State of Louisiana
Department of Natural Resources
Coastal Restoration Division and
Coastal Engineering Division

2007 Operations, Maintenance, and Monitoring Report

for

East Mud Lake Marsh Management

State Project Number CS-20
Priority Project List 2

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Cameron Parish

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for
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I. Introduction

The East Mud Lake Marsh Management Project area consists of 8,054 acres located in the Calcasieu/Sabine Basin in Cameron Parish, Louisiana (figure 1). The project is bounded by Louisiana Highway (LA Hwy) 82 to the south, LA Hwy 27 to the west, Magnolia Road to the north, and an existing levee and property line near Oyster Bayou to the east.

The East Mud Lake project area is physiographically complex with three wetland habitat types (Deep, Shallow, and Meadow Marsh; after USDA-SCS 1951) and has been characterized as brackish marsh since the first vegetation map of 1949 (O'Neil 1949). Although the project area has remained a brackish marsh over time, adjacent marsh to the west and northwest has freshened to intermediate marsh over time (Chabreck et al. 1968, Chabreck and Linscombe 1988, Visser et al. 2000). Prior to 1960, the south end of Mud Lake contained dense stands of *Ruppia maritima* (widgeon grass). However, hydrologic conditions have changed, causing elevated water levels, rapid water level fluctuations, high salinities, and wide salinity fluctuations, which has led to the disappearance of this important submerged aquatic and other emergent wetland vegetation (USDA-SCS 1994). Analysis of aerial photos of the area indicates a marsh loss rate of 76 acres per year from 1953 to 1983 (USDA-SCS 1992). Excluding Mud Lake, the land to open water ratio has deteriorated from 99:1 in 1953 to 60:40 in 1983. Based on the Wetland Value Assessment from 1992, the project area included 3,233 acres of vegetated marsh and 2,433 acres of open water excluding Mud Lake, resulting in further marsh deterioration to 57:43.

Tidal flow into and out of the project area has historically been from the north (Cal/Sab River Basin Study 1993, pers.comm. SCS). Oyster Bayou and Mud Pass provide outlets from the area on the east and south. Fresh water historically entered the area from the west via sheet flow and input from First and Second Bayous; however, the installation of LA Hwy 27 and its associated borrow canals has restricted freshwater input from the west (figure 1). Second Bayou has silted in since 1957 and now provides little or no freshwater flow. First Bayou remains the main source of freshwater introduction into the area; however, it is also silting in, and much of the remaining fresh water is diverted by the LA Hwy 27 borrow canal.

Several human-induced hydrologic changes, highlighted by the installations and maintenance of the Calcasieu and Sabine Ship Channels and the Gulf Intracoastal Waterway (GIWW), have increased tidal fluctuations farther into the coastal wetlands and led to the deterioration of the marsh over the years on a basin wide scale (see LCWCRTF 2002). Specific to the project area, Mud Lake and its adjacent marshes suffer from increased flooding and salinity via the Calcasieu Ship Channel/Pass and isolation/fragmentation from adjacent marshes. The project area is connected by water to the Calcasieu Ship Channel (CSC) via Mud and Oyster Bayous to the east and the West Cove Canal to the north. Because the CSC/Pass is maintained at a depth of 40' and bottom width of 400' without obstruction since 1968, this hydrologic connection draws high tidal amplitudes and salt water from the Gulf of Mexico into the project area. In addition, high water levels are impounded over the marsh and slow to recede in this area because of LA Highways 82 to the south and 27 to the west; the levees demarking property lines to north, east, and south; and several ring levees and roads within the project area. This combination of sustained high water levels and increased salinity stress has deteriorated the vegetation and led to "ponding" (USDA-SCS 1994). In addition, the subsidence rate and sea level rise have led to a 0.25 inch water level increase per year from 1942-1988 (Penland et al 1989), which results in even less suitable conditions for vegetative production.

The East Mud Lake Marsh Management Project is designed to reduce wetland degradation by reducing rapid fluctuations in water and salinity levels and prolonged periods of marsh inundation in the project area and by enhancing regeneration of desired emergent and submergent vegetation. This project will increase vegetative occurrence by reducing salinity-induced stress and alleviating excessive water levels while not creating tidal scour problems (Louisiana Coastal Wetlands Conservation and Restoration Priority List, 1992).

The project area is divided into two Conservation Treatment Units (CTUs) that will be managed independently. CTU #1 contains Mud Lake and will be managed passively. Structures and features present in this unit consist of shoreline repair, vegetative plantings, earthen plugs, culverts with flap gates, and variable crest culverts. CTU #2 will be actively managed for drawdown capabilities in order to encourage shallow areas to revert to emergent vegetation (figure 1).

The East Mud Lake project involves installing and maintaining water control structures, repairing and constructing levees, and planting vegetation, as components of a marsh management plan for the two CTU's that make up the project area. The structures are designed to reduce the extreme fluctuations in salinity and water levels, while at the same time providing adequate water flow. The structures will help to create a hydrology conducive to the establishment of brackish emergent and submergent vegetation, thereby minimizing marsh deterioration. Vegetative plantings will aid in reverting shallow open waters less than 0.5 feet deep to emergent marsh. The vegetative plantings will also help stabilize and protect eroding shorelines.

The types and numbers of structures and features of the project are as follows:

1. Variable Crest Culverts with Flap gates 6
2. Variable Crest Culverts With Slots 3
3. Gated Culvert 1
4. Culverts with Flap gates 5
5. Variable Crest Box Structure 1
6. Earthen Plugs 2
7. Shoreline Repair 2
   (Total = 25,153 cubic feet of dredged material)
8. Levee Repair 1
   (66,461 cubic yards of dredged material needed to shore up the step levee on the north, east, and southeast sides of CTU #2)

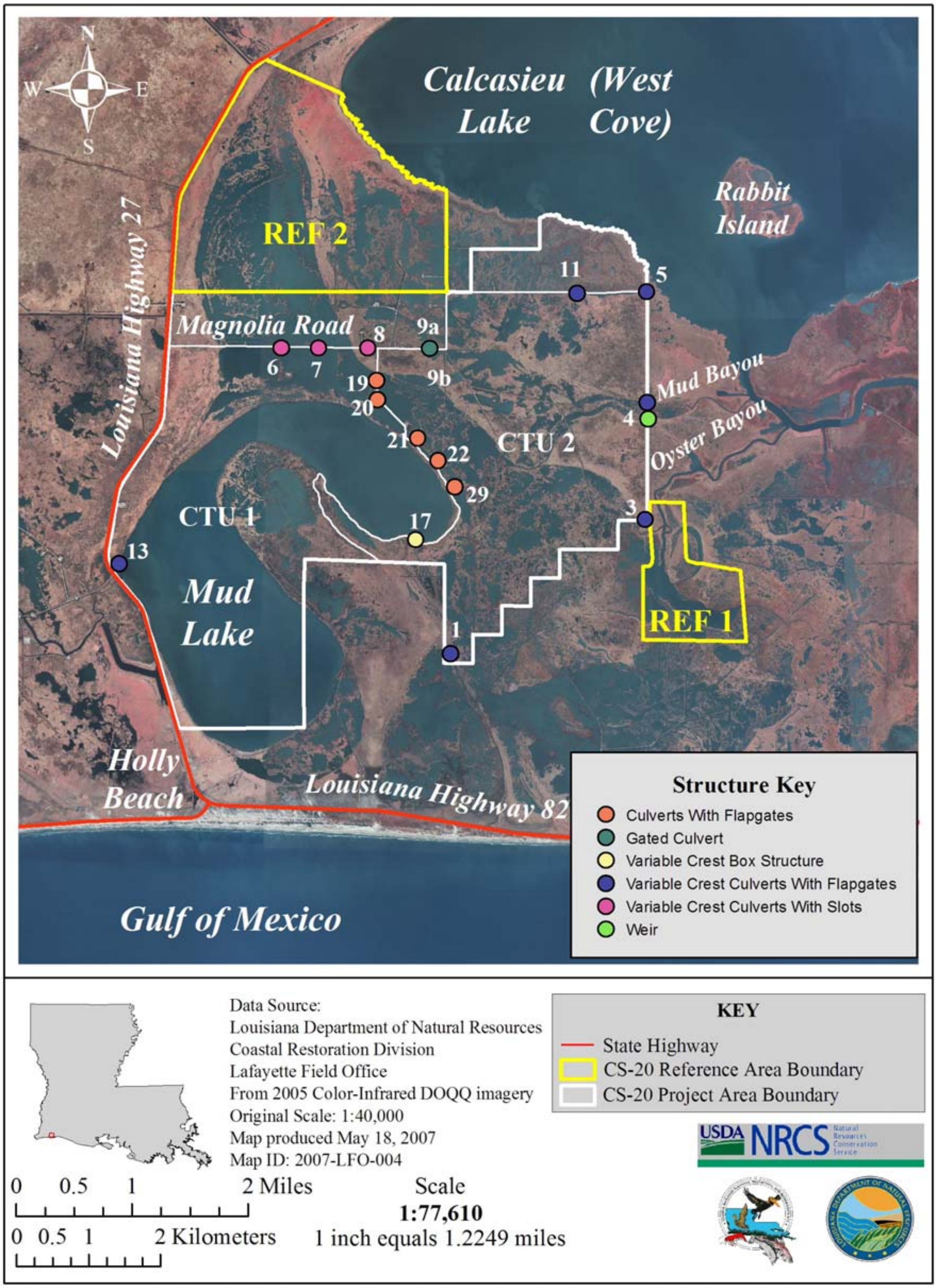


Figure 1. East Mud Lake Marsh Management (CS-20) project map depicting project boundaries, conservation treatment unit boundaries, reference area boundaries, and project features.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the East Mud Lake Marsh Management Project (CS-20) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, Louisiana Department of Natural Resources (LDNR) shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs. The annual inspection report also contains a summary of maintenance projects, if any, which were completed since completion of constructed project features and an estimated projected budget for the upcoming three (3) years for operation, maintenance, and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix B.

An inspection of the East Mud Lake Marsh Management Project (CS-20) was held on March 5, 2007, under sunny skies and cool temperatures. In attendance were Stan Aucoin, Darrell Pontiff, Patrick Landry, Garrett Broussard, and David Castellanos from LDNR, Dale Garber representing the Natural Resources Conservation Service (NRCS), Rick Hartman representing the National Marine Fisheries Service (NMFS), Steve Gonzales and Dirk Paulin representing the Federal Emergency Management Agency (FEMA), Lonnie Harper and Chris Fountain representing LGH Engineers, and Scott Rosteet representing Apache Louisiana Minerals, Inc. The annual inspection began at approximately 10:30 a.m. at Structure No. 6 and ended at Structure No. 13 at approximately 2:00 p.m.

The field inspection included a complete visual inspection of all features. Staff gage readings where available were used to determine approximate elevations of water, rock armor, earthen embankments, steel bulkhead structures, and other project features. Photographs were taken at each project feature (see Appendix A) and field inspection notes were completed in the field to record measurements and deficiencies (see Appendix C).

b. Inspection Results

ES-6 –2-36" culverts with stop logs, and a 4” fish slot

The overall condition of Structure No. 6 appears to be very good. Water level gauges weren’t available near the structure. The timber piles, stop logs, grating, etc. are in good condition; however, the metal pile caps are rusting out. Rock placed around the outlet side of the structure has held up well and stabilized the shoreline. Erosion is occurring on the bank line adjacent to the inlet side of the structure. The ends of the outlet pipes are clogged with marsh and other debris. The padlocks on the stop log locking devices have rusted and cannot be operated. As a result of the inspection of Structure No. 6, LDNR and NRCS agree that approximately 114 tons of stone needs to be added on the cut bank lines adjacent to the access roadway, padlocks replaced, metal pile caps replaced, and marsh debris cleaned out of ends of both outfall pipes. (Photos: Appendix A, Photos 1 & 2).

ES-7 – 2-36" culverts with stop logs, and a 4" fish slot

Structure No. 7 appears to be in very good condition. The water level gauge on the inside was missing and the outside gauge was not readable. Both ends of this structure are clogged with marsh debris and have silted up. Erosion is occurring on the bank line adjacent to the inlet side of the structure. The padlocks on the stop log locking devices have rusted and cannot be operated. As a result of the inspection of Structure No. 7, LDNR and NRCS agree that approximately 66 tons of stone needs to be added on the cut bank lines adjacent to the access roadway, padlocks replaced, metal pile caps replaced, staff gages on inlet and outlet side of the structure replaced, and marsh debris cleaned out of ends of both outfall pipes. (Photos: Appendix A, Photos 3 & 4).

ES-8 – 2-36" culverts with stop logs, and a 4" fish slot

Structure No. 8 appears to be in very good condition. Water level gauges were unavailable. Both ends of this structure are clogged with marsh debris and have silted up. It appears very little flow is going through the pipes due to washover of the access road rock material into the water. Erosion is occurring on the bank line adjacent to the inlet side of the structure. The padlocks on the stop log locking devices have rusted and cannot be operated. LDNR and NRCS agree that this structure requires clean out of the ends of outlet pipes, placement of approximately 66 tons of rock along cut bank lines adjacent to the structure, replacement of padlocks, and replacement of metal pile caps. (Photos: Appendix A, Photo 5).

ES-9a – 1- 36" culvert with stop logs and a flap gate

Structure No. 9a is in good condition. The staff gage on the inside was leaning and not readable and the gage on the outside was also not readable. Both ends of this structure are clogged with marsh debris and have silted up. The handle on the outlet pipe flap gate has been broken off. The metal pile caps on the pilings have rusted out. The padlocks on the stop log locking devices have rusted and cannot be operated. LDNR and NRCS agree that this structure requires replacement of the metal pile caps, clean out of the ends of outlet pipes, replacement of staff gages inside and out, replacement of padlocks, and repair of the flapgate handle. (Photos: Appendix A, Photos 6 & 7).

ES-9b – 1- 48" culvert with sluice gate and flap gate

Structure No. 9b is in good condition. Both ends of this structure are clogged with marsh debris and have silted up. The staff gage on the inside was leaning and not readable and the outside gage was also not readable. The handle on the outlet pipe flap gate has been broken off. The gear box on the sluice gate is showing signs of rust and the stem cover is missing. Apache personnel have reported that it, so far, is not a problem; however, it will probably need to be addressed. Metal pile cap covers have rusted out. The seat flange on the flap gate is broken. LDNR and NRCS agree that this structure is in operable condition and maintenance will be required to replace the gear box and stem cover, replace the seat flange on the flap gate, clean out the ends of the outlet pipes, replace padlocks, replace metal pile caps, and repair the flapgate handle. (Photos: Appendix A, Photos 6, 7, & 8).

ES-11 – 1- 36" culvert with stop logs and flap gate

The structure is in good condition. Water level could not be determined on the outside staff gage. The staff gage on the inside of the structure is missing. There is some erosion of the bank on both the inlet and discharge sides of the structure. Approximately 228 tons of man size rip rap will be required to reinforce the bank around the structure. The bank line near the outlet flap gate has eroded and the boardwalk is not accessible. The metal pile cap covers have rusted out. The padlocks on the stop log locking devices have rusted and cannot be operated. LDNR and NRCS agree that maintenance work is required to add rip rap on both sides of the structure, extend the wooden boardwalk, replace metal pile caps, replace padlocks, and replace staff gages inside and out. (Photos: Appendix A, Photos 9 & 10).

ES-5 –1- 36" culvert with stop logs and flap gate

The structure itself is in good condition. Staff gauges inside and outside of the structure are damaged and not readable. Erosion was noted along the bank on both the inlet and discharge sides of the structure. Approximately 342 tons of rock will be needed to reinforce the bank around this structure. The boardwalk at the outlet pipe flap gate is missing. The metal pile cap covers have rusted out. The padlocks on the stop log locking devices have rusted and cannot be operated. LDNR and NRCS agree that maintenance work is required to add rip rap, replace metal pile caps, replace padlocks, replace the wooden boardwalk, and replace staff gages inside and out. (Photos: Appendix A, Photos 11 & 12).

ES-4 – 5- 48" culverts with stop logs and flap gates

This structure is a pre-existing structure that was incorporated into the CS-20 project. It is in disrepair and needs to be replaced. A new structure was let out for bids on February 10, 2005; however, it was over budget and the bid was rejected. This structure will be replaced with a structure similar to ES-13, and the existing structure will be abandoned in place. Staff gauge readings were not available. (Photos: Appendix A, Photo 13).

ES-3 – 1- 36" culvert with stop logs and flap gates

This is also a pre-existing structure that was incorporated into the CS-20 project. The wooden walkways on the outside and the inside of the structure are missing. The structure is silted up with marsh debris. The bank, however, is showing signs of some erosion and will require approximately 209 tons of man-size rip rap for reinforcement. The staff gages on the outside and inside are not readable. The padlocks on the stop log locking devices have rusted and cannot be operated. LDNR and NRCS agree that maintenance work is required to add rip rap, clean out debris, replace both walkways, replace padlocks, and replace staff gages inside and out. (Photos: Appendix A, Photos 14 & 15).

ES-1 – 1- 36" culvert with stop logs and flap gates

Vandals have stolen all of the grating on the inlet side of the structure. The structure is silted up with marsh debris. The bank, however, is showing signs of some erosion and will require approximately 470 tons of man-size rip rap for reinforcement. The staff gages on the outside and inside are not readable. The padlocks on the stop log locking devices have rusted and cannot be operated. The metal pile cap covers have rusted out. The wooden boardwalk needs to be extended. LDNR and NRCS agree that maintenance work is required to add rip rap, clean out debris, extend the boardwalk, replace metal pile caps, replace padlocks, and replace staff gages inside and out. (Photo: Appendix A, Photos 16 & 17).

ES-17 – variable crest weir with boat bay

The sheet pile cap is severely rusted out on both sides of the structure. The locking tabs on the landing side of the stop log slots are missing. The warning sign is missing. The padlocks on the stop log locking devices have rusted and cannot be operated. The staff gauge is leaning and not readable. The metal pile cap covers are rusted out. LDNR and NRCS agree that maintenance work is required to replace the sign and pile cap on the sheet pile wall, replace the staff gage, replace metal pile cap covers, replace padlocks, and replace locking tabs. (Photos: Appendix A, Photo 18).

ES-13 – sheet pile bulkhead with two variable crested weirs and flap gates

The warning sign is missing. Staff gages outside and inside were not readable. The structure is silted up with marsh debris. The padlocks on the stop log locking devices have rusted and cannot be operated. The metal pile cap covers have rusted out. The sheet pile cap on top of the sheet pile wall is severely rusted. LDNR and NRCS agree that maintenance is required to replace the warning sign, replace the metal pile cap covers, replace staff gages inside and out, clean out marsh debris, replace padlocks, and replace sheet pile cap on both sides of the structure. (Photos: Appendix A, Photos 19 & 20).

ES-19, 20, 21, 22, & 29 – 24" culverts with flap gates

These structures were not directly inspected on this inspection as agreed jointly by LDNR and NRCS personnel. According to Mr. Rosteet, they are in working order and functioning as designed. LDNR and NRCS agree that no maintenance is required at this time.

ES-29a – earthen plug

Due to logistics, this plug also was not directly inspected on this trip. According to Mr. Rosteet, it is stable and functioning as designed. LDNR and NRCS agree that no maintenance is required at this time.

