**State of Louisiana**

**Coastal Protection and Restoration Authority of Louisiana**

**Office of Coastal Protection and Restoration**

# 2010 Operations, Maintenance, and Monitoring Report

for

# GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02)

State Project Number BA-02
Priority Project List 1

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2010 Operations, Maintenance, and Monitoring Report
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GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02)

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# I. Introduction

The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project is located in Lafourche Parish, Louisiana, southeast of the GIWW, east of Bayou Lafourche, and north of the Breton Canal, and west of Little Lake (figure 1). The project area totals 14,840 acres (6,006 hectares) and is part of the last contiguous marsh tracts in the Barataria Basin.

Within the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project the average rate of change from marsh habitat to non-marsh habitat (including wetland loss to both open water and commercial development) has been increasing since the 1950's. The mean wetland loss rates were 0.36%/year between 1945 and 1956, 1.03%/year between 1956 and 1969, and 1.96%/year between 1969 and 1980 (Sasser et al. 1986). Impacts from the numerous oilfield canals constructed in the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project area include changes in hydrology, marsh impoundments, reduction in sediment accretion, and saltwater intrusion (Turner et al. 1984; Swenson and Turner 1987; Wang 1988; Turner 1990). The Clovelly Canal is connected to Little Lake on the eastern end and likely facilitates the transport of more saline waters from Little Lake to western regions of the project area.

Since 1949, marsh types have changed throughout the project, especially in the southern area. The entire project area was characterized as fresh marsh and floating three corner grass by O'Neil in 1949 (Coastal Environments, Inc. 1989). Since 1968, areas of intermediate and brackish marsh have encroached into the project area from the east, and by 1978, the project area contained almost entirely intermediate marsh with some brackish marsh along the Little Lake shoreline. In 1988, none of the project area was characterized as fresh marsh (Chabreck et al. 1968; Chabreck and Linscombe 1988), but the 1997 survey showed some pockets of fresh marsh in the northwest portion with the remainder of the project area as intermediate marsh. In 2001, the areas of fresh marsh in the northwest remained, some brackish marsh occurred in pockets in the southeast, but intermediate marsh was still predominate. It is unclear whether the changes in these areas have been due to an increase in salinity, a change in the water level regime, or a combination of the two. Increasing land loss rates for the Cut Off area (1932-1985: 0.10%; 1983-1990: 0.25%) (Dunbar et al. 1992), along with the changes in marsh types, are raising concerns that the quality of the marsh is declining and marsh will be converted to open water. Based upon the most recent Coastwide Reference Monitoring System (CRMS) Wetlands information, the project area is primarily intermediate marsh dominated by *Spartina patens* (Ait.) Muhl. (marshhay cordgrass).

The project objective is to protect intermediate marsh in the project area by restoring natural hydrologic conditions that promote greater use of available freshwater and nutrients. This will be accomplished through structural measures aimed at limiting rapid water level changes

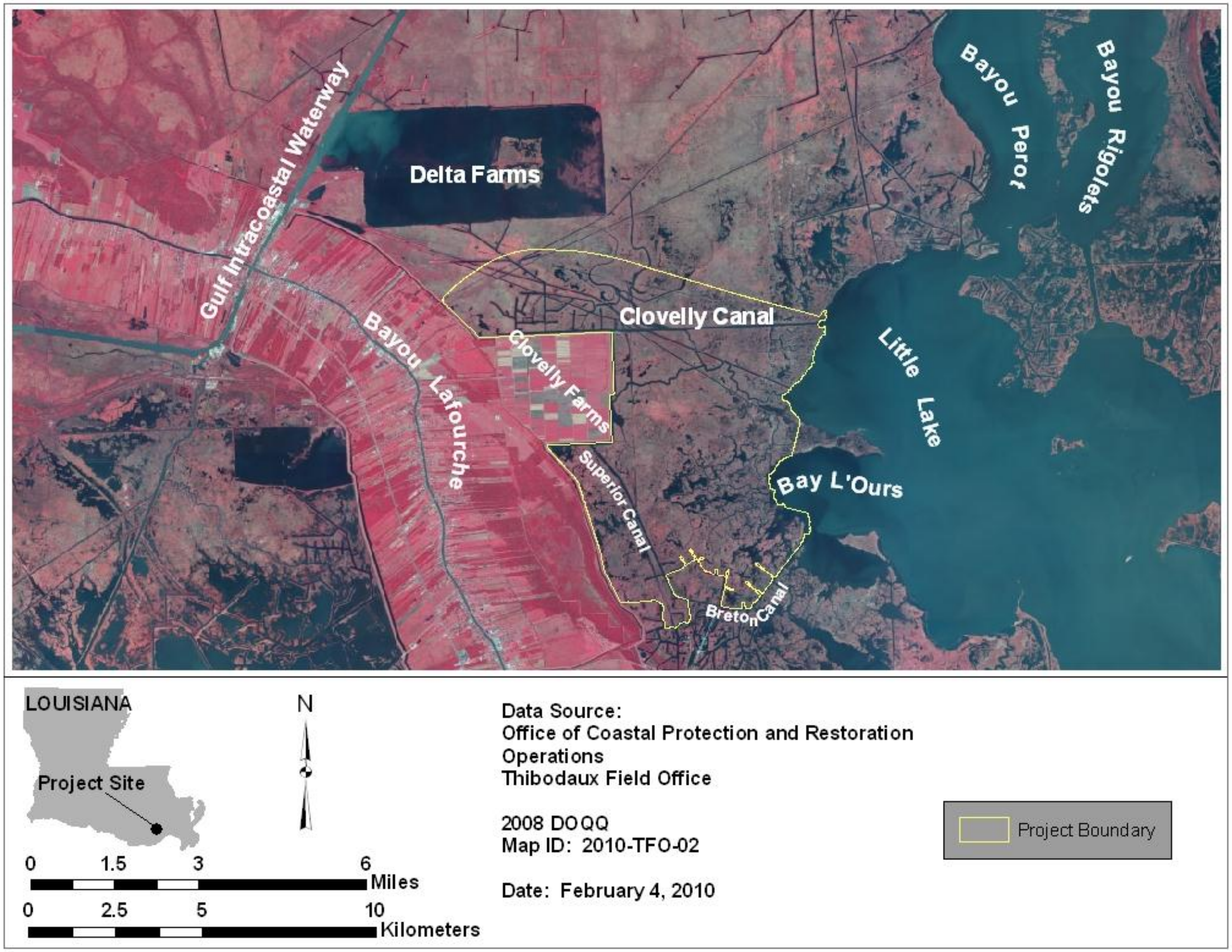



Figure 1. Location map with project boundary for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

slowing water exchange through over-bank flow, reducing rapid salinity increases, and reducing saltwater intrusion (Lear 2003).

Construction of project features occurred in two construction units. Construction Unit No. 1 has a twenty-year (20-yr) project life that began in October 1997, and Construction Unit No. 2 has a twenty-year (20-yr) project life that began in October 2000.
Project features include (LDNR et al. 2002):

Construction Unit No. 1 (04/21/1997 – 10/06/1997)

- Construction of three (3) fixed crest rock weirs with boat bays, from 200 pound class rock riprap cap on top of geotextile with a crest elevation approximately 3.8 to 4.0 ft (1.2 m) NAVD88, and a crest width approximately 8 to 8.9 ft (2.6 m) (figure 2; Structures 2, 4, and 7). Weir lengths varied depending upon their locations.
- Construction of two rock riprap channel plugs on top of geogrid. The plugs varied in crest elevation and length depending upon their locations (figure 2; Structures 43 and 4A).
- Construction of one rock riprap weir with a boat bay (figure 2; Structure 8).
- Construction of one 102 linear ft (36.6 m) rock-filled channel plug with a crest elevation of 3.2 ft (1.0 m) NAVD88, with a 36 inch diameter 10 gauge pile supported corrugated aluminum pipe through the plug embankment, and a 36 inch aluminum flap gate (figure 2; Structure 91).
- Construction of one 78 ft. (23.8 m) rock riprap channel plug with an 8 ft (2.4 m) wide crest with 3:1 side slopes. It was set at 3.5 ft (1.07 m) above marsh level on top of geogrid mat (figure 2; Structure 8A).

Construction Unit No. 2 (04/14/2000 – 10/13/2000)

- Construction of approximately 5,665 linear ft (1,727 m) of lake-rim rock shoreline protection from 650 pound class rock riprap on top of geotextile with a design crest elevation of +2.0 ft (+0.6 m) and an average constructed crest elevation of 3.0 ft (0.9 m) NAVD88, and a crest width of 4 ft (1.2 m), along the southwestern shorelines of Little Lake, Bay L'Ours, and Brusle Lake (figure 2).
- Construction of approximately 5,023 linear ft (1531 m) of rock bank stabilization from 200 pound class rock riprap on top of earthen and rock fill on top of geotextile with a design crest elevation of +2.0 ft (+0.6 m) NAVD88, an average constructed crest elevation of +3.0 ft (+0.9 m) NAVD88, and a crest width of 4 ft (1.2 m), along the northern shoreline of Breton Canal (figure 2).

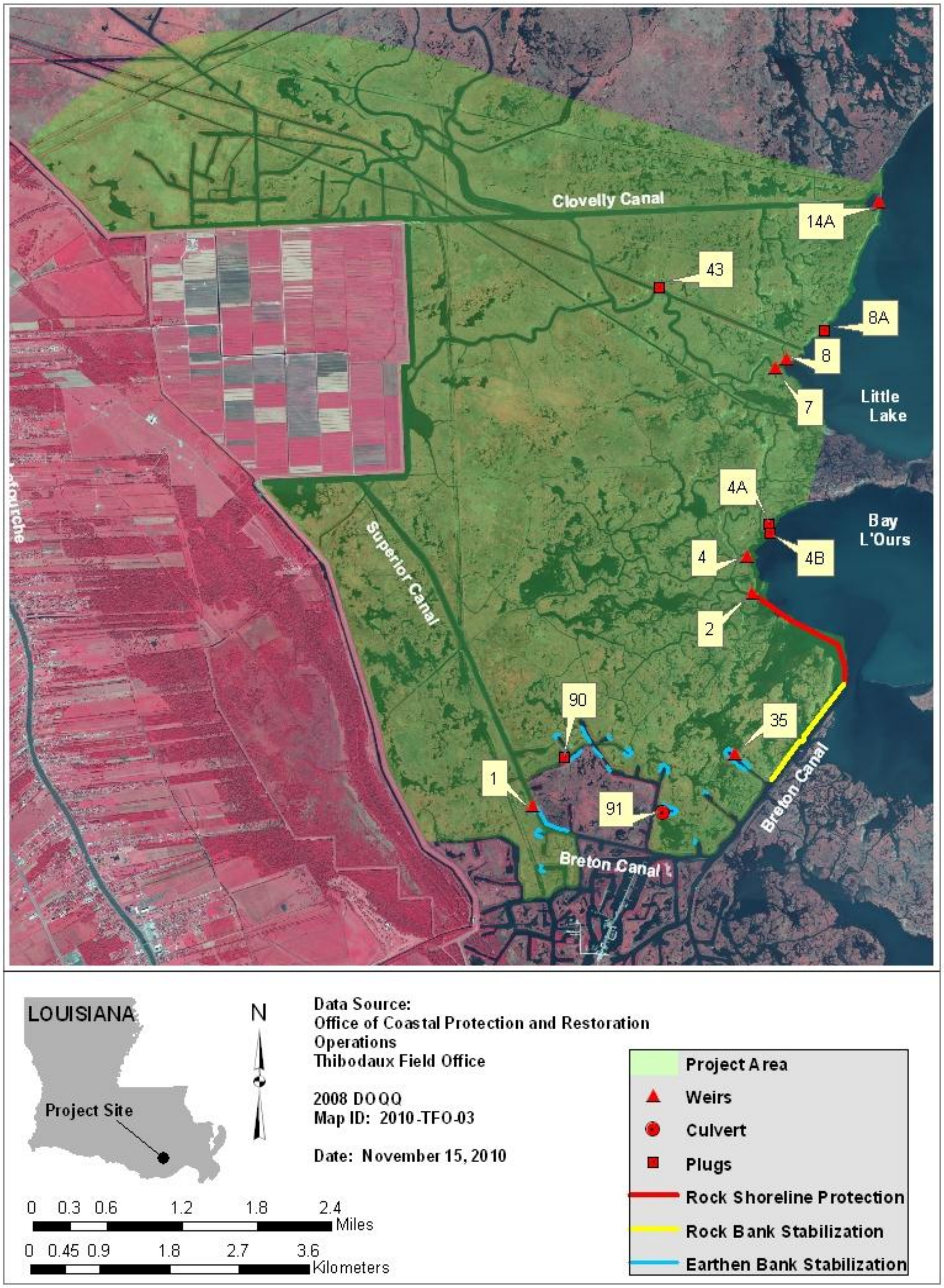



Figure 2. Infrastructure map for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

