State of Louisiana
Coastal Protection and Restoration Authority of Louisiana

2013 Operations, Maintenance, and Monitoring Report

for

West Lake Boudreaux Shoreline Protections and Marsh Creation (TE-46)

State Project Number TE-46
Priority Project List 11

December, 2013
Terrebonne Parish

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Suggested Citation:

Lear, E. J., G. Curole, A. Ledet and J. Curole 2013. *Operations, Maintenance, and Monitoring Report for West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46),* Coastal Protection and Restoration Authority of Louisiana, Thibodaux, Louisiana 45 pp. and Appendices.

2013 Operations, Maintenance and Monitoring Report
For
TE-46 West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46)

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Preface

This report includes monitoring data collected through December 2012, and the annual Maintenance Inspection completed in May 2013. The West Lake Boudreaux Shoreline Protection and Marsh Creation project (TE-46) is sponsored by the United States Department of Interior/Fish and Wildlife Service (FWS) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III, Priority List 11).

The 2013 report is the first report in a series of reports since the end of construction on this project in October 2009. This Operations, Maintenance, and Monitoring Report as well as future reports in this series will be posted on the Coastal Protection and Restoration Authority (CPRA) website at *http://coastal.louisiana.gov/.*

I. Introduction

The West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46) project area is located in the Terrebonne Basin on the western rim of Lake Boudreaux in Terrebonne Parish, LA (Figure 1). It encompasses 1,177 acres (476 ha) including 250 acres (101 ha) of intermediate marsh and 927 acres (375 ha) of open water habitat. It is bounded on the east by Lake Boudreaux, on the north by a private canal adjacent to Bayou Butler, on the west by Bayou Grand Caillou, and on the south by an unnamed drainage canal.

The project area is on the Teche Ridge, a feature of the Terrebonne delta plain which is a result of landforms produced by the Teche-Mississippi delta cycle 4500 to 3500 years ago (Gagliano and Wicker 2002). Lake Boudreaux was created as a result of fault events between the early to middle 1800's when the area's fresh marshes and swamps reached maximum development and the marsh was continuous and unbroken. A severe flood in 1903 prompted the construction of a dam across the head of Bayou Lafourche at Donaldsonville (completed in 1904), effectively cutting off all sediment flow from the Mississippi River. Since the turn of the 20th century a combination of natural and anthropogenic alterations within the Terrebonne delta plain has contributed to its deterioration (Gagliano and Wicker 2002).

The western shoreline of Lake Boudreaux has experienced erosion and high marsh loss rates due to factors such as exposure to wind-generated wave energy, subsidence, turbidity detrimental to submerged aquatic vegetation (SAV) populations, and saltwater intrusion (USFWS 2005a). The United States Geological Survey (USGS) has estimated that between 1983 and 1990 interior marsh loss rates in the Lake Boudreaux area were approximately 3.68 % (USGS 2001). An analysis of shoreline erosion rates by the USGS using 2001 through 2004 aerial photography indicates shoreline erosion rates ranged from 10 ft per year (3 m per year) along the southwest

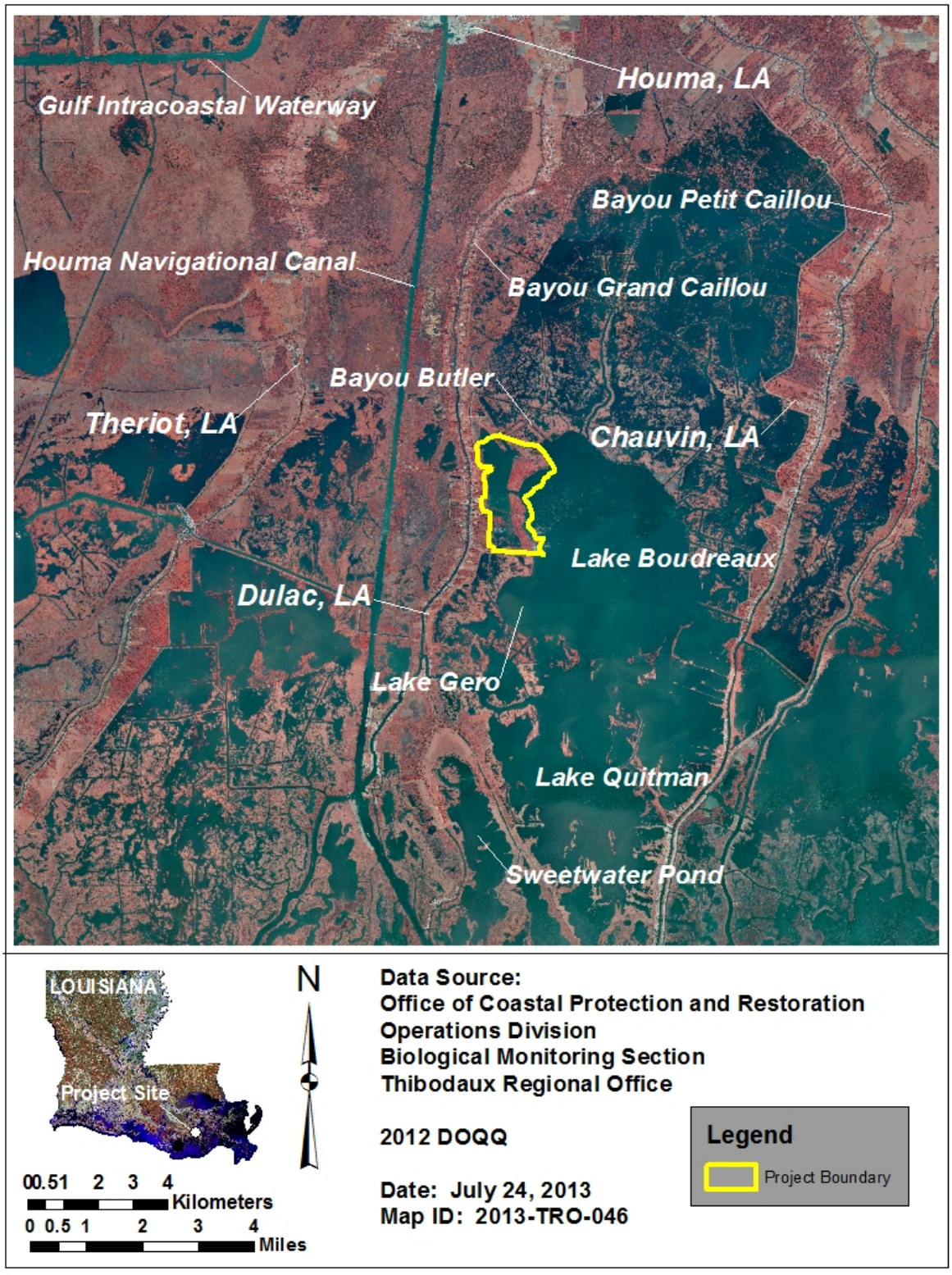

Figure 1. Location map of the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-44) project.

shoreline to 91 ft per year (27.7 m per year) along the northwest shoreline, with a total weighted average shoreline erosion rate of 42 ft per year (12.8 m per year) (USFWS 2005b). Additionally, based upon a 2004 survey by Professional Engineering and Surveying Company, Inc. (PENSCO) as much as 600 ft (182.88 m) of shoreline erosion has occurred since the baseline aerial photo utilized for the project plan was taken on February 4, 1998 (Hill and Brass 2005). Concerns are that the erosion will convert the productive shallow, open water areas behind the eroding shoreline to a less productive open lake habitat and the interior marsh and adjacent infrastructure will be compromised.

The purpose of the project is to reduce shoreline erosion and to create additional marsh along the southwest shoreline of Lake Boudreaux while protecting shallow aquatic grass beds adjacent to the shoreline.

Constructed features have a twenty-year (20-yr) project life that began when construction was completed in October 2009.
Project features include (CPRA 2012):

- Construction of three segments of foreshore rock dike along the western shoreline of Lake Boudreaux (Figure 3). The dikes were constructed using rock riprap (ASTM D 6092-97 Riprap R-300) to an elevation of +3.5 feet NAVD88 (vertical tolerance of +0.5 feet) with a 3-foot crest width and 2.5 to 1 side slopes for the northern segment and 2 to 1 side slopes for the central and southern segments. The rock dike segments were constructed upon a geotextile fabric base. Where the rock dike was constructed adjacent to the marsh fill areas, the earthen containment dike was constructed against the marsh-side slope of the rock dike. Galvanized steel settlement plates were installed within the rock dike segments at various locations. Northern Segment is 5,350 linear ft (1,630.6 m), Central Segment is 2,140 linear ft (652.2 m), and Southern Segment is 4,957 linear ft (1,510.8 m). Construction of 24,553 linear ft (7,483.7 m) of earthen containment dike to be partially degraded in the third year following construction (Figure 2).

- Construction of an earthen plug located in the northwest corner of an oil and gas access channel off of Lake Boudreaux at the north end of the project area (Figure 2). It was constructed using dredged material from the oil and gas access channel. The plug was constructed to an elevation of +4.0 feet NAVD88 with an 8-foot top width and 3 to 1 side slopes. The plug is approximately 75 linear ft (22.8 m).

Figure 2. Map indicating the locations and types of constructed features inside the boundary of the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46) project.

- Construction of a choke down section located between the southernmost extent of the northern rock dike segment and the northernmost extent of the central rock dike segment (Figure 2). It consists of a 2-foot thick layer of rock riprap (ASTM D 6092-97 Riprap R-300) constructed across the opening in the shoreline between the northern and central marsh creation areas. The choke down section is approximately 150 linear ft (45.7 m) (direction along the shoreline) by approximately 75 ft (22.8 m) wide and was constructed to reduce scour in that area.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46) project is to evaluate the constructed project features in order to identify any deficiencies. The inspection results are used to prepare a report detailing the condition of the project features and recommending any corrective actions considered necessary. Should it be determined that corrective actions are needed, the CPRA shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, construction, and contingencies, as well as an assessment of the urgency, of such repairs. The annual inspection report also contains a summary of maintenance projects 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. A summary of past operation and maintenance projects completed since construction of the West Lake Boudreaux (TE-46) project is outlined in Section IV.

The annual inspection of West Lake Boudreaux (TE-46) project took place May 7, 2013. In attendance were Brian Babin, Adam Ledet and Elaine Lear with CPRA, and Robert Dubois with the Fish and Wildlife Services. The attendees met at a launch in Dulac, near the bridge at Four Point, and traveled to the project area by outboard. The inspection began around 10:00 am at most southern marsh creation area and rock dike, and concluded around 11:30 a.m. at the most northern marsh creation area and rock dike. The trip included a visual inspection of the project features, structures and outer edges of the marsh creation areas. Photographs of the inspection are located in Appendix A.

b. Inspection Results

<u>North Segment – Rock Dike</u>

The northern segment of the rock dike appeared to be in good condition. There are no signs of settlement along the rock dike; the elevation is consistent throughout the entire length of the

structure. There is some evidence of erosional shadowing on the north end of this segment, measuring approximately 70 feet wide and 20 feet deep. This erosion of such a small area does not impede the function of the structure; however this area has been identified and will continue to be monitored on future inspections. There are no recommendations for maintenance at this time. (See Appendix A, Photos 14 through 18)

Central Segment – Rock Dike

The central segment of the foreshore rock dike also appeared to be in good condition. There are no signs of settlement along the rock dike; the elevation is consistent throughout the entire length of the structure. There are no recommendations for maintenance at this time. (See Appendix A, Photo 10)

Southern Segment – Rock Dike

The southern segment of the rock dike appeared to be in good condition. There are no signs of settlement along the rock dike; the elevation is consistent throughout the entire length of the structure. All of the warning signs along this segment are visible and appear to be in good condition. On the southern end of the structure, the adjacent marsh shoreline has eroded significantly since the time of construction. This has caused the southern end of the rock dike to protrude approximately 150 feet into the lake. It may be prudent to add a navigational warning sign in this area to indicate this hazard, but due to the large cost involved with installing a single sign the warning sign should be included in the next maintenance event. There are no recommendations for maintenance at this time, but this area will continue to be monitored on future inspections to determine if any corrective actions need to be made. (See Appendix A, Photos 1 through 8)

Earthen Plug

The earthen plug located on the northern end of the project area in an existing oilfield canal appeared to be in good condition. The structure is fully vegetated since construction and there are no signs of settlement or erosion of the plug. There are also no signs of erosion or washouts of the embankment tie-ins on either end of the structure. Overall, the earthen plug appears to be in good condition and there are no recommendations for corrective actions at this time (No Photo Available).

Choke Down Section

The choke down section of the foreshore rock dike could not be observed during the annual inspection as it is submerged under the waterline. The warning sign on the Lake Boudreaux side of the choke down section is missing. The timber piling support is still in its location and in good condition, but the sign itself is no longer there. It is recommended that this sign be

replaced to notify boaters coming from the lake of the navigational hazard posed by the choke down section. (See Appendix A, Photos 11 through 12)

c. Maintenance Recommendations

All of the structures to be maintained in the TE-46 West Lake Boudreaux Shoreline Protection and Marsh Creation Project are in good condition. The foreshore rock dike segments remain at a consistent elevation with no evidence of settlement or displacement of the rock. From a visual inspection, these structures appear to have fared well since the end of construction. There was some erosion noticed on the northernmost and southernmost ends of the foreshore rock dike, but neither of these areas are of a magnitude which the structure cannot operate as designed or corrective actions are needed. The earthen plug on the north side of the project area was well vegetated with no observed settlement or erosion of the plug. The subaquatic choke down section looked to be in good shape from what was visible from above the waterline. The only deficiency found during this year's annual inspection was the fore mentioned warning sign on the lake side of the choke down section. It is recommended that this sign be replaced as it is the only indicator of the submerged structure for vessels traveling in that direction. There are no other recommendations for maintenance at this time.

d. Maintenance History

As of now there have been no maintenance events.

III. Operation Activity

As of now there are no project features that require routine operation.

