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

# 2007 Operations, Maintenance and Monitoring Report

for

# FRITCHIE MARSH RESTORATION

State Project Number PO-06
Priority Project List 2

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St. Tammany Parish

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for
Fritchie Marsh Restoration (PO-06)

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## Preface

The 2007 Operations, Maintenance and Monitoring (OM&M) Report format is a streamlined approach which combines the Operations and Maintenance annual project inspection information with the Monitoring data and analyses on a project-specific basis. This format includes monitoring data collected through December 2006, and annual Maintenance Inspections through May 2007.

## I. Introduction

The Fritchie Marsh Restoration project area contains 6,291 acres (2,546 hectares) of intermediate and brackish marsh located southeast of Slidell in St. Tammany Parish (Figure 1). The area is bound by U.S. Highway (Hwy) 190 to the north, U.S. Hwy 90 to the south and east, and Louisiana Highway (La. Hwy) 433 to the west and south.

From 1956 to 1984, 2,260 ac (915 ha) of emergent marsh within the project area have been converted to open water, with the greatest loss occurring in the northern project area. This loss reflects a pattern of marsh deterioration from north to south due to a reduction of freshwater and sediment input into the northern part of the project area. Natural hydrologic patterns have been disrupted by the construction of the perimeter highways. These embankments isolate the marsh from the West Pearl River and have restricted inflow of freshwater, nutrients, and sediment. Additionally, saltwater from Lake Pontchartrain enters the marsh through the W-14 canal and Little Lagoon during high tides and strong winds. As a result, the project area has converted from a predominantly fresh marsh in 1956 to a predominantly brackish marsh in 1990.

The objective of the Fritchie Marsh Restoration project is to reduce marsh loss by restoring more natural hydrologic conditions in the project area through management of available freshwater. Specific objectives are (1) to increase freshwater flow and promote water exchange into the area from West Pearl River by enlarging the culvert at U.S. Hwy 90 and by dredging portions of Salt Bayou and (2) to increase freshwater flow into the northern project area by diverting flow from the W-14 canal. The Fritchie Marsh Restoration project was constructed in one phase beginning in October 2000 and completed in March 2001. The project has a 20-year economic life which began in March 2001.

The principal project features include:

- Installation (jack and bore) of a 72-inch diameter by 136-foot long concrete culvert under U.S. Hwy 90, rock riprap lining of the Salt Bayou channel bottom and pipe outlets, and installation of 308 linear feet of sheet piling to form a bulkhead.
- Installation of a weir in the W-14 canal. The weir consists of 108 linear feet of sheet pile with a 20-foot wide boat bay.
- Dredging of approximately 400 linear feet of the W-14 diversion channel and 5300 linear feet of the Salt Bayou channel.


**Figure 1.** Fritchie Marsh Restoration (PO-06) project boundary, construction features, continuous recorder and staff gauge locations, and water flow monitoring locations.

## II. Maintenance Activity

### a. Project Feature Inspection Procedures

An inspection of the Fritchie Marsh Restoration (PO-06) project was held on March 26, 2007, by Barry Richard and Peter Hopkins of Louisiana Department of Natural Resources (LDNR) and Warren Blanchard of the Natural Resources Conservation Service (NRCS). The purpose of this annual inspection was to evaluate the constructed project features, to identify any deficiencies, and to prepare a report detailing the condition of project features and recommended corrective actions needed. The field inspection included a complete visual inspection of the entire project site from both land and water.

### b. Inspection Results

**Hwy 90 Culvert and Stone Revetment**

There is no change in this structure from the previous inspection. The bank scour reported in previous inspection reports is still of concern (Photo #1). If this bank were to completely breach, the hydrologic exchange between the marsh and Salt Bayou would be altered. Tracked vehicles appear to be using this route to access the marsh. Scour is also evident on the south bank just east of the culverts (Photo #2).

**Salt Bayou Dredging**

During the inspection, it was noted that a considerable portion of Salt Bayou is now inaccessible to conventional vessels due to the large amount of sediment that was deposited into the bayou during Hurricane Katrina. Several locations along the bayou are blocked by large sections of sheared marsh, which greatly reduce the flow of water. The spoil bank is being degraded by repeated airboat transit between the bayou and marsh in one location.

**W-14 Weir**

This structure sustained no visible damage due to Hurricane Katrina.

**W-14 Diversion Channel Dredging**

There were no visible signs of damage or siltation of the dredged channel.

### c. Maintenance Recommendations

#### i. Immediate/ Emergency Repairs

- No immediate repairs are suggested.

#### ii. Programmatic/ Routine Repairs

- Dredging of Salt Bayou and repair of the scour at Hwy 90 are recommended.

**Photo #1 –Salt Bayou Scour.** Facing the north bank of Salt Bayou inside the project area from the Hwy 90 culverts. Note the large section of bank which has been scoured out.

**Photo #2 – Salt Bayou Scour.** Facing the south bank of Salt Bayou inside the project area from the Hwy 90 culverts. Note the erosion of the far bank.

## III. Operation Activity

### a. Operation Plan

This project requires no operations activity, therefore no operation plan has been generated.

### b. Actual Operations

This project requires no operations activity, therefore no structure operations have been conducted.

## IV. Monitoring Activity

This is a comprehensive report and includes all data collected from the pre-construction period and the post-construction period through December 2006.

### a. Monitoring Goals

The objective of the Fritchie Marsh Restoration project is to restore more natural hydrologic conditions in the project area resulting in the protection of the existing marsh.

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

1. Decrease rate of marsh loss.
2. Increase freshwater flow and promote water exchange into the area from West Pearl River by enlarging the culvert at U.S. Hwy 90 and by dredging portions of Salt Bayou.
3. Increase freshwater flow into the northern project area by diverting flow from the W-14 canal.
4. Document species composition and relative abundance of vegetation to evaluate change over time.

### b. Monitoring Elements

**Photography**

Color-infrared aerial photography (1:12,000 scale) has been obtained of the project area and reference area. Pre-construction photography was obtained in 1996 and 2000. Post-construction photography was obtained in 2004, and will be obtained again in 2010 and 2019. Aerial photography flights will always be carried out at low water conditions. The acquired photography has been geo-rectified, photo-interpreted, mapped, and analyzed with GIS using standard operating procedures documented in Steyer et al. (1995, revised 2000). Although the original monitoring plan stated that habitat analyses would be conducted, these were changed to land/water analyses upon the implementation of the Coastwide Reference Monitoring System (CRMS) in 2003. The implementation plan for CRMS included a review of monitoring efforts on currently constructed Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) projects, which concluded that habitat analyses on these projects should be converted to land/water analyses.

**Salinity**

To monitor the effects of increased flow of freshwater into the project area at the Salt Bayou culvert, salinity has been recorded hourly at four permanent stations. Three continuous recorders were placed in Salt Bayou and one was placed in the marsh near the diversion of the W-14 canal to monitor hydrologic conditions pre-construction and post-construction. Salinity was monitored during the pre-construction period, from 1997 to 2000, and during the post-construction period, from 2001 to mid 2005.

**Water Level**

To monitor the effects of increased flow of fresh water into the project area at the Salt Bayou culvert and its effects on the marsh, water level was recorded hourly at four permanent stations. Water level was monitored during the pre-construction period from 1997 to 2000 and during the post-construction period from 2001 to mid 2005.

**Water Flow**

To monitor the increased flow of water into the project area at the Salt Bayou culvert and at the diversion at the W-14 canal, water flow was measured near the same locations where continuous recorders were present. Current meters were deployed and cross-sectional channel transects were conducted to characterize the vertical and horizontal flow structure and to calculate the instantaneous volume flux through the channel. The meters were deployed for a one year period prior to construction and for the same duration after construction.

**Vegetation**

Species composition and relative abundance of vegetation were documented in 1997 and 2000 (pre-construction) and in 2004 (post-construction). Vegetation surveys will be conducted again in 2007, 2010, 2013, 2016, and 2019. The Braun-Blanquet method is being used to survey vegetation in 29 randomly selected 4-$m^2$ plots. Information on herbivory and submerged aquatic vegetation (SAV) occurrence will be recorded during the surveying of the vegetation stations.

### c. Preliminary Monitoring Results and Discussion

**Land/Water Analysis**

The 1996, 2000, and 2004 land/water analyses are shown in Figures 2, 3, and 4. The results are summarized in Table 1.

| Year | Project Acres | | Reference Acres | |
|---|---|---|---|---|
| | Land | Water | Land | Water |
| 1996 | 4,096 | 2,196 | 295 | 122 |
| 2000 | 3,970 | 2,322 | 289 | 128 |
| 2004 | 3,983 | 2,309 | 285 | 132 |

Table 1. Land/water analysis results for the Fritchie Marsh Restoration (PO-06) project area and reference area for the years 1996, 2000, and 2004.