- Construction of approximately 11,711 linear ft (3,570 m) of earthen bank stabilization on top of geotextile with a design crest elevation of 2.0 ft (0.6 m) NAVD88, an average constructed elevation of +3.0 ft (+0.9 m) NAVD88, and a crest width of 4 ft (1.2 m) to 14 ft (4.3 m), along dead-end oilfield canals on an average crest width of 4 ft (1.2m) to 14 ft (4.3m), along dead-end oilfield canals on the northern edge of Breton Canal (figure 2).
- Construction of one 263 linear ft (80 m) fixed crest weir from rock riprap with a 20 ft (6.1 m) barge bay from rock riprap with a crest elevation of 4.0 ft (1.2 m) NAVD88 and the invert of the barge bay set at -6.4 ft (-1.9 m) NAVD88 (figure 2; Structure 1).
- Construction of one 1,665 linear ft (507.5 m) fixed crest rock riprap weir with an 80 ft (24.4 m) barge bay, with a crest elevation of 4.0 ft (1.2 m) NAVD88 and the invert of the boat bay at an elevation of -6.5 ft NAVD88 (-2.0 m) (figure 2; Structure 14A).
- Construction of one 511 linear ft (155.8 m) rock riprap channel plug with a crest elevation of 3.5 ft (1.1 m) NAVD88 (figure 2; Structure 4B).
- Construction of one 213 linear ft (64.9 m) rock riprap channel plug with a crest elevation set at 4.0 ft (1.2 m) NAVD 88 (figure 2; Structure 90).
- Construction of one 80 linear ft (24.4 m) sheet pile variable crest weir with a 10 ft (3 m) wide variable crest section containing a 10 ft (3 m) wide stop log bay containing 12 stop logs. The stop logs can be adjusted from 1.0 ft to -3.0 ft (0.3 m to -0.9 m) NAVD88 using a movable crane with a hand winch. The fixed crest section of the structure was constructed with earthen wing walls to a crest elevation of 2.89 ft (0.88 m) NAVD88 on either side of the weir (figure 2; Structure 35).

## II. Maintenance Activity

### a. Inspection Purpose and Procedures

The purpose of performing an annual inspection is to evaluate the constructed project features, identify any deficiencies, prepare a report detailing the condition of such features, and to recommend corrective actions needed, if any. Should it be determined that corrective actions are needed, Office of Coastal Protection and Restoration (OCPR) shall provide, in report form, a detailed cost estimate for engineering, design, supervision, inspections, construction contingencies, and an assessment of the urgency of such repairs (LDNR et al. 2002). This Operations, Maintenance and Monitoring (OM&M) Plan and/or Annual Inspection Report contains a summary of maintenance projects completed to date and an estimated project budget for the upcoming three (3) years of operation, maintenance and rehabilitation. The budget projections for the upcoming three (3) years are outlined in Appendix A and the summary of past operations and maintenance projects are located under Section II.b of this report.

The 2010 inspection of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project was held on April 26, 2010 under clear skies and windy conditions. In attendance were Brian Babin, Shane Triche and Elaine Lear from OCPR, Quin Kinler and Warren Blanchard with Natural Resources Conservation Service (NRCS) and Randy Moertle representing the landowner. The attendees met at the Clovelly Public Boat Launch in Larose, La. The inspection began at approximately 9:00 a.m. and ended at 1:00 p.m. The field inspection included a complete visual inspection of all of the constructed features within the project area. Photographs were taken during the field inspection and are shown in Appendix B. Staff gauge readings, where available, were documented and used to estimate elevations of the constructed features. In addition to documented visual observations, the 2008 survey profiles of the rock weirs, lake-rim and earthen embankments were used to estimate settlement for purposes of planning the 2010 Maintenance Project. The survey profile drawings can be found under Appendix D of the 2009 Annual Inspection Report by Babin (2009).

**b. Summary of Past Operation and Maintenance Projects**

**Navigational Aid Maintenance:** Below is a short description of repairs, dates, costs, and ongoing tasks associated with the maintenance of navigational aids at Structure 14A:

5/16/02 Automatic Power of Larose, La., performed maintenance service to repair navigation lights at Structure 14A. Seventeen (17) bulbs were replaced at a total cost of $421.50.

12/16/03 Automatic Power performed maintenance on Structure 14A, replacing battery and bulbs in all four (4) navigation lights at a total cost of $2,189.80.

11/4/04 Automatic Power serviced navigation lights at Structure 14A, replacing one (1) lamp changer, one (1) battery and bulbs at a total cost of $922.23.

11/29/06 OCPR received bids for a State-wide Navigation Maintenance Contract for the inspection, diagnostic testing, and maintenance of twenty-seven (27) navigational aid systems at ten (10) different locations state-wide. The low bidder for this contract was Automatic Power, Inc., offering a bid in the amount of $83,424. This maintenance contract is a one (1) year contract with an option to extend for another two (2) years. The contract was awarded to Automatic Power and inspections began in February 2007. The GIWW/Clovelly (BA-02) project has four (4) navigational aids marking the barge bay opening at Structure 14A along Clovelly Canal near the entrance to Little Lake. The state-wide contract is set up on a time and material basis and as deficiencies are identified, the contractor is paid for repairs at a pre-determined rate outlined in the schedule of bid items in the contract.

12/11/06 Construction began to replace an existing timber pile cluster (dolphin) supporting the navigational aids and signage on the northeast side of the barge bay at Structure 14A. The timber dolphin was demolished by a large vessel accessing the barge bay opening. The timber pile cluster replacement project included the removal of the existing structure below the mud line and installing four (4) 60 ft (18.3 m) long, 2.5 CCA treated timber piles with navigation light and signage. All engineering services including construction administration was provided by OCPR- Thibodaux Field Office (TFO). Tidewater Dock, Inc. of Galliano, La., was awarded the construction contract to replace the structure on 12/6/06 and completed the work on 12/20/06. The total replacement cost of this structure was $14,000.

**c. Inspection Results**

**Construction Unit No.1**

<u>Structure No. 2 – Fixed crest weir with boat bay</u>

Structure No.2 was constructed using a fixed crest weir consisting of rock riprap material. The as-built drawings indicate that the sill elevation closest to the bank (bank section) on both sides of the structure was constructed to an elevation of +3.9’ NAVD. The sill section between the bank section and the boat bay was constructed to an elevation of 2.3’ NAVD and the sill of the boat bay section was constructed to an elevation of -5.1’ NAVD. As reported on previous inspections and verified through the 2008 profile surveys, moderate settlement was noted between the boat bay and the bank section (ranging from 1.3’ to 1.5’) and severe settlement within the limits of the boat bay. Based on these observations and supporting survey data, we have included provisions in the 2010 Maintenance Project to refurbish Structure No.2 to the original design elevations. The method of repairs and corrective actions are outlined in the conclusion of this report. The warning signs and supports appeared to be in good condition and will not require repairs (Appendix B, Photos No. 1 through 4).

<u>Structure No. 4 – Fixed crest rock weir with boat bay</u>

Structure No.4 was also constructed using a three (3) level fixed crest weir consisting of rock riprap material. The rock weir section closest to the bank (bank section) on both sides of the structure was constructed to an elevation of +3.8’ NAVD. The intermediate section between the bank section and the boat bay was constructed to an elevation of +2.4’ NAVD, and the sill beneath the boat bay was constructed to an elevation of -3.9’ NAVD. The condition of Structure 4 appears to be similar to what was observed during the previous 2009 inspection The most severe settlement was noted on the south side of intermediate crest section with settlement rates as high as 6’ to 7’. On the north side of the structure, settlement was moderate with rates ranging between 1.5' to 2.0'. We also noted that the sign and support on the north side of the structure was missing and recommended for replacement. Based on past and current observations along with supporting the 2008 survey profile data, Structure 4 is also included in the 2010 Maintenance Project for refurbishment. The method of maintenance repairs and corrective actions are outlined in the conclusion of this report. (Appendix B, Photos No.5 through No.8)

Structure No. 7– Fixed crest rock weir with boat bay

Structure No.7 appeared to be in fair condition with no visual damage to the rock weir or washouts around the ends of the structure. The as-built drawings indicate that the fixed crest rock weir was constructed to elevations of -4.4 NAVD 88 at the boat bay and +2.4' NAVD 88 on the north and south sides between the bank section and the boat bay. Elevation profiles taken in 2008 revealed that the rock weir had subsided uniformly throughout the length of the structure with settlement rates ranging from 1.0' to 1.5'. All signs, supports and earthen embankment tie-ins appear to be in good condition. Considering that the settlement of Structure 7 is uniform and relatively minor, we are not recommending corrective actions at this time. The inspection team will continue to monitor the condition of Structure 7 on future site visits and make recommendations for repairs as needed. (Appendix B: Photos No.9).

