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

Little Lake Shoreline Protection/Dedicated Dredging near Round Lake
CWPPRA Priority Project List 11
State No. BA-37

September 25, 2003

Karim Belhadjali
And
Jean L. W. Cowan

Restoration Technology Section
Coastal Restoration Division
Louisiana Department of Natural Resources

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 September 25, 2003.

ECOLOGICAL REVIEW

Little Lake Shoreline Protection/Dedicated Dredging near Round Lake

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 Little Lake Shoreline Protection/Dedicated Dredging near Round Lake project is located in the Barataria Basin, in Lafourche Parish. The project is located in southwestern Little Lake, in the vicinity of Round and Brusle lakes (Figures 1 and 2) and consists primarily of intermediate marsh and open water habitat (Chabreck and Linscombe 1997).

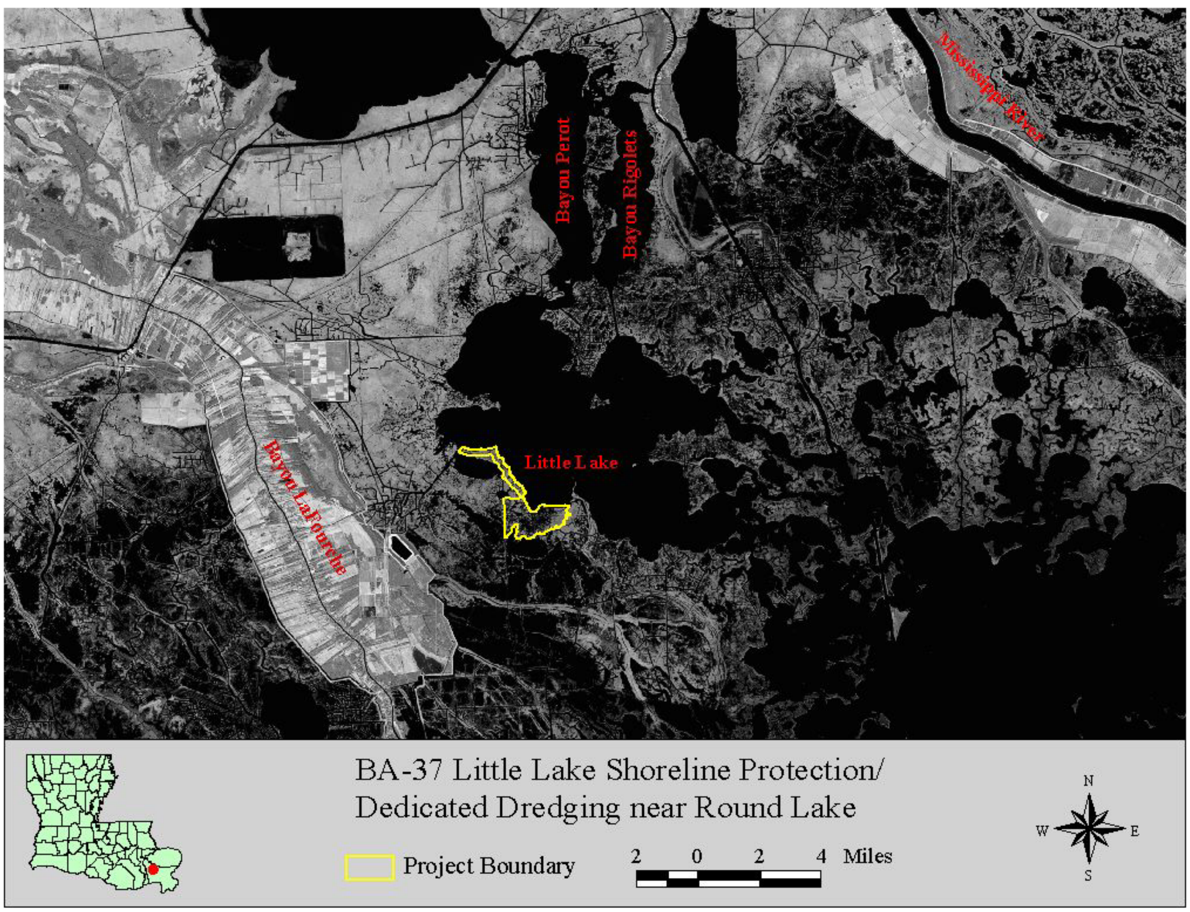

Figure 1. BA-37 project area and vicinity

The project is co-sponsored by the National Marine Fisheries Service (NMFS) and the Louisiana Department of Natural Resources (LDNR). It proposes to prevent erosion along the southwestern shoreline of Little Lake and to create and nourish marshes using dredged material in the southern portion of Round Lake. The project area is currently experiencing high shoreline erosion rates in Little Lake (20-40 feet per year) (Sweeny 2001) and a high marsh subsidence rate (0.025-0.029 feet/year) (National Research Council 1987; Penland and Ramsey 1990). Preserving bay and lake shoreline integrity and using dredged material for marsh creation were recommended by *Coast 2050* as regional ecosystem strategies (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (LCWCRTF&WCRA) 1998).