IV. Monitoring Activity

Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, the TE-46 Monitoring Plan has been merged with CRMS-*Wetlands* to provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There are no Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) stations located inside the TE-46 project area. Two stations, CRMS0390 and CRMS0392, are located approximately 2 miles north of the project boundary (Figure 3), and will be used as references for purposes of data analysis. Site CRMS0390 was established in June 2006 and site CRMS0392 was established in July 2007. Both sites are classified as

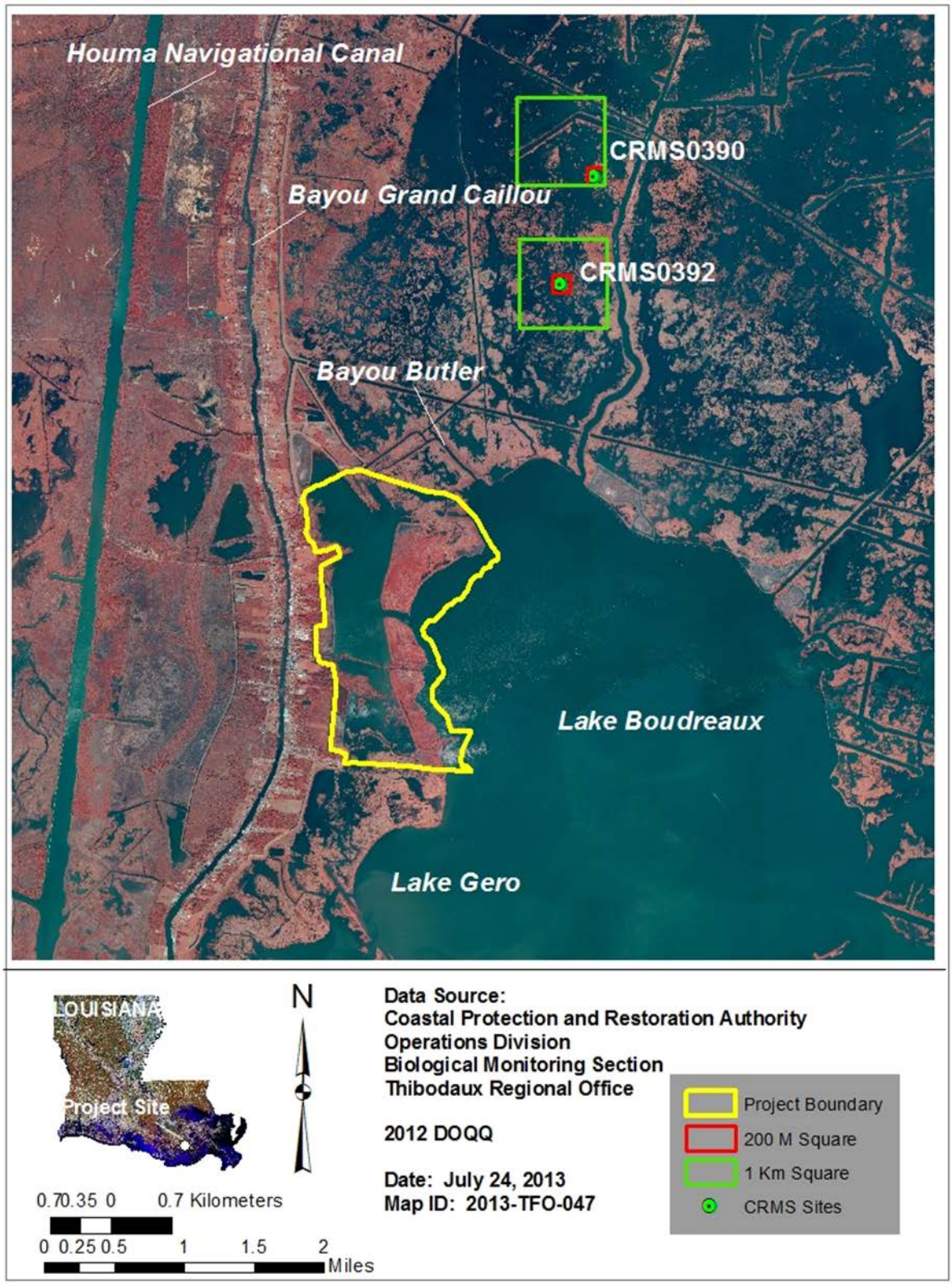

Figure 3. Location map for CRMS-*Wetlands* sites just north of the West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46) project.

oligohaline wiregrass marsh. The marsh classifications at CRMS0390 and CRMS0392 have shifted from fresh to a more saline community (Chabreck and Hoffpauir 1962; Chabreck and Linscombe 1978, 1988, 1997, and 2001, and Sasser and Visser 2008).

Mean salinity at sites CRMS0390 and CRMS0392 is approximately 8.4 ppt and 8.3 ppt respectively, with spikes above 15 ppt. CRMS0390 and CRMS0392 are experiencing heavy land loss with rates of 1.84% and 1.68% per year. Data collected from both sites will be used to document monitoring variables such as land-water classification, annual vegetation, continuous water level and salinity, discrete hydrographic, bi-annual accretion, and surface elevation (RSET).

a. Monitoring Goals

The project's objective is to reduce erosion of the west Lake Boudreaux shoreline, which in turn will protect interior low salinity marshes and aquatic grass beds from the high wave energy and turbidity found in Lake Boudreaux; it will create emergent marsh along the southwestern shoreline of Lake Boudreaux and at interior marsh sites through the deposition of material dredged from the Lake bottom.

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

1. Stop shoreline erosion along approximately 12,447 linear ft (3,794 m) of the western shoreline of Lake Boudreaux over the 20-year project life.

2. Initially create 220 acres (89 ha) of marsh by the completion of project construction with intertidal marsh developing after year 3 of the project's life.

3. Reduce erosion rates by 50%, from 3.68% per year to 1.84% per year, in the created and nourished marsh over the 20-year project life.

4. Reduce erosion rates by 25%, from 3.68% per year to 2.76% per year, in the non-directly affected marsh over the 20-year project life.

b. Monitoring Elements

Aerial Photography:

Near-vertical color-infrared aerial photography (1:20,000 scale) was used to measure land to open water ratios and land change rates for the project area as well as the marsh creation areas inside the project boundary. The photography was obtained in 2012 three years post-

construction. Aerial photography will be captured again using CRMS coastwide flights for year 11 (2020) and year 19 (2028). The 2012 aerial photography was checked for flight accuracy, color correctness, and clarity, and was scanned, mosaicked, and geo-rectified by United States Geological Survey/National Wetland Resource Center (USGS/NWRC) personnel according to standard operating procedures (Steyer et al. 1995, revised 2000).

Historic data was assessed utilizing the CRMS spatial viewer for land-water quantification in the project area as well as in reference CRMS sites. The years analyzed were 1956, 1978, 1988, 2004, 2006, and 2008 (Barras et al. 2008). The large spatial scale of the data did not lend itself to the calculation of exact acreages however, the land-water changes were assessed in terms of trends.

Shoreline position data were analyzed to estimate shoreline changes inside the TE-46 project area using the Digital Shoreline Analysis System (DSAS version 2.1.1) extension of ArcView® GIS (Thieler et al). Pre-construction and post-construction change rates were calculated for shorelines behind the foreshore rock shoreline protection structure. Shoreline positions were determined by digitizing aerial photographs at a 1:800 scale as per the Steyer et al. (1995) method, which defines shoreline position as the edge of the live emergent vegetation. The resulting polylines established the shoreline positions in UTM NAD 83 coordinates. Pre-construction and post-construction aerial photographs were acquired over a fifteen year period to discern the foreshore rock shoreline protection structure's effect on shoreline erosion rates.

Pre-construction aerial photographs were collected on February 4, 1998, January 25, 2004, and November 1, 2005 while post-construction aerial photographs were captured on October 30, 2008 and October 28, 2012. All images were georectified using UTM NAD 83 horizontal datum. The map scale for all aerial photographs was 1:16,000.

The February 1998, January 2004, and November 2005 shorelines were examined in ArcView® GIS software to establish pre-construction shoreline change rates, and the October 2008 and October 2012 shorelines were examined to establish post-construction shoreline change rates. An offshore baseline was established for the project area and the DSAS attribute editor was populated by identifying shorelines and the baseline and dating shorelines. Next, 3000 m (9,842 ft) simple transects were cast from the baseline at 50 m (164 ft) intervals producing shoreline change, intersect, and transect shapefiles. These shapefiles were edited by eliminating transects that intersect the shorelines at irregular angles. Next, shoreline change data were imported into Excel® to calculate average and annual erosion rates for each period. Shoreline change rates were assessed and graphed for the ensuing periods February 1998-January 2004, February 1998-November 2005, January 2004-November 2005, and October 2008-October 2012 for the area behind the 3,794 m (12,447 ft) TE-46 foreshore rock

shoreline protection structure. Finally, the annual erosion rates were imported into the JMP (v10) statistical package and a one-way ANOVA was used to test for significance.

Emergent Vegetation:

Species composition and relative abundance were evaluated inside the project marsh creation areas using a modification of the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974). The stations consisted of 42 randomly selected replicate 2m × 2m plots located along 14 east-west transects divided amongst the three marsh creation areas. Sampling occurred in year 3 (2012), and will occur again in years 11 (2020) and 19 (2028). Species composition and relative abundance were also evaluated at CRMS sites (CRMS0390 and CRMS0392) pictured in figure 2. These two sites will serve as reference sites in the analysis of vegetation data. The 1 km^2 CRMS sites contained a 200 m^2 data collection area, which in turn had ten (10) replicate 2m x 2m stations located along a single transect. Vegetation species composition and relative abundance were evaluated in 2006, 2007, 2008, 2009, 2010, 2011, and 2012 using the modified Braun-Blanquet methodology.

Floristic Quality Index (FQI) was determined for the project. The FQI is used to quantitatively determine the condition of a particular habitat using the plant species composition (Cretini et al. 2009). It has been regionally modified for coastal Louisiana by a panel of local plant experts in order to determine changes in wetland conditions based upon the presence of non-native, invasive and disturbance-prone species across community types. The coefficient of conservatism (CC) score is a score from 0 to 10 assigned by the panel to flora and is used to calculate the FQI. Species are scored higher if they are dominant (9-10) or common (7-8) in vigorous coastal wetland communities, not as high if they occur primarily in less vigorous coastal wetland communities (4-6), even lower if they are opportunistic users of disturbed sites (1-3), and lowest if they are invasive plant species (0). The panel did not assign CC scores to 1) submerged aquatic vegetation, 2) parasitic species, 3) plants identified only to genus or family, or 4) unidentifiable plants. Non-native species were assigned a score of 0 by the panel. Plants identified only to genus were assigned a CC score for the species if only one species was on the list for that genus. The mode of the species scores was assigned to a plant if it was identified only to genus and more than one species for the genus was listed, provided the CC scores for those species were within a 3 point range. No CC score was assigned to a plant within the genus if the CC scores for the species had a wider range than 3 points. If *Distichlis spicata* (seashore saltgrass) was present, it was assigned a community-specific CC score; a high score in healthy brackish and salt marshes where it is a codominant, and a low score in fresh and intermediate marshes where its presence is indicative of a disturbance.

To identify other potential sites with similar vegetation, the TE-46 vegetation data was compared to all coastwide CRMS sites as well as project sites with vegetation data for the

same year (2012). The Bray-Curtis dissimilarity measure was used to quantify the compositional dissimilarity between the TE-46 project vegetation and all other sites. Bray-Curtis is an appropriate dissimilarity measure for these data as it satisfies several guidelines for a dissimilarity measure, including: 1) it takes 0 only when two samples are identical, 2) it takes the maximum value of 1 when two samples have no species in common, and 3) a simple scaling change does not affect the relative values of dissimilarities (Clarke et al. 2006). The ten most similar sites were chosen as baseline sites for comparison over the life of the project.

CRMS Supplemental

In addition to the project specific monitoring elements listed above, a variety of other data is collected at CRMS-W*etlands* stations which can be used as supporting or contextual information (Figure 3). Data types collected at CRMS sites include hydrologic from continuous recorders, vegetative, physical soil characteristics, discrete porewater salinity, surface elevation change, vertical accretion and land-water analysis of a 1 km^2 area encompassing the station (Folse et al. 2012). For this report, hydrologic and vegetation data were used to assess project goals, and physical soil characteristics, discrete porewater salinity, surface elevation change, vertical accretion and land-water analysis were used to provide contextual information for the project. Data was utilized from two reference sites outside the project area (CRMS0390 and CRMS0392).

IV. Monitoring Activity (continued)

c. Monitoring Results and Discussion

Aerial photography:

2012 Project Area Land-Water:

The 2012 USGS/NWRC land-water classification for TE-46 indicates that the overall project area contained 39.7% (484 acres) land to 60.3% (736 acres) water (Figure 4). The marsh creation areas comprised 44.4% (215 acres) of the overall land area inside the project boundary, while they contained only 9.5% (70 acres) of the water.

Looking exclusively at the three marsh creation areas, they contained a combined 75% (215 acres) of land to 25% (70 acres) water. The north creation area was the largest in area of the three, with 71.3% (112 acres) land to 28.6% (45 acres) water. The central creation area contained 85.1% (40 acres) land to 14.9% (7 acres) water, and the south creation area contained 77.8% (63 acres) land to 22.2% (18 acres) water.

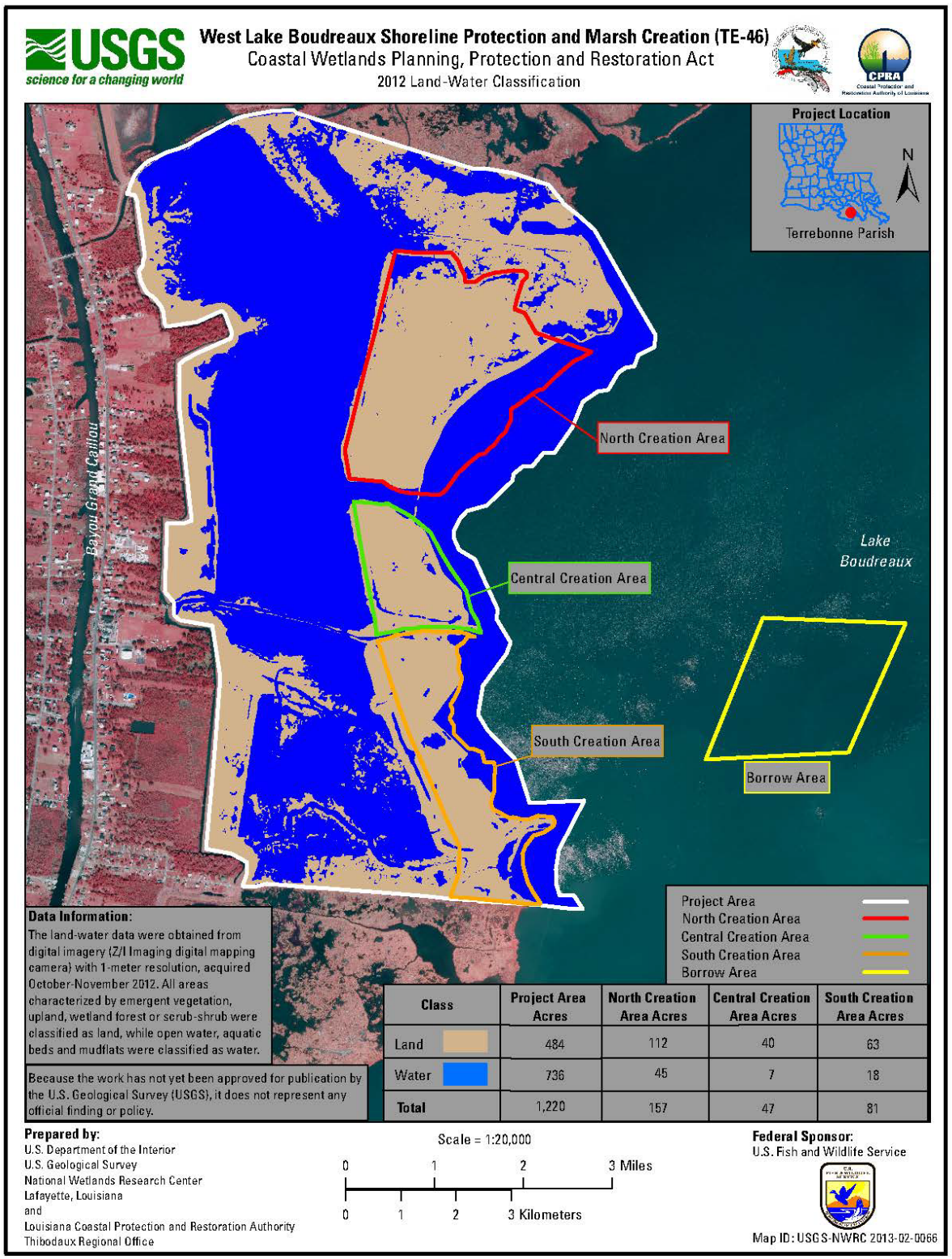

Figure 4. Land-water analysis of aerial photography collected October-November 20, 2012.