According to the land/water analysis, the project area experienced a loss of 126 acres of land between 1996 and 2000, approximately 3% of the total 1996 land area. However, between 2000 and 2004 the acreage of land within the project area remained relatively stable and actually showed a gain of 13 acres. The reference area showed a loss of 6 acres of land between 1996 and 2000. Although this loss seems small by comparison, it represents about 2% of the land within the 1996 reference area, which is proportionally similar to the loss seen in the project area. The reference area lost another 4 acres of land between 2000 and 2004, indicating the rate of land loss within the reference area was very slow to nearly stable during that period.

Field observations made within the project area after Hurricane Katrina in 2005 indicated significant land loss within the project area. In order to determine the effects of Hurricane Katrina, a separate analysis was conducted using 2004 and 2005 Landsat 5 satellite imagery (Figure 5). This analysis showed a loss of 1,037 acres of land between 2004 and 2005, or approximately 22.5% of the pre-storm acreage. The imagery shows that a significant portion of the land loss occurred within the northeastern quadrant of the project area, which contained the most fragmented marsh before the storm. It should be noted that the land/water acreages obtained from the satellite analysis can not be directly compared to the aerial photography analysis due to differences in resolution and processing methods. The next aerial photography analysis to be conducted in 2010 will indicate whether deterioration of the marsh will continue to occur following this extreme land loss event.