Structure No. 8– Rock riprap weir

Structure No.8 is a small rock weir with boat bay located on the north side of Structure 7 with a steel gate closure across the weir to prevent access to the existing channel leading to the interior marsh. This structure was not profiled during the most recent survey completed in 2008. From a visual inspection, the rock weir appeared to be in fair condition with no obvious erosion or washouts around the structure. The gate closure constructed across the weir was destroyed during Hurricanes Gustav and Ike and no longer existed as of the 2009 inspection; however, we did notice that the landowner had installed a series of floating barrels strung across the opening to restrict access. At this time, there are no recommendations for recapping the rock weir or replacing the steel gate. (Appendix B: Photos No. 10)

Structure No. 43 – Rock riprap channel plug

As reported in previous inspection reports, there is a 5 to 7 ft. wide shallow depression in the rock embankment on the east side of the plug. Although it was difficult to visually inspect the structure due to excessive vegetative growth around the structure, it appeared that the low area has not increased in width or depth from previous inspections and that there was no indication of water transfer across the plug. Under high tide events, it is possible that water may by-pass the plug because the crest of the structure is slightly above the existing marsh elevation. The crest of the plug was originally constructed to an elevation of +2.45' NAVD 88. At this time, there are no recommendations for maintenance of Structure No. 43. (Appendix B: Photos No. 11)

Structure No. 91 – Rock plug with culvert and flap gate

The rock plug structure with flap-gate appeared to be in good condition with no indication of settlement or washouts around embankment tie-ins of the structure. The culvert, flap gate, signs, timber supports and earthen embankments were also in good condition. As noted on previous inspections, the sheet metal covering the tops of the timber piles supporting the corrugated metal pipe were rusted and corroded. To prevent rotting of the timber pile heads, we have included provisions in the 2010 Maintenance Project replacement of the sheet metal caps covering the timber piles. As a preventative measure, we are also recommending that the flap-gate be removed, inspected, cleaned, and re-installed if needed. (Appendix B: Photo No. 12)

## CONSTRUCTION UNIT NO. 2

Structure No. 1 – Fixed crest weir with barge bay

The rock weir with barge bay appeared to be in good condition with no obvious settlement or rock displacement. The weir was constructed to a -6.4’ NAVD at the barge bay and +4.0’ NAVD along the crest on both sides of the weir between the barge bay and bank line. Staff gauge readings from station BA02-57 just north of the structure indicated that the water elevation at the time of the inspection was 0.9’ NAVD and salinity readings were 2.5 ppt. As mentioned in previous inspection reports, there was substantial damage to the four (4) timber pile dolphins at the entrance of the barge bay caused by oilfield service barges accessing the barge opening. In most cases, the vertical timber piles were split, the batter piles were off center and the surface of the piles were worn and scarred. Subsequent to the 2010 inspection, the timber cluster pile on the southwest side of the barge bay was completely destroyed and no longer exists. Considering the poor condition of the remaining three (3) timber dolphins, we have included the replacement of all four (4) dolphin structures in the 2010 Maintenance Project. As a preventative measure, we are also recommending that the new timber dolphin structures be relocated slightly outwards towards the bank to allow for additional clearance for barges moving through the barge bay. (Appendix B: Photos No. 13 through 16)

Structure No. 4 A and B – Rock riprap channel plug

Structures 4A & 4B appeared to be in poor condition with average crest elevations of approximately 1.5’ NAVD. As-built data indicates that the original crest elevation of the channel plug was constructed to an elevation of +3.0 NAVD. From visual inspections and survey profile data from 2008, it was estimated that the rock plug has settled between 1.5’ and 2.0’ across the entire structure.

Following Hurricanes Gustav and Ike, a large portion of marsh on the south side of the plug from Structures 4A and 4B to Structure 4 suffered extensive erosion, leaving a very large opening in the shoreline estimated to be approximately 1,500 ft. Due to expense of mobilizing a dredge to rebuild the marsh that was lost, we have included a less expensive alternative in the 2010 Maintenance Project of constructing a rock dike across the opening and along the shoreline extending from Structure 4A to Structure 4 to protect the remaining marsh south of Structures 4A. (Appendix B: Photos No. 17 through 21)

Structure No. 14A – Fixed crest rock weir with barge bay

The crest of the structure on both sides of the barge bay was constructed to an elevation of +4.0 NAVD. The scour pad at the bottom of the barge bay was constructed to -6.5' NAVD. From the 2008 survey profiles of the weir, it was estimated that settlement of the rock weir on both sides of the barge bay was minimal (less than 1') with the exception of a small area on the southern end of the barge bay opening where the existing rock section was displaced during Hurricane Ike. The most severe settlement and scour was near the bottom of the barge bay itself. The 2008 profile survey data showed that the bottom depths ranged between -6.5' to -15' NAVD, indicating that the scour pad and riprap at the bottom of the channel had eroded or washed out by the strong currents moving through the bay opening. Considering the extent of the erosion of the scour pad, we have included corrective measures in the 2010 Maintenance Project to reconstruct the scour pad with a larger stone to prevent the potential displacement of rock material from strong currents moving through the barge bay opening. The timber navigational aid supports were in poor condition with visible damage to three (3) of the timber pile dolphins. Longitudinal cracks, scrapes and abrasions were noted on the face of the timber batter piles and the cable wraps tying the batter piles together were very loose. In addition to repairing the scour pad, we have included provisions in the 2010 Maintenance Project to replace three (3) of the four (4) timber pile dolphins. The timber dolphin on the southeast side of the barge bay opening was replaced in 2006 and remains in good condition. (Appendix B, Photos 22 through No.32)

In addition to the settlement and scour at the bottom of the barge bay, the landowner and NRCS representatives visited the site in June 2006 and identified several locations along the shoreline south of Structure 14A where small breaches in the shoreline were discovered. Apparently, these breaches were located in areas where small interior ponds were located along the shoreline. Rather than dredging material from the lake to close the breaches and fill the ponds, NRCS proposed a less costly alternative of planting smooth cord grass and bullwhip along the shoreline to buffer the wave energies from the lake. Subsequent to the 2010 annual inspection, NRCS completed a plantings project along the shoreline south of Structure 14a to address these issues, concentrating on areas where there were small breaches in the shoreline, mainly in locations where small interior ponds were in close proximity to the existing shoreline. It appears that the plantings project was successful in stabilizing the openings in the shoreline and reduced the negative affects of wave and tidal action through the breaches. (Appendix B, Photos No. 33 through No.35)

Structure No. 35 – Variable crest weir, water control structure

As reported in previous inspections, other than minor corrosion and paint chipping along the channel cap of the bulkhead, handrails and movable boom deck, the structure itself was in good condition. The stop logs, cables, signs, supports and other hardware appear to be operable and in good condition. The conveyance channel from the weir to the interior marsh was open and appeared to be allowing adequate flow through the structure. At this time, we are not recommending any corrective actions to conveyance channel maintenance. (Appendix B: Photos No. 36 through No. 39)

Structure No. 90 – Rock riprap channel plug

The rock riprap channel plug appeared to be in very good condition with no apparent settlement or erosion around the ends of the structure. The signs and supports were also in good condition. (Appendix B: Photos No.40 and 41)

Lake Rim Restoration

The lake rim structure was constructed between a +2.0' and +3.0' NAVD with six (6) fish dips at various locations along the structure. As indicated on previous inspections and the 2008 survey profiles, the rock dike has displayed minor to moderate settlement along the entire length of the structure. The most notable segments include segments between Stations 7+00 and 13+00, 36+00 and 41+00, and the intersection near the mouth of Breton Canal. During the 2010 field inspections, we observed additional low areas along the north bank of Breton Canal from the mouth of Bay L' Ours proceeding southwest to the first oilfield location canal where Structure 35 is located. Based on the current condition of rock dike, we have included provisions in the 2010 Maintenance Project to recap the entire length of the lake rim to the original design elevation. (Appendix B: Photo No.42 through 52)

Earthen Bank Stabilization

There are five (5) breaches identified for repairs and/or refurbishment to be included in the 2009/2010 Work Plan. Breach 1 is located along the north bank of Breton Canal just southwest of the first location canal from Bay L' Ours and is approximately 20' wide. Breach 2 is located along the northeast bank of the second location canal north of Breton Canal and is approximately 10' wide. Breach 3 is located on the south bank of the same location canal as Breach 2 and is approximately 25' wide. Breach 4 is located on the west bank of a location canal that intersects Superior Canal east of Structure No. 1 and is approximately 30' wide. Another breach, designated as Breach 5, was discovered at the end of a dead end oil field slip south of Breach 4. It is recommended that all five (5) breaches be closed using in situ material from adjacent canals to reconstruct the bank line. (Appendix B, Photos (Photos No.53 through 53).

## III. Operation Activity

### a. Operation Plan

The water management plan for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project required the active operations of a single variable crest weir structure located northwest of Breton Canal near the southern boundary of the project area (Structure No. 35). Normal operations include manipulating the stop logs twice a year in accordance with the following operation schedule:

The stop logs are set at 0.5 ft (0.1 m) BML (Below Marsh Level) from April to November and removed from November to April (weir sill level = 2.0 ft [0.6 m] BML) to allow for sediment and nutrient inflow during the spring.

### b. Actual Operations

**Structure Operations:** In accordance with the operations schedule outlined in the Operations and Maintenance Plan for the GIWW to Clovelly (BA-02) project and the special conditions of the permit, Structure No.35 has been operated during the months of April and November of each year since April 3, 2002. Operations were temporarily suspended in November 2005, following Hurricane Katrina, due to marsh damage behind the structure; however, since that time, the marsh material obstructing the bay opening of the structure has degraded creating a channel to the interior marsh which enabled structure operations to resume in November 2007.

## IV. Monitoring Activity

### a. Monitoring Goals

Specific objectives of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project are (1) to protect and maintain approximately 14,948 acres (6,049 hectares) of intermediate marsh by restoring natural hydrologic conditions that promote greater freshwater retention and utilization, prevent rapid salinity increases, and reduce the rate of tidal exchange; and (2) to reduce shoreline erosion through shoreline stabilization (Lear 2003).

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

1. Increase or maintain marsh to open water ratios.
2. Decrease salinity variability in the project area.
3. Decrease the water level variability in the project area.
4. Increase or maintain the relative abundance of intermediate marsh plants.
5. Promote greater freshwater retention and utilization in the project area.
6. Reduce shoreline erosion through shoreline stabilization.
7. Increase or maintain the relative abundance of submerged aquatic vegetation (SAV).

### b. Monitoring Elements

**Habitat Mapping**

To document vegetated and non-vegetated areas and marsh loss rates, color-infrared aerial photography (1:24,000 scale with ground control markers) was obtained by the National Wetlands Research Center/United States Geological Survey (NWRC/USGS) for the project area. For each flight, the photography was geo-rectified, photo-interpreted, mapped, ground-truthed, and analyzed with GIS by NWRC personnel using techniques described in Steyer et al. (1995, revised 2000). Photography was obtained prior to construction in November 1993 and in December 1996, and after construction in December 2002. A revision of the habitat analysis data was completed in March 2005 upon the request of OCPR personnel. NWRC personnel reviewed the most recent vegetation, water level, and salinity data at the time to assess the photography for revisions.

**Land-Water**

Based on the CRMS-Wetlands (Coastwide Reference Monitoring System) review, land-water analysis instead of habitat mapping was performed on photography collected in 2008 and will be in 2015.

**Water Level**

To monitor water level variability, seven (7) continuous recorder stations were located within the project area; however, two (2) stations (BA02-58 and BA02-59) were discontinued due to severe scouring around the instruments. Discrete water levels were measured monthly at five (5) stations inside the project area using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2008). Staff gauges located adjacent to the continuous recorders were surveyed to the North American Vertical Datum of 1988 (NAVD88) in order to tie recorder water levels to the Louisiana Coastal Zone GPS network. Marsh elevation was surveyed and used in conjunction with continuous recorders to determine duration and frequency of flooding.

Based on the CRMS-Wetlands review, discrete water level readings were discontinued in January 2004, and continuous water level readings from stations BA02-53, BA02-54, and BA02-55 were discontinued in March 2004. As a result, only two of the original project- specific continuous recorder stations remain active.

**Salinity**

To monitor salinity variability, seven (7) continuous recorder stations were located within the project area; however, two (2) stations (station BA02-58 and BA02-59) were discontinued due to severe scouring around the instruments. Discrete salinity was measured monthly at 25 stations inside the project area using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2008).

Based on the CRMS-Wetlands review, discrete salinity readings were discontinued at the project stations in January 2004, and continuous salinity readings from stations BA02-53, BA02-54, and BA02-55 were discontinued in March 2004. As a result, only two of the original project-specific continuous recorders remain active. Analysis of the discrete salinity data was presented in the 2007 Operations, Maintenance and Monitoring (OM&M) report for this project.