CRMS Land-Water:

Assessment of the project area as well as CRMS reference sites utilizing the CRMS spatial viewer was also possible through 2008. Since this assessment is on a larger scale than that used for the 2012 land-water classification by USGS/NWRC, the results are presented in terms of trends and provide a different perspective of the land to water changes over a period of decades (Figure 5). From 1956 to 1988 CRMS0392 retained 100% land, while TE-46 and CRMS0390 alternated from land loss to land gain. Between 1988 and 2006 all three areas experienced a steady downward trend. TE-46 experienced approximately 15% land gain between 2006 and 2008, due to construction of the marsh creation areas in 2007, while CRMS0302 and CRMS0392 continued a steady downward trend of land loss. The largest amount of land loss, approximately 70% of its original land, occurred between 1956 and 1978 for TE-46. The largest conversion of land to water occurred between 1988 and 2004 for both of the CRMS sites. The least amount of land loss for the CRMS sites occurred between 2006 and 2008, while TE-46 experienced its lowest land to water conversion between 2004 and 2006.

Shoreline Change:

Pre-construction data reveals that the TE-46 shoreline was transgressing at a rapid rate. The shoreline erosion rates for this 1998-2005 interval averaged -13.58 m/yr (-44.55 ft/yr) (Figure 6). During the 8 year pre-construction interval, the project area shoreline receded -105 m (-344 ft). Subsequent pre-construction analyses of the TE-46 shorelines produced erosion rates of -17.26 m/yr (-56.64 ft/yr) for the interval from 1998-2004 and -19.77 m/yr (-64.85 ft/yr) for the interval from 2004-2005 (Figure 6). Approximately, 1,200 m (3,937 ft) of the pre-project shoreline were converted to open water during 1998-2005 interval. As a result, no shoreline change data could be generated for these reaches. Figure 6 illustrates the declining population of shoreline replicates over the pre-construction intervals and indicate that the shoreline was breaking up in place at this time. Although the shoreline erosion rate was exceptionally high for the 1998-2005 interval, the erosion estimates are probably underestimated due to the loss of shoreline reaches. The large erosion values and the small number of shoreline replicates reported for the 2004-2005 interval (Figure 6) reveal that erosion and land-loss rates increased for this interval. Indeed, several narrow shoreline reaches were transformed to open water habitat during the 2004-2005 interval. Therefore, it is evident from the shoreline erosion data that the 2005 hurricane season altered and reshaped the project area shorelines (Figure 6). The passage in quick succession of Hurricane Cindy (Jul 2005), Hurricane Katrina (Aug 2005), and Hurricane Rita (Sep 2005) in close proximity to the project area probably eroded large sections of shoreline. Therefore, the 2005 hurricanes hastened the shoreline retreat in the pre-construction project area and intensified the land-loss and fragmentation of the Lake Boudreaux shorelines.

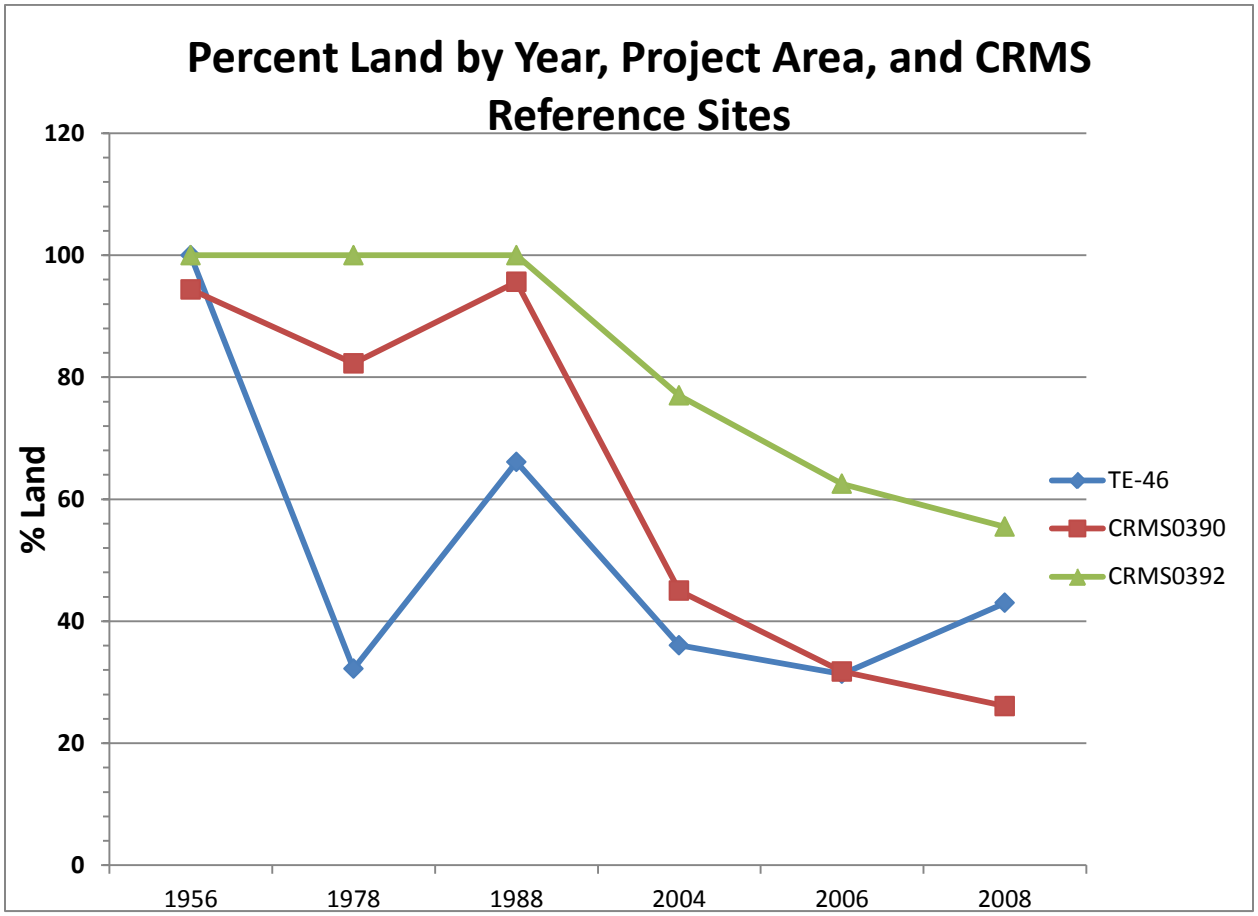

Figure 5. Percent land by year in the TE-46 project marsh compared to CRMS reference marsh sites (CRMS0390 and CRMS0392). Note that the data displayed above is on a different spatial scale than the data in figure 4 and is for trend examination (CRMS spatial viewer land/water, Barras et al. 2008).

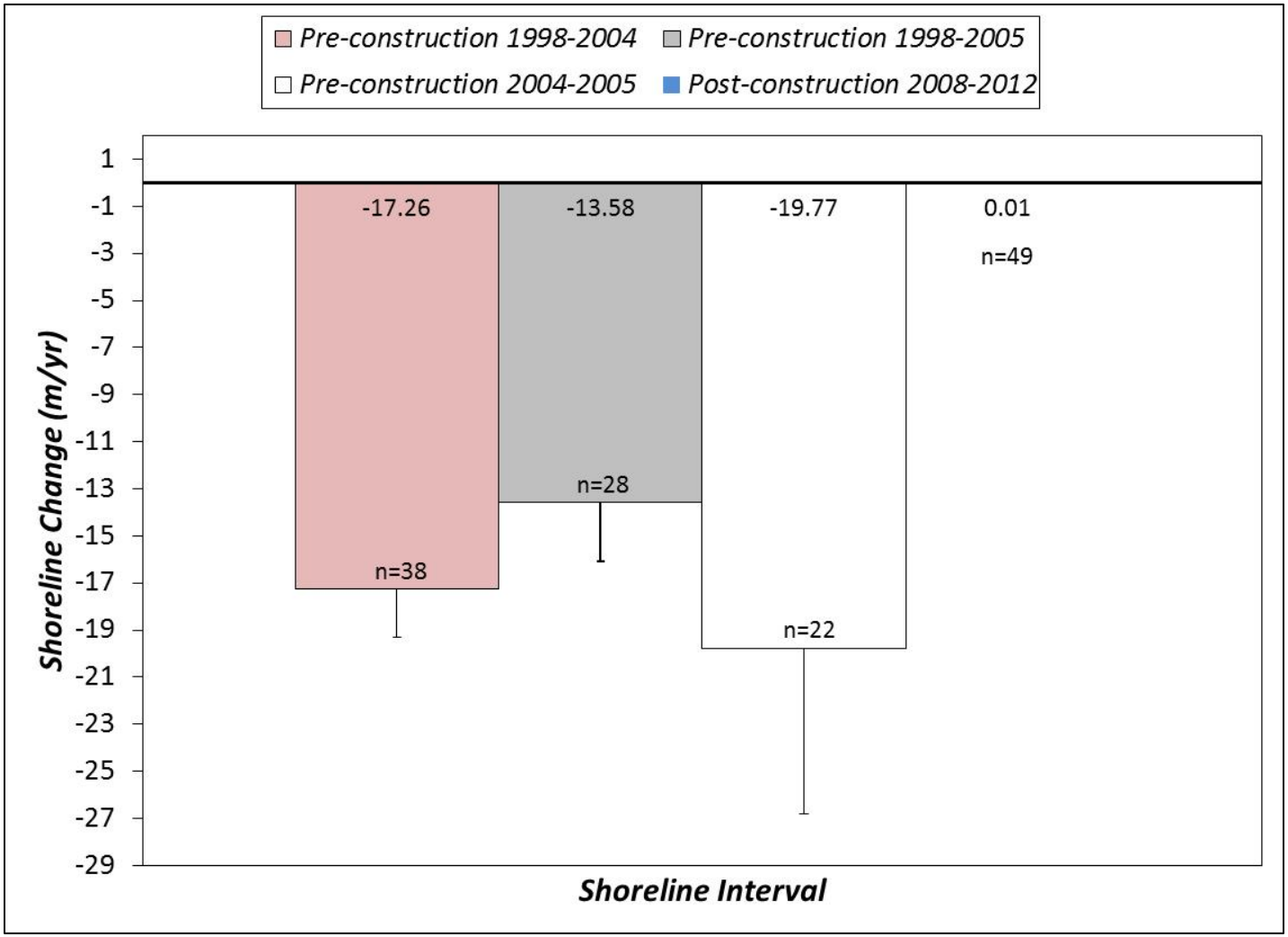

Figure 6. Shoreline change rates for the area behind the foreshore rock protection structure for various time intervals both pre-construction and post-construction.

Since construction of the foreshore rock shoreline protection structure and the marsh creation areas, the marsh edge erosion rate has declined in the project area. The average shoreline erosion rate behind the rock shoreline protection structure was 0.01 m/yr (0.03 ft/yr) from Oct 2008 to Oct 2012 (Figure 6). Actually, the post-construction interval showed minimal progradation. However following visual inspections of the aerial photographs, it became apparent that the shoreline position differences are probably the result of vegetation colonization of mudflat areas in the immediate lee of the structure. The combination of the foreshore rock shoreline protection structure, sediment additions to the marsh creation area shoreline, and the small fetch behind the rock shoreline protection structure likely facilitated the low post-construction erosion rate. This grouping of shoreline protection and marsh creation features has proven to minimize shoreline transgressions on other restoration projects (Curole and Ledet 2012). Future shoreline data will determine if these low erosion rates are sustainable.

Emergent Vegetation:

Project-Specific Vegetation Data Analysis and Results:

Data collection for the TE-46 project area occurred in October 2012 (3 years post-construction). CPRA personnel collected percent cover and species composition data from 42 randomly selected stations located along 14 east-west transects which ran through the three marsh creation areas (Figure 7). In addition to mean percent cover, the mean Floristic Quality Index (FQI) for the project area was estimated using the Cretini et al. protocol (2011). Vegetation composition in the project's marsh creation areas included a mix of *Spartina alterniflora* (smooth cordgrass), *D. spicata*, *Iva frutescens* (bigleaf sumpweed), *Schoenoplectus robustus* (sturdy bulrush), as well as other species indicative of a mainly saline marsh habitat (Figure 8). *S. alterniflora* and *D. spicata* were the species with the greatest mean cover values, with *S. alterniflora* as the dominant species. The project FQI was 56.58 (Figure 8).

Due to slight elevational variations, coupled with changes in soil characteristics from station to station, personnel found interesting vegetative composition mixes embedded throughout the expanse of the marsh creation areas. Based upon the vegetation species composition, each station was classified into a marsh type in the CPRA database, utilizing information gained from Visser and Sasser (2008). Of the 42 vegetation stations, 64% (27) were classified as saline marsh, 24% (10) were brackish, 5% (2) were intermediate, and 7% (3) were classified as freshwater marsh (Figure 9).

It is interesting to note that the dominant species in the natural marshes outside the creation areas was *Spartina patens* (marshhay cordgrass), while the dominant species inside the creation areas was *S. alterniflora* (Figure 8). CPRA observed large expanses of *S. alterniflora* throughout the creation areas, and though *S. patens* was documented it was sparse (<1%) and

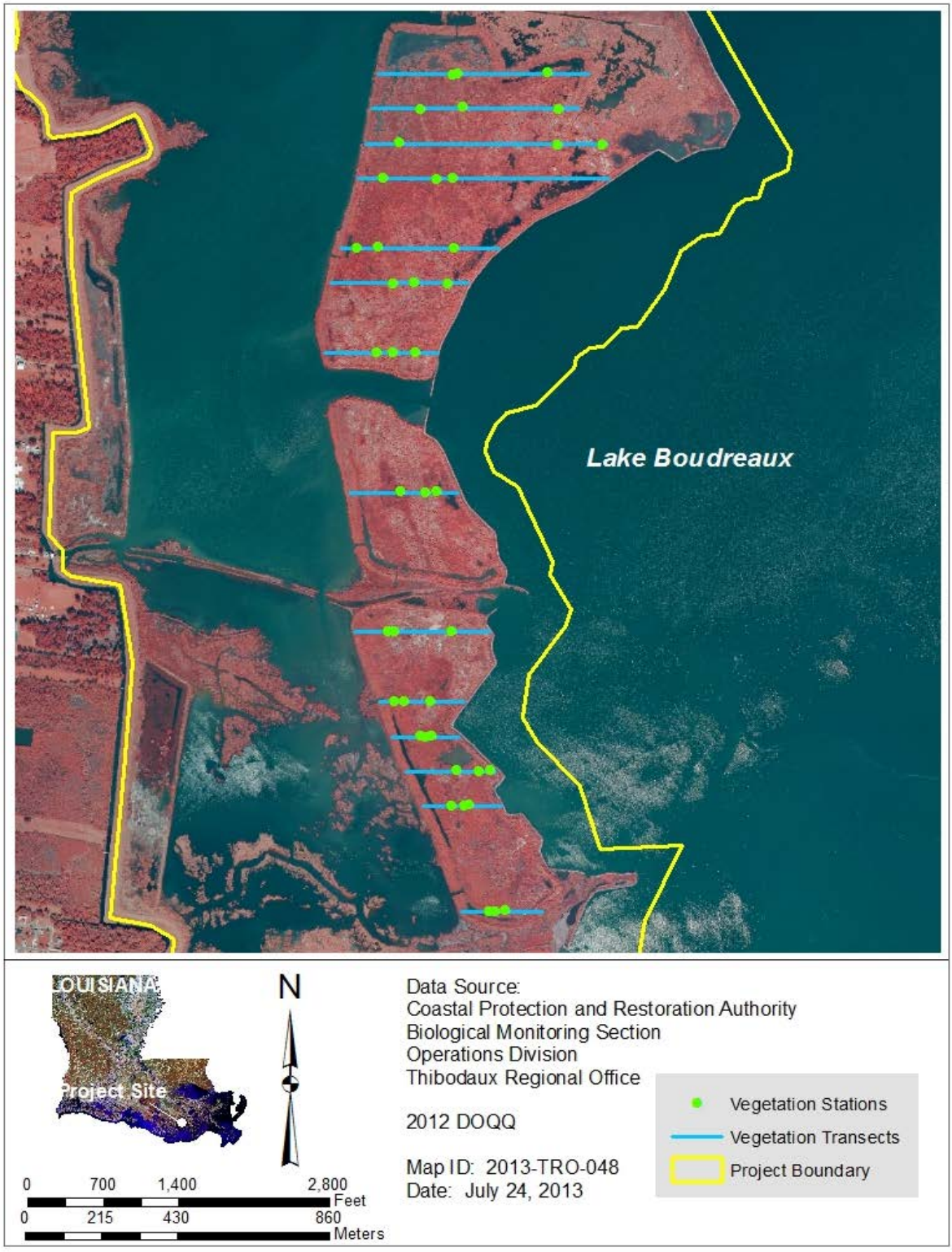

Figure 7. Location of the randomly selected project-specific vegetation stations inside the three marsh creation areas for the TE-46 project.