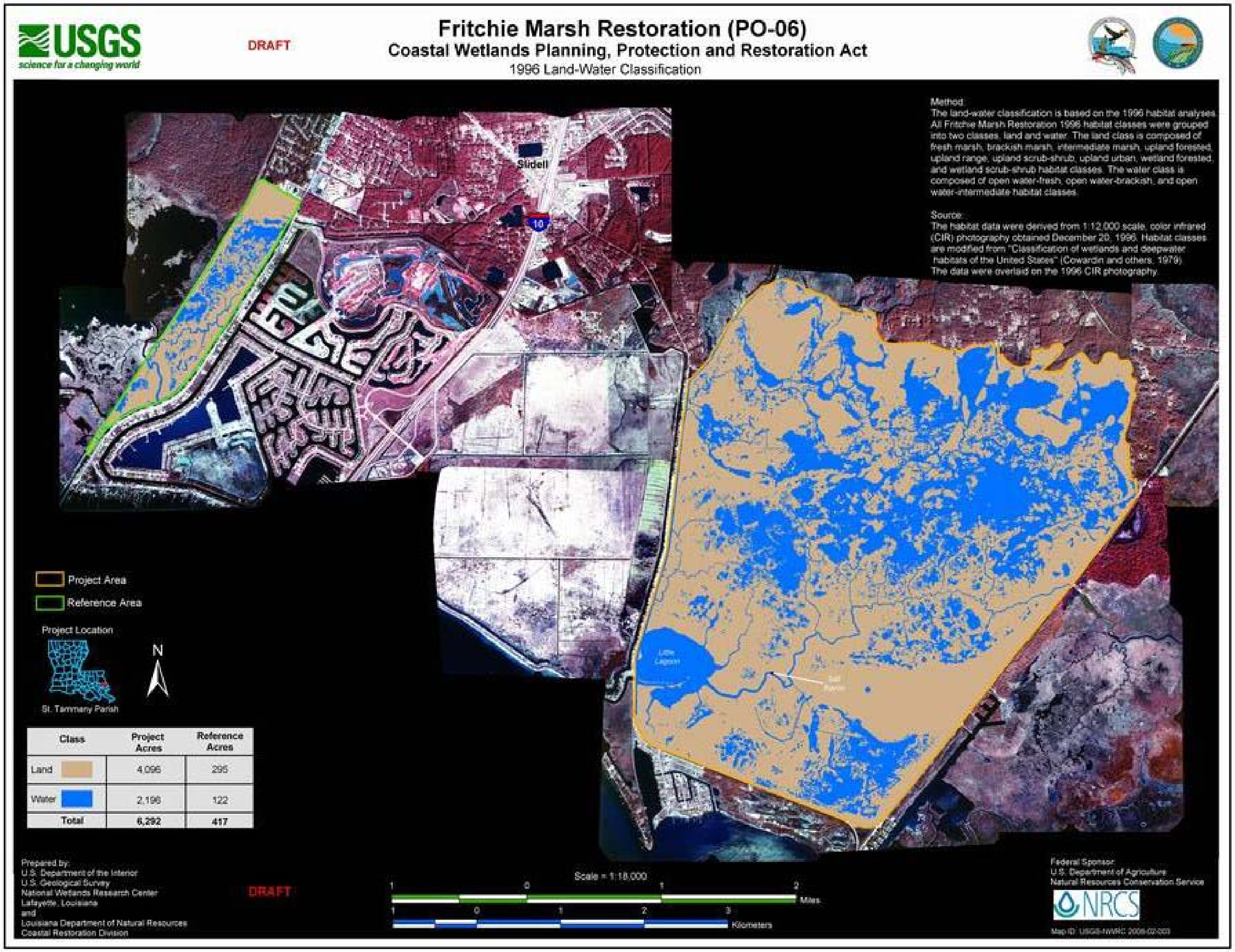


**Figure 2.** 1996 land/water analysis of the Fritchie Marsh Restoration (PO-06) project area.

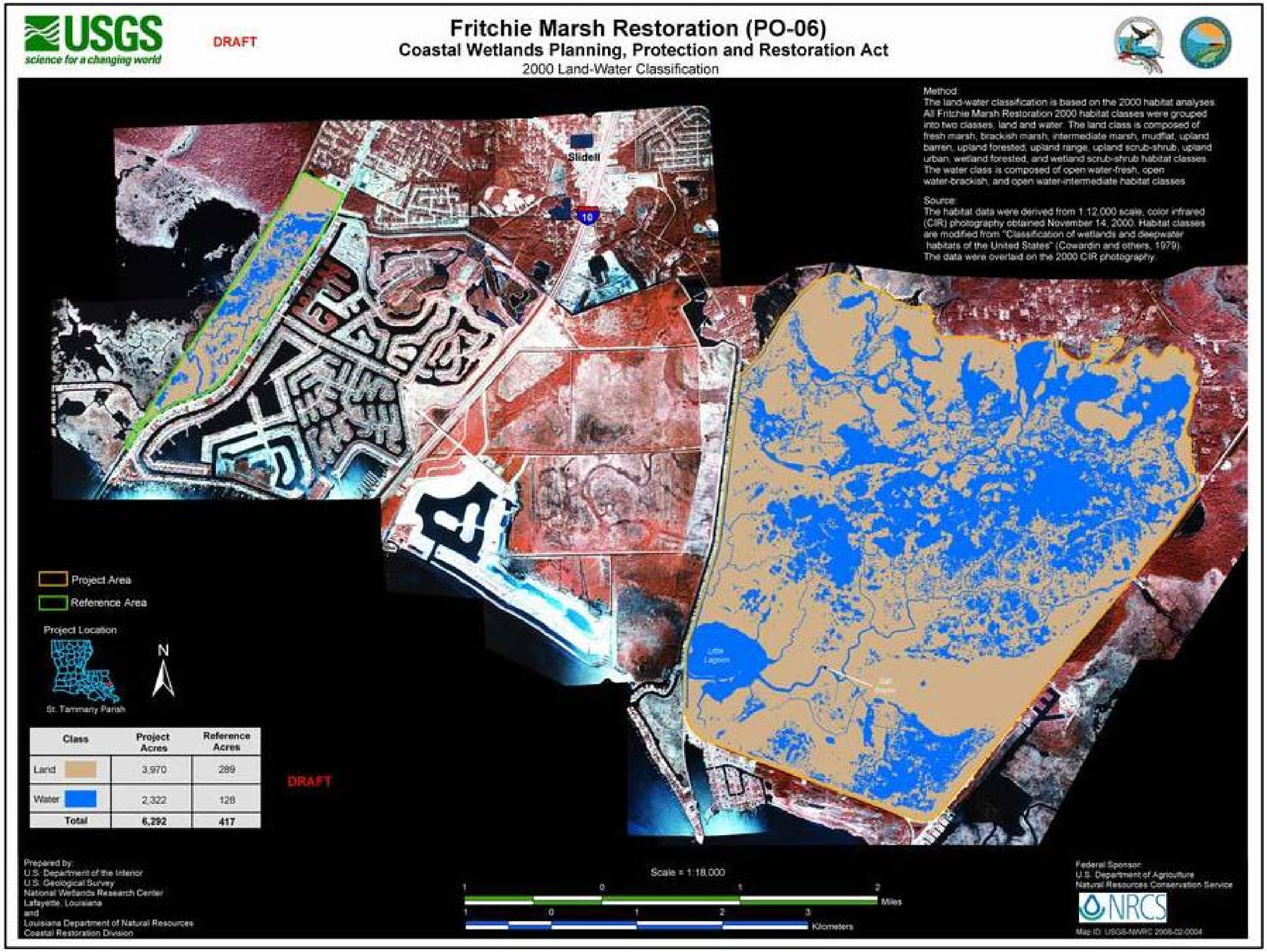


**Figure 3.** 2000 land/water analysis of the Fritchie Marsh Restoration (PO-06) project area.

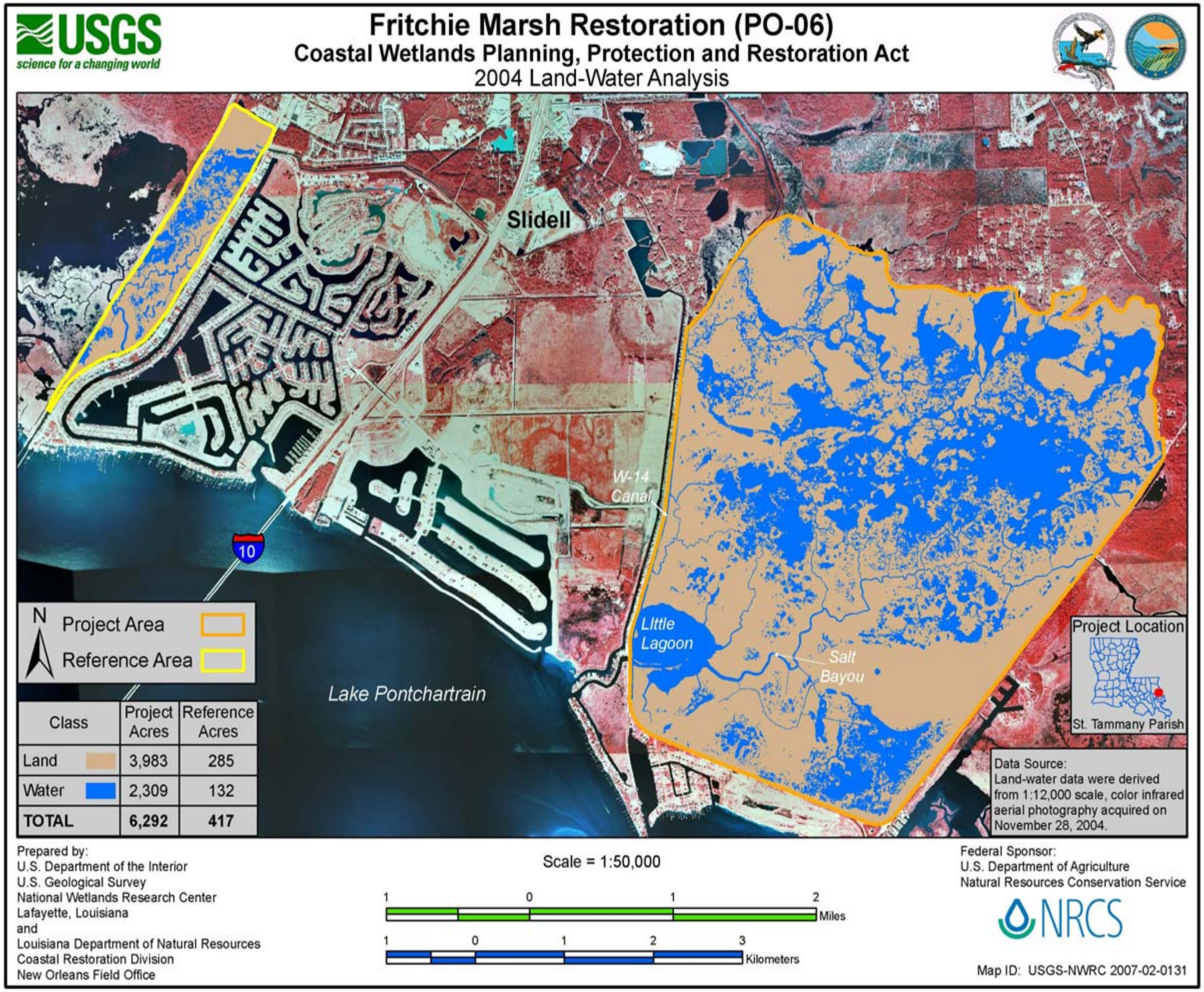


**Figure 4.** 2004 land/water analysis of the Fritchie Marsh Restoration (PO-06) project area.

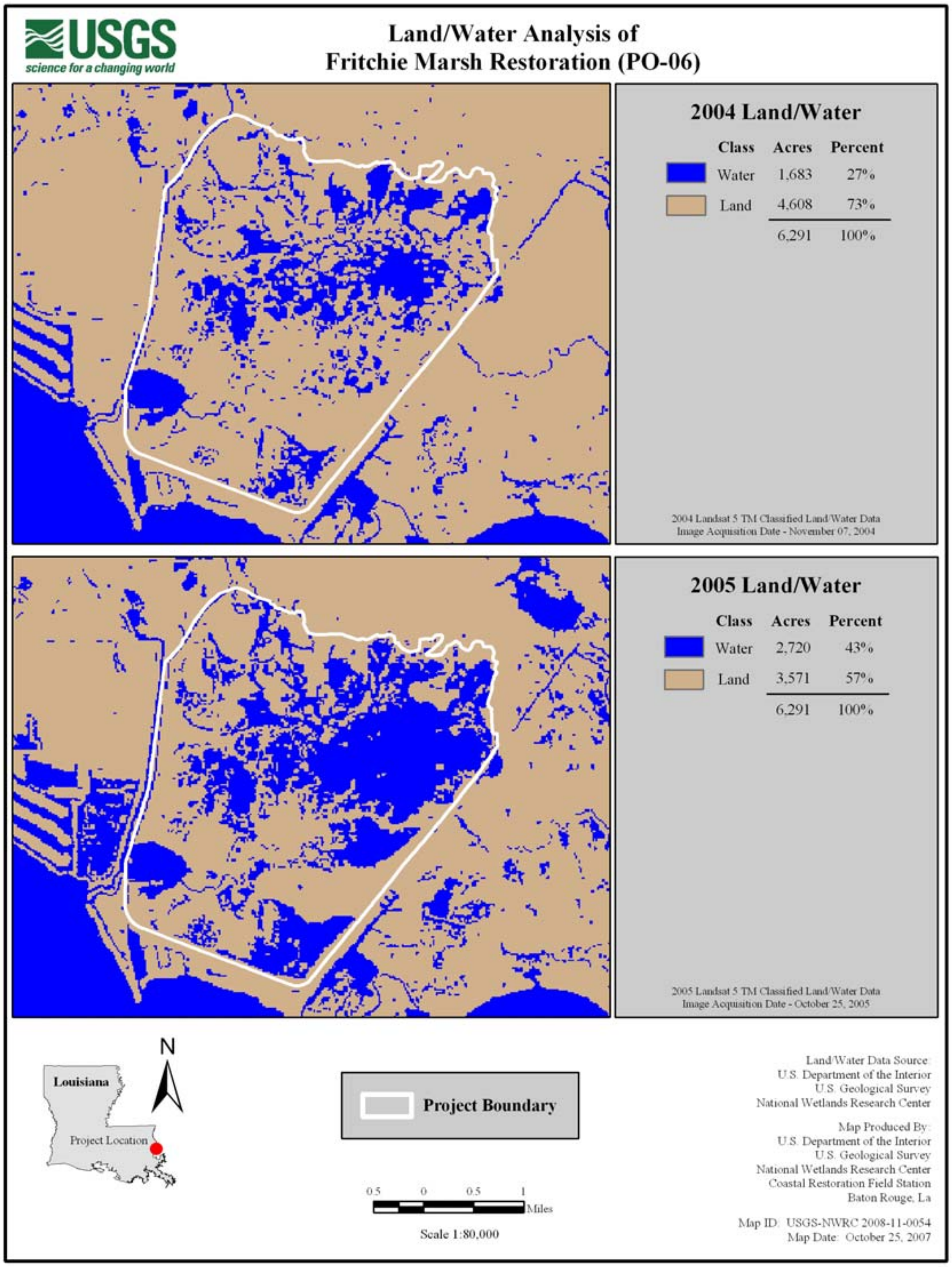


**Figure 5**. 2004 and 2005 land/water comparison of the Fritchie Marsh Restoration (PO-06) project area using Landsat 5 satellite imagery. The 2005 imagery was acquired two months after the passage of Hurricane Katrina.