ES-14 - 15 – 5,000 linear feet of earthen embankment on East Mud Lake

See ES-29a comments.

40,600 linear feet of levee refurbishment along the Step Canal

The inspection of the earthen levee consisted of a visual inspection of the entire length of levee along the Step Canal. In addition to the erosion noted above, the storm surge has eroded portions of the levee in various locations. In addition the storm surge has placed large amounts of marsh and other debris into the east-west sections of the Step Canal. In these areas of the canal, the water depth was very shallow. The north-south sections appear to be relatively free of any obstructions. LDNR and NRCS agree that maintenance is required to repair the levees and remove trash from the canal. (Photos: Appendix A, Photos 21 & 22).

II. Maintenance Activity (continued)

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

None at this time.

ii. Programmatic/ Routine Repairs

None at this time.

d. Maintenance History

General Maintenance: Below is a summary of completed maintenance projects and operation tasks performed since April 1996, the construction completion date of the East Mud Lake Marsh Management Project (CS-20).

December 1999 Maintenance Project – LDNR: This maintenance project included the installation of approximately 600 tons of stone rip rap around Structure No. 4, aluminum fabrication and installation of flapgate lifting devices and a stop log channel repair at Structure No. 4, approximately 950 linear feet of earthen levee repair, and placement of approximately 100 tons of stone rip rap at Structures 6, 7, 8, 9a & 9b. Construction was completed in December 1999. The costs associated with the engineering, design and construction of the East Mud Lake Maintenance Project are as follows:

Construction:	$113,848.21
Engineering & Design:	$ In house
Construction Oversight/As built surveys:	$ 11,902.28

TOTAL CONSTRUCTION COST: $125,750.49

(Does not include costs associated with in-house design.)

III. Operation Activity

a. Operation Plan

The project area is divided into Conservation Treatment Unit (CTU) #1 and CTU #2. Operational plans and procedures for CTU #1 are designed to stabilize salinity and water levels. Operational plans and procedures for CTU #2 are designed to expose mud flats for seed germination and planting. Once vegetative plantings are established, operations and procedures for CTU #2 are designed to gradually increase water levels to maintain and enhance vegetative growth for optimum waterfowl and furbearer utilization and to stabilize salinity.

CTU #1 – Water Management Scheme – January 1 – December 31

1. Structures ES-#6, ES-#7, and ES-#8 – The stop logs will be set no higher than 6 inches below marsh level. The vertical slots in the structures will remain open except to protect marsh vegetation during the periods of high salinity. These slots will be closed when salinity inside the marsh exceeds 15 ppt, 100 feet south of structure ES-#7.

2. Structures at ES-#13 (First Bayou) – Set stop logs 6 inches below marsh level. Lock flap gates open except when salinity exceeds 7 ppt in the road ditch on the west side of LA Highway 27 at the Drainage District's Structure.

CTU #2 – Water Management Scheme Phase I – Revegetation Phase 1a
February 15 – May 31 (or to July 15)

1. Remove all stop logs and allow flap gates to operate at structures ES-#1, ES-#3, ES-#4, ES-#5, ES-#9a, and ES-#11.

2. Screw gate open and allow flap gate to operate at structure ES-#9b.

3. Allow flap gates to operate at structures ES-#19, ES-#20, ES-#21, ES-#22, and ES-#29.

4. Set stop logs at 12 inches above marsh level at structure ES-#17.

CTU #2 – Water Management Scheme Phase I – Revegetation Phase 1b
May 31 (or July 15) – February 14 +/- 2 weeks

1. Set stop logs 6 inches below marsh level and lock flap gates open at structures ES-#1, ES-#3, ES-#4, ES-#9a ,and ES-#11.

2. Set the weir crest of one 5-foot wide bay at 12 inches below marsh level and the crest of the other 5-foot wide bay at 6 inches below marsh level and lock flap gate open at ES-#5.

3. Screw gate open and lock flap gate open at structure ES-#9b.

4. Lock flap gates open at ES-#19, ES-#20, ES-#21, ES-#22, and ES-#29.

5. Remove all stop logs at structure ES-#17.

CTU #2 – Water Management Scheme Phase II – Maintenance Phase
January 1 – December 31

1. Set stop logs 6 inches below marsh level and lock flap gates open at structures ES-#1, ES-#3, ES-#4, ES-#9a, and ES-#11.

2. Set the weir crest of one 5-foot wide bay at 12 inches below marsh level and the weir crest of the other 5-foot wide bay at 6 inches below marsh level and lock flap gates open at structure ES-#5.

3. Screw gate open and lock flap gate open at structure ES-#9b.

4. Lock flap gates open at structures ES-#19, ES-#20, ES-#21, ES-#22, and ES-#29.

5. Remove all stoplogs at structure ES-#17.

Safety Provisions

1. Storms: Immediately following heavy rain storms or tidal surges, all gates and weirs shall be opened as needed, to provide normal gravity drainage for the area as well as to protect the integrity of the levee system.

2. Water Salinity: Water salinity will be managed to maintain the area as brackish marsh. To protect marsh vegetation during periods of high salinity, the ingress gates will be closed when salinity inside CTU #2 exceeds 15 ppt at ES-#3 or ES-#5.

b. Actual Operations

In accordance with the operation schedule outlined in the Operation and Maintenance Plan and USACE Permit, structures were manipulated as required by Apache Louisiana Minerals, Inc. personnel who are under contract with LDNR. Copies of the quarterly reports that are provided as well as a copy of the operations contract between LDNR and Apache Louisiana Minerals, Inc. are attached in the "Structure Operations" section of the CS-20 East Mud Lake Marsh Management Operation and Maintenance Plan.

IV. Monitoring Activity

Pursuant to a Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Task Force decision on August 14, 2003, to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, updates were made to the CS-20 Monitoring Plan to merge it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There is one CRMS-*Wetlands* site in the CS-20 project area (station 0672) and two nearby reference sites (stations 0655 and 0685).

In response to Hurricane Rita in 2005, 163 LDNR emergent vegetation stations were sampled in the late summer/early fall of 2005 and 2006. The stations represented a subset of the LDNR vegetation stations established on the Chenier Plain to monitor CWPPRA projects, including sites in the CS-20 project area (Appendix A).

a. Monitoring Goals

The objectives of the East Mud Lake Marsh Management Project are:

1. Prevent wetland degradation in the project area by reducing vegetative stress, thereby improving the abundance of emergent and submergent vegetation. This will be achieved through hydrologic structural management to reduce water levels and salinities.

2. Stabilize shoreline of Mud Lake through vegetative plantings.

The following goals will contribute to the evaluation of the above objectives:

1. Decrease rate of marsh loss.

2. Increase vegetative cover along shoreline of East Mud Lake.

3. Increase coverage of emergent vegetation in shallow open water areas.

4. Increase abundance of vegetation in presently vegetated portions of project area.

5. Reduce water level and salinity fluctuations to within target ranges for brackish vegetation. Target range for salinities is less than or equal to 15 ppt and 6" below marsh level to 2" above marsh level for water levels.

6. Decrease duration and frequency of flooding over marsh.

7. Decrease mean salinity in Conservation Treatment Unit #2.

8. Increase accretion in Conservation Treatment Unit #2.

*9. Maintain fisheries abundance.

*Note: This is not a specific goal as addressed in the project documentation. However, due to concerns regarding potential fishery impacts, it has been included in the monitoring plan.

b. Monitoring Elements

<u>Habitat Mapping</u>:
At the National Wetlands Research Center (NWRC), 1:12,000 scale color infrared aerial photography obtained on December 26, 1994, and November 27, 2000, was classified and photo-interpreted to measure land to open water ratios and to map habitat types in the project area pre-construction.

To determine land to open water ratios, the aerial photographs were scanned at 300 pixels per inch and georectified using ground control data collected with a global positioning system (GPS) capable of sub-meter accuracy. These individually georectified frames were then mosaicked to produce a single image of the project and reference areas. Using geographic information systems (GIS) technology, the photo mosaic was classified according to pixel value and analyzed to determine land to water ratios in the project and reference areas. All areas characterized by emergent vegetation were classified as land, while open water, aquatic beds, and mud flats were classified as water. An accuracy assessment comparing the GIS classification of 100 randomly chosen pixels to aerial photography determined an overall classification accuracy of 96%.

<u>Vegetation Plantings</u>:
The *Spartina alterniflora* plantings were divided into three land types due to different stress factors from boat wakes, wave energy, and herbivory. The canal plantings, located on a long, straight canal in CTU #2, are subject to herbivory from cattle year-round. The step levee plantings are located in CTU #2 on short canals where plants were installed at a farther distance from the shoreline. Lakeshore plantings are located on the shoreline of East Mud Lake in CTU #1 and subject to high wave energy due to the long north-south fetch across the lake. To document planting success, 5% of the plants along the step levee and canal and 5% of the plants along the East Mud Lake shoreline were sampled. Nineteen plots along the step levee, 17 plots along the canal, and 4 plots along the shoreline, consisting of 10 plants spaced 5 ft (1.5 m) apart, were selected and sampled. Parameters measured included percent survival of planted vegetation, species composition of encroaching vegetation, and percent cover for each species present. Monitoring stations were placed every 1,000 ft (305 m). The 1-mo, 6-mo, 1-year, and 4-year postplanting sampling was conducted in July 1996, December 1996, August 1997, and June 2000, respectively. A Kruskal – Wallis test was used to compare percent survival and percent cover of *S. alterniflora* among the three planting locations (step

levee, canal, and lake shoreline) for each sampling time. Chi – Square tests were considered significant at $p < 0.05$.

Existing Vegetation:
Sites to monitor existing vegetation were selected using a systematic transect pattern in which five transect lines were drawn in a northwest to southeast configuration from the Calcasieu Lake/West Cove shoreline in the project area and reference area 2. Five stations were chosen at equally spaced points along each transect line, for a total of 25 stations in the project area and 20 stations in reference area 2, to obtain an even distribution of stations throughout the marsh (figure 2). Percent cover, height of dominant species, and species composition were monitored in 1.0 m^2 vegetation plots in 1995 and 1997, and in 4 m^2 plots in 1999 – 2006. Emergent vegetation data were collected in July 1995 (pre-construction) and after construction in July 1997, June 1999, July 2003, December 2005 (special post-Hurricane Rita sample), and June 2006. An Analysis of Variance (ANOVA) was used to test for differences among areas, years, and the area * year interaction. Least Square Means are presented in figures.

Water Level and Salinity:
Data were collected using seven (7) YSI 6000 or YSI 6920 continuous recorders at five stations inside the project area and two stations in the reference areas (figure 3). Water level (ft, NAVD), salinity (ppt), water temperature (^oC), and specific conductance (μS/cm) were recorded hourly at these stations. All continuous recorder data were shifted when necessary due to biofouling when error at time of retrieval exceeded 5%. Percent error caused by biofouling was calculated at the time of retrieval by comparing dirty and clean discrete readings to those taken with a calibrated instrument. Water depth, salinity, and temperature were measured monthly at 27 stations, 15 located inside the project area and 12 in the reference areas (figure 3). Monthly staff gauge readings were taken at 11 stations located within the project area and 10 in the reference areas. Some data are missing due to inaccessibility to sites at some sampling times.

Water level data relative to marsh surface (1.01 ft NAVD) were presented on a yearly basis through 2006 from representative stations of comparable project/reference areas (station 3 of CTU #2/ station 14R of REF 1; station 7 of CTU #1/ station 15R of REF 2). The percent of hourly water level measurements lower, higher, or within the target zone of 2 inches above average marsh level (1.18 ft NAVD) and 6 inches below marsh level (0.51 ft NAVD) were calculated for all years in the above mentioned stations. Yearly mean salinity data was presented through 2006 from the above mentioned stations to evaluate the goal of decreasing mean salinity in CTU #2. The percent of hourly salinity measurements greater than or equal to15 ppt at the above mentioned stations during each year of operation was calculated to determine if the project was effective at maintaining salinities less than or equal to 15 ppt.

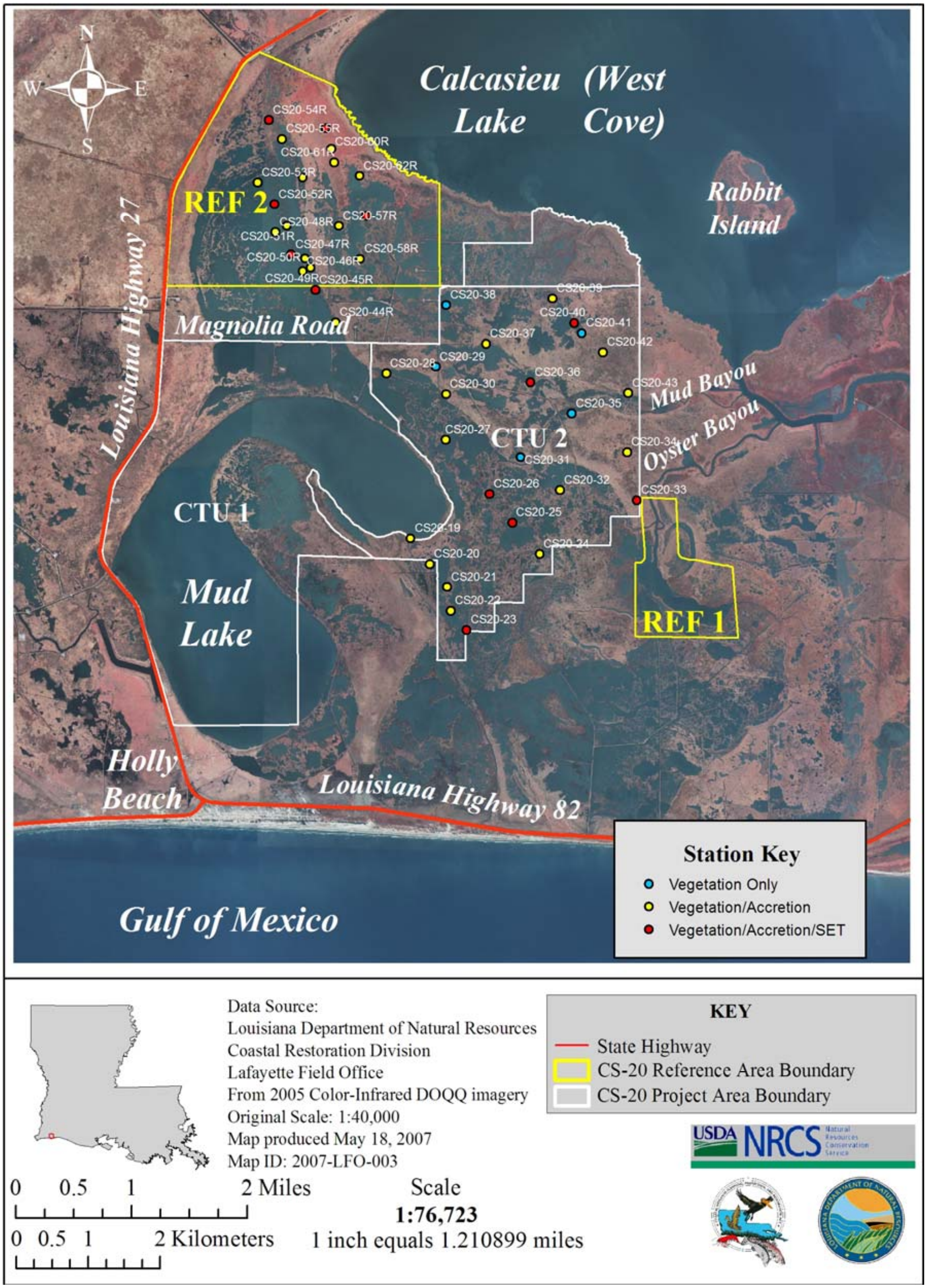


Figure 2. East Mud Lake Marsh Management (CS-20) project map depicting feldspar, emergent vegetation, and Surface Elevation Table (SET) stations.

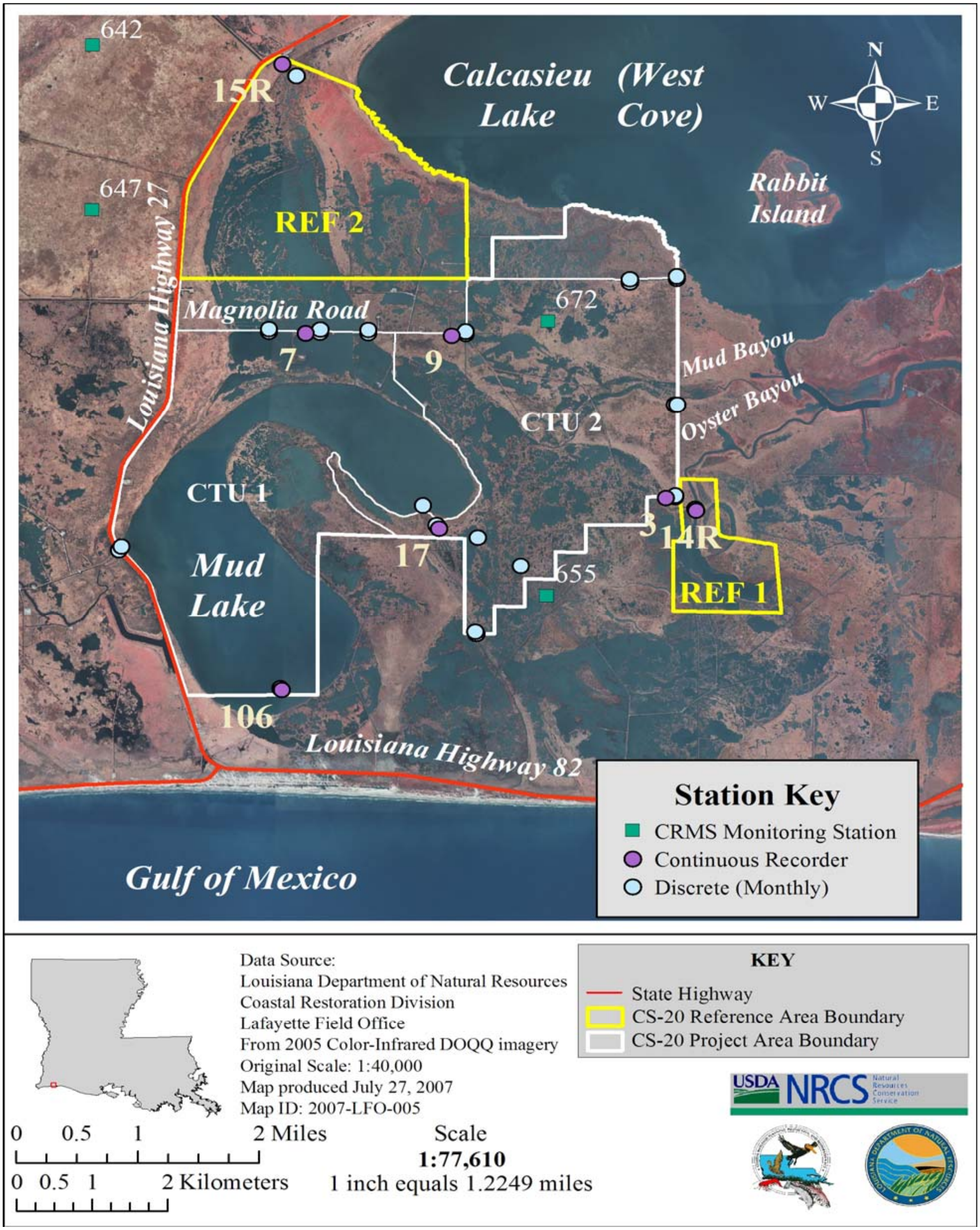


Figure 3. East Mud Lake Marsh Management (CS-20) project map depicting discrete monitoring stations, and continuous recorder stations and CRMS stations.