**Vegetation**

Species composition and relative abundance were evaluated inside the project area using a modification of the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974). Twenty-five (25) plots were established and sampled in the project area during the 1996 sampling event. Eight (8) of these plots in the northern portion of the project area were dropped from monitoring in late spring 1997 due to land rights issues. Vegetation species composition and relative abundance were evaluated once prior to construction in 1996, once in 1999 after Construction Unit No. 1 was completed, and four times after Construction Unit No. 2 was completed in 2000, 2002, 2005, and 2008. Additional data collection will commence at years 2012 and 2016.

Species composition and relative abundance were also evaluated inside the BA-02 project area as well as outside of it using CRMS sites. CRMS0190 is the only CRMS site inside the project area. Five additional CRMS sites just east of the project area and within a similar habitat type were chosen as reference sites. The modified Braun-Blanquet method used with project-specific stations was also used on the CRMS site stations. Each 1 $km^2$ CRMS site contained a 200 $m^2$ data collection area, which in turn had ten (10) vegetation data collection stations located along a single transect. Vegetation species composition and relative abundance were evaluated after construction in 2006, 2007, 2008, and 2009.

**Soil Samples**

To evaluate effects of freshwater retention and saltwater intrusion, project-specific soil samples were taken to determine percent organic matter, bulk density, and soil porewater salinity using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2008). Twenty-five (25) plots were established and sampled in the project area during the 1996 sampling event. Eight (8) of these plots in the northern portion of the project were dropped from monitoring in late spring 1997 due to land rights issues. Soil samples from the remaining seventeen (17) project area plots were evaluated once prior to construction in 1996, once in 1999 after Construction Unit No. 1 was completed, and four times after Construction Unit No. 2 was completed in 2000, 2002, 2005, and 2008. Additional data collection will commence at years 2012, and 2016. Also, soil cores were taken at the project CRMS site (CRMS0190) and at the reference CRMS sites (CRMS0220, CRMS0248, CRMS0253, CRMS0261, CRMS4218) at the time the sites were established.

## Shoreline Change

To evaluate marsh edge movement along the shoreline protection structures placed in Bay L'Ours and along the oil and gas access canal at the southern border of the project area, controlled sub-meter accurate Differential Global Positioning System (DGPS) equipment was used by OCPR personnel to document marsh edge position using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2008). This equipment was used to acquire the coordinates for each shoreline point within 21 randomly selected 300 ft (91.4 m) shoreline segments. DGPS measurements were taken pre-construction in 1993 and 1998, and in 2000, 2003, and 2005 post-construction. In 2008 another survey was conducted by Shaw Coastal, Inc., also using sub-meter accurate equipment described in the preliminary monitoring results and discussions section of this report for shoreline change. Measurements will also be taken in 2012, and 2016.

## Submerged Aquatic Vegetation (SAV)

The frequency of occurrence of SAV was analyzed for the project area. Ten (10) ponds inside the project area and five (5) ponds inside the reference area were sampled once in the fall of 1996 (November) pre-construction. Three (3) ponds in the northern portion of the project area as well as the five ponds in the reference area were dropped from monitoring in the late spring 1997 due to land rights issues. Data collection on the remaining seven (7) ponds occurred four times after Construction Unit No. 1 was completed; during spring 1999, fall 1999, spring 2000, and during fall 2000. Post-construction data collection occurred during fall 2002 and fall 2005. Based upon the CRMS-Wetlands review, all future SAV data collection has been discontinued. All data analysis was presented in the 2007 OM&M Report for this project (Lear et al. 2007).

### c. CRMS-Wetlands

In 2003, the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Task Force adopted the Coastwide Reference Monitoring System (CRMS)-Wetlands program to evaluate the effectiveness of each constructed restoration project. CRMS-Wetlands provides a network or "pool" of reference sites that can be used to not only evaluate the effectiveness of individual projects but also hydrologic basins and entire coastal ecosystems. Each 1 $km^2$ CRMS-Wetlands site is monitored consistently according to a "Standard Operating Procedures" document with the following parameters collected at each site: hourly hydrographic (includes salinity, water level, and water temperature), monthly soil porewater salinity, semi-annual surface elevation and sediment accretion (for non-floating sites), annual emergent vegetation, land:water ratio estimated from aerial photography taken every three to four years, and soil properties collected once at each CRMS site.

CRMS-Wetlands is currently in the operational stage (i.e., land rights are secured, site characterizations are complete, and site construction is complete) and all sites are fully operational. Data collection continues at 390 sites and data will be used to help support project-specific monitoring. The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project has one CRMS-Wetlands monitoring site within its project boundary, CRMS0190, and a few sites east of the project (figure 3) within the same intermediate marsh habitat type (CRMS0220, CRMS0248, CRMS0253, CRMS0261, CRMS4218). Though all of these CRMS sites are in the same hydrologic basin, have very similar vegetation composition, and have the same soil type, the CRMS project site is in floating marsh while the CRMS reference sites are in attached marsh. Data collected from these CRMS-Wetlands sites along with future project-specific data collection efforts will provide a broader evaluation of project effectiveness.

### d. Preliminary Monitoring Results and Discussion

**Habitat Mapping**

Data Analysis Methods for Habitat Analysis:

USGS/NWRC personnel completed scanning, georectification, and the production of habitat analysis maps for the aerial photography obtained prior to construction in November 1993 and in December 1996, and post-construction in December 2002. Photography was scanned in at 300 dots per inch on a sharp JX-610 scanner using WscanNT® software and stored as .TIFF images. ERDAS Imagine®, an image processing and geographic information systems (GIS) software package, was used to georectify individual frames of photography. The scanned images were assembled into a photomosaic and overlaid onto a georeferenced image (such as SPOT imagery and DOQQ imagery) of the same area to rectify it. Photointerpretation of the project and reference areas was completed, habitat classifications were hand digitized and their acreages calculated. Draft maps were sent to the Office of Coastal Protection and Restoration, Thibodaux Field Office (OCPR/TFO) where they were reviewed for comments. Revisions were made to the drafts and final deliverables were sent to the OCPR/TFO. In 2004 upon the request of OCPR personnel, NWRC re-examined the photography from all three flights as well as the most recent vegetation and salinity data available. Revisions were made to the habitat classification data as a result of this review and updated maps were completed in March 2005. Revised maps are presented in this report (figures 4-6).

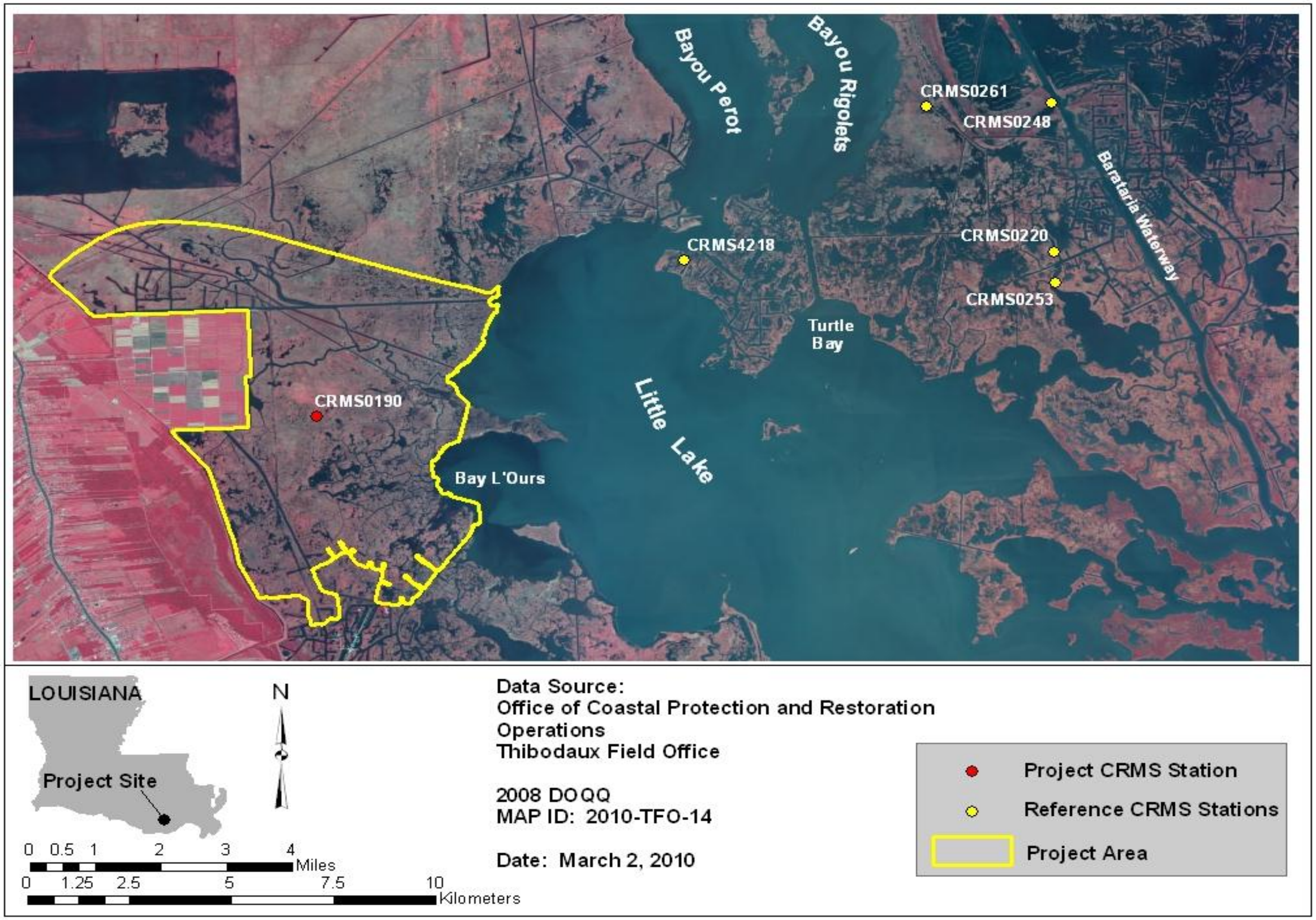



Figure 3. CRMS-Wetlands sites both inside and outside the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