**Salinity and Water Level**

Hourly salinity and water level data have been collected at the following continuous recorder stations (Figure 1):

| Station | Data Collection Period |
|---|---|
| PO06-01 | 2/6/1996 – present |
| PO06-03* | 6/10/1997 – 3/18/1999 |
| PO06-06 | 6/10/1997 – present |
| PO06-11 | 6/10/1997 – present |
| PO06-60* | 3/18/1999 – present |

*The continuous recorder at PO06-03 was removed because the water level dropped below the sonde sensor during normal low-water periods. The replacement station, PO06-60, was installed in deeper water closer to the Hwy 90 culvert.

Discrete staff gauge readings have also been recorded each month since March 1998 at the four continuous recorder stations and at two additional staff gauge locations.

Continuous salinity and water level data were analyzed using a 2 X 4 factorial analysis of variance (ANOVA) in which an interaction between the main effects is tested for statistical significance. The main effects were defined as *period* (pre-construction vs. post-construction) and *location* (station ID). These are applications of the BACI paired series designs discussed in Stewart-Oaten et al. 1986, Underwood 1994, and Smith 2002. A standard BACI analysis uses a 2 X 2 factorial treatment structure, with the individual stations representing spatial replication within the two levels of the Control-Impact (CI) treatment (i.e., reference area and project area). However, this project was designed without reference stations, so the four stations were compared with each other using *location* as a random effect and with no single station designated purely as a reference station. The only additional assumption needed is that if the project had an impact it would apply unevenly among the four stations. Hydrological conditions in the project area support this assumption. The design matches the one described in Table 1.b of Underwood (1994) with the difference that no sub-sampling takes place, so the residual error term is the *T(B)*L* interaction.

The statistical model depends on simultaneity of measurements among the various stations, treating each week in the study as a temporal block. For this reason, hourly salinity and water level measurements were aggregated into weekly means, with one week being sufficient to average out temporal lags among the stations during tidal and meteorological events. Another advantage to using weekly means is that they exhibit less serial correlation than hourly means; sample independence is an important underlying assumption of the statistical model. Hourly salinity measurements were transformed into common logarithms in order to better approximate the assumptions of normal distribution and uniform variance. These log salinities were then aggregated into weekly means on which the statistics are based.

The data show that the mean weekly salinity was lower and water level was higher at all four continuous recorder stations during the post-construction period (Figures 6 and 7). Salinity and water level are shown in Figures 8 and 9 as a time series of quarterly means. These data showed a significant interaction ($p<0.0001$) between stations in both the salinity and water level analyses. The significant *period* by *location* interaction indicates that the relative magnitude of changes in salinity and water level was different between stations, indicating a project effect. These effects show up graphically as lines out of parallel in Figures 10 and 11.

Interpretation of these results is complicated by a record-setting drought from September 1999 to December 2000, which led to increased salinity during some of the pre-construction period (Figure 8). The statistical design controls against this kind of nuisance fluctuation only under the assumption that the four sites would respond equally to the drought. In order to test this assumption, the analysis was repeated with the drought period removed. The *period* by *location* interaction was again found to be significant ($p < 0.0001$) indicating that there was a significant project effect despite the occurrence of the drought.

Another complication is that the analysis may have created an interaction purely as an artifact of the low pre-construction salinity at Station 60, which is located near the 72-inch culvert (Figure 10). Testing the *period* by *location* interaction allows inference as to whether the post-construction drop in salinity at all of the stations may be attributed to project construction and not to a general downward fluctuation over the 10-year monitoring period. While the other stations all decreased in salinity by three to four parts per thousand, Station 60 began with a mean pre-construction salinity already at two parts per thousand and therefore lacked the range necessary to match this trend. Although the log transformation compensates for this, the analysis was repeated on the drought-deleted data with Station 60 removed to test whether the significant interaction was an artifact of the low salinity at Station 60. Again, the *period* by *location* interaction was significant ($p < 0.0001$), indicating a project effect at the remaining stations. Station 11, which is located near the W-14 weir, experienced a greater drop in salinity (i.e., steeper slope) than Stations 01 and 06. This indicates that the weir may be having a positive affect on the salinity in the area near Station 11. The decrease in salinity was very similar at Stations 01 and 06, which indicates that the salinity at these stations is being affected by the project almost equally.

The interaction of mean water level between stations shows strong evidence of a project effect at Station 60 (Figure 11). Mean water level at this station was effectively doubled in the post-construction period. The magnitude of water level change was much greater at this station than at the other three stations, indicating that the addition of the culvert had a significant effect on water level. In contrast, the interaction results indicate that the W-14 weir has had comparatively less impact on water levels in the project area. Station 11, which is located near the weir, experienced an increase in water level very similar to that of Station 01. Station 06 experienced a slightly greater increase in water level than Stations 11 and 01. It should be noted, however, that the direct purpose of the weir was to reduce salinity in the marsh and not necessarily to increase water levels. It should also be noted that post-Hurricane Katrina inspections of Salt Bayou by LDNR engineers showed considerable sediment deposition along areas of Salt Bayou. The

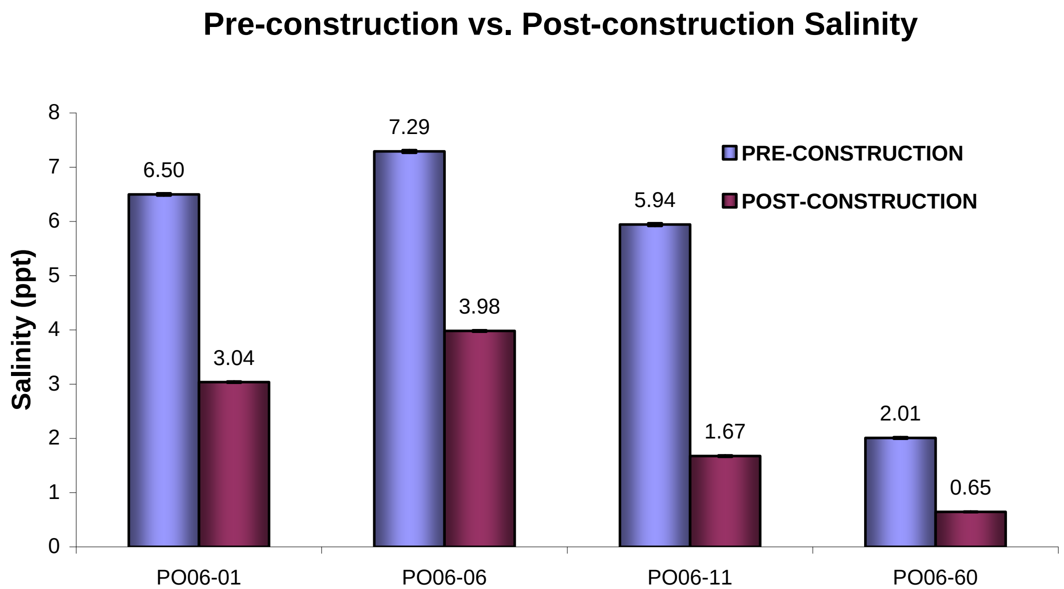


**Figure 6.** Mean weekly salinity at four YSI continuous recorder stations located in the Fritchie Marsh (PO-06) project area during pre-construction and post-construction periods.