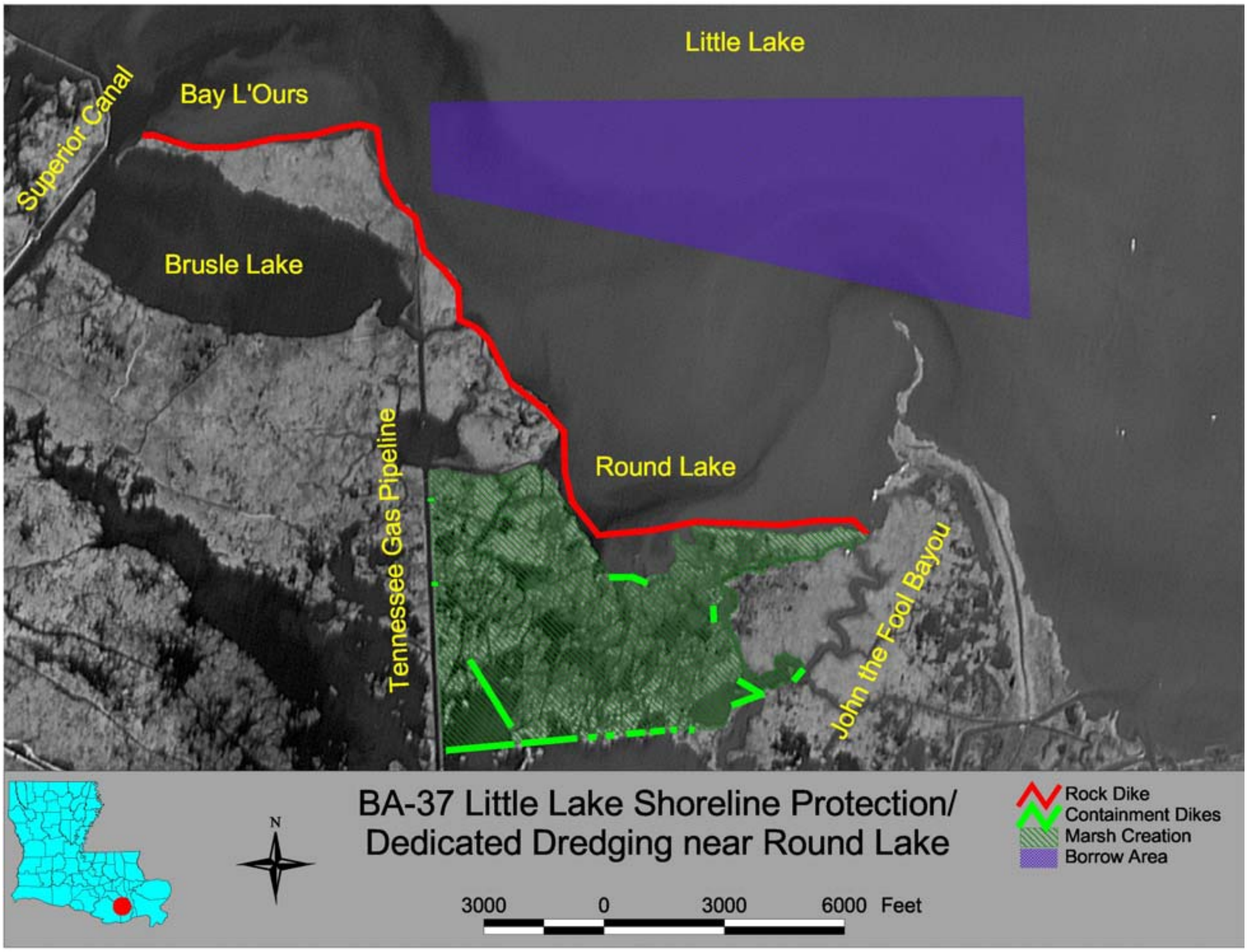

Figure 2. BA-37 project features.

II. Goal Statement

- Stop erosion along the southwestern shoreline of Little Lake.
- Create 551 acres of intertidal habitat suitable for marsh establishment at construction and nourish 406 acres of existing marsh.
- Of the original 957 acres of marsh created/nourished, maintain 799 acres of emergent marsh at the end of the 20-year project life.

III. Strategy Statement

- Erosion along the southwestern shoreline of Little Lake will be stopped through the construction of a 25,092-foot foreshore rock dike at the -2 foot water depth contour.

- The creation of 551 acres of intermediate marsh will be achieved through the confined placement of dredged material at an average elevation of 2.1 feet NAVD-88 and vegetation plantings in critical areas.
- Marsh nourishment will be achieved through the placement of 7-14 inches of dredged material atop 406 acres of existing marsh.

IV. Strategy-Goal Relationship

The construction of a foreshore rock dike will stop erosion along the southwestern Little Lake shoreline by damping wind-induced wave energy. The rock dike will be constructed to a final elevation of 2.5 feet NAVD-88. The placement of dredged material and subsequent establishment of vegetation in open water areas south of Round Lake will result in the direct creation of marsh habitat at an initial elevation of 2.1 feet NAVD-88, which will subside to an elevation of 1.0-1.1 feet NAVD-88 by year 5 post-construction. The deteriorated marshes in the project area will be nourished through the placement of a 7-14 inch layer of sediment atop the existing marsh. This will mimic the natural processes of vertical sediment accretion and will introduce nutrients and decrease problems associated with prolonged flooding. By reducing the land loss rate of 1.785 acres/year by 50% (Sweeney 2001), the combination of strategies is expected to maintain a minimum target of 799 acres of emergent marsh by the end of the 20 year project life, resulting in the loss of 158 acres of marsh over the project life.

V. Project Feature Evaluation

Components of the BA-37 project include a foreshore rock dike with openings for fisheries access, a discontinuous earthen dike to contain dredged material placed in the open water portions of the project area, and dredged material placed to nourish existing marsh (Figure 2). The project area is 1,374 acres and is bounded by Little Lake/Round Lake to the north, John the Fool Bayou to the east, the boundary between marsh and open water to the south, and Superior Canal to the west. The shoreline protection component extends along the southern rim of Little Lake/Round Lake from John the Fool Bayou to Superior Canal. The marsh creation/nourishment area is bounded by Round Lake on the north, a tributary of John the Fool Bayou to the east and south and the Tennessee Gas pipeline canal to the west. Details of each are outlined below.