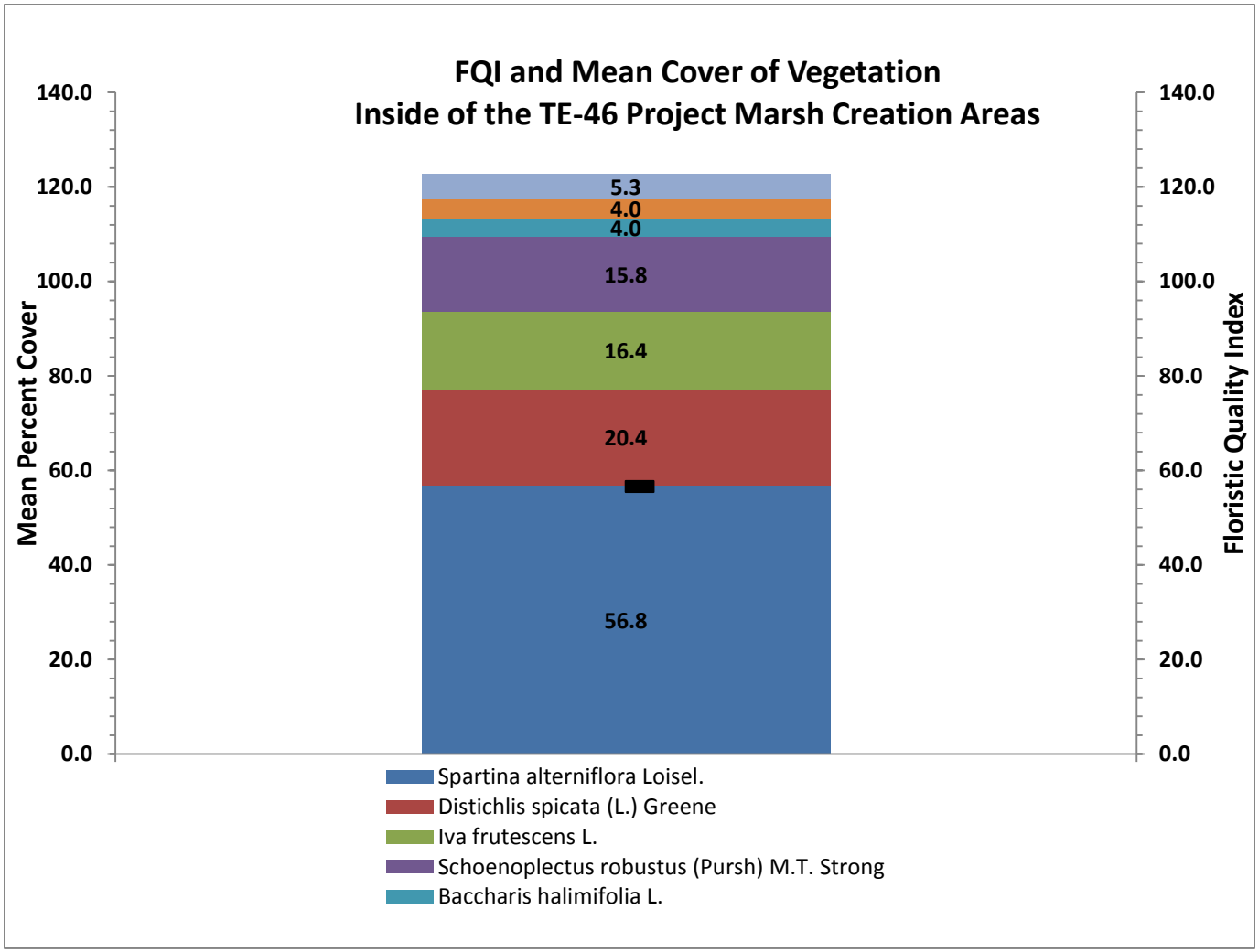

Figure 8. Mean percent cover and Floristic Quality Index for the TE-46 project-specific vegetation stations in the marsh creation areas.

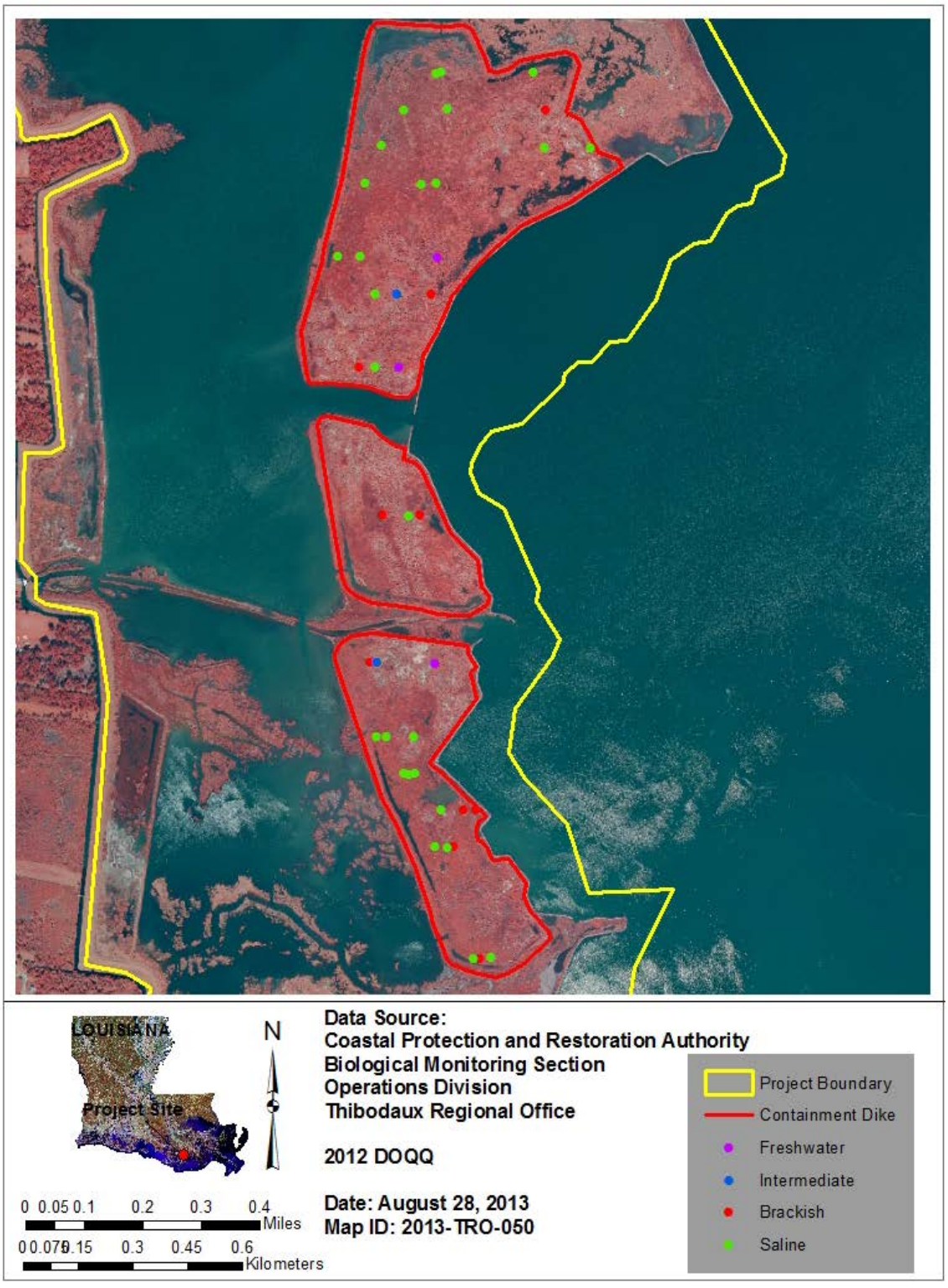

Figure 9. Map of the 2012 TE-46 project-specific vegetation stations classified by marsh type.

not in large continuous swaths. Investigations into the construction phase of this project yielded information that the non-profit group Barataria Terrebonne National Estuary Program (BTNEP) sponsored a group of volunteers to install plantings within the boundaries of the marsh creation areas in July 2009. The plantings consisted of approximately 5,500 bareroot *S. alterniflora* plugs. Most of the plugs were installed along the toe of the earthen containment dikes facing the foreshore rock shoreline protection structure. In the northern marsh creation area some were installed just inside the earthen containment dike along the northern portion as well as in a shallow interior pond approximately 100-150 feet in from the dike. Some of the plantings were installed at the toe of the earthen containment dikes on either side of the fishing access between the north and central marsh creation areas. These plantings would partially explain the successful recruitment of *S. alterniflora* on the created marsh platform for all three creation areas.

The ten most similar sites were identified, all of which have comparable Bray-Curtis dissimilarity values (Table 1). Similar to TE-46, these ten sites are dominated by *S. alterniflora* and, for several sites, varying quantites of *D. spicata* (Figure 10). In addition, CS28, CRMS0355, CRMS0400 and CRMS6301 all contain moderate quantities of *I. frutescens*, as does TE-46.

Table 1. Bray-Curtis dissimilarities for the 10 most similar sites and the 2 geographically proximate sites.

Station/Site	Bray-Curtis Dissimilarity	FQI
CS28	32.3	
CRMS0355	32.9	55.5
CRMS6301	37.9	74.6
CRMS0282	38.2	74.3
CRMS0164	39	62.71
CMRS0310	39.1	39
CRMS0338	39.1	39
CRMS0400	39.8	61.6
CRMS0377	39.9	77.6
CRMS0978	39.9	41.2
CRMS0392	97.2	6.6
CRMS0390	91.4	36.2

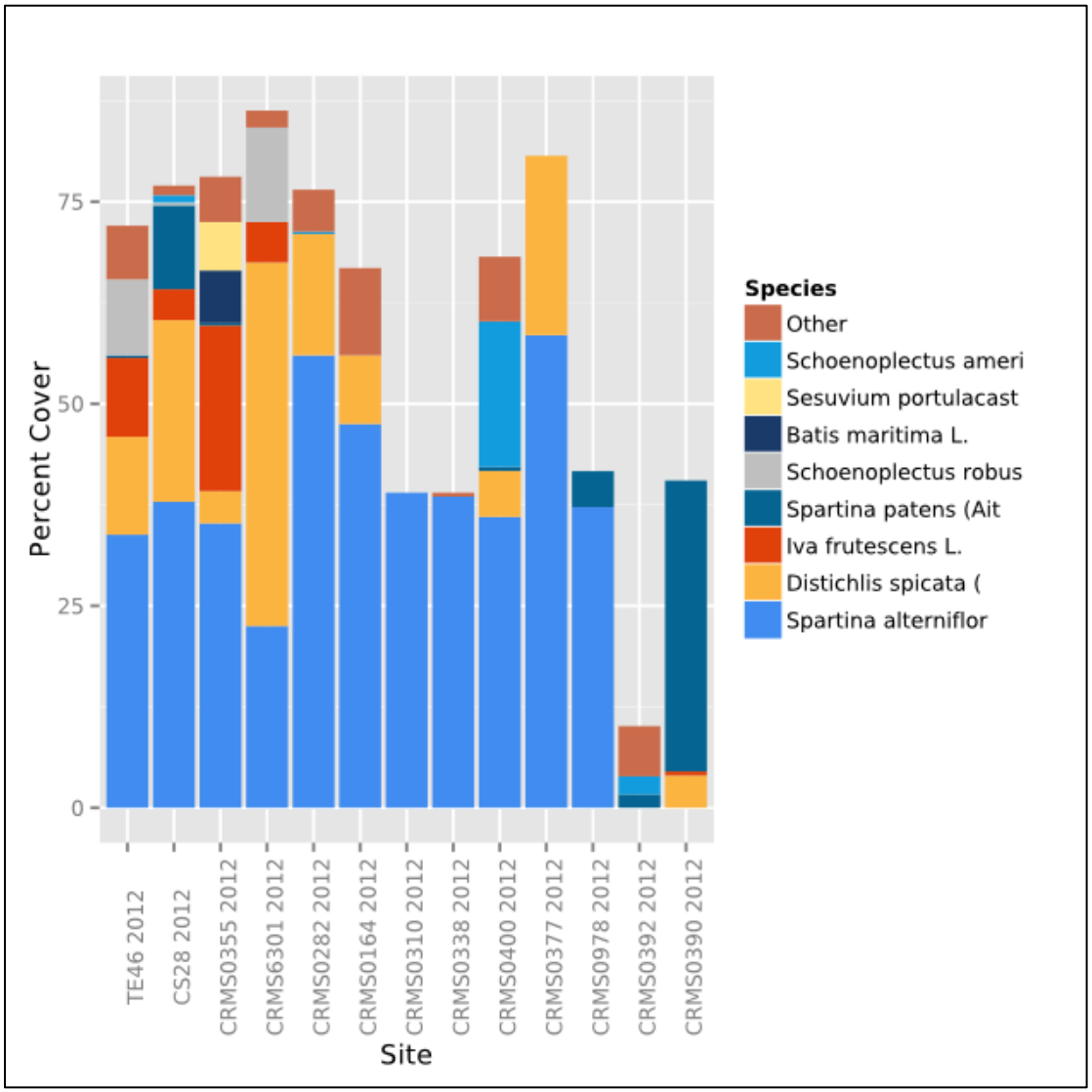

Figure 10. Bar graph of the vegetative composition of TE-46, the 10 most similar sites, and the two most geographically proximate sites.

Despite their compositional similarity, not all of these sites are not geographically proximate. Of these sites, CRMS0282 and CRMS0164 are in the Barataria Basin (near Port Sulfur and Bayou Lafourche, respectively), and CRMS6301 and CS28 are both located in the Calcasieu-Sabine basin near Calcasieu Lake (CRMS6301 is located within the CS28 project area). However, CRMS0355, CMRS 0310, CRMS0338, CRMS0400, CRMS0377, and CRMS0978 are located in the Terrebonne Basin (south of the project area). In contrast, the two geographically proximate sites (CRMS0390 and CRMS0392) show substantially different vegetation composition (Figure 10) and accordingly high dissimilarities (Table 1).

CRMS Vegetation Analysis and Results:

For CRMS reference sites CRMS0390 and CRMS0392, the data were entered into an electronic format where CPRA/TRO personnel followed QA/QC procedures and saved to the Louisiana Department of Natural Resources (LDNR) database prior to data analysis as stated in Folse et al. (2012). The charting tool from the CRMS website, based upon the Cretini and Steyer protocol (2011) was utilized to determine mean percent cover and FQI within each CRMS reference site for each year of data collection (Figures 11 & 12). The charting tool was also used to generate box charts which depict a comparison of the 2012 FQI of each reference CRMS site to all other CRMS sites coastwide, and to all sites within the same hydrologic basin within the same marsh type (Figures 13 & 14). Finally, the FQI scores for each year of data for each site were compared against a box plot of all scores for all sites coastwide within the same marsh types (Figures 15 & 16).