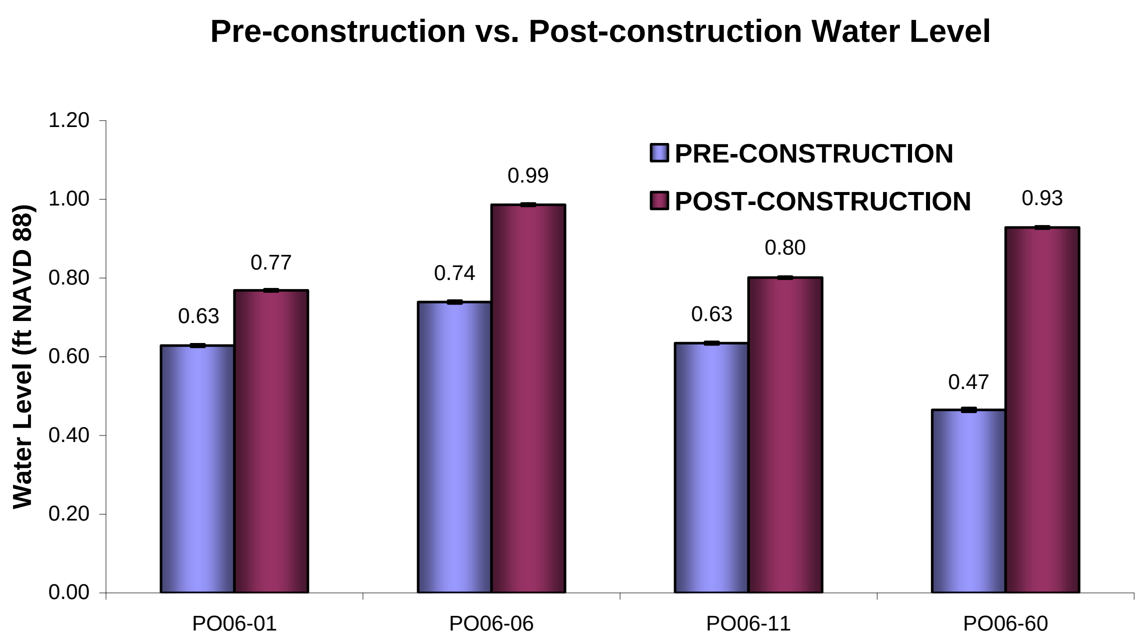


**Figure 7.** Mean weekly water level at four YSI continuous recorder stations located in the Fritchie Marsh (PO-06) project area during pre-construction and post-construction periods.

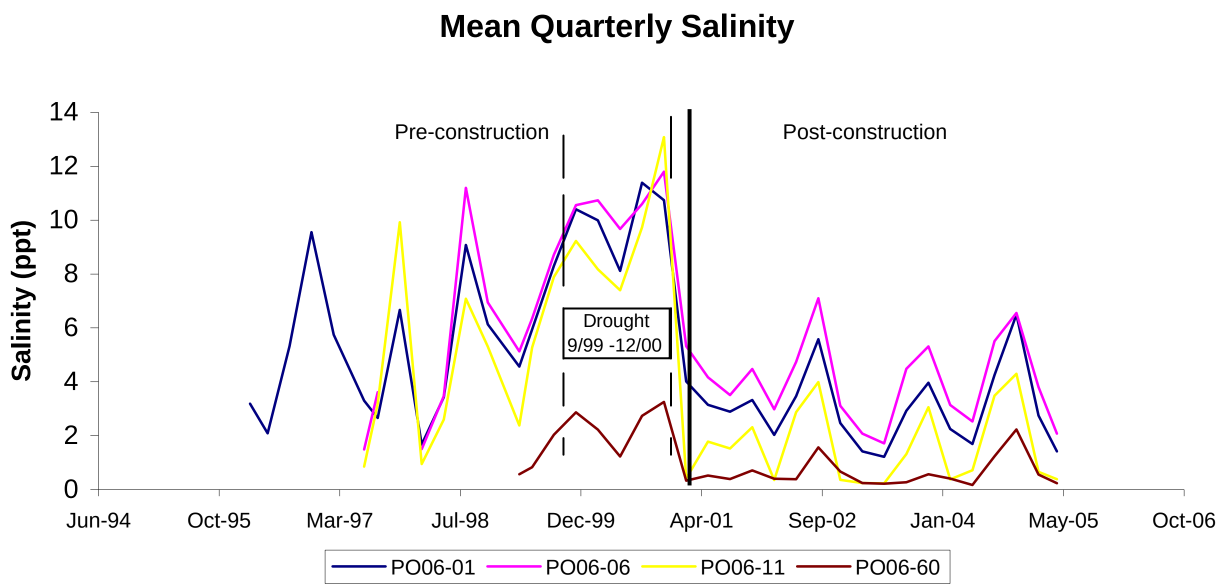


**Figure 8**. Mean quarterly salinity (ppt) at four continuous recorder stations located in the Fritchie Marsh Restoration (PO-06) project area.

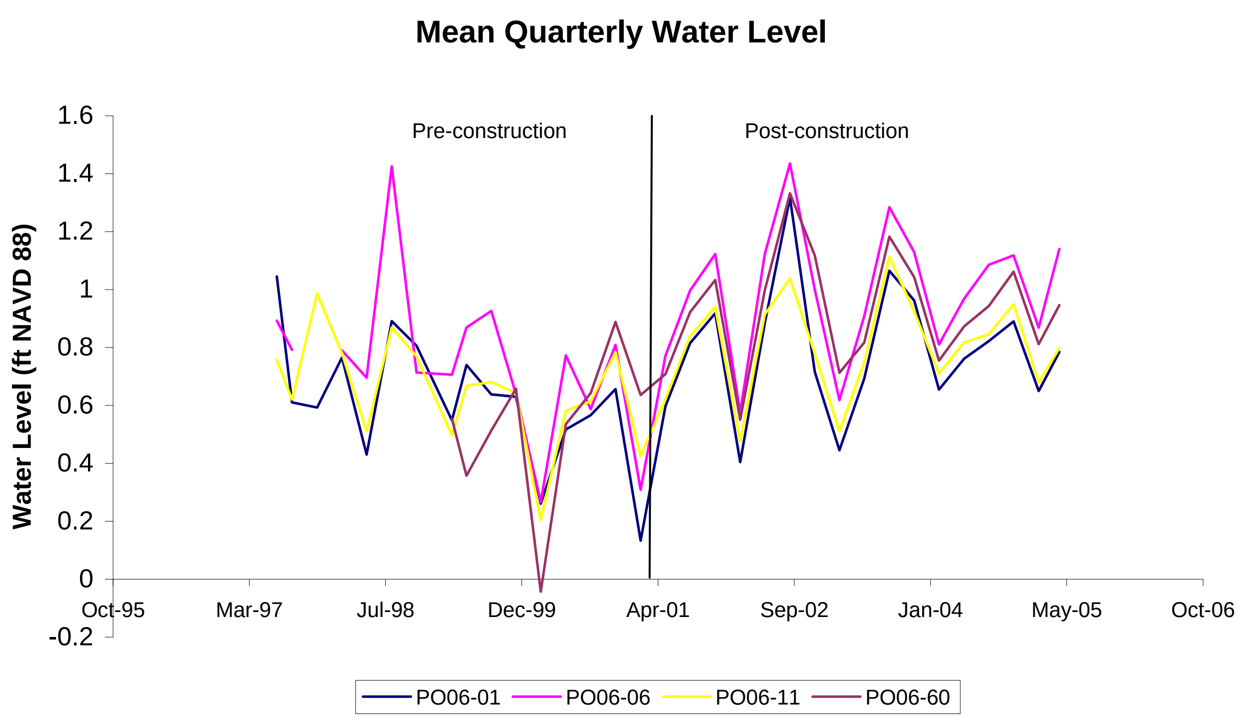


**Figure 9**. Mean quarterly water level (ft NAVD88) at four continuous recorder stations located in the Fritchie Marsh Restoration (PO-06) project area.

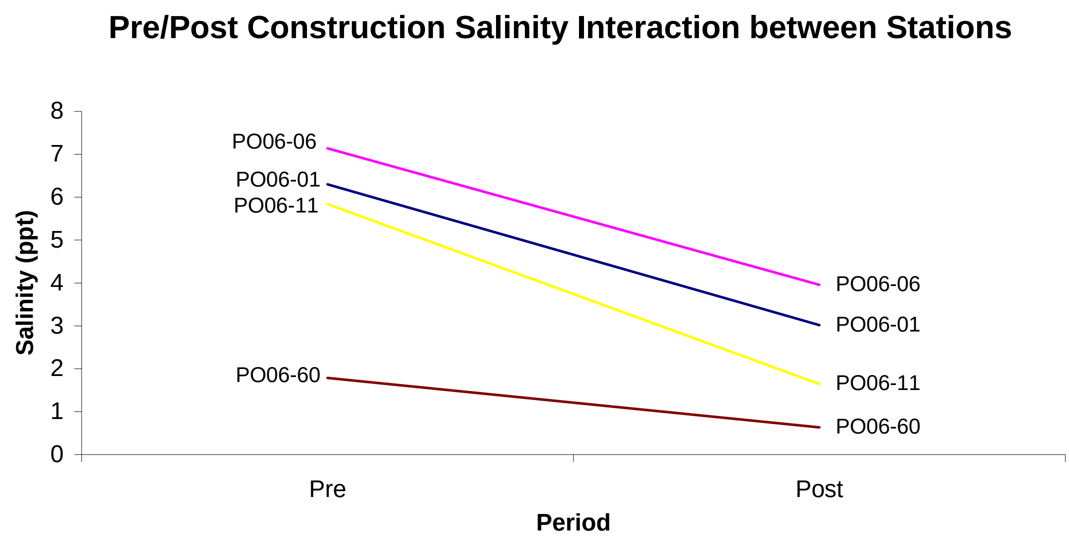


**Figure 10**. Interaction of mean weekly salinity during pre-construction and post-construction periods between four YSI continuous recorder stations in the Fritchie Marsh Restoration (PO-06) project area. A significant interaction (*p<0.0001*) between stations was detected indicating a project effect.