<u>Foreshore Rock Dike</u>

A 25,092 foot-long rock dike structure overlying geotextile material will be constructed along the -2 foot contour of the southern shore of Round Lake and Bay L'Ours, from John the Fool Bayou to Superior Canal. The resulting distances that the dike will be from the existing shore range from 30 to 1,801 feet. On the western end, the dike will tie into another rock dike project being installed by a pipeline operator. On the eastern end, the dike will tie into the shoreline immediately to the west of John the Fool Bayou. The rock dike will be constructed using 250-pound rock overlying geotextile material and will have a crest elevation of 2.5 feet NAVD-88, a 3.5-foot crown, 1(V):4(H) side slopes on the lake side, and 1(V):2(H) side slopes on the land side. Based on water level data collected in Little Lake between April 25, 1996 and December 31, 2002 (USGS DCP No. 073800335), the 2.5-foot dike will be overtopped by waves 1% of the time. The material excavated for the construction of floatation channels will be permanently placed between the rock dike and the Little and Round lake shorelines at a maximum elevation of 2.1 feet NAVD-88 and at a minimum distance of 10 feet from both the rock dike and the shoreline.

Soil borings in this area indicate that approximately 6 to 12 inches of very soft brown and black humus and extremely soft to very soft dark gray sandy clay with organic matter and shells overly 20 feet of extremely soft to very soft gray clay, silty clay, and sandy clay (Eustis Engineering Company, Inc. 2003). Based on the dike dimensions and geotechnical information stated above, it is expected that the centerline of the solid rock dike will experience less than one foot of consolidation over the 20 year project life, while the toe will settle 4 to 5 inches over the long-term (Eustis Engineering Company, Inc. 2003). It is anticipated that a maintenance event may be required at year 15 with a lift of 1 foot (LDNR 2003).

Openings for fisheries access will be spaced between 1,000 and 1,495 feet apart along the length of the structure. As much as possible, the gaps will coincide with naturally existing inlets and bayous. The gaps will be 20 feet wide, and the bottom will be armored with rock at a thickness of approximately 2 feet, flush with the existing bottom.

Containment Dikes and Marsh Creation/Nourishment

An earthen dike, built to 3.5 feet NAVD-88 with side slopes of 3(H):1(V) using *in situ* material, will be built along the southern rim of the project area in order to contain the dredged material that will be used for marsh creation and nourishment in this location (Figure 2). In order to keep it as consolidated as possible, this material will most likely be excavated and placed by bucket dredge. Material dredged from the Little Lake/Round Lake borrow area will be used to fill approximately 551 acres of open water to an elevation of 2.1 ± 0.3 feet NAVD-88. Additionally, 406 acres of existing marsh will be nourished with 7 to 14 inches of dredged material. Soil types from the sediment surface to -20 feet in the Little Lake/Round Lake borrow area are classified as soft/extremely soft gray clay, sandy clay, and silty clay with shell fragments (Eustis Engineering Company, Inc. 2003). Borings in the fill area indicate that *in situ* material is extremely soft/very soft brown, black, and gray humus, organic clay, and clay. The dredged material will be excavated and pumped into the project area using hydraulic methods.

Average marsh elevation in the project area, determined from a survey conducted at 3 locations by T. Baker Smith (2003), is currently 1.2 feet. Mean low water is 0.67 feet NAVD-88, and mean high water is 1.28 feet NAVD-88. Thus, the created marsh platforms, built at 2.1 ± 0.3 feet, will initially be above mean high water. However, these elevations will decrease over time because of subsidence as well as volume loss brought on by settlement, shrinkage, and dewatering of the dredged material. In order to evaluate elevation loss over time, it was necessary to use a range of rates to predict final marsh elevation because parameters are not constant over time and are estimated based on the geotechnical report (Eustis Engineering Company, Inc. 2003) and on calculations made by LDNR engineers. The low ranges of these parameters were combined to derive a low range estimate of elevation change over the 20-year project life. Similarly, the same was done for the high range estimate. Details of these estimates are found in Table 1.

Table 1. "Low Range" and "High Range" elevation change estimates. TY=Target Year. Estimates were derived from information provided by Eustis Engineering Company, Inc (2003) and from calculations made by LDNR engineers.