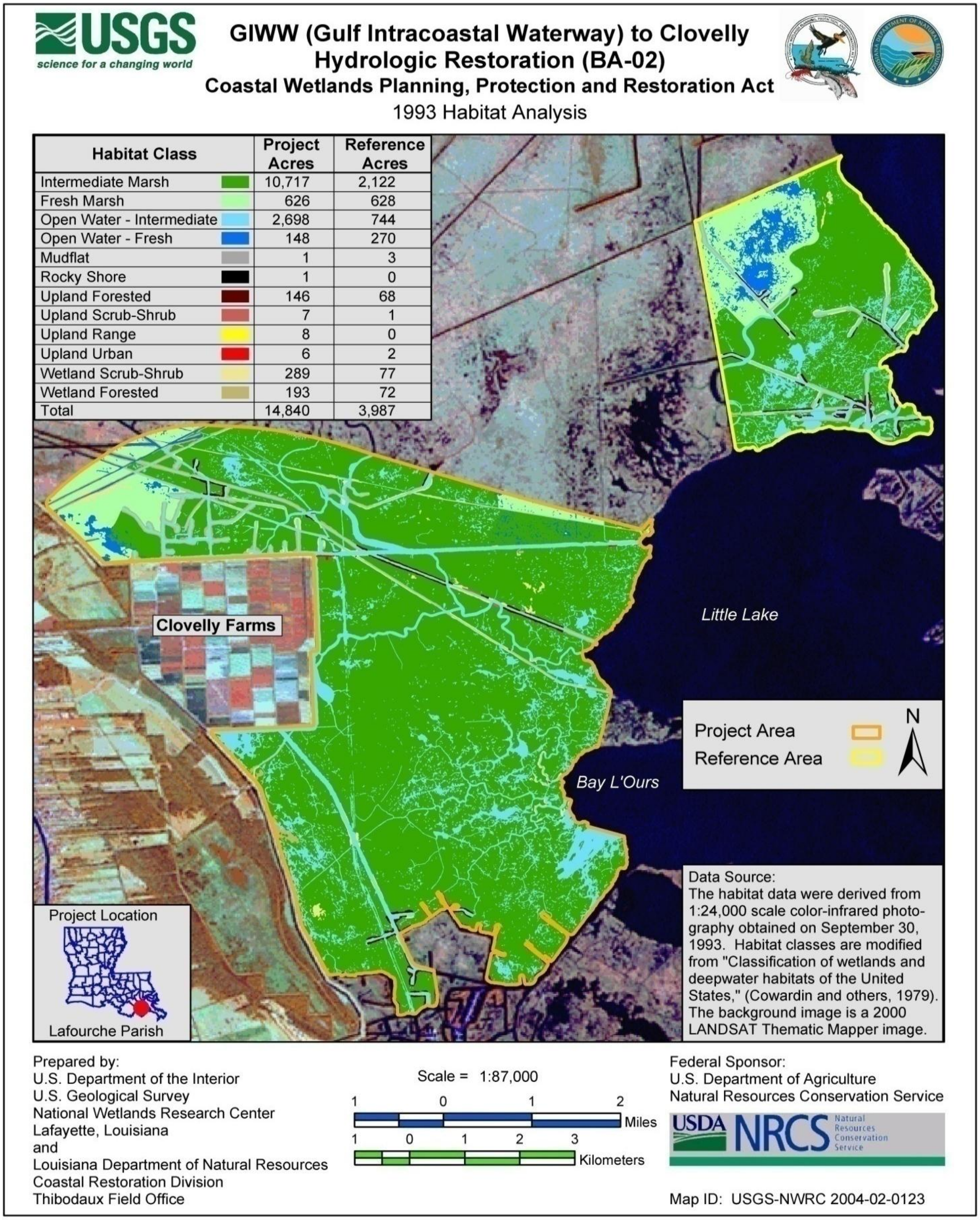
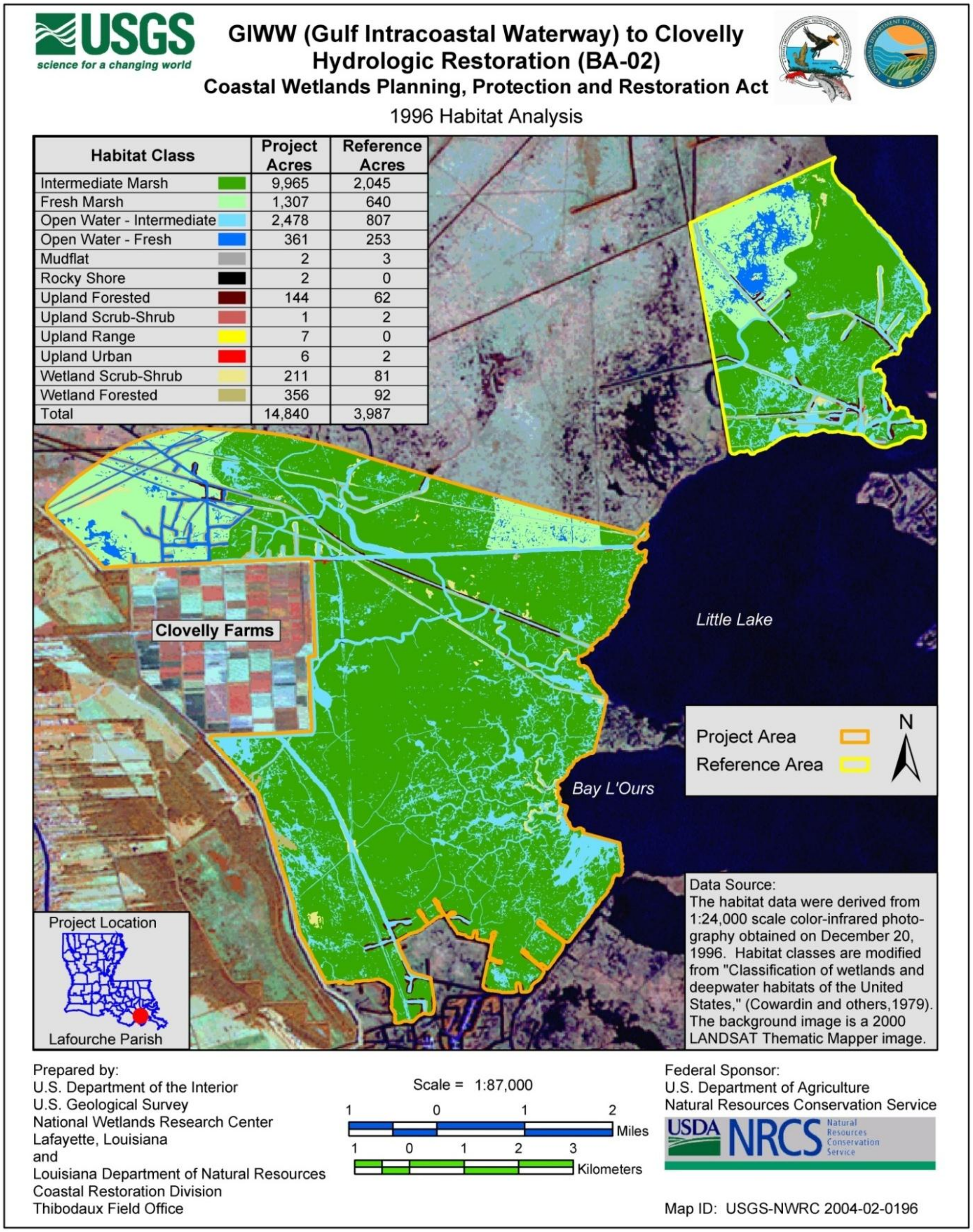



Figure 4. 1993 habitat analysis map for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.




| Habitat Class | Project Acres | Reference Acres |
|---|---|---|
| Intermediate Marsh | 9,965 | 2,045 |
| Fresh Marsh | 1,307 | 640 |
| Open Water - Intermediate | 2,478 | 807 |
| Open Water - Fresh | 361 | 253 |
| Mudflat | 2 | 3 |
| Rocky Shore | 2 | 0 |
| Upland Forested | 144 | 62 |
| Upland Scrub-Shrub | 1 | 2 |
| Upland Range | 7 | 0 |
| Upland Urban | 6 | 2 |
| Wetland Scrub-Shrub | 211 | 81 |
| Wetland Forested | 356 | 92 |
| Total | 14,840 | 3,987 |

Figure 5. 1996 habitat analysis of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

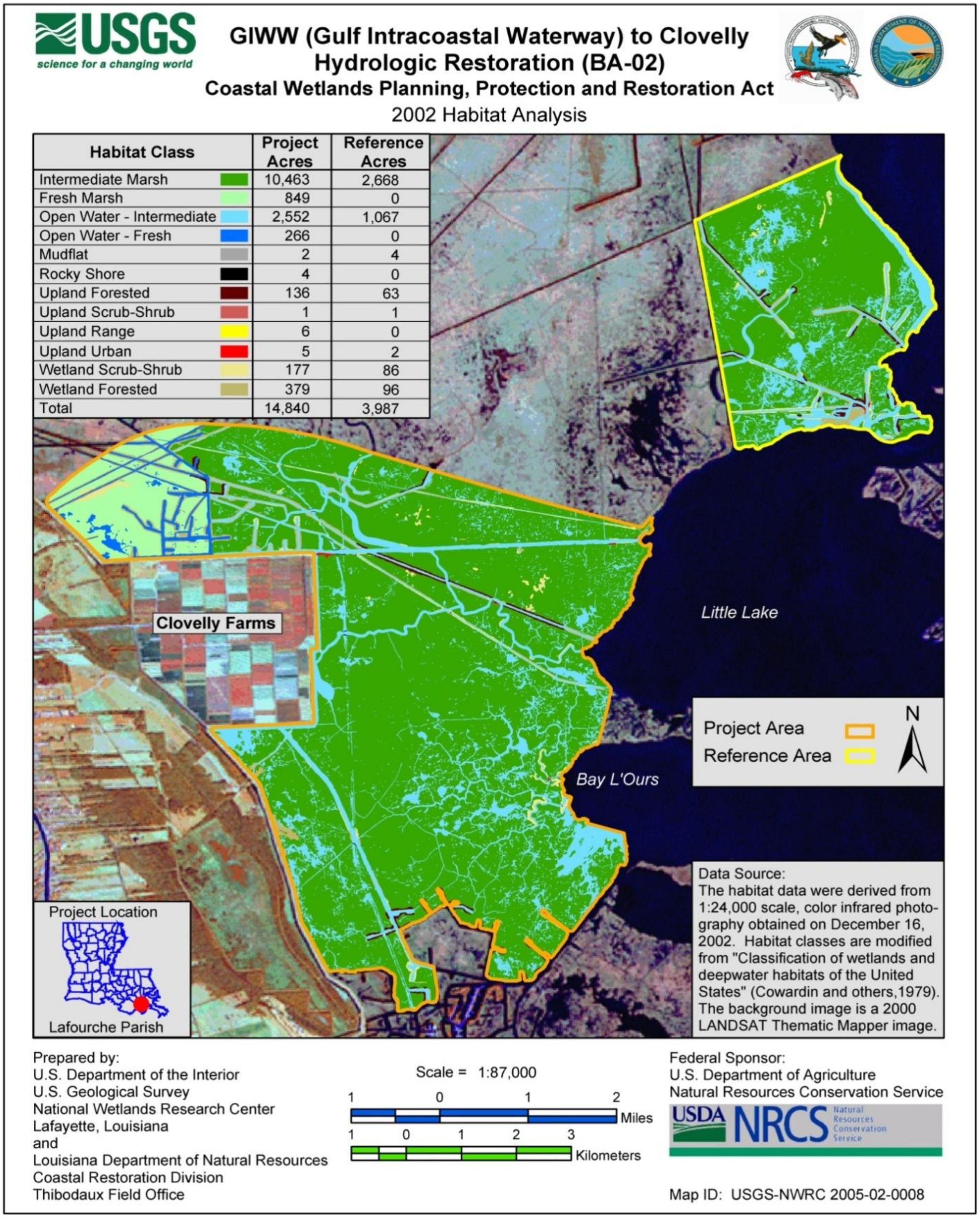



Figure 6. 2002 habitat analysis for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Habitat Mapping Results and Discussions

Results and discussions of the analysis are presented in the 2007 OM&M Report for this project (Lear et al).

## Land Water

Data Analysis Methods for Land Water:

USGS/NWRC personnel completed scanning, georectification, and the production of a land-water map for the aerial photography obtained post-construction in November 2008 (figure 7). In addition to this map, land-water acreages were calculated from the habitat analysis maps (figures 4-6). Statistics for intermediate and fresh water bodies were grouped together to get the open water component, while all other habitat types were grouped together for the land component (figure 8). Figure 8 also provides what these acreages translate to in percentages. The percent change of land-water during pre-construction, construction, post-contruction and overall is presented in figure 9.