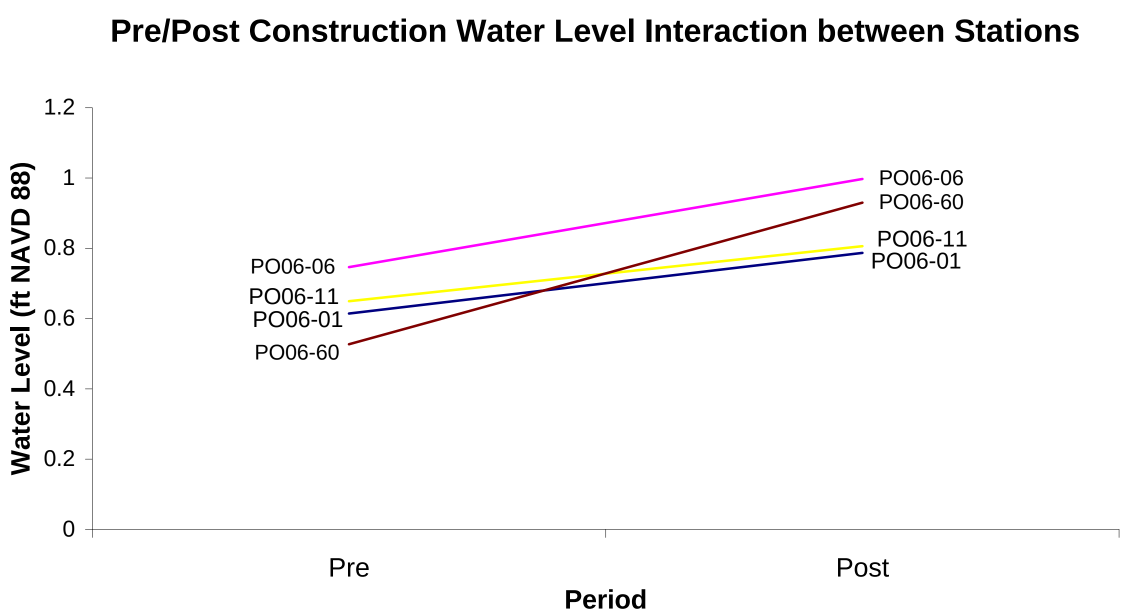


**Figure 11**. Interaction of mean weekly water level during pre-construction and post-construction periods between four YSI continuous recorder stations in the Fritchie Marsh Restoration (PO-06) project area. A significant interaction (*p<0.0001*) between stations was detected indicating a project effect.

**Salinity and Water Level (cont.)**

restriction of water flow from the culvert may have an impact on post-storm salinity and water level in the area.

Discrete water level readings were recorded at six staff gauges on a monthly basis throughout the project area (at the four recorder stations and two additional stations). Mean discrete water level at each station exhibited no significant change between pre- and post-construction time periods based on a least square means analysis ($p>0.05$) (Figure 12). However, all stations except for PO06-03 experienced an increase in water level in the post-construction period. It should be noted that there were fewer readings from PO06-03 in both the pre-construction and post-construction periods due to difficulty accessing the station during low water periods. Seasonal variability in monthly water level was evident with lowest water levels occurring in January and February, and highest water levels generally occurring in September (Figure 13).

**Water Flow**

Hourly current meter data were collected by Louisiana State University (LSU) at five stations from October 1998 to January 2000 (pre-construction) and from December 2001 to December 2002 (post-construction) (Figure 1). Flow volume estimates at each station were made using recorded current data, channel cross sections, and water level data from the associated continuous recorder station. Unfortunately, the flow data has been determined by LDNR to be unsuitable for analysis. A meeting was held in May 2005 in which representatives from LSU and LDNR, as well as an expert hydrologist from the U.S. Geological Survey (USGS), were present. Several anomalies in the data were discussed but were unable to be sufficiently resolved. This determination was based on several factors including unreasonably high observed flow rates during some periods, inability to confirm cross-sectional area calculations of the channel, and too many zero values in the post-construction data. According to the USGS expert, further problems were due to improper meter type and placement, as well as the absence of developing adequate index/mean velocity relationships. These relationships must be developed from flux measurements that change over time and under different flow conditions. These problems cannot be repaired through re-processing because the proper ground truth data were not collected.

**Vegetation**

Pre-construction vegetation surveys were conducted in September 1997 (N=25 plots), September 1999 (N=4 plots), and August 2000 (N=29 plots), and one post-construction survey was conducted in August 2004 (N=29 plots) (Figure 14). Because future landrights access was uncertain to four of the original 25 plots, four plots were added and surveyed in 1999.

The project area was dominated by *Spartina patens* (saltmeadow cordgrass) in all survey years in terms of both frequency of occurrence and mean percent coverage (Figure 15, Table 2). *S. patens* was found within 100% of the plots in each of the survey years. Mean percent coverage of *S. patens* across all plots dropped from 93% in 1996 to 65% in 2000, and showed little change by 2004 at 69%. However, there were some changes within the relative abundance of other commonly found species. *Schoenoplectus* sp. (bulrush) was the second most dominant species in

1997 at 21% mean coverage, but in 2000 and 2004 it had a coverage of only 3 and 4%, respectively. The mean percent coverage of *Vigna luteola* (hairypod cowpea) fluctuated from 16% in 1997 to only 1% in 2000, and then back up to 14% in 2004. *Distichlis spicata* (saltgrass) which is generally indicative of brackish to salt marsh, was not found during the 1997 survey, but

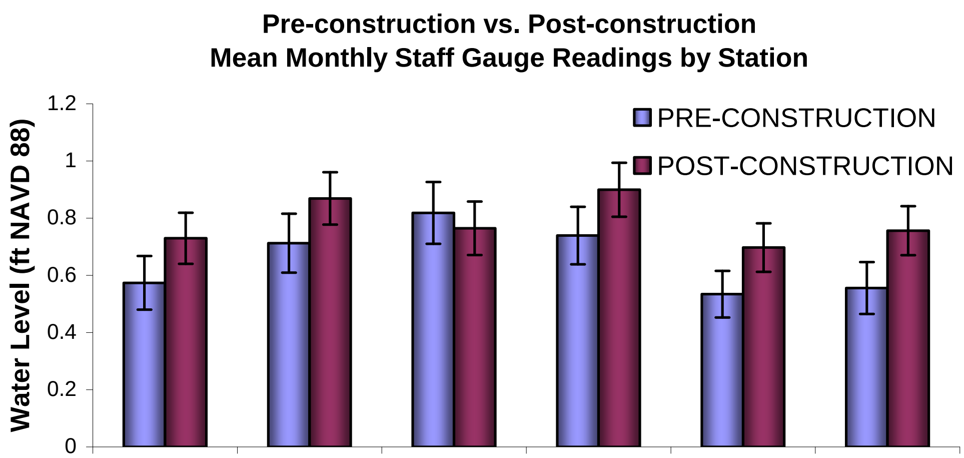


**Figure 12.** Mean of monthly staff gauge readings at the six staff gauges located in the Fritchie Marsh (PO-06) project area during the pre-construction (3/98-2/01) and post-construction (3/01-6/05) periods.