The CRMS spatial viewer assessment of CRMS0390 indicated that this was classified as a brackish marsh by 2012 and that the dominant species was *S. patens* for all 7 years of data collection (Figure 11). The FQI and the mean cover of *S. patens* followed a similar trend and closely tracked each other. This was because *S. patens*, the species with the greatest cover, had a high cc score therefore, it had a large impact on the FQI value. Species cover and FQI were at their peak in 2010 and at their lowest levels in 2006. The low 2006 score was likely a response to the damage this area suffered from the impacts of hurricanes Cindy and Katrina in 2005. It is interesting to note that a vegetation shift occurred by 2010, in which species with lower cc scores like *Bacopa monnieri* (coastal waterhyssop) and *Eleocharis parvula* (dwarf spikesedge) disappeared, and *D. spicata*, which had a higher cc score appeared. The 2012 FQI score for this site (36.2) was lower than all CRMS sites within the same marsh type in the Louisiana coastal zone (Figure 13). The 2012 FQI was also lower than the TE-46 project area FQI (56.58). Additionally, CRMS0390 shifted from an intermediate marsh classification to a brackish marsh classification by 2009 and has remained a brackish marsh through 2012 (Figure 15).

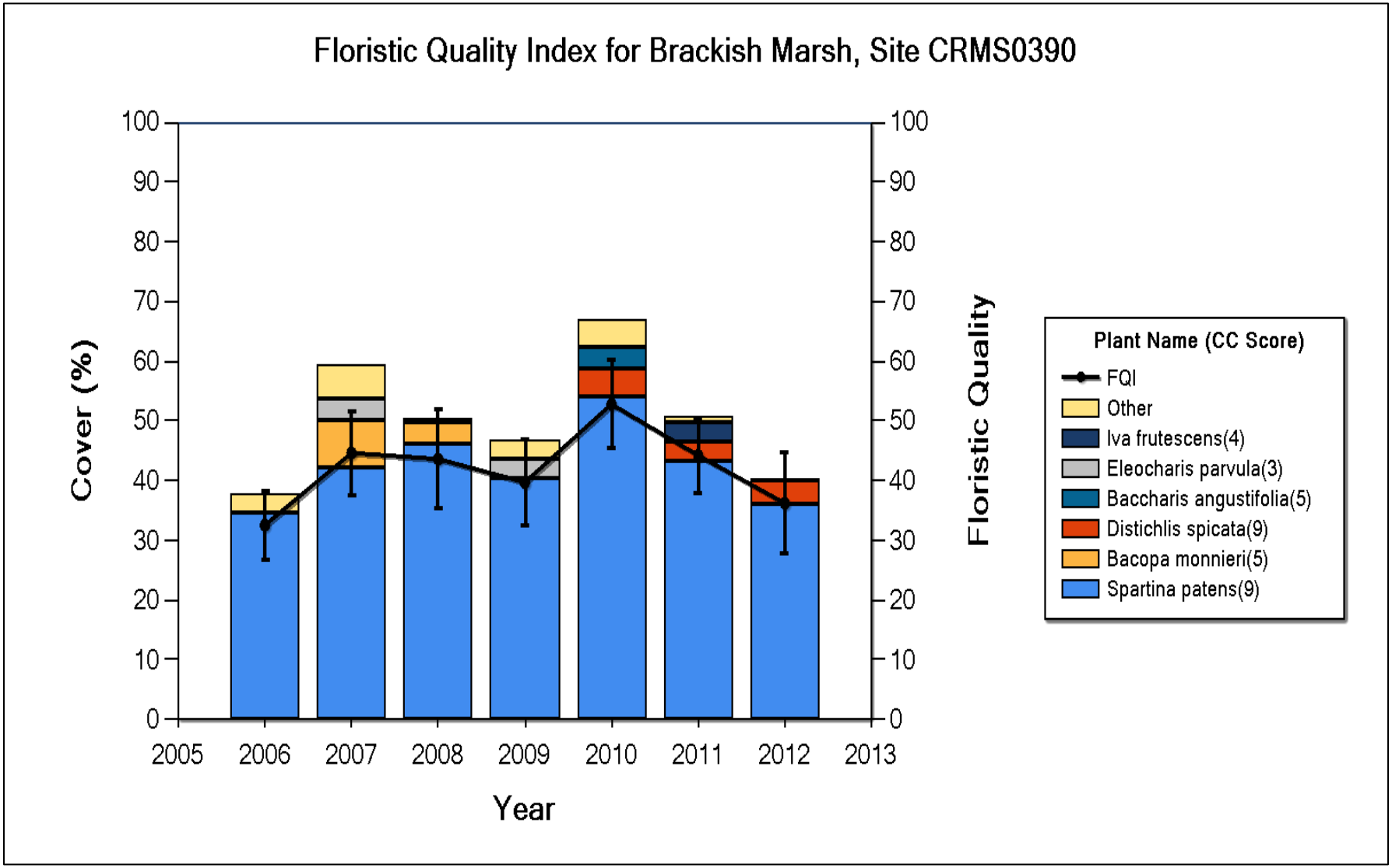

Figure 11. FQI and species composition with mean cover for brackish marsh site CRMS0390.

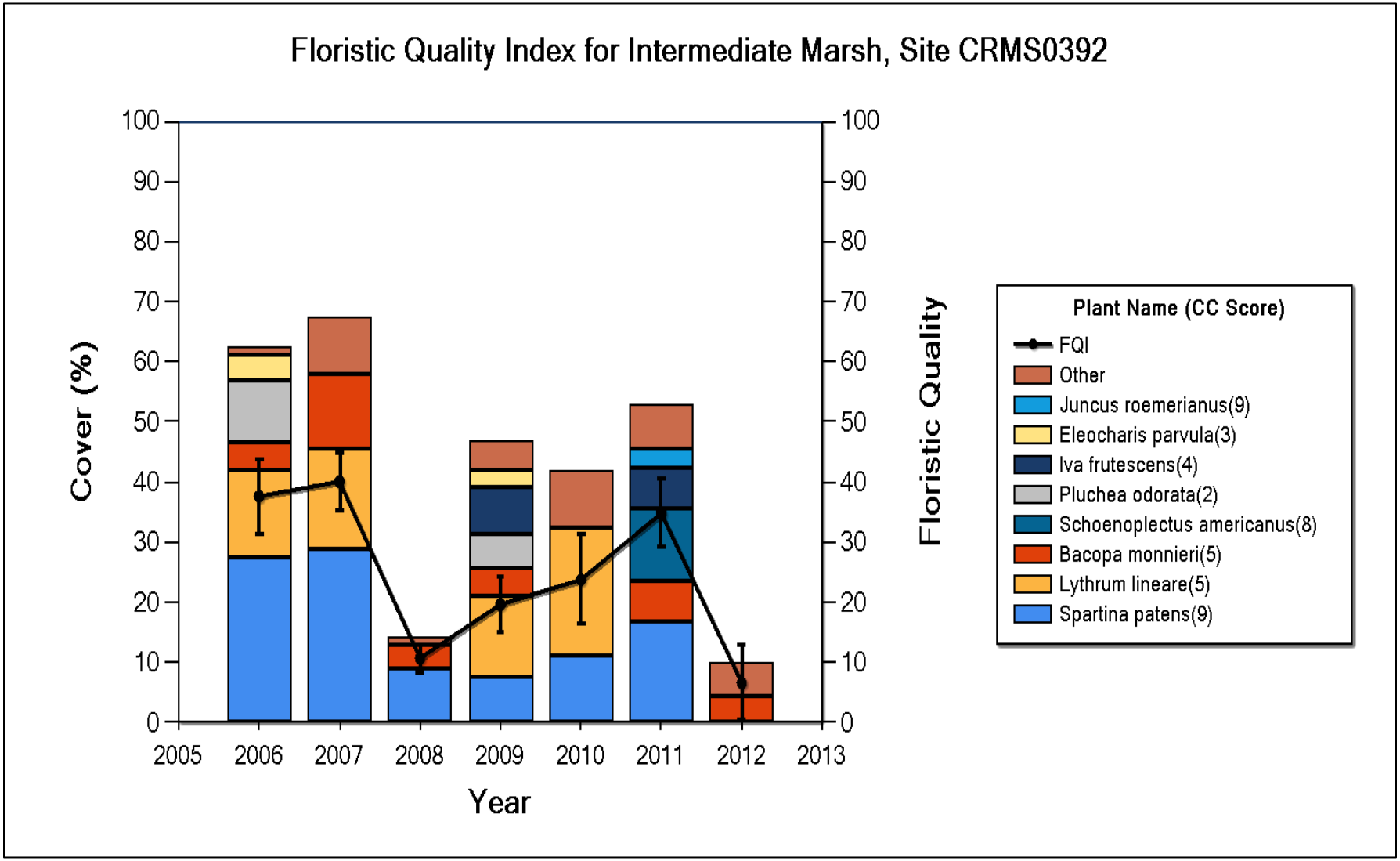

Figure 12. FQI and species composition with mean cover for intermediate marsh site CRMS0392.

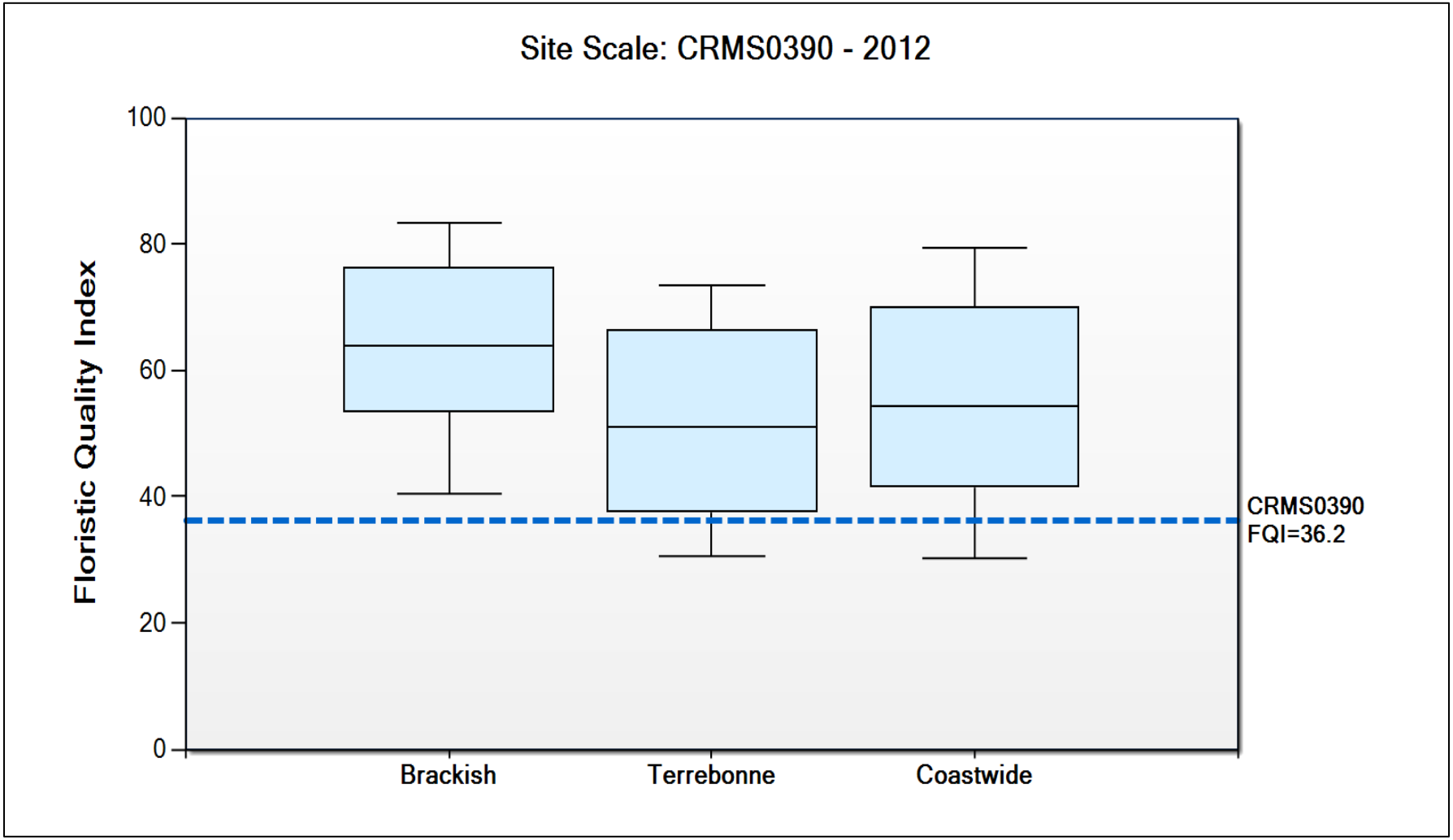

Figure 13. Box plot indicating the CRMS0390 site FQI score for 2012 compared to the distribution of scores for all coastwide CRMS sites within the same marsh type, within the same hydrologic basin, and across the entire LA coastal zone.

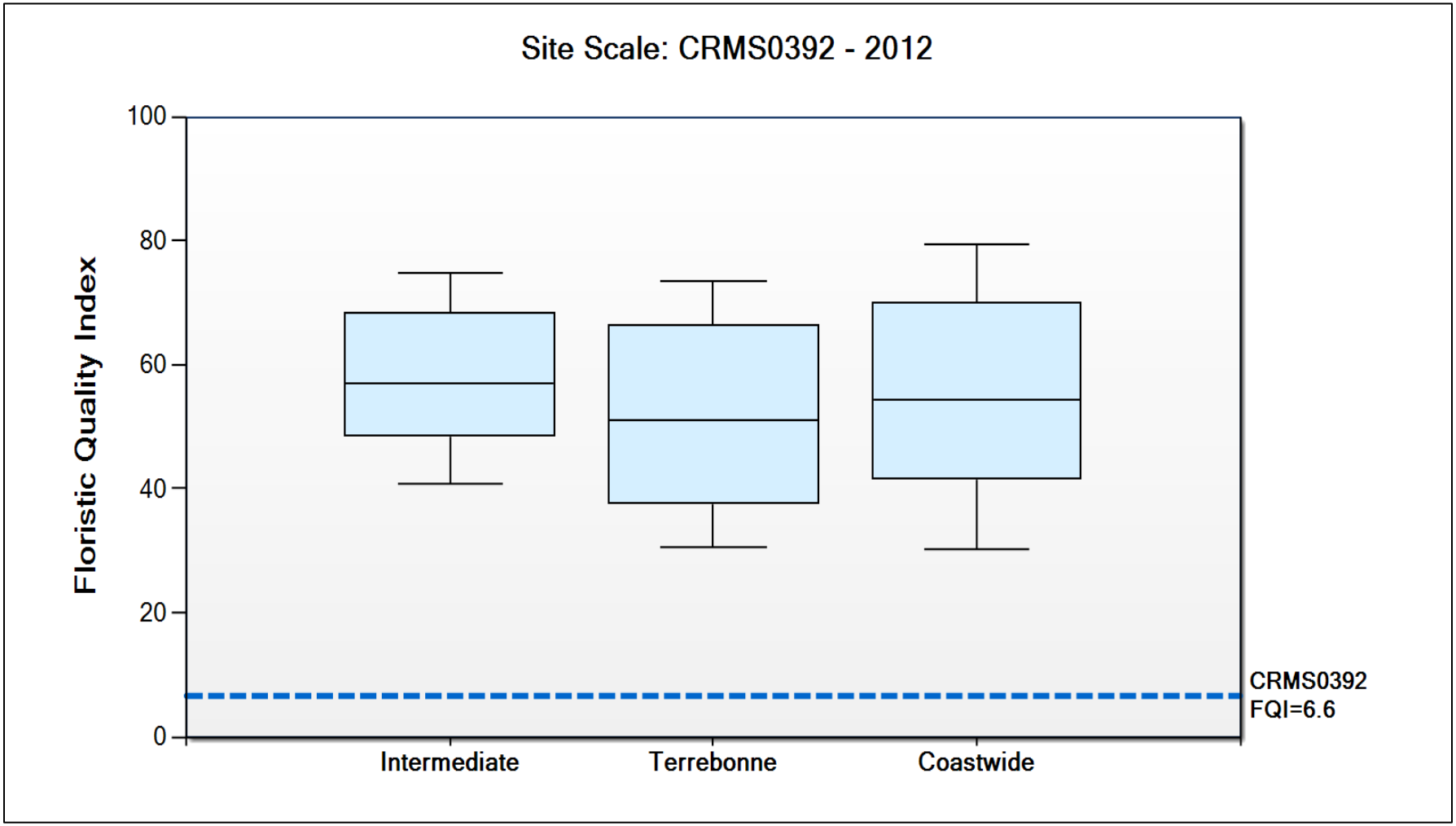

Figure 14. Box plot indicating the CRMS0392 site FQI score for 2012 compared to the distribution of scores for all coastwide CRMS sites within the same marsh type, within the same hydrologic basin, and across the entire LA coastal zone.