Soils: Soil cores from vegetation monitoring plots in the project and reference areas were collected in July 1996 (pre-construction), July 1999 (post-construction), and June 2006 (post-Hurricane Rita). Cores were taken with a Swensen corer, refrigerated, and delivered to Louisiana State University (LSU) Agronomy Department (LSU Ag) to be analyzed for bulk density (BD) and percent organic matter (%OM). At LSU Ag the soil cores were air dried and then oven dried at approximately 100 ^{o}C for 24-48 hours to determine BD (grams of dry field sample/volume of field sample). The BD soil was subsampled to determine %OM via loss on ignition ((1-(weight of ash/weight of subsample))*100).

Marsh Elevation Change:
Elevation change data was compiled from 12 stations (6 each in project area CTU #2 and reference area REF 2) that contained both vertical accretion (VA) and surface elevation measurements (SET) (figure 2; details of installation and data collection are below). The data was divided into three time intervals with distinct signatures: pre-construction to early post-construction (1995-1998), post-construction (1998-2003), and post-Hurricane Rita (2003-2006). Cumulative elevation change rates (mm/yr) were computed from the direct measurements of vertical accretion and SET. Shallow marsh subsidence (subsidence) rate was then calculated from the difference of VA and SET rates (subsidence = VA – SET). Marsh elevation change rates are presented as means with standard errors of the project and reference areas for each time interval.

Vertical accretion - Feldspar platforms were constructed August 1995 at 20 stations in CTU #2 in the project area and 20 stations in reference area 2 along the same transect lines as the vegetation stations to detect changes in vertical accretion (figure 2). In July 1996, two feldspar marker horizon plots were established at each of 14 stations in CTU #2 and 16 stations in reference area 2. Sites that were inaccessible in July were established in December 1996: six stations in CTU #2 and three stations in reference area 2. New feldspar plots were laid at all sites in December 1997 and the original plots were abandoned. Post-construction data were collected December 1996, July 1997, December 1997, June 1998, June 2000, July 2003, December 2005 (post-Hurricane Rita subset), and June 2006. Some sites were not visited during sampling periods due to inaccessibility.

Feldspar was placed in 0.5 x 0.5 m plots marked with two PVC poles at opposing corners to enable location of the feldspar over time, and cores from randomly selected locations within each plot were taken with a cryogenic corer (Knauss and Cahoon 1990). Vertical accretion (sediment depth above the feldspar) was measured to the nearest millimeter with a vernier caliper at 1-7 locations on each core. A maximum of three cores per plot were taken at each sampling period; however, feldspar was not always clearly visible on any of the three cores. After the measurement was taken, the core material was returned to the sample hole to prevent sediment trapping.

Surface elevation - Surface elevation table (SET) stations were established in August 1995 at 12 of the 40 feldspar stations to detect changes in marsh surface elevation due to subsidence and accretion/erosion combined (figure 2). Six SET stations were located in the project area and six in reference area 2. Stations in the Bancker soils include stations 27, 29, and 29A in the reference area, and stations 23, 25, and 26 in the project area. Stations located on Creole soil types include stations 31, 31A, and 35A in the reference area, and stations 33, 36, and 40 in CTU #2 of the project area. Stations 15 and 31A are in close associations with a ridge of the Mermentau soil type. Nine pin measurements were taken in four directions at each of the stations. Detailed procedures for the SET are documented in Steyer et al. (1995). Marsh surface elevation was measured pre-construction in December 1995, and post-construction in July 1996, December 1996, July 1997, December 1997, June 1998, June 2000, July 2003, December 2005, and July 2006 (post-Hurricane Rita). Due to low water levels, only 10 of the 12 SET station sites were accessible for the first two measurements.

Fisheries:

Fisheries monitoring was conducted to estimate abundance and species composition in the project and reference areas to determine whether the project affected fish abundance. Thirty samples each were collected from CTU #2 in the project area and reference area 2, concurrently, during each sampling period, with a 1-m^2 throw trap with 1-m high walls constructed of 1.6 mm mesh nylon netting (Kushlan 1981). A 0.25 in (0.64-cm) diameter steel bar, bent into a square, was attached to the bottom of the net to make it sink rapidly in the water. A floating collar of plastic pipe 0.75-in (1.91-cm) diameter was attached to the top of the net to keep the throw trap vertical in the water column after deployment. Additional samples were collected randomly using a 20-ft (6.1-m) minnow seine with 3/16 in (0.48 cm) mesh to compensate for the potential deficiency of the throw traps for determining species composition. A minimum of three seine pulls were conducted in the project area and both reference areas at each sampling event to determine whether throw traps adequately depict species composition. Mean density, relative abundance, and total biomass (dry weight in grams) of each species were recorded. A water sample was collected at each site and measurements taken for water temperature (^oC), salinity (ppt), dissolved oxygen (mg/l), water depth (cm), and distance to the marsh edge (m). At each site, presence or absence of submerged aquatic vegetation (SAV) was noted. Sampling locations were randomly chosen from a grid pattern for each sampling trip. Personnel from LDNR/CRD conducted sampling in June 1995, October 1995, April 1996 (during drawdown), October 1996, and March 1997. National Marine Fisheries Service (NMFS) personnel and the LDNR/CRD monitoring manager conducted sampling in April 1997 (during drawdown), September 1997, April 2001, and November 2001. NMFS analyzed data from June and October 1995 and April 1996 and determined that throw trap sampling depicted species composition of the area at least as well as seine sampling, and seine sampling was discontinued.

Density and biomass means and standard errors for each fish and crustacean species were calculated for the project and reference area for each sampling period. Means and standard errors for all environmental variables collected were calculated for the project and reference area per sampling period. Although construction was not completed until after the April 1996 sampling time, access to the project area was disturbed by the ongoing construction and April 1996 was thus considered post-construction. Two factor ANOVA's with interaction were used to compare mean animal densities and environmental variables between the project and reference areas for pre-construction sampling times to estimate the suitability of the reference area. The specific environmental variables tested were salinity, temperature, dissolved oxygen, depth, and distance to edge and the animal variables were total fishes, total crustaceans, transient fishes, transient crustaceans, resident fishes, and resident crustaceans. The same set of environmental and animal variables were then compared between pre-construction and post-construction sampling times with a one-way ANOVA for each area separately (Appendix A). Prior to statistical analyses, Hartley's F-max test was used to determine if variances in the treatment cells were equal (Milliken and Johnson 1992). We performed a ln(x+1) transformation on the density, species richness, and biomass data, because cell means were positively related to standard deviations. In cases where cell means were positively related to variances (i.e., salinity, water temperature, dissolved oxygen concentration, water depth, distance to edge), a square root transformation was used prior to analyses. These transformations generally reduced the relationships between means and standard deviations or variances. However, F-max tests still indicated heterogeneity for some variables. Despite this failure to meet the assumption of homogeneity of variances in all cases, ANOVA tests were conducted on transformed data because the test is considered robust, and failure to correct heterogeneity does not preclude its use (Green 1979, Underwood 1981). An alpha level of 0.05 was used to determine statistical significance for all ANOVA tests.

c. Preliminary Monitoring Results and Discussion

Land to Water Ratio and Habitat Mapping:

Between 1994 and 2000, the per year rates of marsh loss in CTU #1, REF 1, and REF 2 were similar to the 1978 to 1988 rates, but in CTU #2, there was a 22.7 acre (9.19 ha) per year gain from 1994 to 2000, up from a 5.2 acre (2.1 ha) per year loss from 1978 to 1988 (figure 4). While the project and reference areas both experienced decreases in marsh loss rate, the project area CTU #2, which had managed drawdowns in 1996 and 1997, had the greatest net gain of vegetative expansion. Some of the gain was in areas that had vegetative plantings that were not a part of the original project plan, but other areas of gain had no such plantings. Although marsh gains occurred overall in the project areas, localized marsh loss in CTU #2 appeared in the more fragmented, lower elevation marsh. In CTU #1, the marsh loss was largely restricted to one area on the peninsula in East Mud Lake. From examination of 1998 DOQQ photography, it appears that the loss on the peninsula happened or at least began by 1998, but there was no obvious cause for this loss.

Vegetative Plantings:

The following is a summary of percent cover change and marked plant survival detailed in the CS-20 Three Year Comprehensive Report (Castellanos 2005); no additional data has been collected. Vegetative cover along the shoreline of East Mud Lake (CTU #1) was not increased by vegetative plantings; however, about 50% of plantings along the canal (east border of CTU #2) and step levee (southeast border of CTU #2) areas remained four years after planting, and maintained over 20% cover. The original plan to install all plantings on the lakeshore was modified because of unexpected difficulty securing suitable planting substrate. Only a small portion of the plants were put on the lake shoreline. The 1994 – 2000 land water change analysis shows a land to water gain on the northwest shoreline of the lake directly across from the peninsula

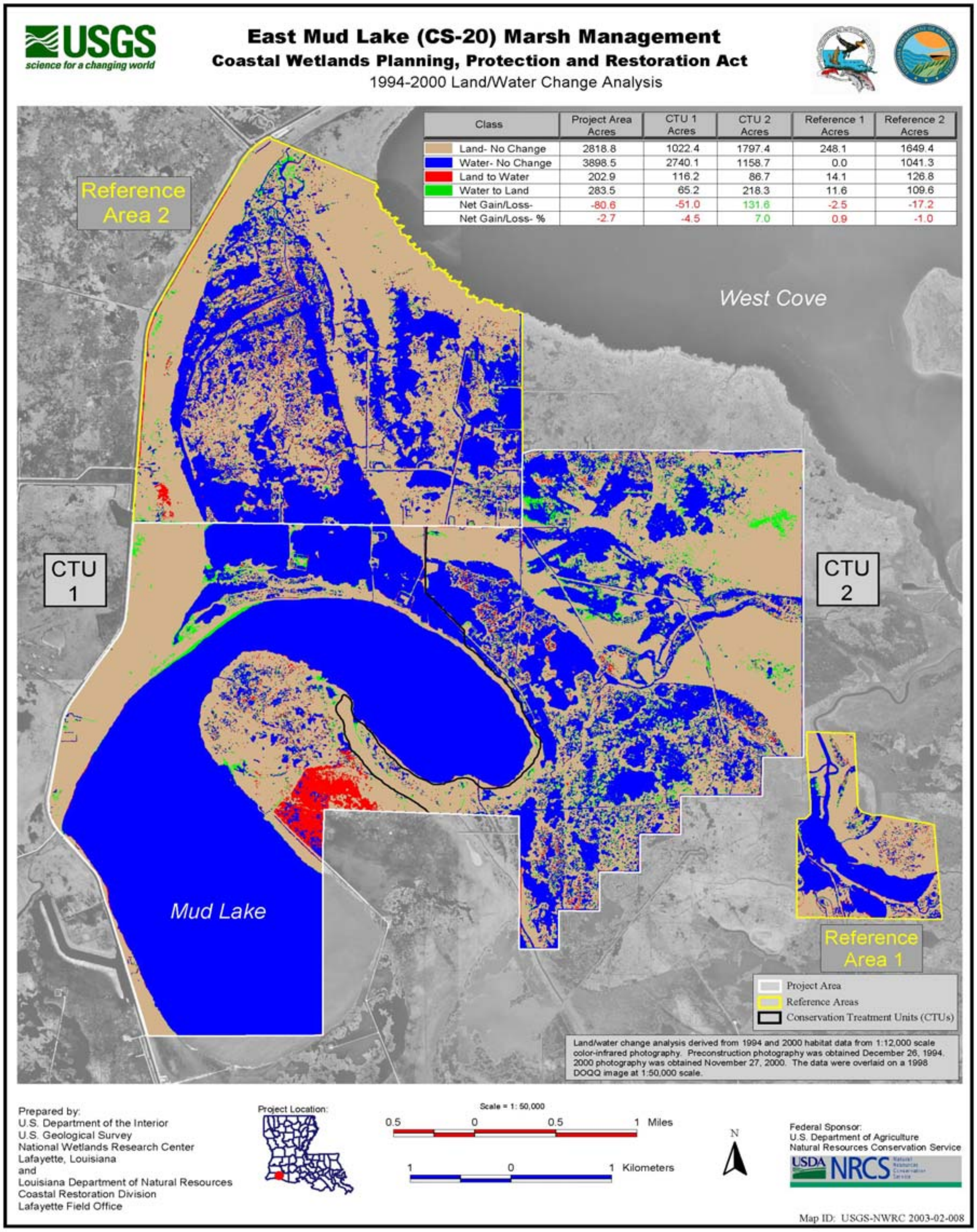


Figure 4. Land water change analysis from 1994 to 2000 for East Mud Lake Marsh Management (CS-20).

tip; however, the vegetative plantings that were installed in that area cannot be definitively credited for the new land. According to our planting monitoring data, the shoreline plots we sampled survived well for six months, but never increased in cover. At the time of our last sampling in 2000, there were no surviving plants and 0% cover. The water to marsh change could be due to protection of the shoreline made possible by the short fetch in that narrow part of the lake coupled with favorable winds that ultimately allowed deposition of resuspended sediment. The existing vegetation could have then colonized the new, higher elevation substrate. The new land could also be the result of the expansion of existing vegetation into previously unvegetated mudflat that had not been detected by earlier aerial photography. Native species colonizing the shoreline and step levee were indicative of drier/saltier conditions and included *Distichlis spicata* (salt grass), *S. patens*, *Heliotropium currassivicum* (seaside heliotrope), *Lycium carolinianum* (salt matrimony-vine), and *Salicornia bigelovii* (glasswort).

Marked individuals of *Spartina alterniflora* from plantings survived longer along the canal and step levee than along the shoreline of East Mud Lake over a four year period (July 1996 – June 2000). Plant survival was greater than 90% after 6 mos across all land types. Along the canal, plant survival was greater than 90 % through 12 mos and then decreased to 55% after 48 mos. Along the step levee survival decreased to 45-50% after 12 mos and maintained through 48 mos. Plant survival sharply declined to 15% from 6 to 12 mos, and no marked plants from the plantings survived to 48 mos. Typical plant turnover or stress caused plant survival decreases along the canal and step levee; whereas plantings were physically removed by wave energy along East Mud Lake.

Existing Vegetation:
The goal to increase coverage of emergent vegetation in shallow, unvegetated, open water areas was achieved, but the amount is difficult to quantify. The drawdown phase of the project was intended to allow germination of marsh vegetation seeds and expansive tillering. Because our formal emergent vegetation sampling only incorporated existing vegetated areas, the only way to attempt to evaluate this goal was through analysis of aerial photography and through observations during field trips. Land / water analysis 1994 – 2000 did show a land gain in CTU #2, and we believe it is due mainly to expansion of *P. vaginatum* and *S. alterniflora* at the marsh-water interface. Evidence of this new vegetation became apparent during vegetation sampling after the drawdown and drought in 1996.

Percent vegetative cover at sampling stations in the project area declined from 97% in 1995 (pre-construction) to 58% in 1997 (postconstruction and 1996 drought) and did not recover through 2003; whereas percent cover in the reference area was greater than 75% through 2003 (figure 5a). Soon after Hurricane Rita in December 2005, vegetative coverage dropped to about 10% in both the project and reference areas, and both increased through the following growing season of 2006 with the project area demonstrating better recovery (figures 5a and 6). Species richness increased in both areas from 1995 to 1999 (figure 7). In 2003 richness in the reference area decreased and the project remained about the same as in 1999. Mean richness in both areas decreased to about 1 species per 4 m^2 plot in 2005 following Hurricane Rita. By the June 2006 sampling, mean richness had increased to both areas' previous maximums or higher (figure 7). Dominant species composition changed over time, especially

in the project area (figure 5b). In 1995, each area was dominated by *S. patens*. By 1997, in the project area, *S. patens* made up only about 50% of the cover in the average sample plot. *Amaranthus australis* and *D. spicata* made up the majority of the other 50% along with a small increase in *S. alterniflora*. *D. spicata* actually grew in on top of dead *S. patens*. The reference area was
still mostly *S. patens*, but *A. australis* and *D. spicata* appeared for the first time. In 1999, the reference was still dominated by *S. patens* with *D. spicata* contributing about 10% of the cover. The project area continued to be dominated by *S. patens* but now with the virtual absence of *S. alterniflora* and a seemingly permanent *D. spicata* presence. In 2003, the project area was still about half *S. patens*, and half other species, with *D. spicata* the most abundant of them. *S. alterniflora* cover increased in the project area and reference area samples. Some of the *S. alterniflora* expansion was due to plantings not part of the project plan (figure 4). The reference area continued to be dominated by *S. patens*, but with a small increase in cover by other, more salt tolerant, species.

Water Level and Salinity:
As detailed in the CS-20 Three Year Comprehensive Report (Castellanos 2005), water levels were less variable at the project stations than reference stations through 2003; this pattern remained through 2005. Water levels were much more sporadic post Hurricane Rita in 2006, as yearly water levels ranged from 18" below (REF 2) to 15" above marsh elevation (REF 1) in the reference areas and, a more moderate range, 6" below (CTU #1) and 7 ½" above marsh elevation (CTU #2) in the project areas (figure 9). Comparing project areas to reference areas, station 3 (CTU #2) was flooded above the target range (2" above marsh elevation) for 70 % of the year (figure 10); however, water levels were half that of its corresponding reference area station, 14R (REF 1), which was flooded above the target range nearly 100% of 2006 (figure 11). Conversely, REF 2 and CTU #1 were drier in 2006. Station 7 (CTU #1) spent about 60% of 2006 below the target water level (figure 12) while water levels at station 15R (REF 2) were about three times lower as that station spent 95% of 2006 below the target water level (figure 13). Although more moderate than the reference areas, contrasting water levels in CTU #2 (high) and CTU #1 (low) are confounded with operation problems of water control structures that are either sunken and allowing water to enter CTU #2 (structure 4) or have debris stuck in the flap gates allowing water to flow out of CTU #1 (structure 13).

Overall, salinity doubled from 2004 through 2006 approaching concentrations existing during the drought of 1999-2000. As in previous years, station 14R (REF1) was the saltiest station, with the other stations becoming saltier relative to 14R as the overall salinity increased (figure 14). By 2006, all stations spent over 60% of the days above the maximum target of 15 ppt (figure 15). From 2003 through 2005 the project areas were above 15 ppt less of the time than their paired project areas; however, no consistent pattern between the paired areas was evident in 2006. Station 7 (CTU #1) spent 80% of 2006 above 15 ppt, which was second among the stations; this is of note because it has spent the most time below 15 ppt of all the stations from 2001-2005 (figure 15).

