh design includes placement of the dredged material at an elevation of 3.0 feet NAVD-88. As currently designed, and according to the geotechnical investigation (STE, Inc. 2002), it is expected that the created marsh will reach the intertidal range (0.27 to 1.45 feet NAVD-88) one year post construction (Figure 5), and continue to subside over time, eventually projected to subside below mean low water elevation sometime around year 10. By using the geotechnical investigation to predict the settlement of the dredged material, by phasing the construction in two lifts, and by using a small dredge, the LDNR project team feels that it is likely that this is the optimum achievable result considering the soft nature of the existing soil. However, some consideration should be given to the possibility of returning during the maintenance phase, to allow fine-tuning of the final elevation (Raynie and Visser 2002).

The deteriorated marshes in the project area will be nourished through the placement of a 12 inch layer of sediment atop the existing marsh, which is consistent with values reported in the literature from other nourishment projects. This material placement is designed to mimic the natural processes of vertical sediment accretion and will introduce nutrients and minimize plant stress associated with prolonged flooding. The earthen containment dike is expected to degrade to marsh elevation, thereby eliminating the need for it to be manually breached. However, if this does not occur naturally, breaks will be made so that the created marsh does not become impounded. Breaks in the containment dikes will promote a more natural hydrologic flow within the project area, thereby allowing movement of organisms to and from the marsh, and allowing for sediment and nutrient transport (Shafer and Streever 2000).

To restore the hydrologic barrier function of the North Lake Mechant landbridge, the design also incorporates the use of shoreline protection structures and various types of plugs. The purpose of the plugs is to restrict the flow of water of different salinities between the northern and southern portions of the project area. This hydrological restriction is likely achievable under the present proposal, as long as the structures, and the adjacent shorelines, remain intact. The results of the geotechnical report indicate that some settlement of the structures is anticipated; however the structures should function as intended. The shoreline protection structures are intended to stabilize the shoreline of Raccourci Bayou and prevent the straightening of the bayou, which would increase tidal exchange between the marine system to the south and the fresh marshes to the north. The results of the previous shoreline protection projects in Louisiana indicate that this component will likely be successful.

VII. Recommendations

Based on the investigation of similar restoration projects and a review of engineering principles, the LDNR project team feels that the proposed strategies of the North Lake Mechant Landbridge Restoration project will likely achieve the desired ecological goals for the majority of the 20-year project life. Without a maintenance event to increase marsh elevation during the project life, it is likely that the created marsh will subside below mean low water around year 10, while the nourished marsh will likely persist beyond the 20 year project life. At this time, the Louisiana Department of Natural Resources, Coastal Restoration Division recommends that the North Lake Mechant Landbridge Restoration, Construction Unit 2 project be considered for CWPPRA Phase 2 authorization; however, the following issue merits further discussion.

- This project would benefit greatly from an Operations and Maintenance plan that would include a scheduled marsh nourishment event, to maintain marsh elevation in the desired range throughout the project life.

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