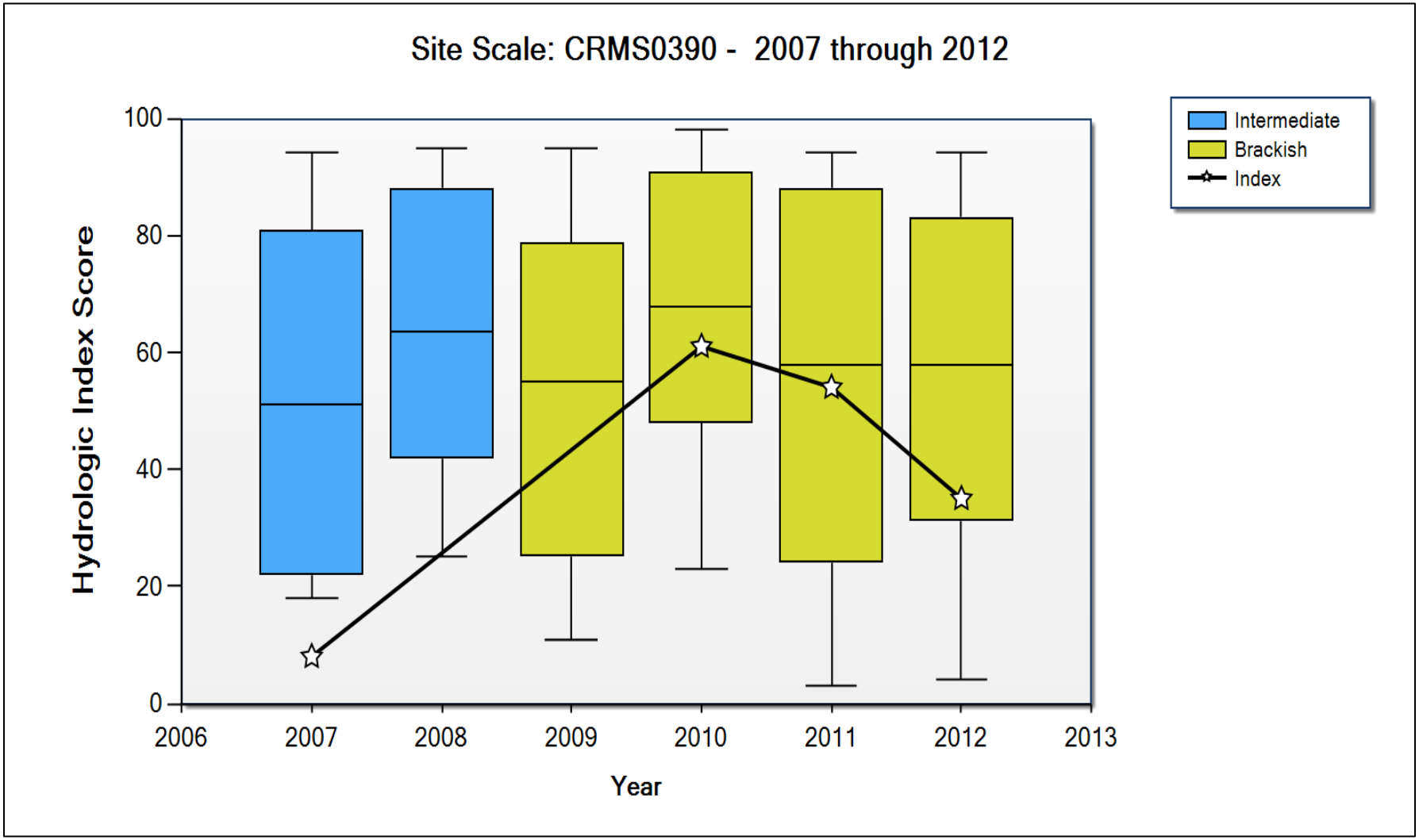

Figure 15. A time series of FQI scores for CRMS0390 relative to a box plot of scores for all the CRMS sites within the same marsh type each year. Marsh type classifications for each year are based on species composition data for that year at the specific CRMS site.

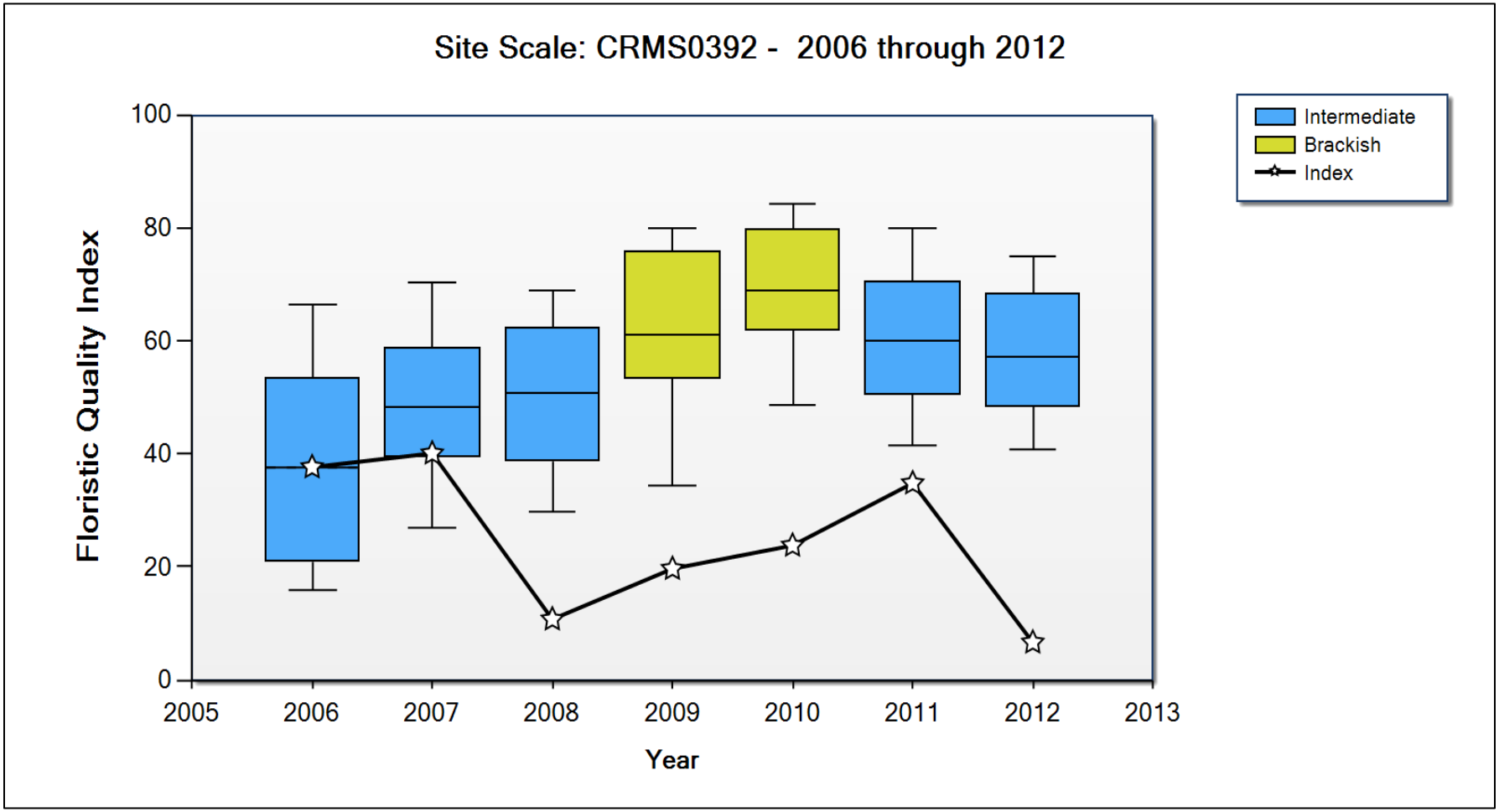

Figure 16. A time series of FQI scores for CRMS0392 relative to a box plot of scores for all the CRMS sites within the same marsh type each year. Marsh type classifications for each year are based on species composition data for that year at the specific CRMS site.

CRMS0392 was classified as an intermediate marsh by 2012 with *S. patens* as the dominant species. Overall, this site had lower FQI values and cover values than CRMS0390 and it was more diverse. Cover values and FQI were at their highest in 2007 and at their lowest in 2012 (Figure 12). Both values plummeted by 2008, but trended steadily upwards through 2011. By 2012 the cover values and FQI (6.6) were markedly lower than those of CRMS0390 and the TE-46 project area. The 2012 FQI score for this site was lower than all CRMS sites within the same marsh type in the Louisiana coastal zone as well as within the same hydrologic basin (Figure 14). CRMS0392 shifted from an intermediate marsh classification in 2008 to a brackish marsh classification in 2009 and back to intermediate in 2011 and 2012 (Figure 16). Finally, with the exception of 2006, between 2007 and 2012, this site's FQI scores were consistently lower when compared to all CRMS sites within the same marsh type. The increase in exposure to large tropical systems due to rapid interior marsh loss and shoreline loss in this area, as well as the less than favorable hydrologic conditions which are discussed later in this report have likely contributed to these low FQI scores.

CRMS Supplemental:

There are no CRMS-*Wetlands* sites inside of the TE-46 boundary, however nearby sites CRMS0390 and CRMS0392 will be used as references to help characterize what conditions are like in this area of the Terrebonne basin. In addition to land-water data and vegetation data presented earlier in this report, the CRMS sites offer additional data for monitoring elements such as salinity, water levels, soil characteristics, surface elevation changes and vertical accretion.

Salinity:

Adjusted salinity data presented in this section covers a monthly means time series beginning in June 2006 for continuous recorder station CRMS0390 and in July 2007 for CRMS0390 through May 2013 for both stations (Figure 17). Mean salinity at sites CRMS0390 and CRMS0392 is approximately 8.4 ppt and 8.3 ppt respectively, with spikes above 15 ppt. Monthly mean salinity is very similar between the two sites and they track each other very closely.

Interstitial soil porewater salinity at the reference CRMS sites was also documented from 2006 through 2012 (Figure 18). Salinities were measured at 10 cm and 30 cm depths. The yearly mean porewater salinity for reference CRMS locations ranged from approximately 12 to slightly above 6 ppt, with variation from year to year. CRMS0392 consistently had slightly higher salinities than CRMS0390 at both depths.

Water Level:

Adjusted water level data presented in this section covers a monthly means time series beginning in June 2006 for continuous recorder station CRMS0390 and in July 2007 for CRMS0390 through May 2013 for both stations (Figure 19). The water level patterns at each

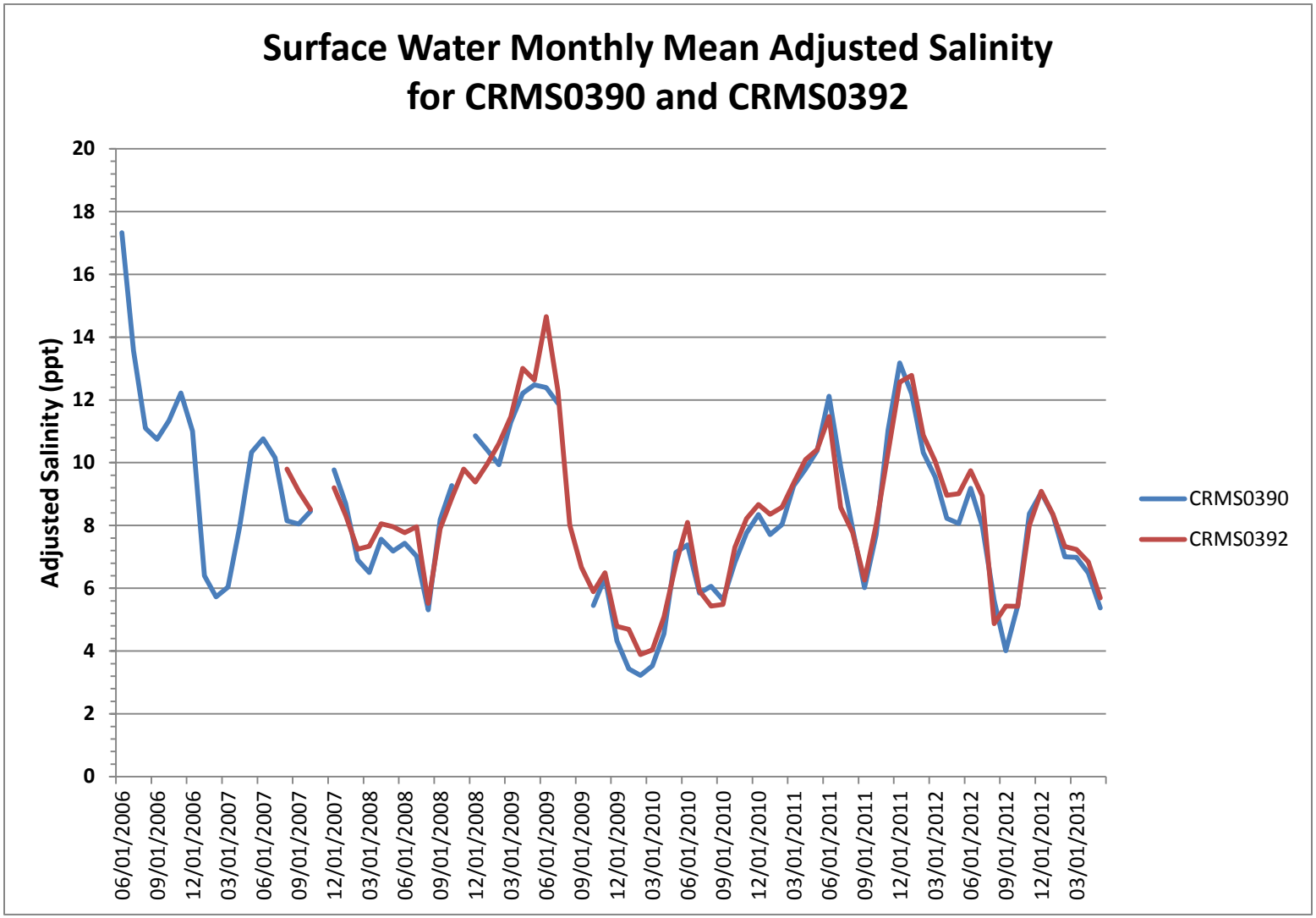

Figure 17. Monthly mean salinity at reference hydrographic stations (CRMS0390 and CRMS0392) from 2006 through 2012.