Soils:
Project (CTU #2) and reference (REF2) areas were similar to one another in terms of bulk density (BD) and % organic matter (%OM) as the soils changed over the three sampling

periods (figures 16 and 17). From 1996 to 1999 (pre- to post-construction), BD decreased about 55% with a slighter decrease of about 20% in %OM. This is indicative of a net loss in soil organic matter, which typically occurs when organic matter decomposition outpaces production (root productivity)/accumulation (sedimentation) (Nyman and Delaune 1993). The loss of BD was more pronounced in the REF2 area than in CTU #2. From 1999 to 2006 (pre- to post-Hurricane Rita), BD sharply increased while %OM sharply decreased with this pattern again being more pronounced in the reference area. This negative relationship between BD and %OM is indicative of a large mineral input like the sedimentation resulting from Hurricane Rita. Although the different areas had the same general patterns, the patterns were more pronounced in the reference than the project area. The hydrologic management and pre-existing levees surrounding CTU #2 buffered the soil by maintaining more stable water levels than the reference area and providing storm surge protection, respectively.

Marsh Elevation Change:

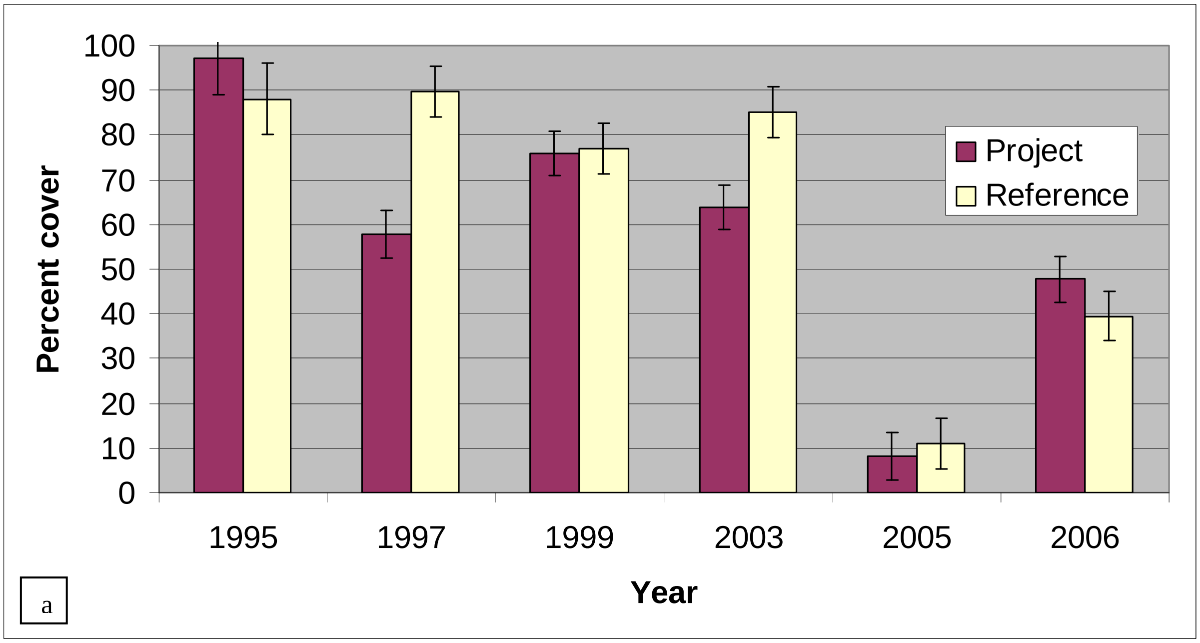
Elevation change through 2003 is detailed in the CS-20 2007 Three-Year Comprehensive Report; therefore, that time frame is summarized here and compared to 2003-2006, which includes Hurricane Rita. From 1995 to 2003 (pre-construction to pre-Hurricane Rita), the project and reference areas had similar vertical accretion rates while the project area had a slightly lower rate of elevation change and a resultant higher rate of subsidence (figure 18). This difference is likely caused by a higher net loss of organic matter (decomposition > production/accumulation) caused by higher decomposition caused by drawdowns (managed and drought induced) and lower plant productivity, attributable to the lower percent vegetative cover (figure 5a), or organic sedimentation impeded by the levees in the project area. From 2003 to 2006 (post-Hurricane Rita), both project and reference areas had a boost in vertical accretion and elevation change, but they also had an increase in shallow subsidence (figure 18). The increased vertical accretion was likely caused by mineral sedimentation during Hurricane Rita, which subsequently results in higher subsidence rates as the more dense mineral matter and water compacts the underlying organic substrate. Overall, components of elevation change are less variable in the project than the reference areas; this is attributable to the water control structures and the pre-existing ring levees around CTU #2.

Fisheries:

Fisheries aspects were collected in CTU #2 of the project area and reference area 2. In order to accurately describe the most important differences in fisheries species abundances, resident and transient species are treated separately. Resident species spend most of their life cycle within the estuary, whereas transient species spawn in nearshore or offshore waters and use shallow estuarine habitats as nursery areas.

The most abundant resident fish species included *Poecilia latipinna* (sailfin molly), *Gambusia affinis* (western mosquitofish), *Menidia beryllina* (inland silversides), and *Cyprinodon ariegates* (sheepshead minnow), while *Brevoortia patronus* (gulf menhaden) and *Anchoa mitchilli* (bay anchovy) were two of the most abundant transient fish species. The most abundant resident decapod taxa include *Palaemonetes intermedius* (brackish grass shrimp), *P. pugio (*daggerblade grass shrimp), and *Palaemonetes* sp., while *Penaeus setiferus* (white shrimp), *P. aztecus* (brown shrimp), and *Callinectes sapidus* (blue crab) represent the most abundant transient decapod species.

Before and after project construction, transient fishes and crustaceans were generally more abundant in the reference area (REF 2) than the project area (CTU #2) (figures 19 and 20), while resident fishes and crustaceans were generally more abundant in the project area than the reference area (figures 21 and 22). This likely indicates a previous and present access restriction for transient species to the project area caused by ring levees, which are more suitable habitat for resident species. Fisheries species densities were temporally variable in both areas, and despite a trend toward higher crustacean densities after project construction in both areas, the project did not have a significant effect on total fisheries species densities. Although transient crustacean densities did increase significantly post-construction in the project area, there was a much greater significant post-construction increase in the reference area in total, transient, and resident crustacean densities, which means that even if the project effects contributed to an increase in animal numbers it was overshadowed by other (likely natural) causes.



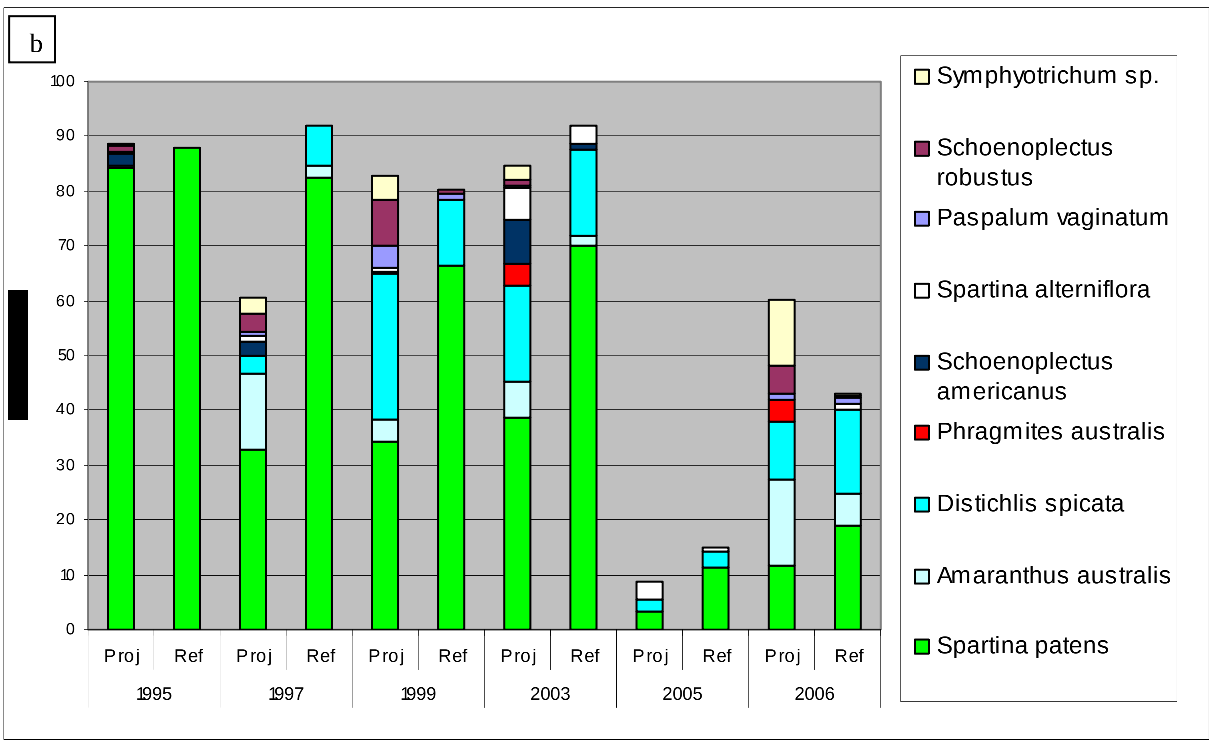


Figure 5. Mean percent cover of total emergent vegetation (a) and dominant emergent vegetation species (b) at East Mud Lake (CS-20) project (n=25) and reference (n=20) areas collected during pre-construction (June 1995) and post-construction (June 1997, 1999, 2003, and 2006, and December 2005).

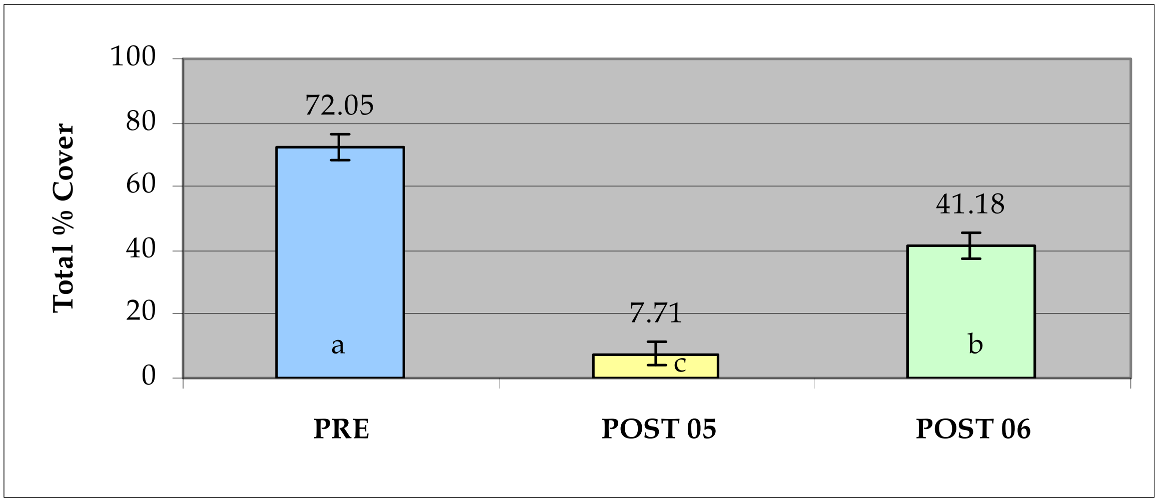


Figure 6. Total % Cover of vegetation at CS-20 Pre- and Post-Hurricane Rita. LS Mean ± SE (n=23 stations). $F_{2,\ 68}$=65.36, p<0.0001. Levels connected by the same letter are not significantly different.

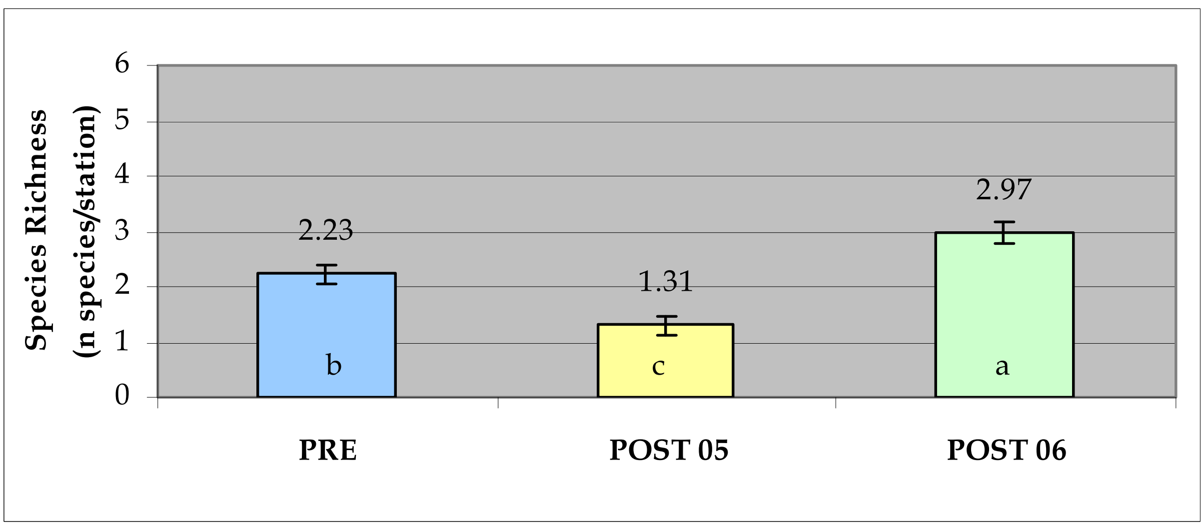


Figure 7. Species Richness at CS-20 Pre- and Post-Hurricane Rita. LS Mean ± SE (n=23 stations). $F_{2,\ 68}$=22.76, p<0.0001. Levels connected by the same letter are not significantly different.

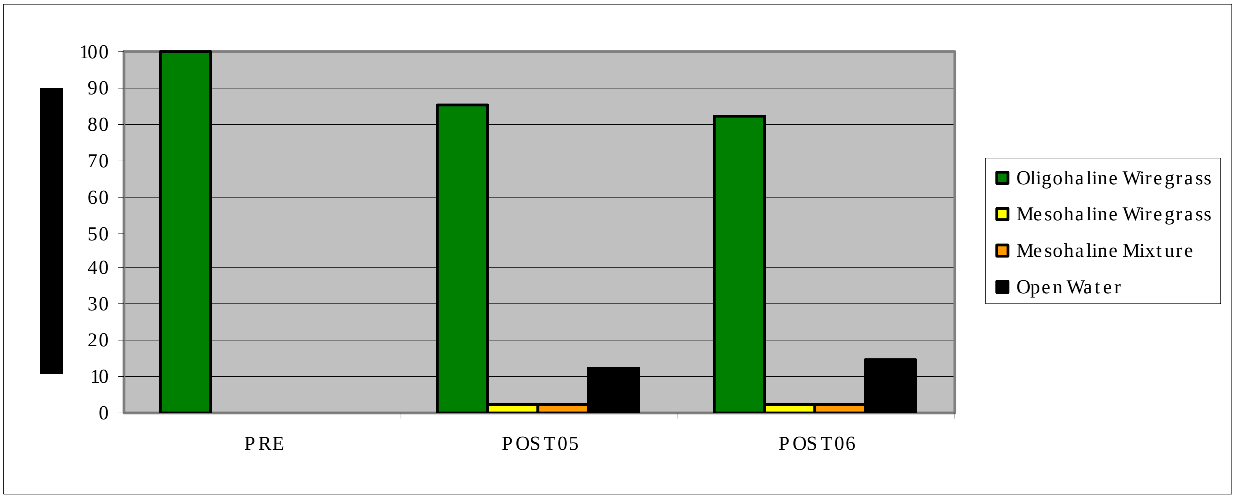


Figure 8. Percent of CS-20 vegetation stations in each Visser vegetation type before and after Hurricane Rita (n=23).

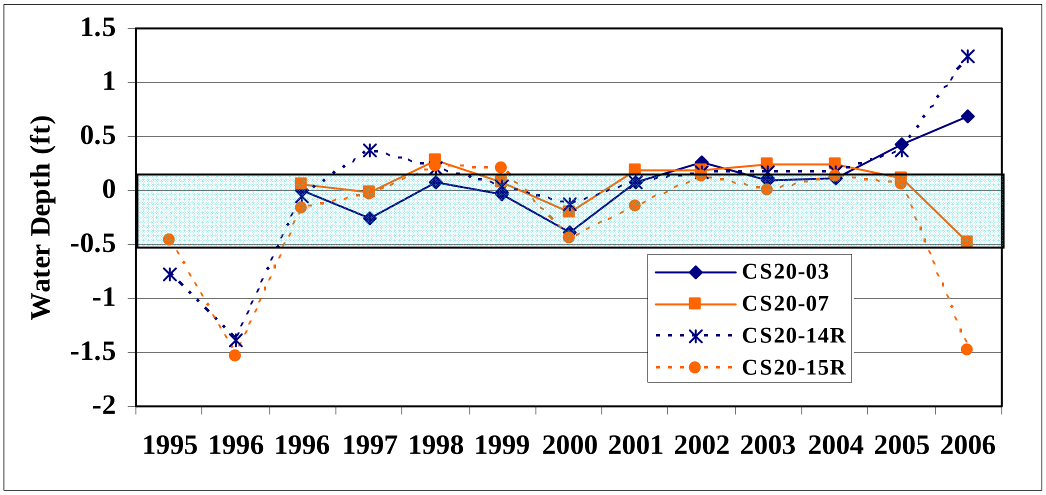


Figure 9. Mean water level relative to marsh elevation (1.01 ft NAVD) per year collected by continuous water level recorders within the project (solid lines) and reference (dashed lines) areas. The colors represent comparable stations (project/reference). Shaded area is the targeted zone for water level for the project areas.

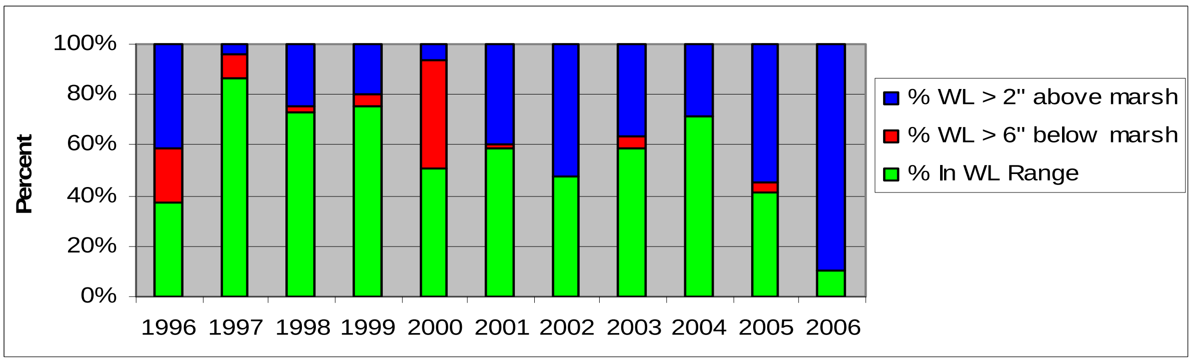


Figure 10. Percent of days at project station 3 in CTU #2 that water levels were within target range of 2” above to 6” below marsh level. Marsh level is averaged at 1.01 ft NAVD.