Low Range Elevation Loss		High Range Elevation Loss	
TY1: All Shrinkage	0.996"	TY1: All Shrinkage	1.494"
TY1: All Dewatering	8.4"	TY1: All Dewatering	8.4"
Subsidence:	0.3 "/yr	Subsidence:	0.35 "/yr
Settlement (single drainage, elevation 1.2 ft):	("/yr)	Settlement (single drainage, elevation 1.2 ft):	("/yr)
TY1-5:	0.28	TY1-5:	0.28
TY6-10:	0.10	TY6-10:	0.10
TY11-15:	0.06	TY11-15:	0.06
TY16-20:	0.04	TY16-20:	0.04

It is expected that these factors will lead to the created marsh reaching elevations between mean low and mean high water by year 1 of the project life and, although decreasing every year, will remain in this range for the majority of the project life (Figure 3).

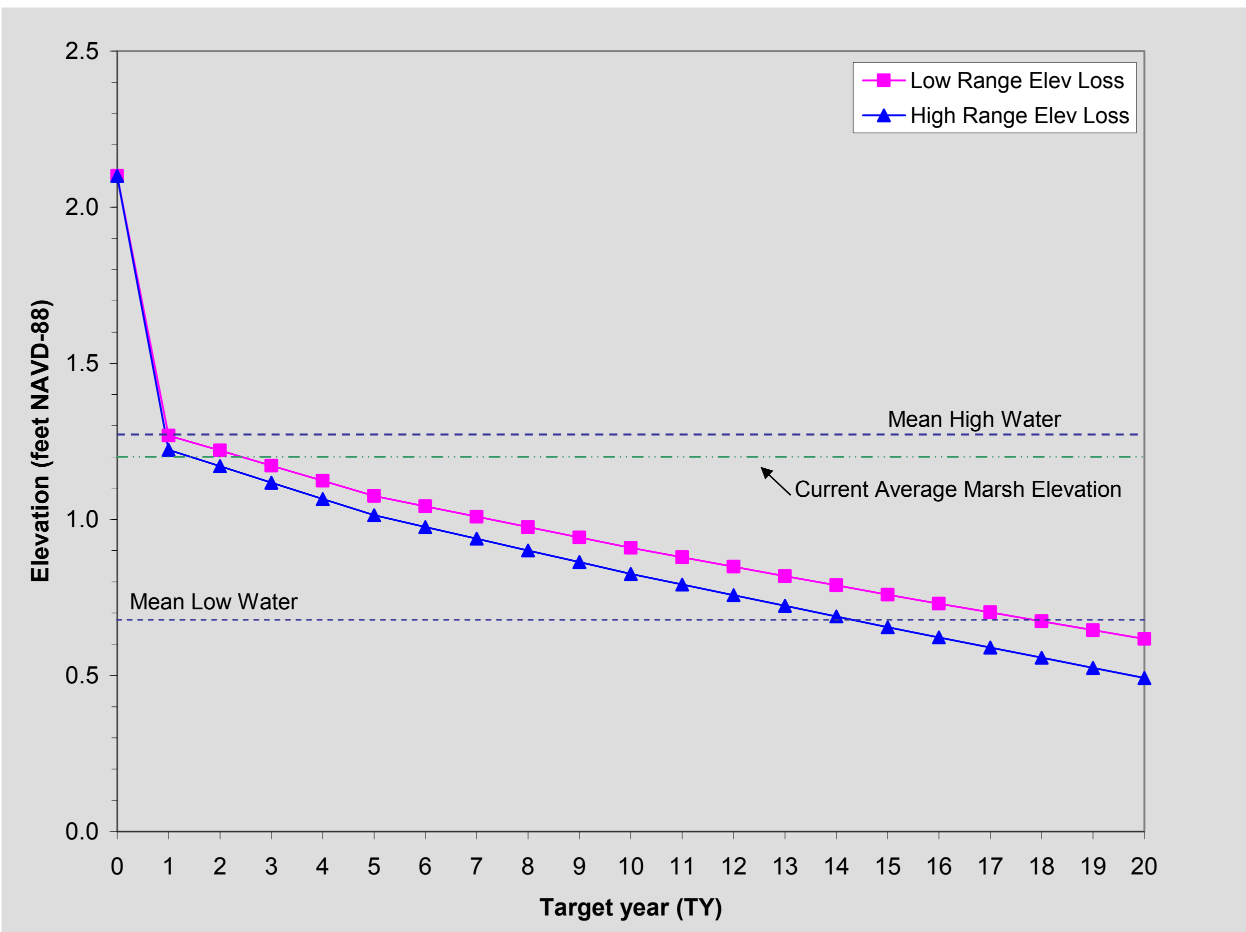

Figure 3. Estimated Elevation change over the 20-year project life.