Land Water Results and Discussions

There has been a trend from land to open water between 1993 and 2008 in both the project and reference areas, where the reference area exhibited a slightly higher percent change from land to water (-8.03 %) than the project area (-6.57 %) (figure 9). A small percent change from open water to land occurred during pre-construction between 1993 and 1996 inside the project area, while the reference area experienced the opposite. There was a slight positive change from open water to land between 1996 and 2002 during construction inside the project area while the change was opposite for the reference area. This could be partially attributed to project effects since all construction was completed by October 2000.

The most notable change occurred inside both the project and reference areas between 2002 and 2008 (post-construction). Both areas experienced a large shift from land to open water. It is possible that the large powerful tropical weather systems which made landfall in the northern Gulf of Mexico, hurricanes Katrina and Rita in 2005, and Gustav and Ike in 2008 being among those may have contributed to these changes. Despite the storms, the change from land to water was slightly lower in the project area in comparison to the reference area. This could be attributed to possible project affects, where the land loss may have been somewhat slower.

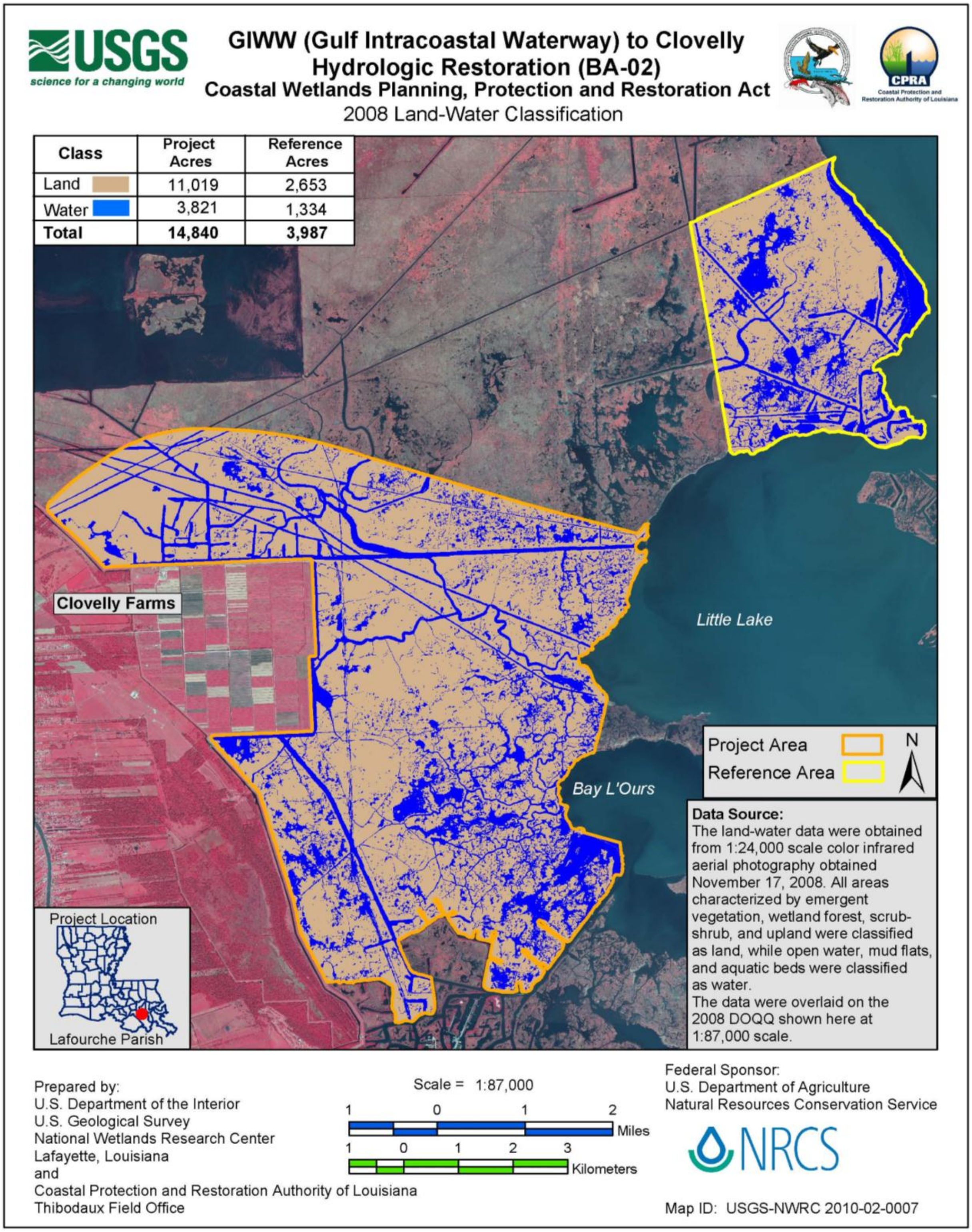



Figure 7. 2008 Land-Water analysis of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

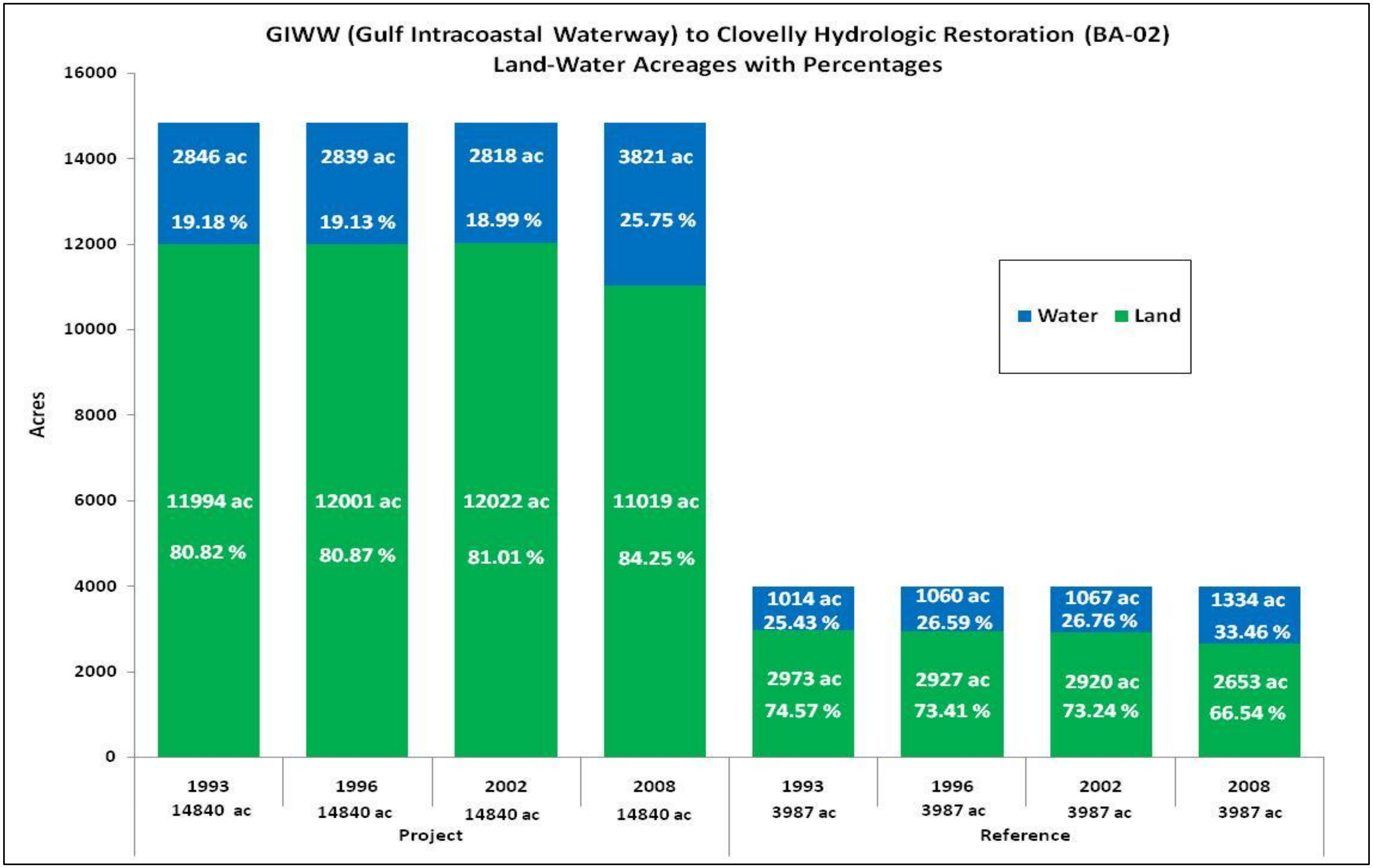



Figure 8. 1993, 1996, 2002, and 2008 land-water acreages and percentages by project and reference area for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

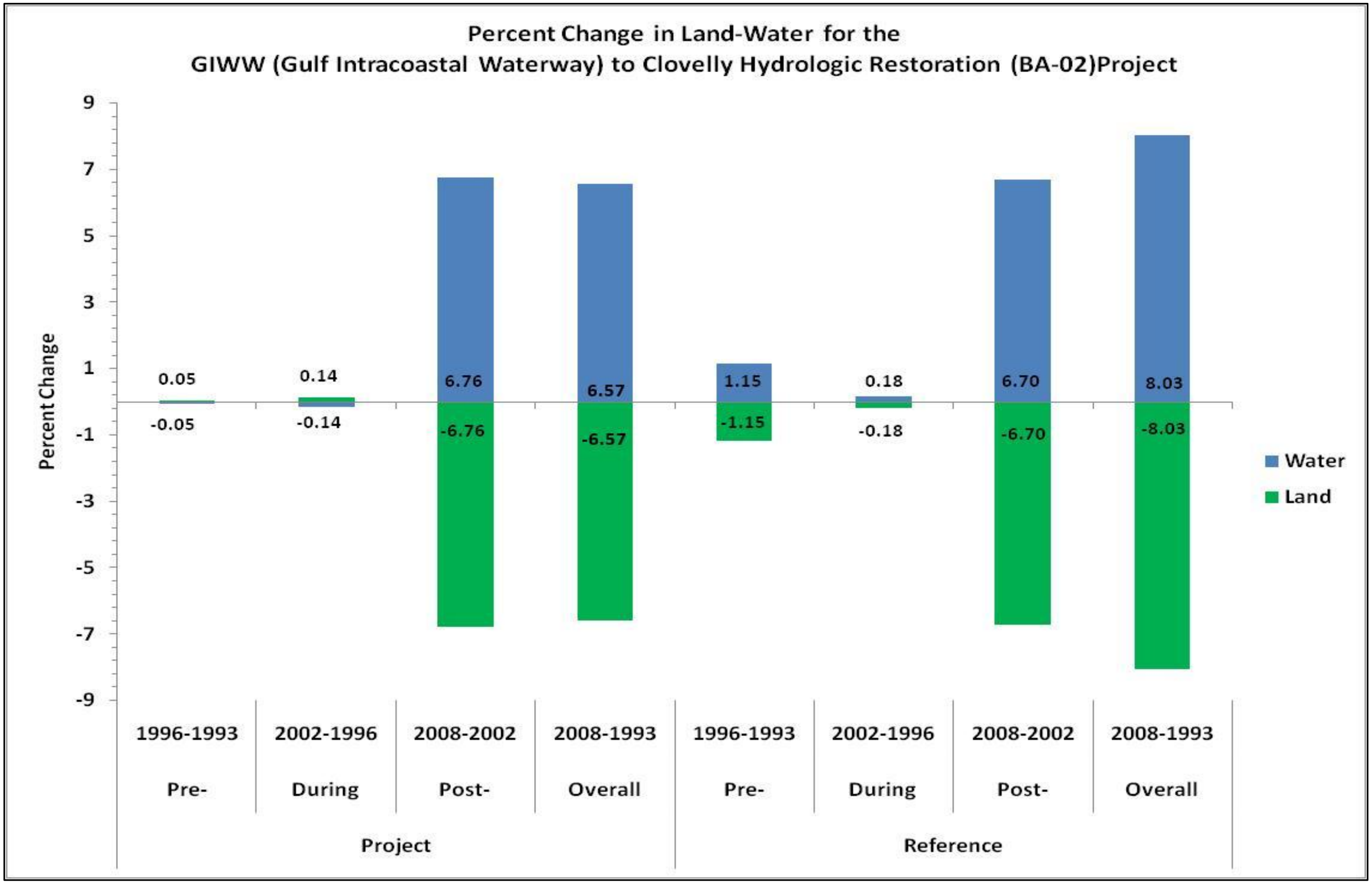



Figure 9. Percent change in Land-Water for pre-construction, construction, post-construction, and overall for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