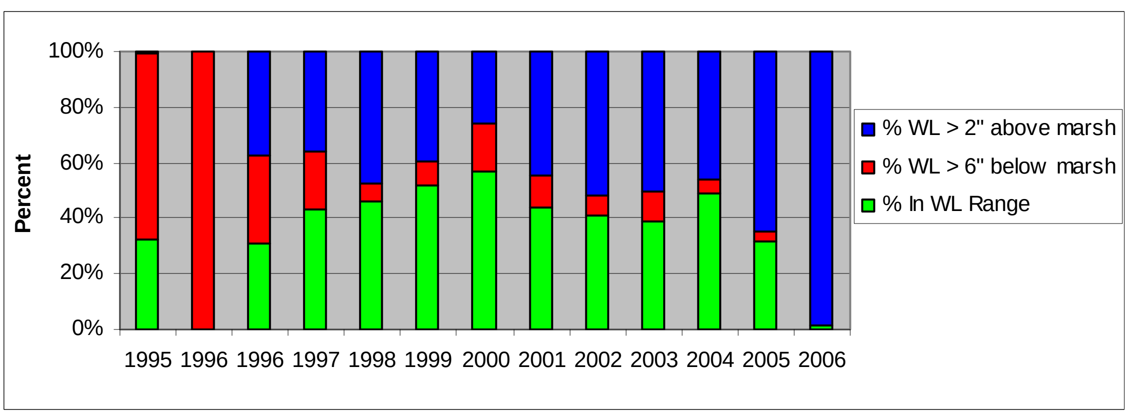


Figure 11. Percent of days at reference station 14R in REF1 that water levels were within target range of 2” above and 6” below marsh level. Marsh level is averaged at 1.01 ft NAVD.

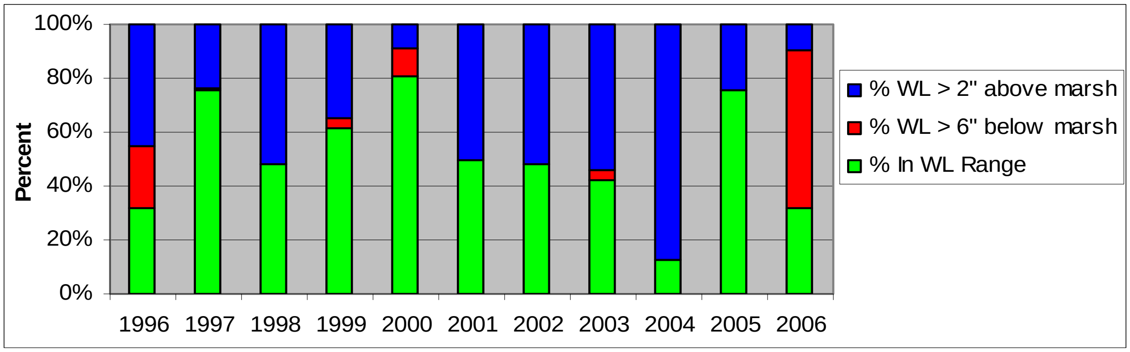


Figure 12. Percent of days at project station 7 in CTU #1 that water level was within the target range of 2" above to 6" below marsh level. Marsh level is averaged at 1.01 ft NAVD.

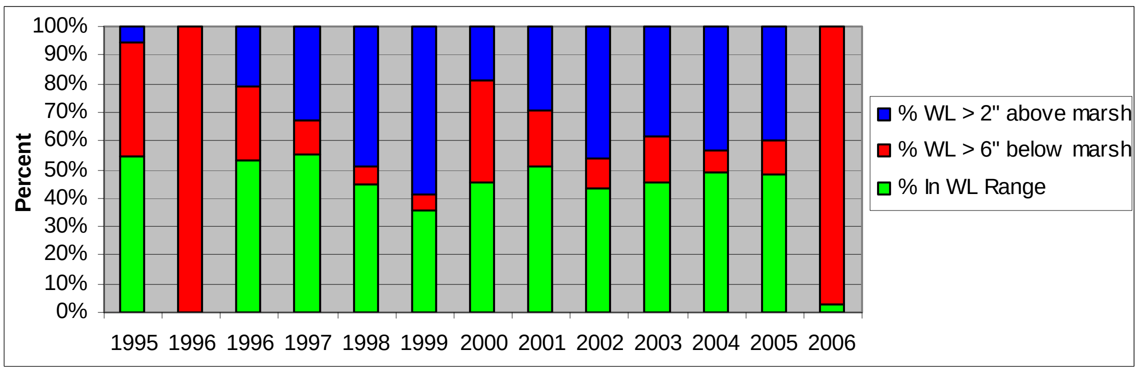


Figure 13. Percent of days at reference station 15R in REF2 that water level was within the target range of 2" above to 6" below marsh level. Marsh level is averaged at 1.01 ft NAVD.

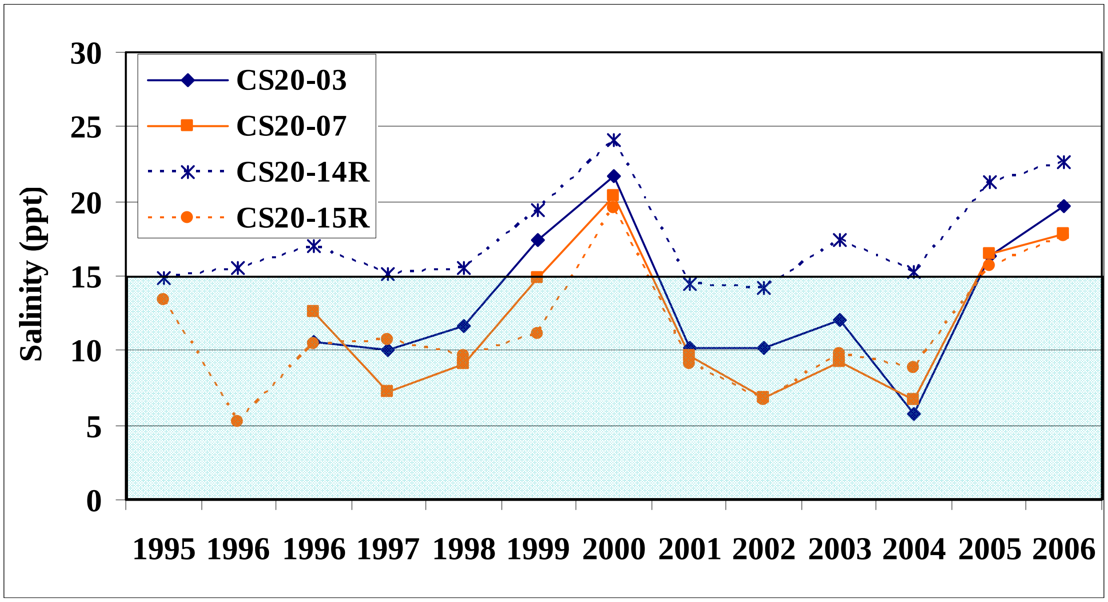


Figure 14. Mean water salinity per year collected by continuous water level recorders within the project (solid lines) and reference (dashed lines) areas. The targeted salinity for the managed areas is below 15 ppt.

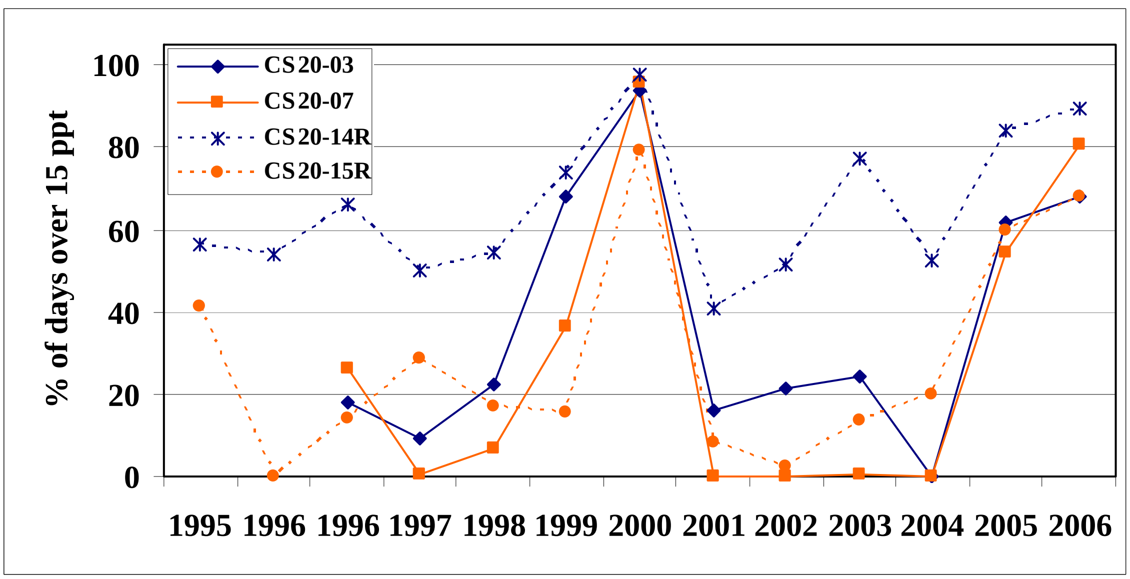


Figure 15. Percentage of days that salinity was greater than 15 ppt per year collected by continuous water level recorders within the project (solid lines) and reference (dashed lines) areas.

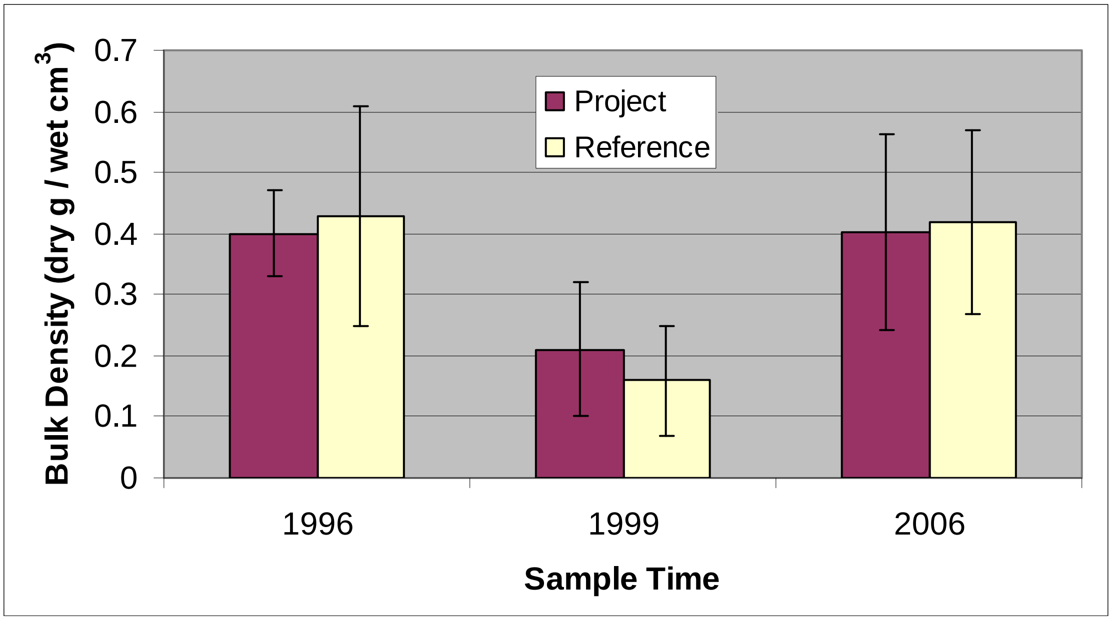


Figure 16. Bulk density of soils collected from project (n=25) and reference (n=20) sites pre-construction (1996), post-construction (1999), and post-Hurricane Rita (2006). Values are means and standard deviations.

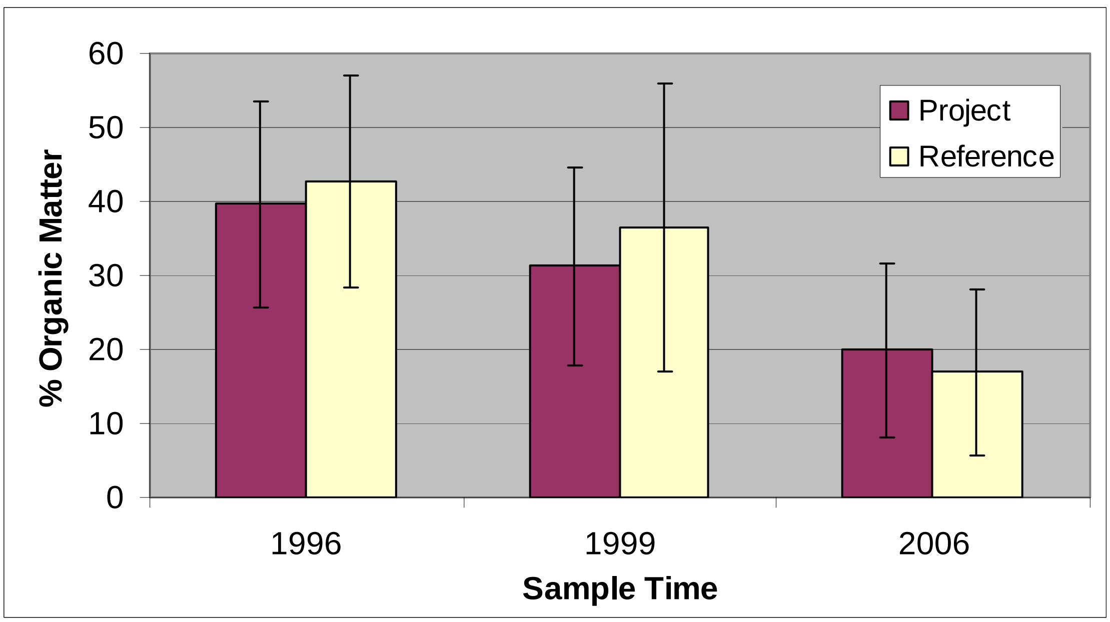


Figure 17. Percent organic matter of dry soil collected from project (n=25) and reference (n=20) sites pre-construction (1996), post-construction (1999), and post-Hurricane Rita (2006). Values are means and standard deviations.

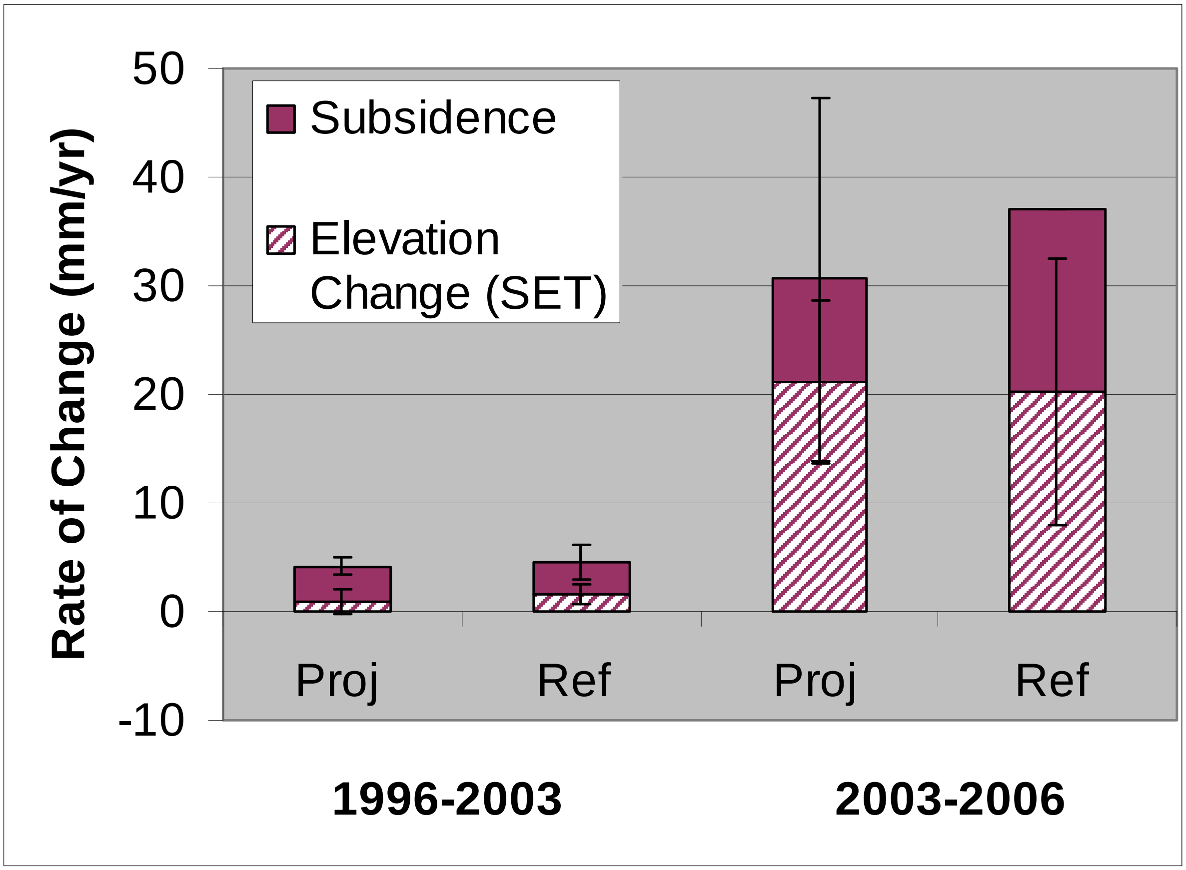


Figure 18. Rate of elevation change in project/reference areas in two time intervals: pre-construction through 7 years of project (1998-2003) and encompassing Hurricane Rita (2003-2006). The entire column represents the measured vertical accretion and is divided into the calculated shallow subsidence and measured elevation change (SET).