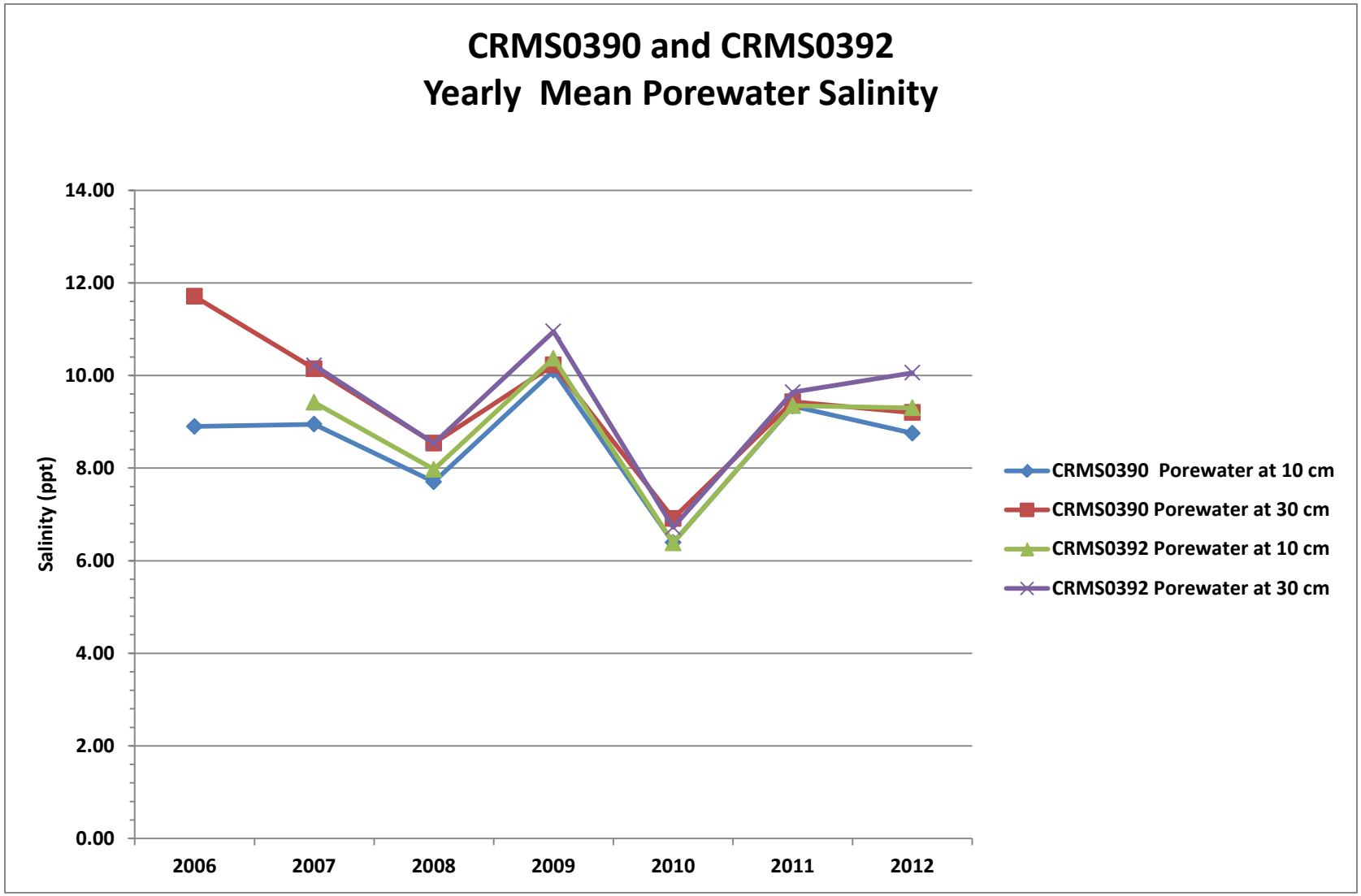

Figure 18. Mean yearly interstitial porewater salinities for reference CRMS sites from 2006 through 2012.

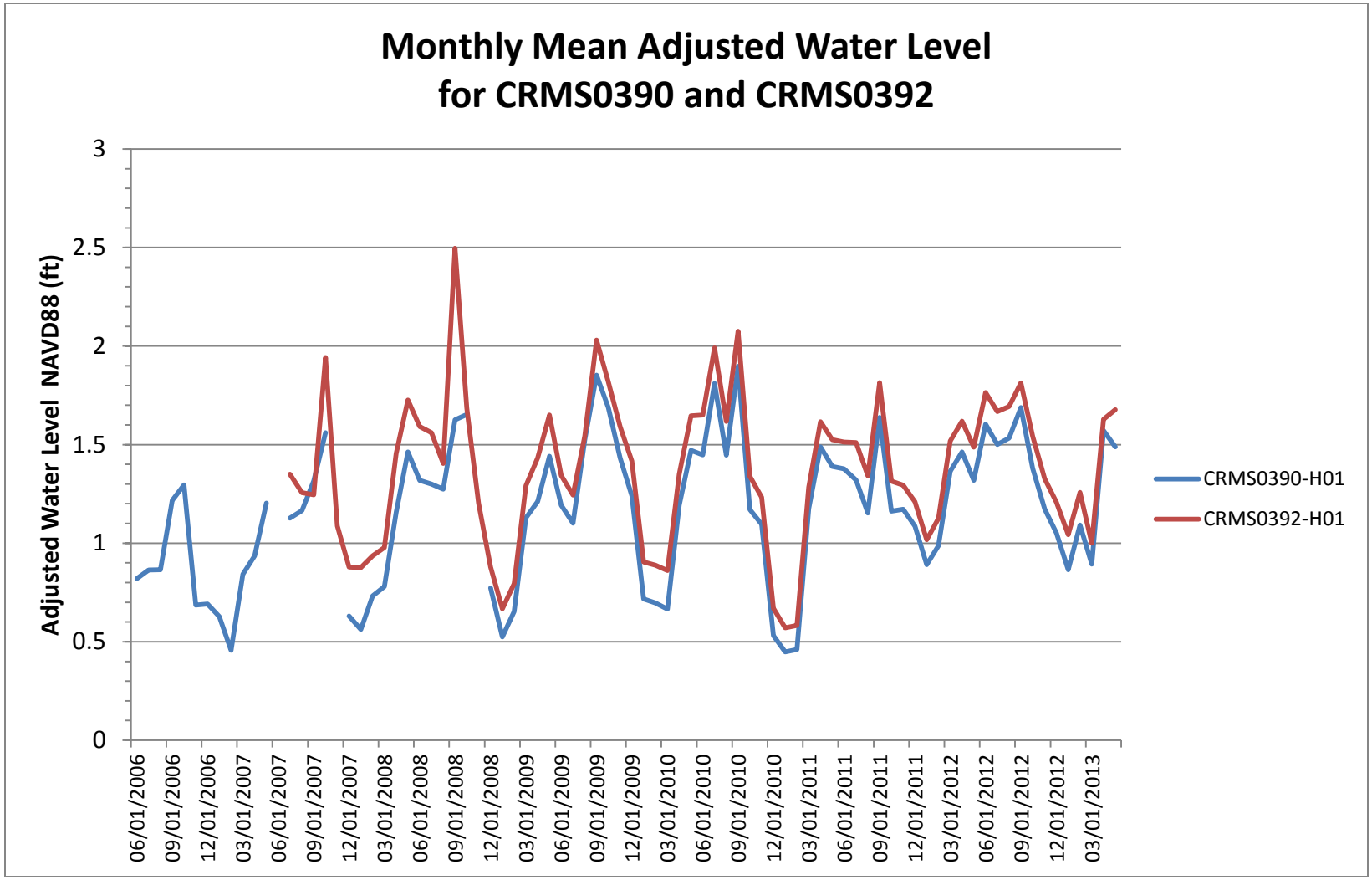

Figure 19. Monthly mean adjusted water levels at reference hydrographic station (CRMS0390 and CRMS0392) from 2006 through 2012.

recorder station were very similar, and like the salinity data, they track each other very closely. CRMS0392 had consistently slightly higher adjusted water levels than CRMS0390. Adjusted mean monthly water levels at CRMS0390 ranged from 0.4 ft NAVD 88 to 1.89 ftNAVD 88, while CRMS0392 experienced a range from 0.57 ft NAVD 88 to 2.49 ft NAVD 88.

Hydrologic Index:

The Hydrologic Index (HI) score was developed by CRMS analytical teams based upon parameters collected at CRMS sites from 2006 through 2009 across the Louisiana coast from which they developed a baseline distribution. The index was designed to help better understand the condition of coastal wetlands at various time and spatial scales. A site was classified as good if it's score was greater than 75% of all CRMS site scores calculated during this baseline period, fair if it fell within the 25% to 75% range, and poor if did not exceed 25%. The HI score is calculated by year, and requires greater than 70% data completeness for a particular year in order to obtain a score. HI scores indicate if the project area hydrologic conditions have provided a healthy environment for the marsh vegetation to thrive. The HI scores for the CRMS reference sites are presented in Figures 19 and 20. The box plots indicate a comparison of the HI scores from 2006 through 2012 to scores from all the Louisiana coastal zone CRMS sites within the same marsh type. Due to the lack of data completeness for water years 2006, 2008, and 2009 for CRMS0390, comparisons to all other CRMS sites was not available (Figure 20). Interestingly the box plot indicates the change in marsh classification from intermediate to brackish as time progresses. The CRMS0390 HI scores are all lower than the comparative sites. The HI scores for CRMS0392 are not shown for water years 2006 and 2007 because the data sets did not meet the data completeness threshold (Figure 21). Marsh classifications changed from intermediate to brackish to intermediate throughout the data series. HI scores for CRMS0392 were all lower than the comparative CRMS sites, particularly for years 2008, 2011, and 2012.

Soil Characteristics:

Three soil cores were extracted from each site during construction as stated in Folse et al. (2012). CRMS0390 was constructed in June 2006 and CRMS0392 was constructed in July 2007. The cores are analyzed in four cm increments down to 24 cm, however CRMS0390 had soils that were too fluid or unconsolidated to extrude and slice with any precision. Therefore, three cores were collected to a depth of 16 cm. The cores for CRMS0392 were sliced, however comparisons between the two CRMS sites will only be shown for the 16 cm depth. For this analysis, bulk density and percent organic matter for the 16 cm depths from each sites' cores were averaged (Figures 22 and 23). Bulk density as well as organic matter content was higher at CRMS 0392 than at CRMS0390. Both the reference sites had low measurements for bulk density, below 1.5 g/cm^3. Percent organic matter was below 70% for both sites and just below 50% for CRMS0390.

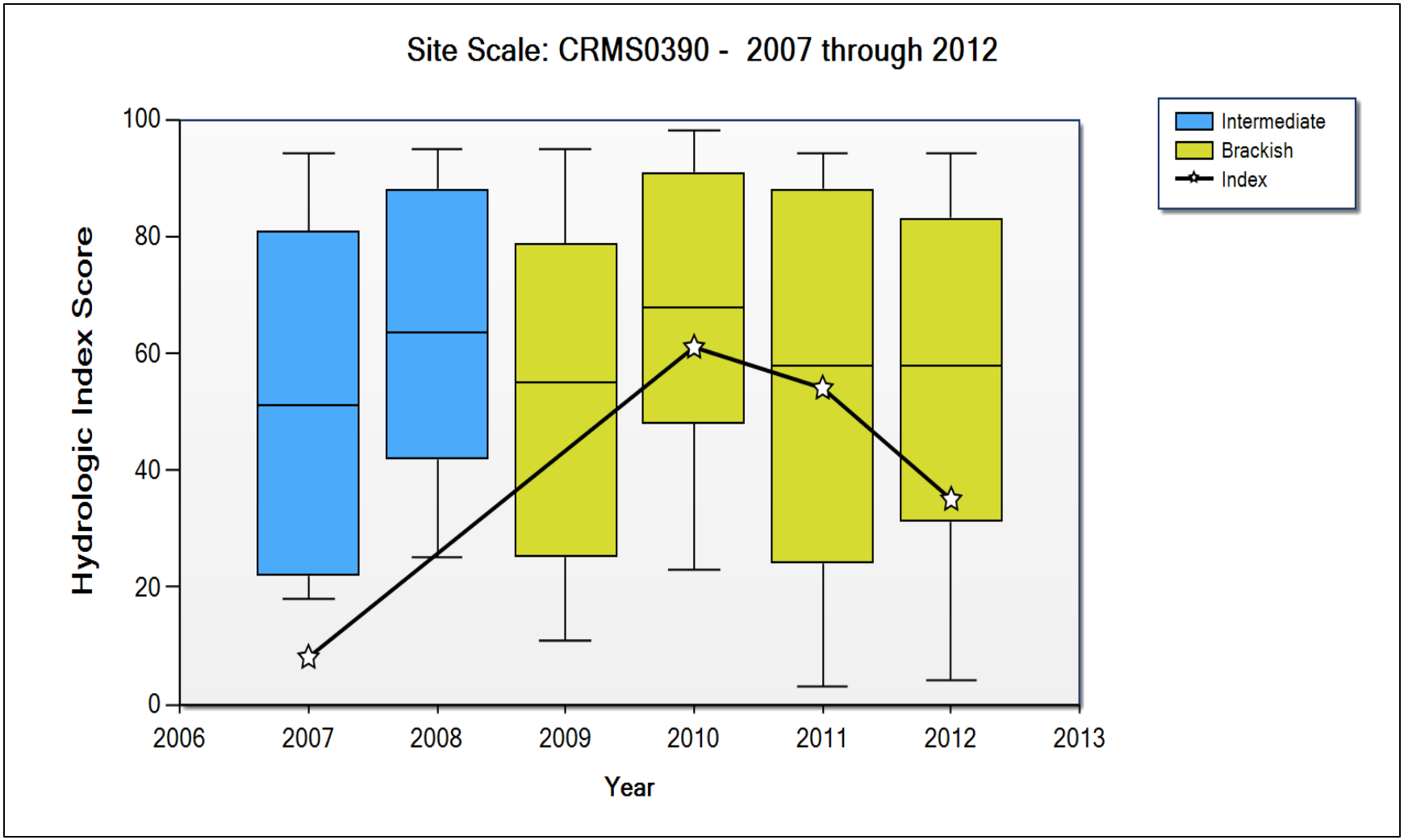

Figure 20. A time series of Hydrologic Index scores for CRMS0390 relative to the boxplot of the scores for all the sites within the same marsh type each year. The HI score for CRMS0390 is not shown for 2006, 2008, and 2009 because the data set for those water years did not meet the data completeness threshold of >70%.