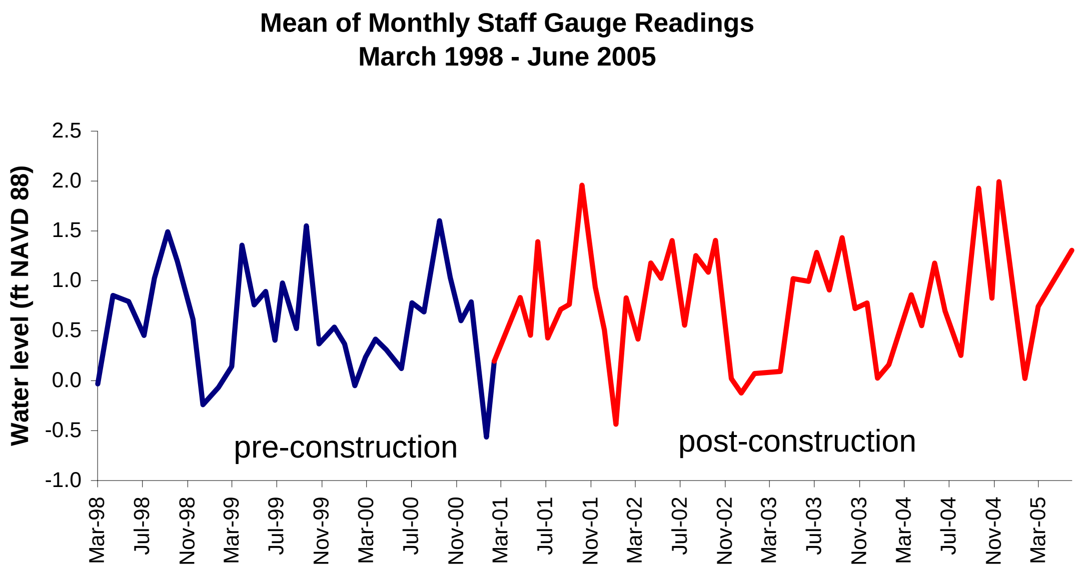


**Figure 13.** Mean of monthly readings from six staff gauges located in the Fritchie Marsh Restoration (PO-06) Project area from March 1998 to June 2005.

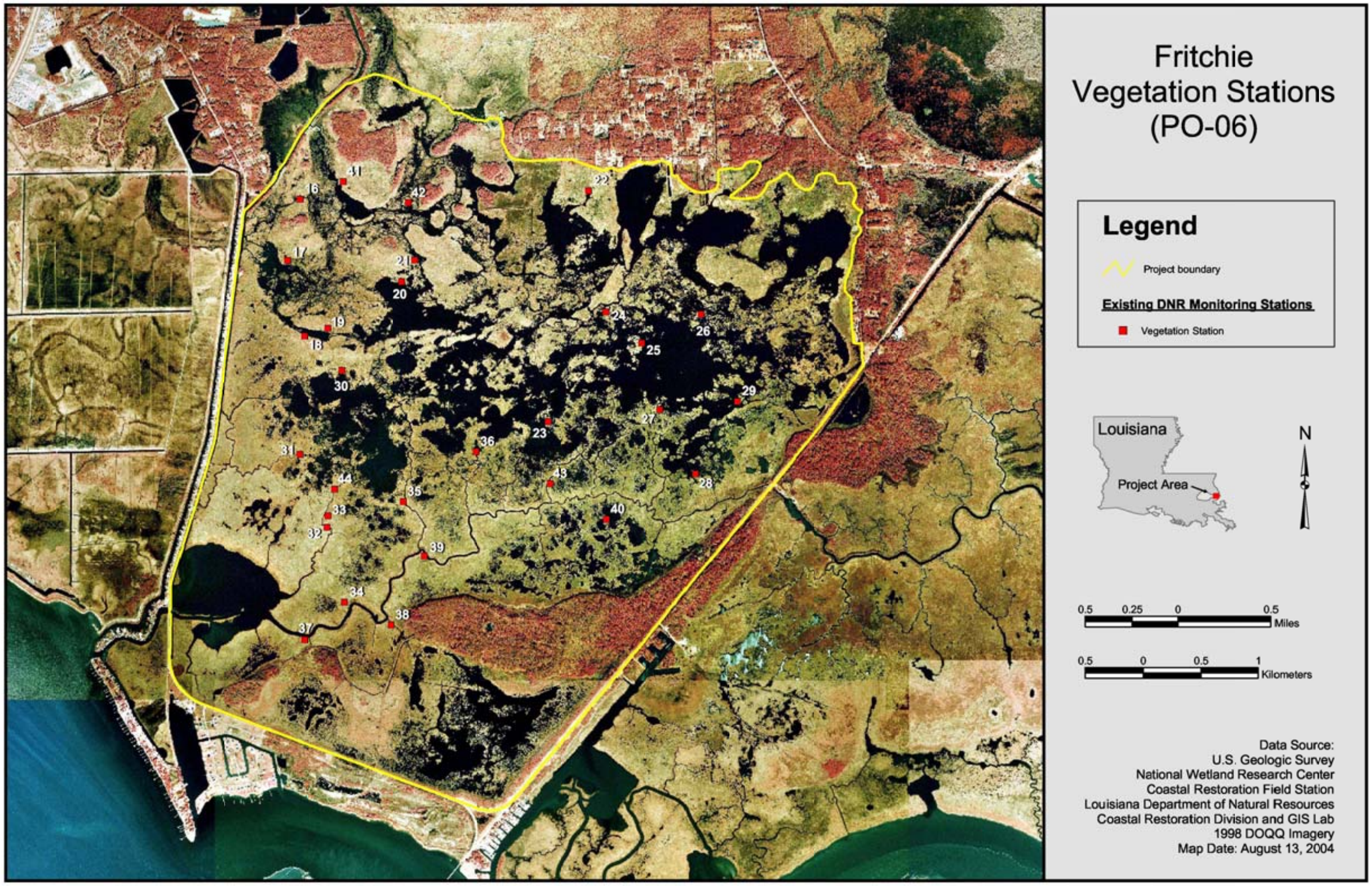


**Figure 14.** Braun-Blanquet vegetation stations within the Fritchie Marsh Restoration (PO-06) project area.

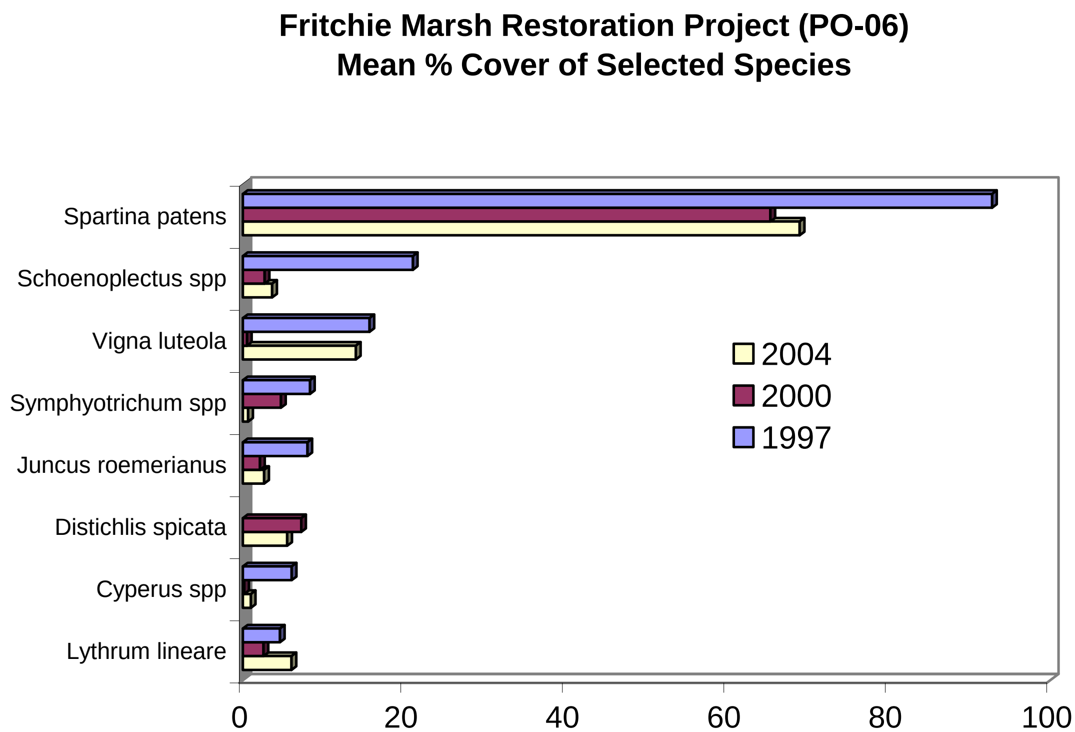


Figure 15. Mean % cover of selected species across all 4-$m^2$ plots within the PO-06 project area during September 1997 (N=25 plots), August 2000 (N=29 plots), and August 2004 (N=29 plots). Vegetation was sampled using the Braun-Blanquet method.