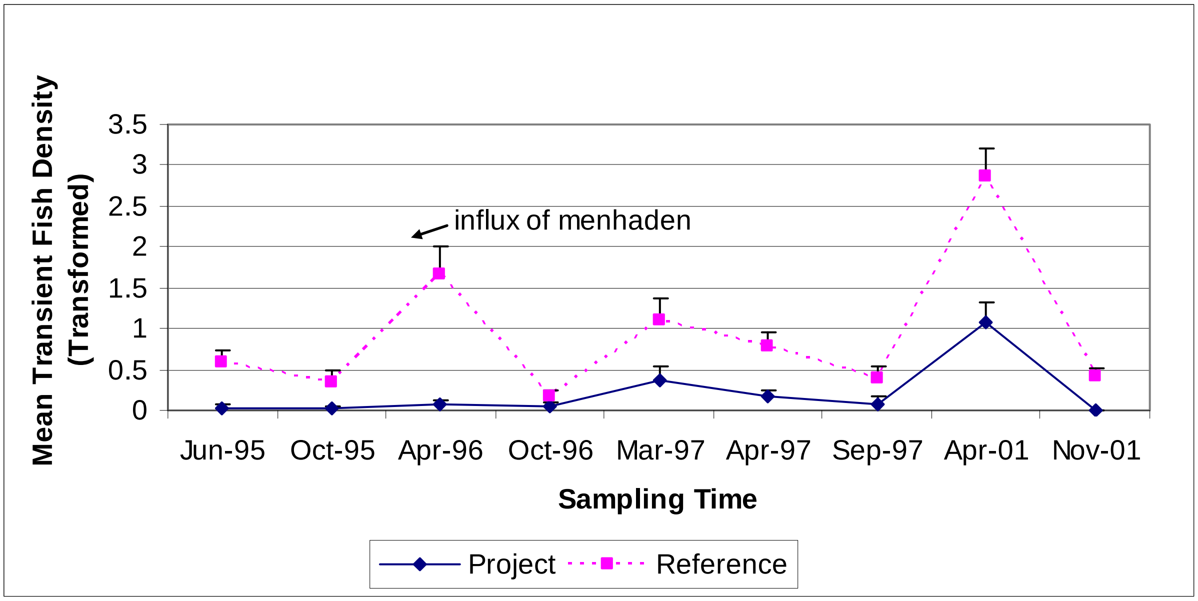


Figure 19. Transformed mean density per square meter of transient fish species collected in the East Mud Lake Marsh Management (CS-20) project and reference areas at sampling dates between June 1995 and November 2001**.**

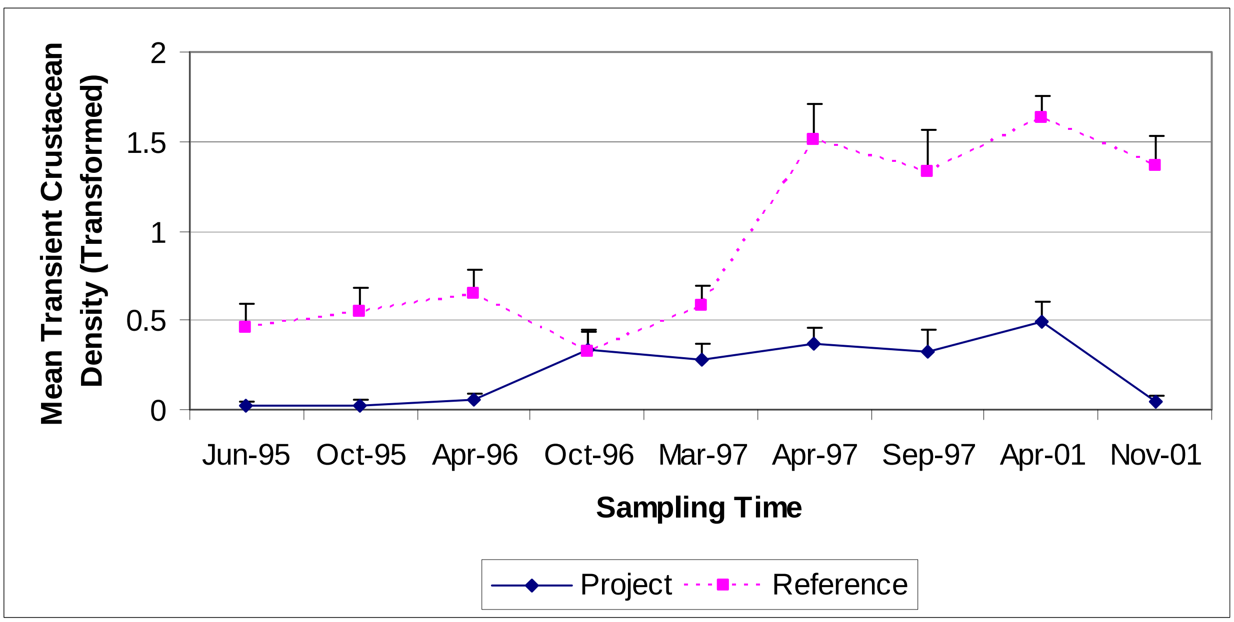


Figure 20. Transformed mean density per square meter of transient crustacean species collected in the East Mud Lake Marsh Management (CS-20) project and reference areas at sampling dates between June 1995 and November 2001.

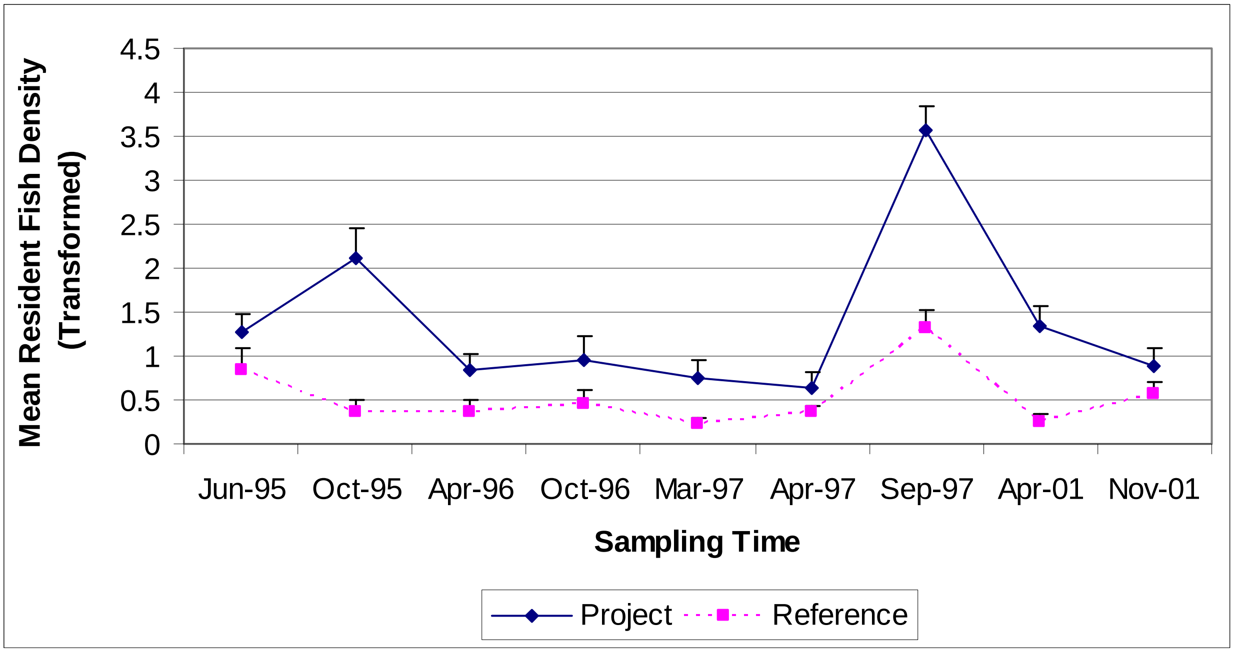


Figure 21. Transformed mean density per square meter of resident fish species collected in the East Mud Lake Marsh Management (CS-20) project and reference areas at sampling dates between June 1995 and November 2001.

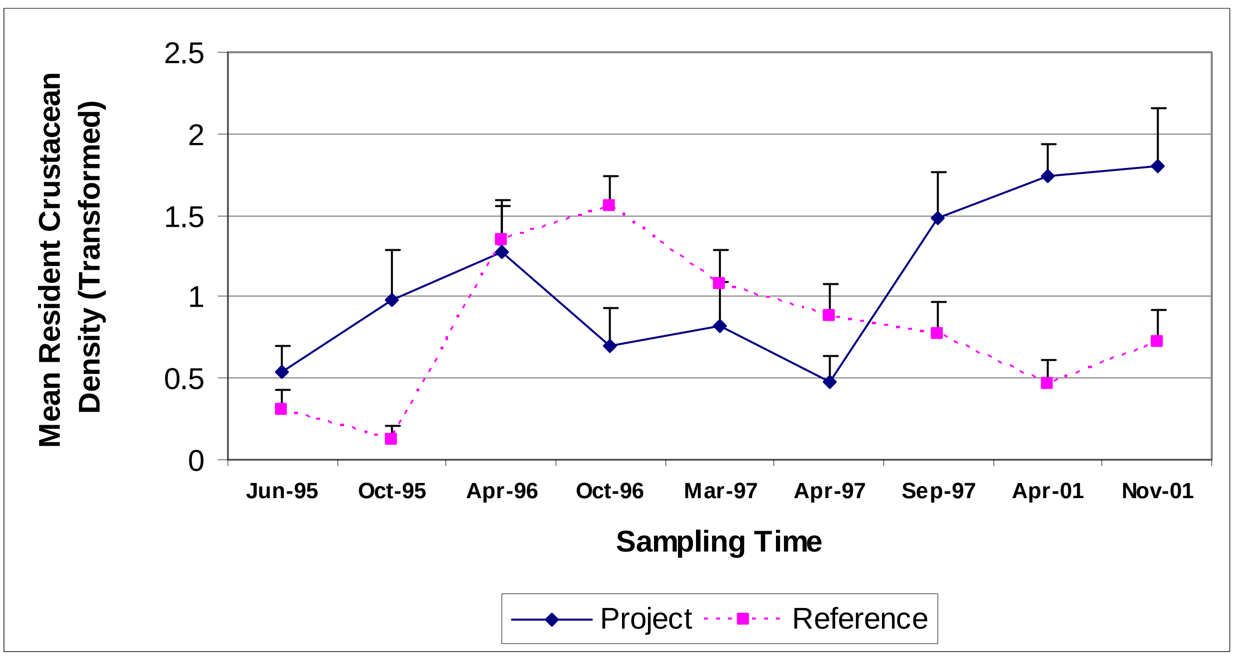


Figure 22. Transformed mean density per square meter of resident crustacean species collected in the East Mud Lake Marsh Management (CS-20) project and reference areas at sampling dates between June 1995 and November 2001.

V. Conclusions

a. Project Effectiveness

Land to water ratios in the project and reference areas pre- and postconstruction had not changed significantly prior to Hurricane Rita. Land/water analysis from 1994 to 2000 did show a land gain in CTU #2 that was due to expansion of salt tolerant plant species (*P. vaginatum* and *S. alterniflora*) after the drawdown and drought in 1996. The new vegetation extending from the marsh edge can increase the amount of valuable emergent marsh.

Operation of water control structures coupled with the previous impoundment of the area moderates water levels and attenuates the high salinities that occur outside the project area during normal weather conditions. But, even when water control structures are operated correctly, strong weather/climate patterns dominate control of water level and salinities inside and outside of project area, as demonstrated by the high salinity during the 1999 – 2000 drought (> 15 ppt for 95% of the year) that was not controlled by the structures. Unfortunately, it is extreme weather/climate patterns, rather than normal conditions, that impact coastal marshes the most. Since Hurricane Rita (September 2005), water levels were highly variable among the areas as water levels remained above the target in CTU #2 and water dropped below the target in CTU #1, and salinities were above 15 ppt for more than 65% of 2006 in both project areas. In a positive note for the project, water levels in the project areas are closer to the target than the reference areas following Hurricane Rita. The ability to determine project effects on water level and salinity are confounded by the operational status of the water control structures. Scheduled maintenance of structure 3 and replacement of structure 4 will facilitate drainage of CTU #2; also, planned maintenance of structure 13 should resume freshwater input to CTU #1. Unfortunately, siltation has been a chronic problem at structure 13 because of low flow rates from First Bayou; therefore, more efforts will be needed to increase flow of First Bayou.

Total vegetative cover in the project area declined from 97% pre-construction to 58% by 1997 (1996 drought/flood), then rebounded to about 75% in 2003; where as, the reference area was consistently > 75% through 2003. After Hurricane Rita (Sept 2005), cover in both the project and reference areas was decimated to 10% in Dec 2005; by June 2006, % cover recovered to almost 50% in the project area and 40% in the reference area. Dominant species composition changed over time, especially in the project areas, as vegetation type shifted to more saline plants (oligohaline wiregrass to mesohaline mixtures) since the flood in 1996 and Hurricane Rita.

Increasing the land to water ratio by encouraging vegetation growth on the marsh edge is a worthwhile effort and a goal of the project, but it will only last if the marsh elevation is maintained or increased. It appears that neither the project nor reference areas' vertical accretion rates are great enough to completely counter the effects of subsidence over time. The project area receives less allochthonous input than the reference area because of the pre-existing ring levees; however, recently it appears that the accretion rates of the two areas are similar so it is doubtful that the lack of suspended material input is the only factor influencing marsh elevation change. The post-hurricane vertical accretion measurements ranged from 20 to 117 mm with half of the measurements at 50 mm or greater; the average accretion in the project area was 67 mm and the reference average was 52 mm. These amounts are relatively large and seem to overwhelm years or even decades or normal deposition, considering that recent accretion rates in the area average between 3 and 11 mm/yr. However, these sediments are very unconsolidated and the thickness of the new layer will likely decrease over time. Therefore we should be cautious when we relay results such as this. Only more sampling over time will tell us how much elevation we have gained from this event.

Fisheries species were sampled in CTU #2 and reference area 2. The project had maintained fisheries abundance prior to Hurricane Rita. Resident fishes and crustaceans were generally more abundant in the project area, and transient fishes and crustaceans were generally more abundant in the reference area prior to and 5 years after project construction. This indicates the pre-existing ring levee has restricted access of transient species to the project area and provides a more suitable habitat for resident species in the project area. We have not monitored fisheries abundance since Hurricane Rita.

b. Recommended Improvements

Overall, the East Mud Lake Marsh Management Project structural components are in fair condition and functioning as designed; however, maintenance repairs are needed as listed below. Plans and specifications will be prepared for replacement of structure ES-4 and to address maintenance of the other structures in Fiscal 2006/2007.

- ES-6 – add rock rip rap for bank erosion, replace padlocks and metal pile caps, clean out culverts.
- ES-7 – add rock rip rap for bank erosion, replace padlocks and metal pile caps, replace staff gages, clean out culverts.
- ES-8 – add rock rip rap for bank erosion, replace padlocks and metal pile caps.
- ES-9a – replace metal pile caps, clean out culvert, replace staff gages, replace padlocks and repair flapgate handle.
- ES-9b – replace gear box and stem cover, replace seat flange on flap gate, clean out culvert, replace padlocks and metal pile cap covers, repair flapgate handle.
- ES-11 – add rock rip rap for bank erosion, extend boardwalk, replace metal pile cap covers and padlocks, replace staff gages.
- ES-5 – add rock rip rap for bank erosion, replace metal pile cap covers, replace padlocks, replace boardwalk, replace staff gages.
- ES-4 – replace structure, abandon existing structure in place.
- ES-3 – add rock rip rap for bank erosion, clean out culvert, replace boardwalks, replace padlocks and staff gages.
- ES-1 – add rock rip rap for bank erosion, extend boardwalk, replace metal pile cap covers and padlocks, replace staff gages.
- ES-17 – replace warning sign, replace pile cap on sheet pile wall, replace staff gage, replace metal pile cap covers, padlocks, and locking tabs.

- ES-13 – replace warning sign, replace metal pile cap covers, replace staff gages, clean out debris, replace padlocks, replace metal pile cap on sheet pile wall.
- Levee/Step canal – repair levees and remove trash/debris and silt from canal.

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Appendix A
Response of Emergent Vegetation to Hurricane Rita

METHODS

In response to Hurricane Rita in 2005, 163 LDNR emergent vegetation stations were sampled in the late summer/early fall of 2005 and 2006. The stations represented a subset of the LDNR vegetation stations established on the Chenier Plain to monitor CWPPRA projects including CS-20 (40 stations), CS-17 (24 stations), CS-31 (30 stations), CS-28 (18 stations), ME-04 (18 stations), ME-11 (12 stations) (Figure 1).

After the 2005 data collection, the stations were classified according to the level of disturbance/stress they had experienced and the resulting vegetation response. Stations were classified as either Open water, Severely Stressed, Moderately Stressed (also classified as "Stressed"), or Slightly Stressed (Table 1). Data collected in 2006 and the last CWPPRA data available from before Hurricane Rita were also classified by stress.

At each station, a marker had been previously established. A 2m x 2m square was placed on the marsh and Total % Cover, % Cover of each species present in the plot, and height of the dominant species were collected. Presence of other species that were not in the plot, depth of surface water, salinity, and sometimes porewater salinity were noted.

The compiled vegetation data from the three sampling periods were utilized to classify each site according to Visser's vegetation types of the Chenier Plain (Visser et al. 2000). The pre-storm types were determined with photographs and Visser Type definitions. The stations were reclassified after the 2005 and 2006 sampling. Stations that did not fit into any Visser Type after the storm maintained their pre-storm types. If the dominant species shifted to an identifiable Visser Type, the station was reclassified.

The data were analyzed to determine the impact of the storm on Total % Cover and Species Richness at three levels; overall by year (all 163 stations), by CWPPRA restoration project (7 projects), and with Visser vegetation type (6 types).

Table 1. Vegetation Stress Classifications used in this survey.

Vegetation Classification	**Description**
Open Water	Vegetation has been ripped out. 100% of plot is open water.
Severely Stressed	>50% of plot is open water. Vegetation is weak.
Stressed	Perennial grasses and herbs are mostly dead (>50%) or >25% open water. Often dominated by annual shrubs.
Slightly Stressed	Perennial grasses are healthy and vigorous.

RESULTS

COASTWIDE

Prior to Hurricane Rita, most of the vegetation stations utilized for this survey were healthy and intact (>80%). Following the hurricane in 2005, most of the stations were stressed (67%) or worse (20%). A year later in 2006, over 50% of the stations were back to pre-storm stress levels. Severely stressed stations either converted to open water or recovered to a less stressed state. Most stations that had been converted to open water in 2005 did not recover (Figures 1 and 2).

ANOVA was utilized to test for differences in Total % Cover (% of plot covered by living vegetation) and Species Richness (n species per plot) over the three sampling periods, by CWPPRA Project, and with Visser vegetation type classifications.

Total % Cover was significantly different over time (Figure 3). Post ANOVA comparisons (Tukey's HSD) revealed that all three sampling periods were significantly different, meaning Total % Cover for 2006 is still significantly lower than Pre-Rita levels. Species Richness was also significantly different over the three sampling periods (Figure 4). The number of species present before Rita and in 2006 were statistically the same.

Most of the projects had significant differences over time for both Total % Cover and Species Richness, with trends similar to the overall model (Figures 3 and 4). Post ANOVA comparisons were utilized to determine whether the projects had recovered to pre-storm levels for both Cover and Richness (Table 2).

Visser Type was added to the overall model and the interaction between Visser Type and time was analyzed. Both models had significant differences in Visser Type over time (Figures 5 and 6). Post ANOVA contrasts of Cover and Richness Pre-Rita and Post 06 for each Visser Type revealed that all Visser Types were the same in Total Cover (had recovered to pre-storm levels) and in Richness except Fresh Bulltongue (mostly in the ME-04 project area) which had not recovered and in Oligohaline Wiregrass which had significantly more species per plot post Rita than before (up from 2.83 to 3.22 species).