## Water Level

Project construction was completed in two construction units and only a portion of the structures were in place when the monitoring equipment was installed or in use therefore, continuous water level data and discrete water quality data were broken into periods of partial construction and post-construction. One of the continuous recorder stations (station BA02-59) was gone, presumed to be scoured out, during pre-construction; therefore, there are no comparative post-construction data available for this station. Also, due to the CRMS-Wetlands review, stations BA02-53, BA02-54, and BA02-55 were discontinued in 2004. Reference areas selected to the north and northeast of the project boundary were eliminated due to land rights issues during late spring 1997. Project-specific continuous recorder stations where hourly water level data have been collected are found in table 1, figure 10. CRMS sites where hourly water level data have been collected and presented in this report are found in table 2, figure 3.

Table 1. Project-specific continuous recorder stations and their data collection durations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

| Station | Data Collection Period |
|---|---|
| BA02-53 | 07/01/1997 - 03/23/2004 |
| BA02-54 | 07/02/1997 - 03/23/2004 |
| BA02-55 | 06/24/1997 - 03/23/2004 |
| BA02-56 | 06/24/1997 - Present |
| BA02-57 | 07/01/1997 - Present |
| BA02-58 | 07/01/1997 - 07/24/2002 |
| BA02-59 | 07/01/1997 - 10/12/1998 |

*Continuous recorder stations BA02-58 and BA02-59 were lost due to scouring of the channel bottoms where the stations were located.

Table 2. CRMS-Wetlands continuous recorder stations and their data collection durations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

| Station | Data Collection Period |
|---|---|
| CRMS0190-W01 | 06/13/2006 - 09/30/2010 |
| CRMS0190-M01 | 06/13/2006 - Present |
| CRMS0220-H01 | 06/13/2006 - Present |
| CRMS0248-H01 | 05/14/2007 - Present |
| CRMS0253-H01 | 06/13/2006 - Present |
| CRMS0261-H01 | 05/14/2007 - Present |
| CRMS4218-H01 | 02/12/2008 - Present |

* Marsh well (CRMS0190-W01) constant recorder station was removed because of unreliable data and large data gaps in data sets.

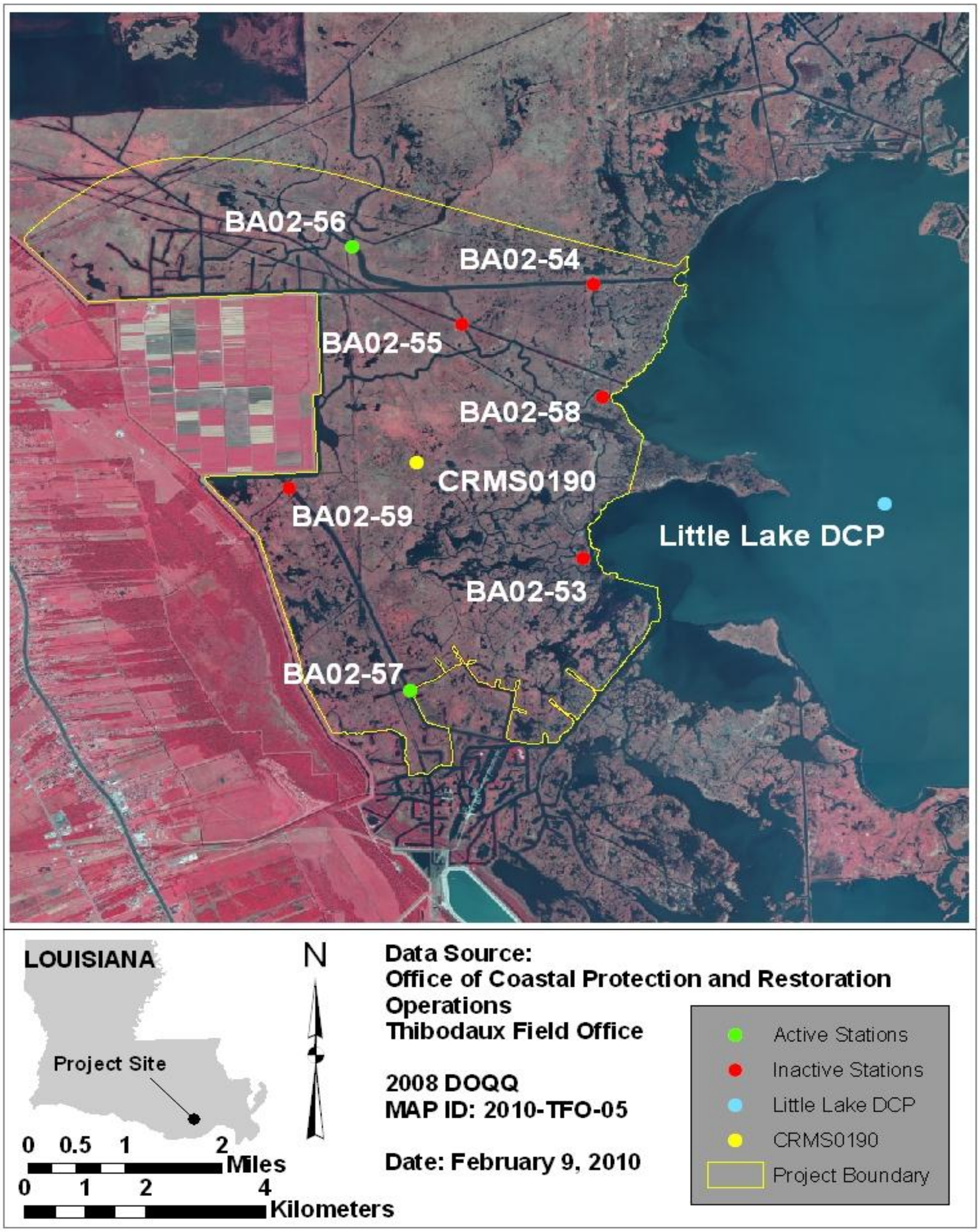



Figure 10. The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project continuous recorder station locations, Little Lake DCP, and CRMS0190 continuous recorder station.

Changes in water level values are measured on a continuous basis (defined as hourly, unless otherwise stated by the OCPR/Operations) where water depths remain deep enough to continually submerge the sensors. These variables are measured using a pressure transducer and a salinity meter (Steyer et al. 1995, revised 2000). The OCPR/Operations utilizes the YSI 6920, YSI 600XLM, or equivalent continuous recorder with a vented cable as the basic model that can measure water level via a pressure transducer, as well as salinity, specific conductance, and water temperature. Likewise, a YSI 30 or equivalent can measure salinity, specific conductance, and water temperature at discrete locations and to assure the data logger is properly calibrated (Folse et al. 2008).

For this project, the actual open water continuous recorder stations consist of a water level support pole for deployment of the continuous recorder, and a separate support pole for a staff gauge within a few feet of the continuous recorder. Each station is located in a canal or natural bayou adjacent to the marsh edge where boat access is possible. At each station a continuous recorder is mounted onto a 16 ft (4.9 m) long 4 in x 4 in (0.1 m x 0.1 m) treated wooden post which is driven into the water bottom to resistance. An elevation point was established on the data recorder post by a professional surveyor to the North American Vertical Datum of 1988, U.S. Survey Feet (NAVD88, Feet). The measured distance from the elevation point to the constant recorder's depth sensor, establishes the sensor's elevation to datum (NAVD88, Feet). The staff gauge consists of a 20 ft (6.1 m) long 4 in x 4 in (0.1 m x 0.1 m) treated wooden pole, driven into the water bottom to resistance, with a 6 ft (1.8 m) long 2 in x 4 in (.05 m x 0.1 m) treated wooden board attached to it. The 2.5 in (.06 m) wide ceramic coated gauge is attached to the 2 in x 4 in (.05 m x 0.1 m) board and established to the vertical datum NAVD88 Feet. Water level readings between the data recorder and the permanent staff gauge were compared to verify that the data recorder was recording the correct water level.

In addition to the open water recorders, one CRMS-Wetlands site with a marsh well continuous recorder setup as well as a floating marsh mat continuous recorder setup was established inside the project area (CRMS0190). Unlike the open-water recorder, the marsh well was mounted onto a treated post in the marsh then driven to resistance. The recorder was positioned inside of a series of PVC pipes with holes and slits cut into them then attached to the post. The PVC pipes were partially submerged in the marsh. This setup allowed surface water to enter and leave the well while the marsh surface was flooded. Once the water levels fell below marsh level (and at times below sensor level) the well's slits allowed pore water to seep in. An elevation point was established on the data recorder post by a professional surveyor to the North American Vertical Datum of 1988, U.S. Survey Feet (NAVD88, Feet). Data from the marsh well recorder was unreliable and not comparable to the open water recorders so it was not used in the analysis for this report.

The floating marsh mat recorder at CRMS0190 was also established in the marsh. The recorder was suspended inside of a series of PVC pipes, the larger outer one attached to a sheet of plywood anchored to the marsh mat surface. As a result, the marsh mat recorder collected data while suspended inside a hole punched into the surrounding marsh mat. Since this setup was not driven into the substrate below the marsh, the entire setup moved up and down with the marsh surface as the water levels changed. There was no surveyed elevation point for this setup because it moved with the marsh. The floating marsh mat data was not used in this report because it was not comparable to the open water recorders.

A differential global positioning system (DGPS) unit was utilized to collect the horizontal position of each continuous recorder setup as well as each staff gauge setup. The unit was also used to collect the station coordinate using the Universal Transverse Mercator (UTM), North American Datum of 1983 (NAD83), Meters coordinate system.

<u>Data Analysis Methods for Water Level:</u>
Extensive project-specific data analyses for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project were presented in the 2007 OM&M Report (Lear et al. 2007). In the report it was noted that assessment of the entire project's impacts was not feasible because full continuous monitoring started only after seven of the water control structures had already been built. The analyses consisted of a partial construction period (December 1, 1997 – October 31, 2000) and a post-construction period (November 1, 2000 – December 31, 2006). Since the 2007 report, three of the five project continuous recorder stations have been inactivated due to the CRMS-Wetlands review. Also, the continuous DCP used as a reference station located in Little Lake was destroyed in 2005 by a hurricane. The data presented in this report will not be as extensive as the 2007 report due to these factors.