**Table 2.** The percentage of the total number of vegetation plots where each species occurred and the mean percent cover of species within plots where they occurred during the 1997 (N=25 plots), 2000 (N=29 plots), and 2004 (N=29 plots) vegetation sampling of the PO-06 project area. Sampling was conducted within 4-$m^2$ plots using the Braun-Blanquet method.

| Scientific Name | Occurrence of Total Plots (%) | | | Mean % Cover in Plots where Species Occurred | | |
|---|---|---|---|---|---|---|
| | 1997 | 2000 | 2004 | 1997 | 2000 | 2004 |
| *Spartina patens* | 100 | 100 | 100 | 93 | 65 | 69 |
| *Cyperus spp* | 60 | 3 | 28 | 10 | 5 | 4 |
| *Lythrum lineare* | 44 | 31 | 59 | 10 | 8 | 10 |
| *Vigna luteola* | 52 | 17 | 45 | 30 | 3 | 31 |
| *Distichlis spicata* | * | 48 | 34 | | 15 | 16 |
| *Schoenoplectus spp* | 44 | 21 | 28 | 48 | 13 | 13 |
| *Symphyotrichum spp* | 36 | 45 | 17 | 23 | 11 | 4 |
| *Polygonum spp* | 4 | | 34 | 4 | | 10 |
| *Ipomoea sagittata* | 24 | 24 | 10 | 12 | 1 | 2 |
| *Juncus roemerianus* | 24 | 21 | 14 | 33 | 10 | 19 |
| *Ammannia spp* | 16 | | 24 | 8 | | 3 |
| *Echinochloa walteri* | 8 | | 21 | 3 | | 1 |
| *Bacopa monnieri* | 4 | 21 | | 5 | 1 | |
| *Galium tinctorium* | | | 21 | | | 1 |
| *Amaranthus australis* | 20 | 17 | 14 | 7 | 1 | 5 |
| *Pluchea spp* | 12 | 7 | 14 | 11 | 3 | 11 |
| *Baccharis halimifolia* | 4 | 14 | | 10 | 4 | |
| *Eleocharis cellulosa* | 8 | | 10 | 45 | | 18 |
| *Iva frutescens* | 4 | 10 | * | 20 | 5 | |
| *Eleocharis parvula* | | 3 | 10 | | 3 | 3 |
| *Eclipta prostrata* | 8 | | | 1 | | |
| *Kosteletzkya virginica* | 8 | * | * | 1 | | |
| *Panicum repens* | 8 | | | 9 | | |
| *Eleocharis spp* | 4 | | 7 | 5 | | 27 |
| *Hydrocotyle spp* | * | | 7 | | | 1 |
| *Ludwigia leptocarpa* | 4 | | 3 | 1 | | 3 |
| *Phragmites australis* | 4 | * | | 25 | | |
| *Sagittaria lancifolia* | 4 | | 3 | 25 | | 1 |
| *Alternanthera philoxeroides* | | * | 3 | | | 1 |
| *Boehmeria cylindrica* | | | 3 | | | 1 |
| *Panicum dichotomiflorum* | * | | | | | |
| *Andropogon glomeratus* | * | | | | | |
| *Sesbania herbacea* | * | | | | | |
| *Setaria magna* | * | | | | | |
| *Setaria pumila* | * | * | | | | |
| *Solidago sempervirens* | * | * | | | | |
| *Spartina alterniflora* | | * | | | | |
| *Fimbristylis castanea* | | | * | | | |
| *Pennisetum glaucum* | | | * | | | |
| *Sabatia spp* | | | * | | | |

***Species were found within 15-ft outside of the vegetation plots.**

was the second most dominant species during the 2000 survey at 7% mean coverage. The mean coverage of *D. spicata* showed little change in the post-construction period at 5%. Although the frequency of occurrence of *Cyperus* spp. (flatsedge) was high during the 1997 and 2004 surveys, the percent coverage of this genus was generally low within the plots where it occurred. The total number of species found has remained relatively steady with the least number of species found in the year 2000 (N=35 (1997), N=22 (2000), N=31 (2004)).

Localized changes in species composition and abundance were seen in some areas of the project in the post-construction period. In 2004 *S. patens* was the dominant species in most plots except for some within the eastern portion of the project area. At Stations 28 and 40, which are the closest stations to Salt Bayou in the vicinity of the Hwy 90 culvert (Figure 14), there has been a steady decrease in the coverage of *S. patens* and an increase in more freshwater indicative species such as *Eleocharis* spp. (spikerush). At Station 40, the number of species increased from 4 in 2000 with *S. patens* as the dominant species, to 19 species in 2004 with *Eleocharis* as the dominant species. However, the marsh in the area north of Salt Bayou, which appears to be floatant, is highly fragmented and appears to be deteriorating. The species composition completely changed at Station 26 in this area in 2004. This station was dominated by *S. patens* (50%) in 2000, but by 2004 the dominant species were *Polygonum* sp. (smartweed) (50%), *Eleocharis* spp. (45%), and *Shoenoplectus americanus* (30%), none of which were present in 2000.

Other stations showed an increase in more brackish to saltmarsh species. Stations 30 and 35, which are located in the western half of the project area, have shown a steady increase in percent coverage of *D. spicata* over the study period, although *S. patens* remains dominant. Located in the northern portion of the project area, station PO06-22 was dominated by *D. spicata* in both 2000 and 2004. Despite the low salinity measured in the northwest corner of the project area, this area remains dominated by brackish marsh species such as *Spartina patens* and *Juncus roemerianus*.

## V. Conclusions

### a. Project Effectiveness

The constructed features of the Fritchie Marsh Restoration (PO-06) project appeared to be having the desired effect on the hydrology of Fritchie Marsh through the end of the monitoring period in June 2005. Mean salinity was lower and mean water level was higher during the post-construction period, suggesting increased flow of freshwater into the project area. Although this response would be expected during the post-construction period due to post-drought conditions, a project effect was detected for both salinity and water level through a significant BA*CI interaction between the four continuous recorder stations even with the drought period removed. The strongest evidence of a project effect was at Station 60, which experienced the largest increase in water level following the construction of the 72-inch culvert under Hwy 90. It was also determined that the salinity at Stations 01 and 06, which are farthest from the project features, is being affected less by the project than at the stations closer to the project features.

The land/water analysis showed a loss of 31.5 acres/yr from 1996 to 2000, and a gain of 3.25 acres/yr from 2000 to 2004. The reference area showed slow rates of land loss during both periods. A separate analysis of satellite imagery acquired before and after Hurricane Katrina indicated significant land loss in the project area after the storm. Future analyses to be conducted in 2010 and 2019 will be necessary in identifying long-term trends in land loss or gain within the project and reference areas.

Localized changes of species composition and abundance were seen in some areas of the project in the post-construction period, particularly at stations closest to the Hwy 90 culvert. An increase in freshwater indicative species was seen at some of the stations near the culvert in the post-construction period. Changes in species composition elsewhere in the project area are slow to occur, with *S. patens* remaining the dominant species. Some interior stations are showing an increase in brackish species such as *D. spicata*. The vegetation survey to be conducted in 2007 will reflect the effects of Hurricane Katrina on the vegetation within the project area.

The structures showed little to no signs of damage due to Hurricane Katrina. However, the marsh and natural waterways were severely altered. In addition to the marsh deposits along Salt Bayou, large sections of interior marsh have converted to open water. Dredging of Salt Bayou and repair of the scour at Hwy 90 are recommended.

### b. Recommended Improvements

**<u>Dredging of Salt Bayou</u>**

Salt Bayou provides the main hydrologic connection between the Hwy 90 culvert and the rest of the project area, and was therefore dredged during construction to increase freshwater transport into the project area. Installation of the Hwy 90 culvert substantially increased the amount of water available to flow via Salt Bayou into the project area. LDNR and NRCS agree that there is a need to re-dredge Salt Bayou due to the sediment deposition which occurred during Hurricane Katrina.

### c. Lessons Learned

Monitoring activities are inherently linked to project feature construction. Construction delays can often result in the need to repeat pre-construction monitoring data collection due to changes in site conditions when construction is delayed. Because of construction delays of the Fritchie Marsh Restoration project, an extra round of pre-construction habitat analysis and vegetation monitoring was conducted in the year 2000, which was an unanticipated cost.
Climatic anomalies, such as drought, may confound hydrologic data results, especially in cases where a reference area was not monitored. In this case, however, a suitable reference area for

hydrologic monitoring did not exist. The approved Coastwide Reference Monitoring System (CRMS) will alleviate this problem in the future by providing a network of "reference" sites across the Louisiana coast. These sites may be used to help evaluate the Fritchie Marsh Restoration project area in the future.

The most important lesson we should learn in the selection and design of future hydrologic restoration projects is to properly consider the structural integrity of existing topographic features, i.e., spoil banks, cheniers, etc., that our project structures will depend on to function. In the event they can be compromised through subsidence, increased water velocity, or erosion during the 20-year life of the project, then proper consideration should be given to the maintenance efforts and costs and these costs should be included in the selection criteria.

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