Vegetation Plantings

In order to stabilize vulnerable areas, the containment dikes and created marsh platform will be planted after sufficient time has passed to allow for dewatering of the newly placed material. The project area may also be aerially seeded with *Spartina alterniflora* in the winter following creation of the marsh platform. The remaining platform should vegetate naturally within a few years after construction. Containment dikes will be vegetated with approximately 5,000 4-inch plugs of *S. alterniflora* as soon as possible to aid with stabilization of the dikes. The created platform will be vegetated with approximately 45,000 plugs of *S. alterniflora* in rows 50 feet apart in the first growing season after the platform has become firm enough to work on.

VI. Assessment of Goal Attainability

Foreshore Rock 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 this 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 per year 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) (O’Neil and Snedden 1999). 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, 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; however later surveys of the area revealed that the rock dike was successful in stabilizing the shoreline and some accretion was occurring behind the structure (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 located in north-central Cameron Parish and 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 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).

<u>Marsh Creation</u>

Marsh creation through the use of dredged material has been practiced in the U.S. for decades. It has been spurred not only for the restoration of coastal wetlands but by the desire to beneficially use material dredged during navigation channel maintenance. Despite years of project construction, 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 *S. alterniflora* marshes indicates that there are significant differences in physical parameters such as marsh-water edge ratios, area perimeter ratio, 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).

However, 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 dredged material beneficial use program (U.S. Army Corps of Engineers 1995), and the Louisiana Department of Natural Resources Dedicated Dredging program (LA-1; 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 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 disposal 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) was designed to be constructed at an elevation of 1.5 feet NGVD-29, which 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 not filled to the correct elevation, and there were construction problems with retainment levees and the dredge discharge pipeline corridor. The project created marsh, but not as much acreage as originally planned (Raynie and Visser 2002).

Marsh Nourishment

Marsh nourishment is a new restoration concept that has not been employed in any Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) 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 coastal 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 a 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.

VII. Recommendations

Raynie & Visser (2002) noted that waves may regenerate behind shoreline protection structures if built too far from shore, thus negating their effectiveness. The original design proposed that the rock dike be built between 216 and 2,460 feet from shore, resulting in as little as a 50-60% reduction in wave energy. This would likely not have achieved the goal of stopping erosion along the southwestern Little Lake shoreline. The design has therefore been modified, and the rock dike is presently proposed closer to shore, ranging from 30 to 1,801 feet. This closer placement should allow the goal of stopping erosion along the southern rim of Little Lake to be achieved.

In view of the shrinkage, settlement, and subsidence rates provided in the design report (LDNR 2003), the created marsh constructed at an elevation of 1.8 feet NAVD-88, as originally proposed, would be between 0.19 and 0.32 feet NAVD-88 at the end of the 20-year project life. This would have resulted in average marsh elevation being below mean low water between years 7 and 9 of the project life. This would likely not have achieved the goal of maintaining 799 acres of emergent marsh in the marsh creation/nourishment area at the end of the 20-year project. The design has therefore been modified to indicate a target marsh elevation at construction of 2.1 feet NAVD-88. By increasing the target marsh elevation at construction to 2.1 feet NAVD-88, the average created marsh elevation is projected to be below mean low water between years 15 and 18 of the project life (Figure 3).

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).