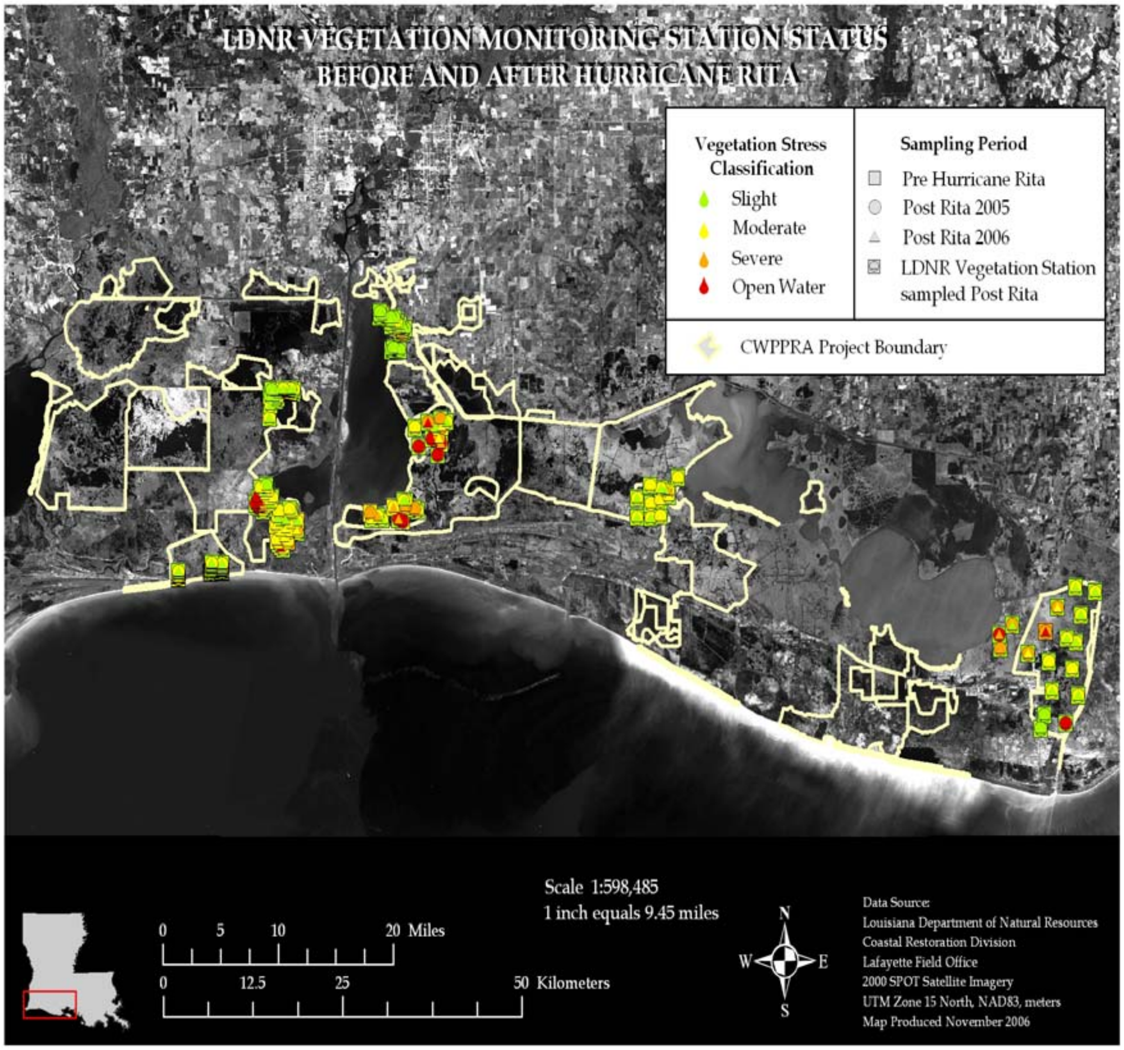

Figure 1. Location and status of LDNR Vegetation stations sampled after Hurricane Rita. Stations were classified according to storm induced stress as described in Table 1.

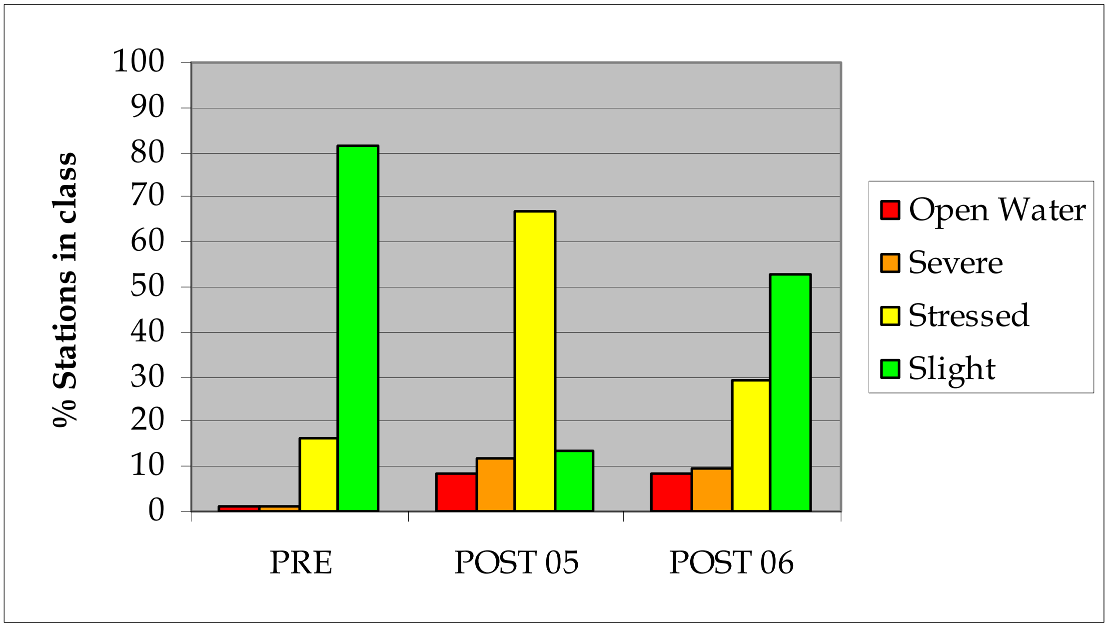

Figure 2. Percent of LDNR Vegetation stations in each stress class before and after Hurricane Rita (n=163).

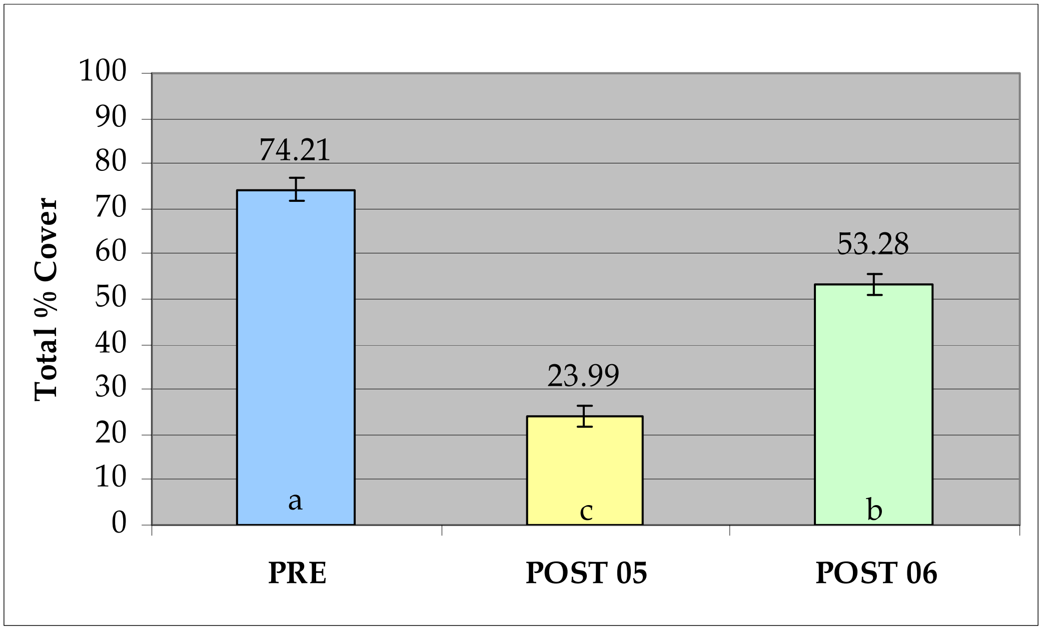

Figure 3. Total % Cover pre- and post-Hurricane Rita. LS Mean ± SE, n=163 stations, $F_{2,\ 488}$=109.7, $p<0.0001$. Levels not connected by same letter are significantly different.

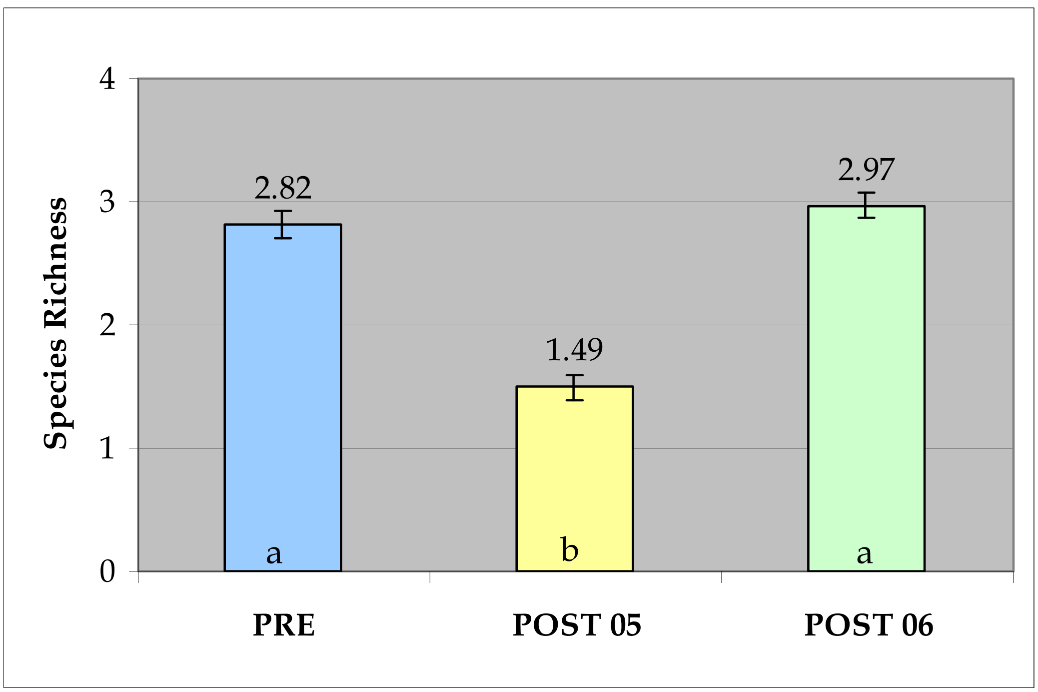

Figure 4. Species Richness pre- and post-Hurricane Rita. LS Mean ± SE, n=163 stations, $F_{2,\ 488}$=56.8, $p<0.0001$. Levels not connected by same letter are significantly different.

Table 2. CWPPRA Project ANOVA Results

Results of Post ANOVA comparisons by CWPPRA Project Summary of 2006 levels relative to pre-Hurricane Rita and 2005		
Project	**Total Cover**	**Species Richness***
CS-17	Not Recovered	Recovered
CS-20	Not Recovered	Recovered
CS-21	Recovered	Recovered
CS-28	Recovered	No Rita Impact.
CS-31	Not Recovered	Recovered
ME-04	Not Recovered	Recovered
ME-11	No Rita Impact	Recovered

***Although the number of species present returned to pre-Rita levels at most projects, many of the species present were disturbance species.

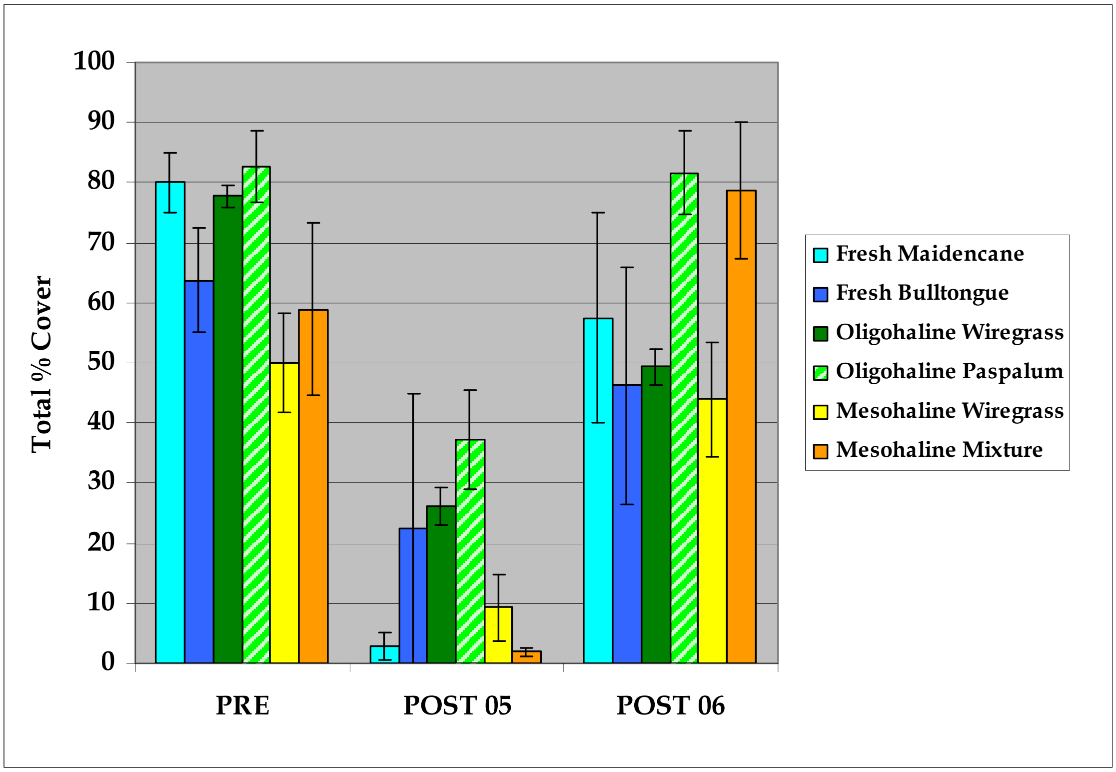

Figure 5. Total % Cover by Visser Vegetation Type. LS Mean ± SE, n=163 stations, $F_{17, 488}$=17.0, p<0.0001.

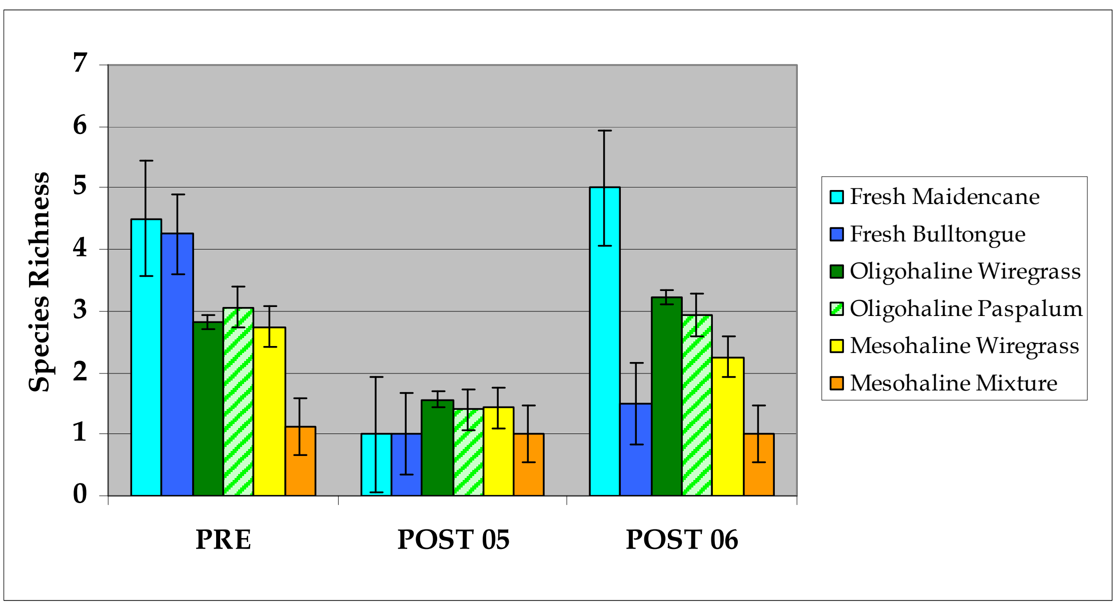

Figure 6. Species Richness by Visser Vegetation Type. LS Mean ± SE, n=163 stations, $F_{17, 488}$=10.9, p<0.0001.

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Visser, J. M., R. H. Chabreck, and R. G. Linscombe. 2000. Marsh vegetation types of the Chenier Plain, Louisiana, USA. Estuaries 23(3) 318-327.

Appendix B
(Inspection Photographs)

Photo 1, Structure No. 6, view looking southeast.

Photo 2, Structure No. 6, showing outlet pipes.

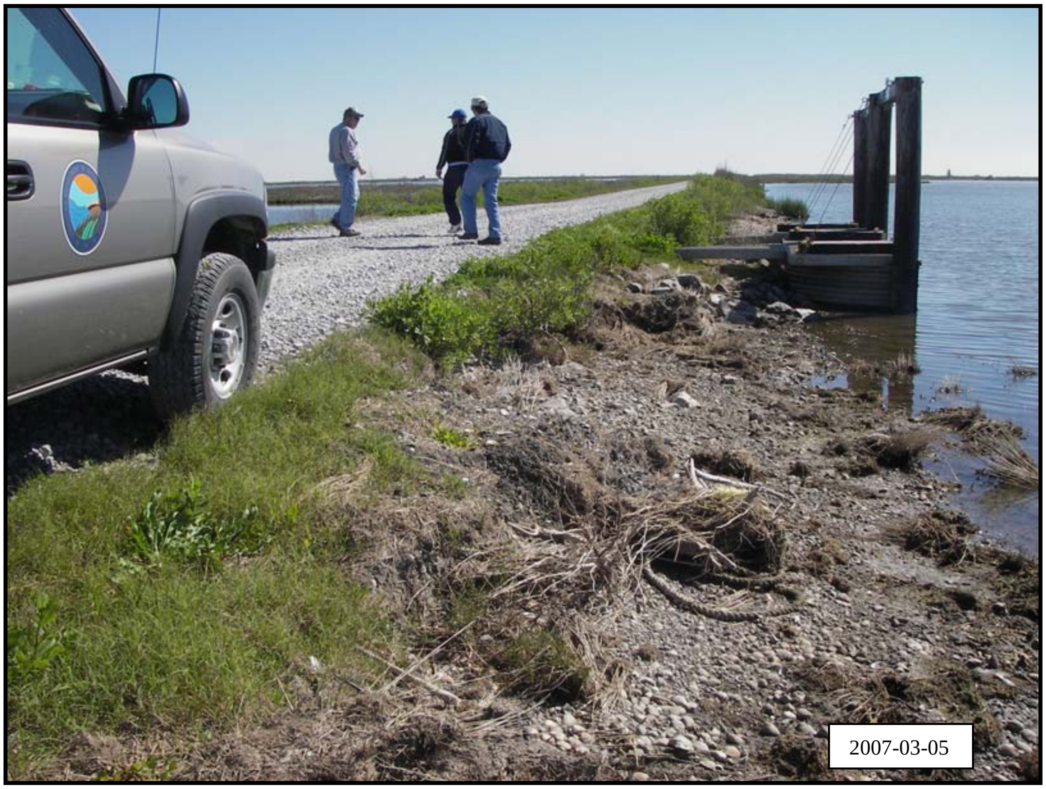

Photo 3, Structure No. 7, view looking east and showing bank line erosion.