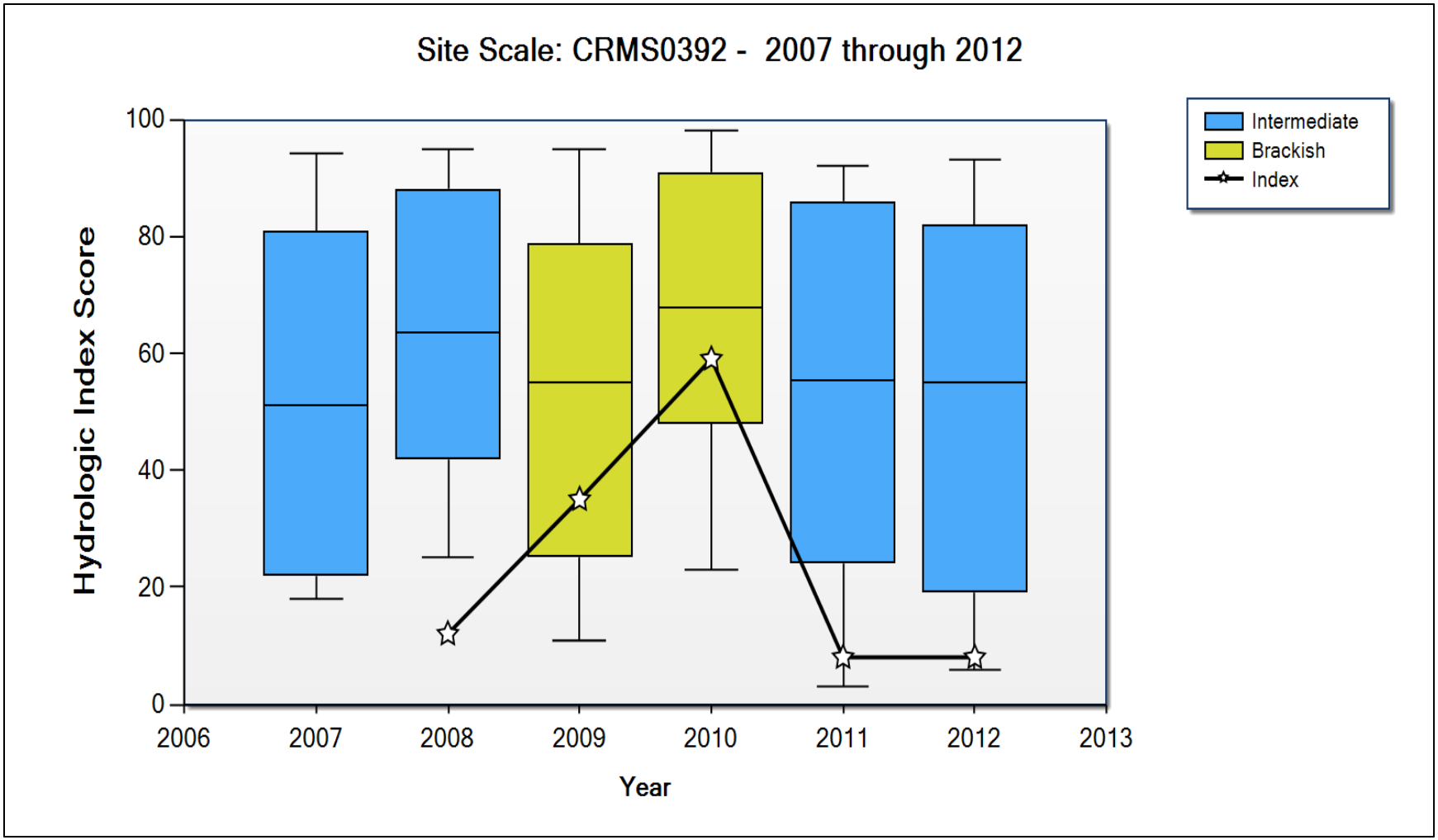

Figure 21. A time series of Hydrologic Index scores for CRMS0392 relative to the box plot of the scores for all the sites within the same marsh type each year. The HI score for CRMS0392 is not shown for 2006 and 2007 because the data sets for those water years did not meet the data completeness threshold of >70%.

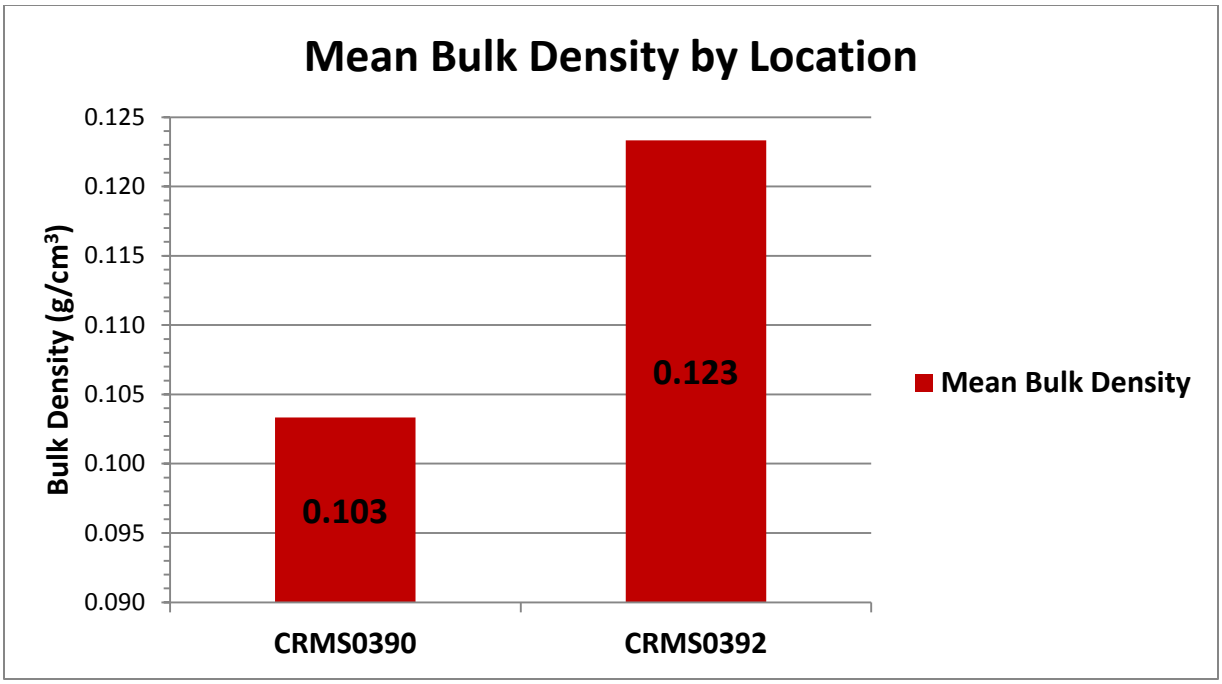

Figure 22. Mean soil bulk density at 16 cm depth of cores taken in reference CRMS marsh sites (CRMS0390 and CRMS0392).

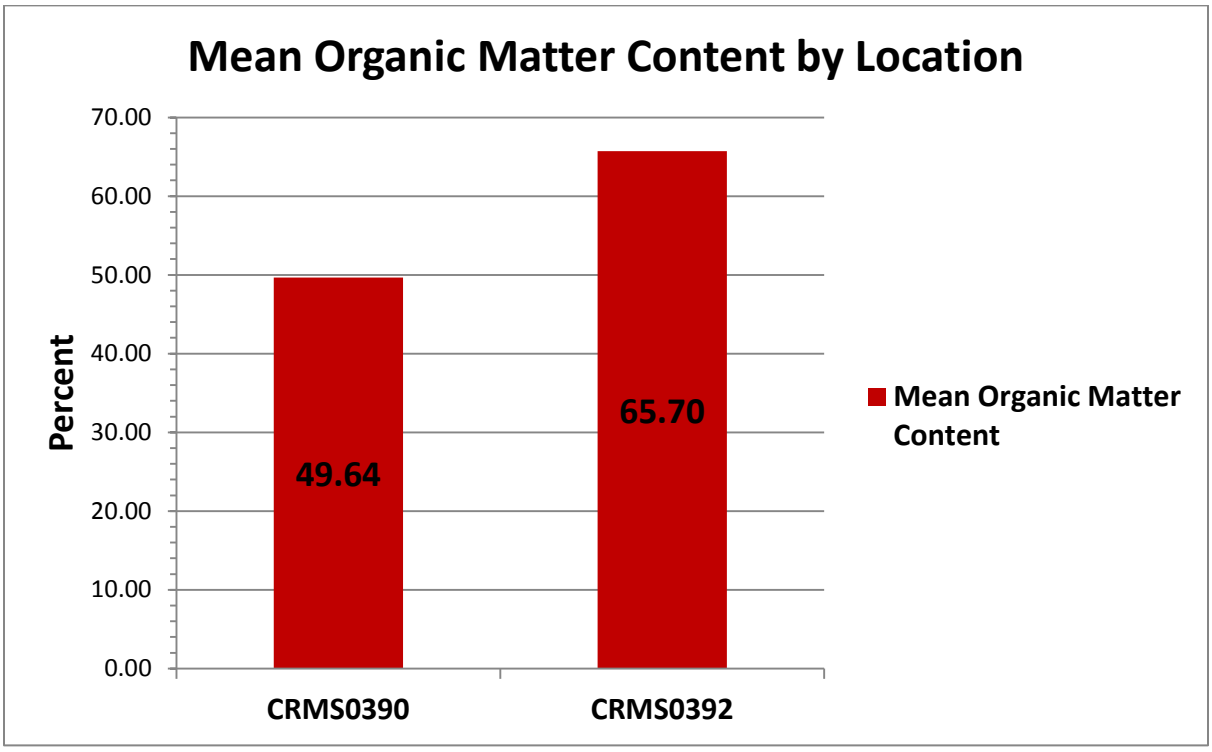

Figure 23. Mean soil percent organic matter at 16 cm depth of cores taken in reference CRMS marsh sites (CRMS0390 and CRMS0392).

V. Conclusions

a. Project effectiveness

The 20 year project life for TE-46 began in October 2009. Since construction was completed only two data collection events have occurred, aerial photography in October 2012 and vegetation data collection in the marsh creation areas in October 2012. Past CRMS photography and historical land loss data have aided in characterizing what the area near TE-46 has experienced. It is very early in the project life to be able to discern if the project goals are being met.

1. **Stop shoreline erosion along approximately 12,447 linear ft (3,794 m) of the western shoreline of Lake Boudreaux over the 20-year project life.** Early analysis of available aerial photography indicates that the TE-46 project shoreline behind the foreshore rock shoreline structure had slightly prograded one year post-construction at a rate of 0.03 ft/yr (0.01 m/yr). Pre-construction erosion rates by comparison were very rapid, with shoreline loss rates of -17.26 m/yr (-56.64 ft/yr) for the interval from 1998-2004 and -19.77 m/yr (-64.85 ft/yr) for the interval from 2004-2005. Powerful tropical storms are considered to have accelerated the loss rates for the 2004-2005 interval, and it is during this time that several shoreline reaches were completely converted to open water. Based upon the aerial photography analysis the project has been effective in stopping shoreline erosion three years post-construction.

2. **Initially create 220 acres (89 ha) of marsh by the completion of project construction with intertidal marsh developing after year 3 of the project's life.** In 2012, three years post-construction, the land-water analysis showed that the TE-46 project area contained approximately 40% land to 60% water. The marsh creation areas comprised approximately 44% (215 acres) of the overall land area inside the project boundary and only 9.5% of the water.

   Vegetation composition in the project's marsh creation areas included a mix of species indicative of a mainly saline marsh habitat dominated by *S. alterniflora* and *D. spicata.* The project FQI was 56.58 in 2012. Nearby reference CRMS sites were dominated by *S. patens* and by 2012 were classified as brackish and intermediate marsh sites respectively. Both of these sites have experienced shifts to a more saline marsh type between 2006 and 2012. Surface and soil salinity data collected from the CRMS reference sites support the growth of brackish marsh vegetation.

   Several CRMS-*Wetlands* sites were identified with similar vegetative composition to that of the TE-46 project area. All of these sites have a relatively high percent cover (25-40%) of *S. alterniflora*. Most of these sites are in the Terrebonne basin and are,

perhaps not surprisingly, saline coastal marsh. Additional vegetative sampling will determine whether the TE-46 project area transitions to an intermediate/brackish marsh similar to the geographically proximate CRMS0390 and CRMS0392 sites or whether it remains similar to saline coastal marsh.

3. **Reduce erosion rates by 50%, from 3.68% per year to 1.84% per year, in the created and nourished marsh over the 20-year project life.** Future land-water analysis of the created and nourished marsh areas will determine if erosion rates have been reduced.

4. **Reduce erosion rates by 25%, from 3.68% per year to 2.76% per year, in the non-directly affected marsh over the 20-year project life.** Future land-water analysis of the project area marsh areas will determine if erosion rates have been reduced.

b. Recommended improvements

All project features are in good shape. It is recommended that the missing warning sign on the lake side of the choke down section be replaced as it is the only indicator of the submerged structure for vessels traveling in that direction.

c. Lessons learned

At this time there are no lessons learned to list.

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APPENDIX A
(Inspection Photographs)

Photo 1: View of the southernmost end of the foreshore rock dike, looking west

Photo 2: View of access corridor for Gulf South pipeline in foreshore rock dike, looking west

Photo 3: View of foreshore rock dike and warning sign for access corridor, looking north

Photo 4: View of the foreshore rock dike near the south end of the marsh creation southern section, looking north

Photo 5: View of the foreshore rock dike near the south end of the marsh creation southern section, looking south

Photo 6: View of the fish dip near the south end of the marsh creation southern section, looking south

Photo 7: View of the foreshore rock dike along the southern section of marsh creation

Photo 8: View of the foreshore rock dike along the southern section of marsh creation

Photo 9: View of No Work Zone between the southern section and the central section, looking west

Photo 10: View of the south end of the central section foreshore rock dike, looking north

Photo 11: View of the choke down section in the foreshore rock dike, looking west

Photo 12: The warning sign on the lake side of the choke down section is missing form its support.

Photo 13: View of the vegetation inside of the marsh creation northern section

Photo 14: View along the foreshore rock dike northern section, looking north

Photo 15: View along the foreshore rock dike northern section, looking north

Photo 16: View along the foreshore rock dike northern section, looking north

Photo 17: View along the foreshore rock dike northern section, looking south

Photo 18: View of the northernmost end of the foreshore rock dike, looking south

Appendix B
(Three Year Budget Projection)

West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46)

Three-Year Operations & Maintenance Budgets 07/01/2013- 06/30/16

Project Manager	O & M Manager	Federal Sponsor	Prepared By
	Babin	*USFWS*	*Babin*
	2013/2014	**2014/2015**	**2015/2016**
Maintenance Inspection	$ 5,097.00	$ 5,265.00	$ 5,439.00
Structure Operation	$ -	$ -	$ -
Administration	$ -	$ -	$ -
COE Administration	$ -	$ -	$ -
Maintenance/Rehabilitation			
13/14 Description:			
E&D	$ -		
Construction	$ -		
Construction Oversight	$ -		
Sub Total - Maint. And Rehab.	$ -		
14/15 Description			
E&D		$ -	
Construction		$ -	
Construction Oversight		$ -	
	Sub Total - Maint. And Rehab.	$ -	
15/16 Description:			
E&D			$ -
Construction			$ -
Construction Oversight			$ -
		Sub Total - Maint. And Rehab.	$ -
	2013/2014	**2014/2015**	**2015/2016**
Total O&M Budgets	**$ 5,097.00**	**$ 5,265.00**	**$ 5,439.00**
O&M Budget (3 Yr Total)			**$ 15,801.00**
Unexpended O&M Funds			**$ 1,658,689.12**
Remaining O&M Funds			**$ 1,642,888.12**

OPERATIONS & MAINTENANCE BUDGET WORKSHEET

Project: West Lake Boudreaux Shoreline Protection and Marsh Creation (TE-46)

FY 13/14 –					
Administration			$	0	
COE Administration				$	
O&M Inspection & Report				$	5,097
Operation:				$	0
Maintenance:				$	0
E&D:		$ 0			
Construction:		$ 0			
Construction Oversight:	$ 0				
FY 14/15 –					
Administration			$	0	
COE Administration				$	
O&M Inspection & Report				$	5,265
Operation:				$	0
Maintenance:				$	0
E&D:		$ 0			
Construction:		$ 0			
Construction Oversight:	$ 0				
FY 15/16 –					
Administration			$	0	
COE Administration				$	
O&M Inspection & Report				$	5,439
Operation:				$	0
Maintenance:				$	0
E&D:		$ 0			
Construction:		$ 0			
Construction Oversight:	$ 0				

O&M Accounting:

Total O&M Budget:	$1,664,815.00
OCPR Expenditures to Date:	$ 6,125.88
Unexpended O&M Budget:	$1,658,689.12