Based on the investigation of similar restoration projects and a review of engineering principles, the proposed strategies of the Little Lake Shoreline Protection/Dedicated Dredging near Round Lake 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 between years 15 and 18, while the nourished marsh will likely persist beyond the 20 year project life. In view of the high subsidence rate in the region (0.025-0.029 feet/year) and the current design constraints for the targeted created marsh elevation (unconfined placement), it is likely that this is the best that can be achieved at this time. At this time, the Louisiana Department of Natural Resources, Coastal Restoration Division recommends that the Little Lake Shoreline Protection/Dedicated Dredging near Round Lake 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. This would obviate the need to initially overbuild marsh platforms in order to retain target marsh elevation by the end of the project life. Instead lifts could be relied upon to maintain marsh elevation in the desired range throughout the project life (Raynie and Visser 2002).

References

Barilleaux, T.C. and N. Clark. 2002. Three-Year Comprehensive Monitoring Report #2: Cameron Prairie Refuge Protection (ME-09). Baton Rouge, Louisiana: Department of Natural Resources. 15 pp.

Cahoon, D. R. Jr. and J. H. Cowan Jr. 1988. Environmental impacts and regulatory policy implications of spray disposal of dredged material in Louisiana wetlands. Coastal management, 16: 341-362.

Chabreck, R. H. and G. Linscombe. 1997. Vegetative type map of Louisiana coastal marshes. Louisiana Department of Wildlife and Fisheries. Baton Rouge, La.

Craft, C., J. Reader, J. N. Sacco, and S. W. Broome. 1999. Twenty-five years of ecosystem development of constructed Spartina alterniflora (Loisel) marshes. Ecological Applications, 9(4): 1405-1419.

Curole, G. 2001. Three-Year Comprehensive Monitoring Report: Barataria Bay Waterway Wetland Creation (BA-19). Baton Rouge, Louisiana: Department of Natural Resources. 17 pp.

Delaney, T. P., J. W. Webb, and T. J. Minello. 2000. Comparison of physical characteristics between created and natural estuarine marshes in Galveston Bay, Texas. Wetlands Ecology and Management, 5:343-352.

Eustis Engineering Company, Inc. 2003. Geotechnical Investigation State of Louisiana Little Lake shoreline Protection and Marsh Creation, Lafourche Parish, Louisiana. DNR Contract No. 2503-03-33. State/ Federal Project No. BA-37. Eustis Engineering Project No. 17623. 21 pp. plus appendices.

Ford, M. A., D. R. Cahoon, and J. C. Lynch. 1999. Restoring marsh elevation in a rapidly subsiding salt marsh by thin-layer deposition of dredged material. Ecological Engineering, 12: 189-205.

Havens, K. J., L. M. Varnell, and B. D. Watts. 2002. Maturation of a constructed tidal marsh relative to two natural reference tidal marshes over 12 years. Ecological Engineering, 18:305-315.

Kuhn, N. L. and I. A. Mendelssohn. 1999. Halophyte sustainability and sea level rise: Mechanisms of impact and possible solutions. *In*: H. Lieth et al (editors). Halophyte uses in different climates, pp113-126. Backhuys Publishers, Leiden, The Netherlands.

Leonard, L. A., M. Posey, L. Cahoon, T. Alphin, R. Laws, A. Croft, G. Panasik. 2002. Sediment recycling: marsh renourishment through dredged material disposal. 49pp. <http://people.uncw.edu/lynnl/Ciceetfinalreport.pdf>

Lee, D.M., G. P. Curole, D. L. Smith, N. Clark, and H. Gaudet. 2000. Three-Year Comprehensive Monitoring Report: Lake Salvador Shoreline Protection Demonstration (BA-15). Baton Rouge, Louisiana: Department of Natural Resources. 45 pp.

Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority. 1998. Coast 2050: Toward a Sustainable Coastal Louisiana. Louisiana Department of Natural Resources. Baton Rouge, LA. 161 pp.

Louisiana Department of Natural Resources, Coastal Restoration Division. 1996. Freshwater Bayou Bank Protection (TV-11): Progress Report No. 1. Baton Rouge, Louisiana: Department of Natural Resources. 5 pp.

Louisiana Department of Natural Resources, Coastal Restoration Division. 1998. Progress Report No. 4: Freshwater Bayou Wetlands (ME-04) Phase 1. Baton Rouge, Louisiana: Department of Natural Resources. 21 pp.