Photo 4, Structure No. 7, outlet pipe location; however, pipes not visible.

Photo 5, Structure No. 8, view looking southwest, showing bank line erosion.

Photo 6, Structure No. 9a & 9b, view looking south.

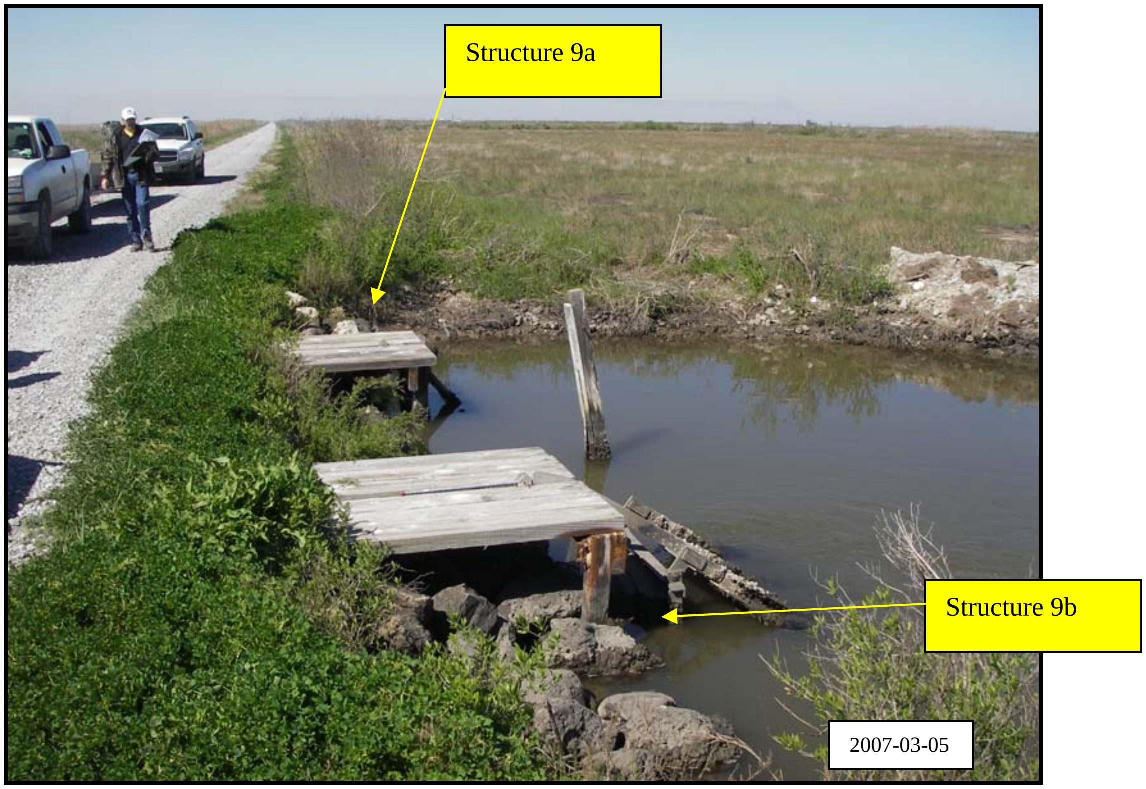

Photo 7, Structure No. 9a & 9b, showing outlet pipe flap gates.

Photo 8, Structure No. 9b, showing corrosion on gear box & missing stem cover.

Photo 9, Structure No. 11, view showing erosion either side of structure.

Photo 10, Structure No. 11, outlet pipe and flap gate.

Photo 11, Structure No. 5, showing erosion either side of structure.

Photo 12, Structure No. 5, showing outlet pipe and flap gate with missing boardwalk.

Photo 13, Structure No. 4, view looking south.

Photo 14, Structure No. 3, showing erosion and missing boardwalk.

Photo 15, Structure No. 3, showing outlet pipe and flap gate.

Photo 16, Structure No. 1, showing missing grating and erosion around structure.

Photo 17, Structure No. 1, showing outlet pipe flap gate and erosion around structure.

Photo 18, Structure No. 17, view looking north.

Photo 19, Structure No. 13, view looking west.

Photo 20, Structure No. 13, showing corrosion on sheet pile cap.

Photo 21, North Levee, looking east, showing washout of top portion of levee.

Photo 22, Step Canal, view looking west, showing marsh/siltation and other debris in the canal.

Appendix C
(Three Year Budget Projection)
E. MUD LAKE/ CS-20 / PPL 2
Three-Year Operations & Maintenance Budgets 07/01/2007 - 06/30/10

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Pat Landry	*Pat Landry*	*NRCS*	*Pat Landry*

	2007/2008	2008/2009	2009/2010
Maintenance Inspection	$ 5,962.00	$ 6,106.00	$ 6,240.00
Structure Operation	$ 6,500.00	$ 6,500.00	$ 6,500.00
Administration	$ 10,000.00		$ -

Maintenance/Rehabilitation

07/08 Description: Maintenance Work on Structures/Replace Structure No. 4/Repair of Hurricane Rita Damages

E&D	$ 9,972.00
Construction	$ 1,454,751.00
Construction Oversight	$ 60,845.00
Sub Total - Maint. And Rehab.	$ 1,525,568.00

08/09 Description:

E&D	
Construction	
Construction Oversight	
Sub Total - Maint. And Rehab.	$ -

09/10 Description:

E&D	$ -
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

	2007/2008	2008/2009	2009/2010
Total O&M Budgets	**$ 1,548,030.00**	**$ 12,606.00**	**$ 12,740.00**

O &M Budget (3 yr Total)	**$ 1,573,376.00**
Unexpended O & M Budget	**$ 932,545.00**
Remaining O & M Budget (Projected)	**$ (640,831.00)**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

E. MUD LAKE / PROJECT NO. CS-20 / PPL NO. 2

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$5,962.00	**$5,962.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$9,972.00	**$9,972.00**
Operations Contract	LUMP	1	$6,500.00	**$6,500.00**
Construction Oversight	LUMP	1	$60,845.00	**$60,845.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	1	$5,000.00	$5,000.00
FEDERAL SPONSOR Admin.	LUMP	1	$5,000.00	$5,000.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$10,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:

Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	10	$1,500.00	$15,000.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$15,000.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:

Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION: Maintenance work on structures, replace Structure No. 4, repair Hurricane RITA damages, clean out Step Canal.

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
Rock Armor at 1, 3, 5, 11	0	0.0	1,363	$145.00	$197,635.00
Rock Armor at 6, 7, 8	0	0.0	246	$71.00	$17,466.00
	0	0.0	0	$0.00	$0.00

Filter Cloth / Geogrid Fabric	SQ YD	0	$0.00	$0.00
Navigation Aid	EACH	0	$0.00	$0.00
Signage	EACH	0	$0.00	$0.00
General Excavation / Fill	CU YD	0	$0.00	$0.00
Dredging	CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)		0	$0.00	$0.00
Timber Piles (each or lump sum)		0	$0.00	$0.00
Timber Members (each or lump sum)		0	$0.00	$0.00
Hardware	LUMP	1	$0.00	$0.00
Materials	LUMP	1	$0.00	$0.00
Mob / Demob	LUMP	1	$130,000.00	$130,000.00
Contingency	LUMP	1	$101,050.00	$101,050.00
General Structure Maintenance	LUMP	1	$242,000.00	$242,000.00
Replace Structure No. 4	LUMP	1	$636,880.00	$636,880.00
Levee Repair	CU YD	19,120	$6.00	$114,720.00
Clean Wrack & Debris	LUMP	0	$0.00	$0.00
			TOTAL CONSTRUCTION COSTS:	**$1,439,751.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$1,548,030.00**

OPERATION AND MAINTENANCE BUDGET 07/01/2008-06/30/2009

E. MUD LAKE/CS-20/PPL2

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$5,570.00	**$5,570.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$0.00	**$0.00**
Operations Contract	LUMP	1	$6,500.00	**$6,500.00**
Construction Oversight	LUMP	1	$0.00	**$0.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
	Secondary Monument	EACH	0	$0.00	$0.00
	Staff Gauge / Recorders	EACH	0	$0.00	$0.00
	Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
	TBM Installation	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
	Borings	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:						
	Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
	Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
	Navagation Aid		EACH	0	$0.00	$0.00
	Signage		EACH	0	$0.00	$0.00
	General Excavation / Fill		CU YD	0	$0.00	$0.00
	Dredging		CU YD	0	$0.00	$0.00
	Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
	Timber Piles (each or lump sum)			0	$0.00	$0.00
	Timber Members (each or lump sum)			0	$0.00	$0.00
	Hardware		LUMP	1	$0.00	$0.00
	Materials		LUMP	1	$0.00	$0.00
	Mob / Demob		LUMP	1	$0.00	$0.00
	Contingency		LUMP	1	$0.00	$0.00
	General Structure Maintenance		LUMP	1	$0.00	$0.00
	OTHER				$0.00	$0.00
	OTHER				$0.00	$0.00
	OTHER				$0.00	$0.00
					TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: $12,070.00

OPERATION AND MAINTENANCE BUDGET 07/01/2009-06/30/2010

E. MUD LAKE/CS-20/PPL2

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$5,737.00	**$5,737.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$0.00	**$0.00**
Operations Contract	LUMP	1	$6,500.00	**$6,500.00**
Construction Oversight	LUMP	1	$0.00	**$0.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	1	$0.00	$0.00
FEDERAL SPONSER Admin.	LUMP	1	$0.00	$0.00
SURVEY Admin.	LUMP	1	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:

Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:

Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navagation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	1	$0.00	$0.00
Materials		LUMP	1	$0.00	$0.00
Mob / Demob		LUMP	1	$0.00	$0.00
Contingency		LUMP	1	$0.00	$0.00
General Structure Maintenance		LUMP	1	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$12,237.00**

Appendix D
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Date of Inspection: 03/05/2007 Time: 12:15pm

Structure No. 1

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin, Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Structure Description: Culvert w/stop logs and Flap

Water Level Inside: Outside:

Type of Inspection: Annual

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Fair			16	Replace all sections of grating that are missing.
Stop Logs	Good				
Hardware	Poor		Yes	16	Corrosion on padlocks, need to be replaced.
Timber Piles	Good				
Timber Walkway	Poor			17	Need to extend walkway.
Timber Wales	Good				
Galv. Pile Caps	Poor		Yes	16	Need to be replaced.
Cables	Good				
Signage /Supports	Good				
Staff Gages	Poor				Need to replace staff gages inside and out.
Rip Rap (fill)	N/A				
Earthen Embankment	Poor			16,17	Rock armor needed both sides of structure.

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism? Yes

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:CS-20 E. Mud Lake

Structure No. 3:

Structure Description: Culvert w/stoplogs and Flapgate

Type of Inspection: Annual

Date of Inspection: 03/05/2007 Time: 12:00pm

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard
David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin,
Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Water Level Inside: Outside:

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Stop Logs	Good				
Hardware	Poor		Yes	14	Corrosion on padlocks, need to be replaced.
Timber Piles/ Walkway	Poor			15	Walkways on the inside and outside of the structure are missing.
Timber Wales	Good				
Galv. Pile Caps	Poor		Yes	14	Need to be replaced.
Cables	Good				
Signage /Supports	Fair				
Staff Gages	Poor				Replace staff gage on inside and outside of the structure.
Rip Rap (fill)	N/A				
Earthen Embankment	Fair	Yes		14,15	Rock armor needed both sides of structure
Channel	Poor			14	Inlet side of the structure is silted up with marsh debris.

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Date of Inspection: 03/05/2007 Time: 11:50am

Structure No. 4:

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard
David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin,
Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Structure Description: Culverts w/stoplogs and Flapgate

Water Level Inside: Outside:

Type of Inspection: Annual

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A			13	**GENERAL NOTE**: Due to severe settlement of the overall structure, it is beyond repair and needs to be abandoned in place, and a new structure built along side.
Steel Grating	Poor				
Stop Logs	Fair				
Hardware	Fair				
Timber Piles	Poor				
Timber Wales	Poor				
Galv. Pile Caps	Good				
Cables	N/A				
Signage /Supports	Good				
Rip Rap (fill)	Fair				
Earthen Embankment	Fair	Yes			

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Date of Inspection: 03/05/2007 Time: 11:40am

Structure No. 5

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard
David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin,
Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Structure Description: Culvert w/stoplog and Flapgate

Water Level Inside: Outside:

Type of Inspection: Annual

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Stop Logs	Good				
Hardware	Poor		Yes	11	Corrosion on padlocks, need to be replaced.
Timber Piles	Good				
Timber Walkway	Poor			12	Replace missing boardwalk.
Timber Wales	Good				
Galv. Pile Caps	Poor		Yes	11	Need to be replaced.
Cables	Good				
Signage /Supports	Good				
Staff Gages	Poor				Staff gages inside and outside of the structure are damaged and not readable.
Rip Rap (fill)	N/A				
Earthen Embankment	Fair	Yes		11,12	Rock armor needed on both sides of structure.

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Structure No. 6

Structure Description: Culvert w/stoplog and Flapgate

Type of Inspection: Annual

Date of Inspection: 03/05/2007 Time: 10:30am

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin, Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Water Level Inside: Outside:

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Stop Logs	Good				
Hardware	Poor		Yes	1	Corrosion on padlocks, need to be replaced.
Timber Piles	Good				
Timber Wales	Good				
Galv. Pile Caps	Poor		Yes	1	Need to be replaced.
Cables	Good				
Signage /Supports	Fair				**General Note:** There are no staff gages at this structure.
Outlet Pipes	Fair			2	The ends of both outlet pipes are clogged with marsh debris.
Earthen Embankment	Fair			1	Rock armor needed on bank line adjacent to inlet structure.

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Structure No. 7

Structure Description: Culvert w/stoplog and Flapgate

Type of Inspection: Annual

Date of Inspection: 03/05/2007 Time: 10:40am

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin, Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Water Level Inside: Outside:

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Stop Logs	Good				
Hardware	Poor		Yes	3	Corrosion on padlocks, need to be replaced.
Timber Piles	Good				
Timber Wales	Good				
Galv. Pile Caps	Poor		Yes	3	Need to be replaced.
Cables	Good				
Signage /Supports	Good				
Satff Gages	Poor				Need to replace staff gages both inside and outside.
Inlet/Outlet Pipe	Fair			4	Inlet and outlet pipes are clogged with marsh debris.
Earthen Embankment	Fair			3	Rock armor needed on bank line adjacent to inlet structure.

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Date of Inspection: 03/05/2007 Time: 10:50am

Structure No. 8

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin, Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Structure Description: Culvert w/stoplog and Flapgate

Water Level Inside: Outside:

Type of Inspection: Annual

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Stop Logs	Good				
Hardware	Poor		Yes	5	Corrosion on padlocks, need to be replaced.
Timber Piles	Good				
Timber Wales	Good				
Galv. Pile Caps	Poor		Yes	5	Need to be replaced.
Cables	Good				
Signage /Supports	Good				
Staff Gages					Note: There are no staff gages inside and outside of this structure.
Inlet/Outlet Pipe	Fair				
Earthen Embankment	Fair			5	Rock armor needed along bank line adjacent to inlet structure.

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Structure No. 9A & 9B

Structure Description: Culvert w/stoplog and Flap, Sluice Gate with Flap

Type of Inspection: Annual

Date of Inspection: 03/05/2007 Time: 11:00am

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin, Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Water Level Inside: Outside:

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Stop Logs	Good				
Hardware	Fair		Yes	6,7,8	Corrosion on padlocks, handles on outlet pipe flap gates are broken.
Sluice Gate	Poor		Yes	8	Gear box corroded and needs to be replaced, stem cover missing, needs to be replaced.
Timber Piles	Good				
Timber Wales	Good				
Galv. Pile Caps	Poor		Yes	6	Need to be replaced.
Cables	Good				
Signage /Supports	Good				
Staff Gages	Poor			6,7	Replace staff gages inside and out.
Rip Rap (fill)	Good				
Earthen Embankment	Good				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:CS-20 E. Mud Lake

Date of Inspection: 03/05/2007 Time: 11:30am

Structure No. 11

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard
David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin,
Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Structure Description: Culvert w/stoplog and Flapgate

Water Level Inside: Outside:

Type of Inspection: Annual

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Stop Logs	Good				
Hardware	Poor		Yes	9	Corrosion on padlocks, need to be replaced.
Timber Piles	Good				
Timber Walkway	Poor			10	Wooden boardwalk needs to be extended.
Timber Wales	Good				
Galv. Pile Caps	Good				
Cables	Good				
Signage /Supports	Fair				
Staff Gages	Poor			9,10	Replace staff gages inside and out.
Rip Rap (fill)	N/A				
Earthen Embankment	Fair	Yes		9,10	Rock armor needed on both sides of the structure.

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Date of Inspection: 03/05/2007 Time: 1:30pm

Structure No. 13

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin, Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Structure Description: VCW with Flap

Water Level Inside: Outside:

Type of Inspection: Annual

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	Poor		Yes	19,20	Some rusting of pile cap is present, needs to be replaced.
Steel Grating	Good				
Stop Logs	Good				
Hardware	Poor		Yes	19	Padlocks corroded, need to be replaced.
Timber Piles	Good				
Timber Wales	Good				
Galv. Pile Caps	Poor			19	Need to be replaced.
Cables					
Signage /Supports	Poor			19	Warning sign is missing, needs to be replaced.
Staff Gage	Poor			19	Staff gages need to be replaced inside and out.
Rip Rap (fill)	N/A				
Earthen Embankment	Good				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-20 E. Mud Lake

Date of Inspection: 03/05/2007 Time: 12:30pm

Structure No. 17

Inspector(s):Stan Aucoin, Pat Landry, Darrell Pontiff, Garrett Broussard David Castellanos, Scott Rosteet, Steve Gonzales, Dirk Paulin, Lonnie Harper, Chris Fountain, Rick Hartman, Dale Garber

Structure Description: VCW with Boat Bay

Water Level Inside: Outside:

Type of Inspection: Annual

Weather Conditions: Sunny and Cool

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	Poor		Yes	18	Steel sheet pile and cap show signs of corrosion. Pile cap needs to be replaced.
Steel Grating	Good				
Stop Logs	Fair			18	The locking tabs on the stop log slots are missing.
Hardware	Poor		Yes	18	Padlocks corroded and need to be replaced.
Timber Piles	Good				
Timber Wales	Good				
Galv. Pile Caps	Poor			18	Need to be replaced.
Cables	Good				
Signage /Supports	Poor			18	Warning sign is missing.
Staff Gages	Poor			18	Staff gage needs to be replaced.
Rip Rap (fill)	N/A				
Earthen Embankment	Good				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?