Louisiana Department of Natural Resources, Coastal Restoration Division. 2000. Closure Report, Initial Funding Allocation, DNR Dedicated Dredging Program (LA-1). Baton Rouge, Louisiana: Department of Natural Resources. 8 pp.

Louisiana Department of Natural Resources, Coastal Restoration Division. 2003. Little Lake Shoreline Protection and Dedicated Dredging near Round Lake (BA-37) Project Design Report. DRAFT.

Minello, T. J. and J. W. Webb, Jr. 1997. Use of natural and created Spartina alterniflora salt marshes by fisheries species and other aquatic fauna in Galveston Bay, Texas, USA. Marine Ecology Progress Series, 151:165-179

Moy, L. D. and L. A. Levin. 1991. Are Spartina marshes a replaceable resource? A functional approach to evaluation of marsh creation efforts. Estuaries, 14(1):1-16.

National Research Council. 1987. Responding to changes in sea level. National Academy Press, Washington, D.C.

O'Neil, T. and G. A. Snedden. 1999. Three-Year Comprehensive Monitoring Report: Turtle Cove Shoreline Protection (PO-10). Baton Rouge, Louisiana: Department of Natural Resources. 25 pp.

Penland, S. and K.E. Ramsey. 1990. Relative sea-level rise in Louisiana and the Gulf of Mexico: 1908-1988. Journal of Coastal Research, 6(2): 323-342.

Raynie, R. C. and J. M. Visser. 2002. CWPPRA adaptive management review final report. Prepared for the CWPPRA Planning and Evaluation Subcommittee, Technical Committee, and Task Force. Baton Rouge, Louisiana. 47 pp.

Shafer, D. J. and W. J. Streever. 2000. A comparison of 28 natural and dredged material salt marshes in Texas with an emphasis on geomorphological variables. Wetlands Ecology and Management, 8(5):353-366.

Streever, W. J. 2000. Spartina alterniflora marshes on dredged material: a critical review of the ongoing debate over success. Wetlands Ecology and Management, 8(5):295-316.

Sweeney, R. 2001. Little Lake Shoreline Protection/Dedicated Dredging near Round Lake Wetland Value Assessment. 12 pp.

T. Baker Smith & Son, Inc. 2003. Little Lake Shoreline Protection/Dedication Project, Project No. BA-37. Survey Methodology Report. Louisiana Department of Natural Resources. Baton Rouge, Louisiana.

Thibodeaux, C. 1998. Three-Year Comprehensive Monitoring Report: Boston Canal/Vermillion Bay Shoreline Protection (TV-09). Baton Rouge, Louisiana: Department of Natural Resources. 21 pp.

Troutman, J. 1998. Three-Year Comprehensive Monitoring Report: Bayou Labranche Wetland Restoration Project (PO-17). Baton Rouge, Louisiana: Department of Natural Resources. 20 pp.

United States Army Corps of Engineers. 1995. Dredge material: Beneficial use monitoring program. New Orleans, Louisiana. 14 pp.

United States Department of Agriculture. 1972. Soil Survey of St. James and St. John the Baptist Parishes, Louisiana. Soil Conservation Service, Louisiana. 75 pp.

Wilber, P. 1992. Case studies of the thin-layer disposal of dredged material-Gull Rock, North Carolina. Environmental Effects of Dredging Technical Bulletin, Vol D-92-3. Waterway Experiment Station, U.S. Army Corps of Engineers. 5 pp.

Wilber, P. 1993. Managing Dredged material via thin-layer disposal in coastal marshes. Environmental Effects of Dredging Technical Bulletin, EEDP-01-32. Waterway Experiment Station, U.S. Army Corps of Engineers. 14 pp.

Wilsey, B. J., K. L. Mckee, and I. A. Mendelssohn. 1992. Effects of increased elevation and macro- and micronutrient additions on *Spartina alterniflora* transplant success in salt-marsh dieback areas in Louisiana. Environmental Management, 16(4): 505-511.