Additional years of data collected from the two remaining project-specific continuous recorders, as well as CRMS reference continuous recorders are presented in this report. Two types of analyses were performed. In the first analysis, the data included years 2006 through 2009. For each station the water level data for all years was combined and averaged by month. For example, figure 11 shows that CRMS0253-H01 had a mean water elevation around 0.50 ft NAVD88 for the month of January for years 2006 through 2009. Not all of the CRMS stations were established at the same time so some did not show up in the record until after 2006 (table 2). Quality Assurance/Quality Control (QA/QC) was completed on all continuous hydrographic data and downloaded from the OCPR database and run in SAS© Version 9.1.3. The analysis was dependent upon simultaneity of readings among the various stations, so only four stations had comparative data in 2006. By 2007 two project stations and four reference CRMS stations had paired data available for analysis.

In the second analysis, the data presented were divided into partial and post-construction time periods, and included data from November 1, 2000 through December 31, 2010. To better identify the effects of this project on water level variability, a tidal analysis was completed. A program was written which identified continuous recorder observations corresponding to the maximum and minimum elevations for each tidal cycle. The difference between maximum elevation (or high tide) and minimum elevation (or low tide) for each cycle was then subjected to an analysis of variance (ANOVA). Data were partitioned into two spatial groups, project and reference, based on whether the station was within project boundaries or outside of project boundaries. In addition, data were partitioned temporally into three groups, a partial-construction period and two post-construction periods. Partial construction dates were assigned based on a previously identified project completion date of 31 October 2000. Post-construction data were split into two periods. The first period ("post 1"), from 1 November 2000 to 31 December 2005 includes data analyzed in the 2007 OM&M report. The second period ("post 2") includes data from 1 January 2006 to 31 December 2010.

Water Level Results and Discussions

*Analysis #1:* All of the constant recorders discussed in this analysis are located in open water. Project-specific stations BA02-56 and BA02-57 had generally higher mean monthly water levels while the two reference stations CRMS0220-H01 and CRMS0253-H01 had the lowest when all four years of paired data were analyzed (figure 11). The scenario appears to be similar when paired with additional CRMS stations but with fewer years of data, with the exception of BA02-57 (figure 12). In both scenarios BA02-56 had noticeably higher means than the others between January and April and BA02-57 tended to have a sudden downward turn in mean water levels between January and February. Whether these differences point to project driven effects remains to be seen. The short duration of data collection from the comparative CRMS stations does not allow for such conclusions at this time. Additional years of data collection will provide a better idea of project effects. These early analyses show that overall, the project-specific stations and the CRMS reference stations generally track each other, and they all have standard deviations with an overlap in variance. This overlap indicates that the sites are not very different from each other.

*Analysis #2:* Figure 13 shows an analysis of water level elevation data from the 1st of July to the 12th of August in 1997 at station BA02-53. This analysis clearly identifies high (in red) and low (in blue) tides for each cycle; cycles greater than 15 hours in length are excluded. Tidal cycles for July 17-19 are excluded because of the abnormally long length of the tidal period (28 and 16 hours), suggesting that these high and low tides are due to weather effects and not the natural tidal cycle. Overall the analysis does an excellent job of identifying high and low tidal points.

Tidal range was calculated for all data by identifying maximum and minimum elevations for each cycle, then subtracting from the maximum elevation the minimum elevation following

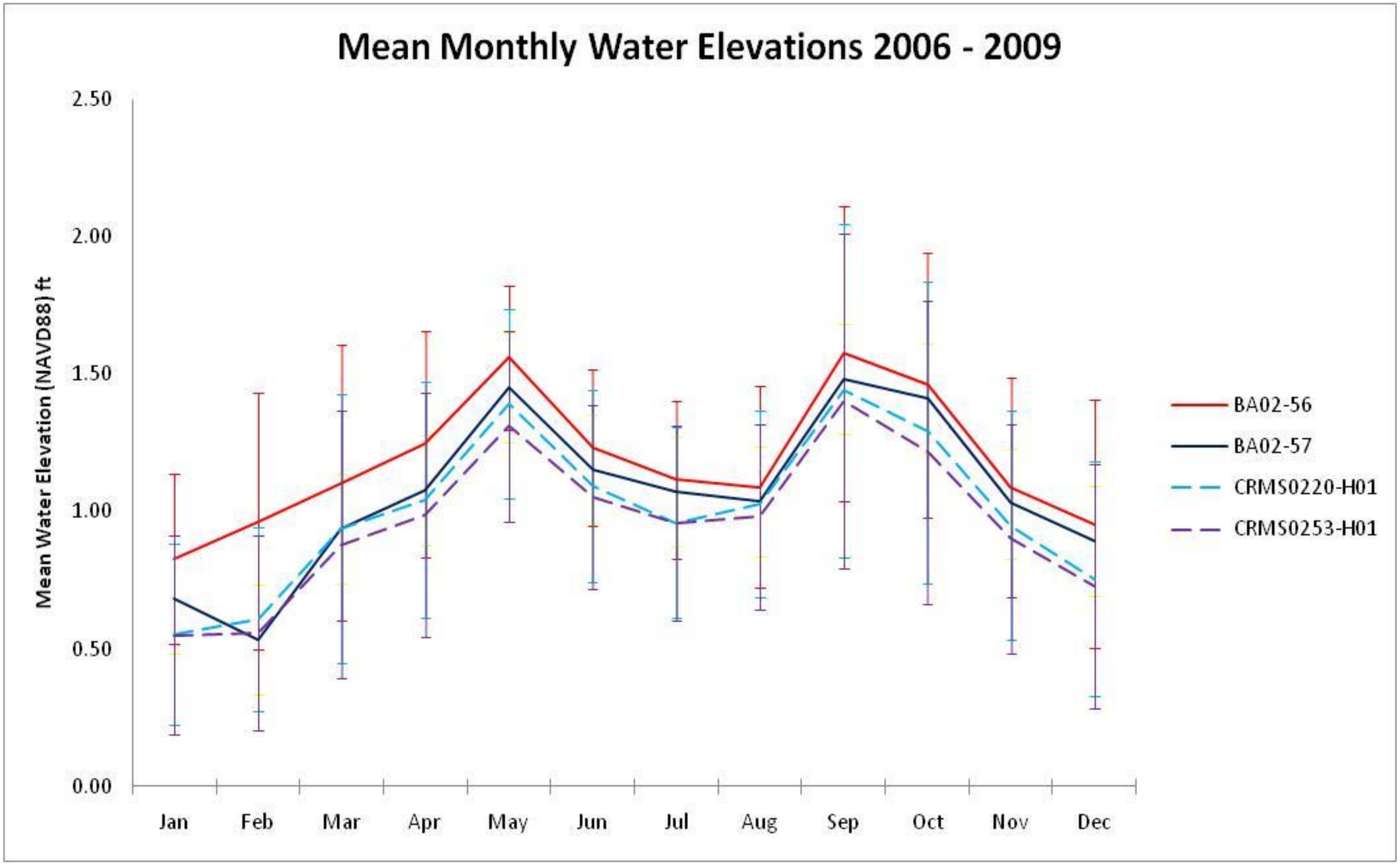



Figure 11. Mean monthly water elevations for project-specific and CRMS reference stations for years 2006 through 2009, for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

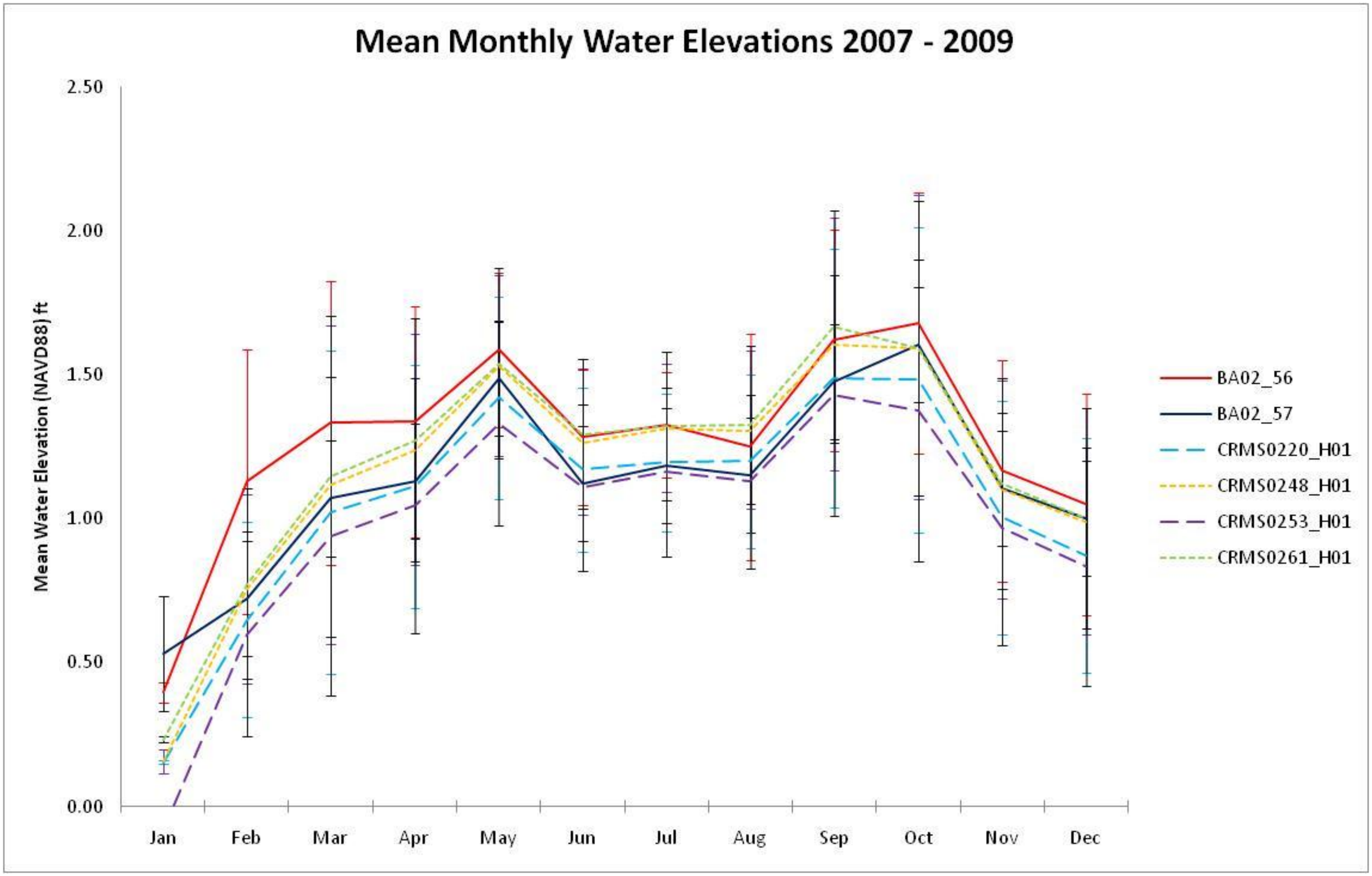



Figure 12. Mean monthly water elevations for project-specific and CRMS reference stations for years 2007 through 2009, for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

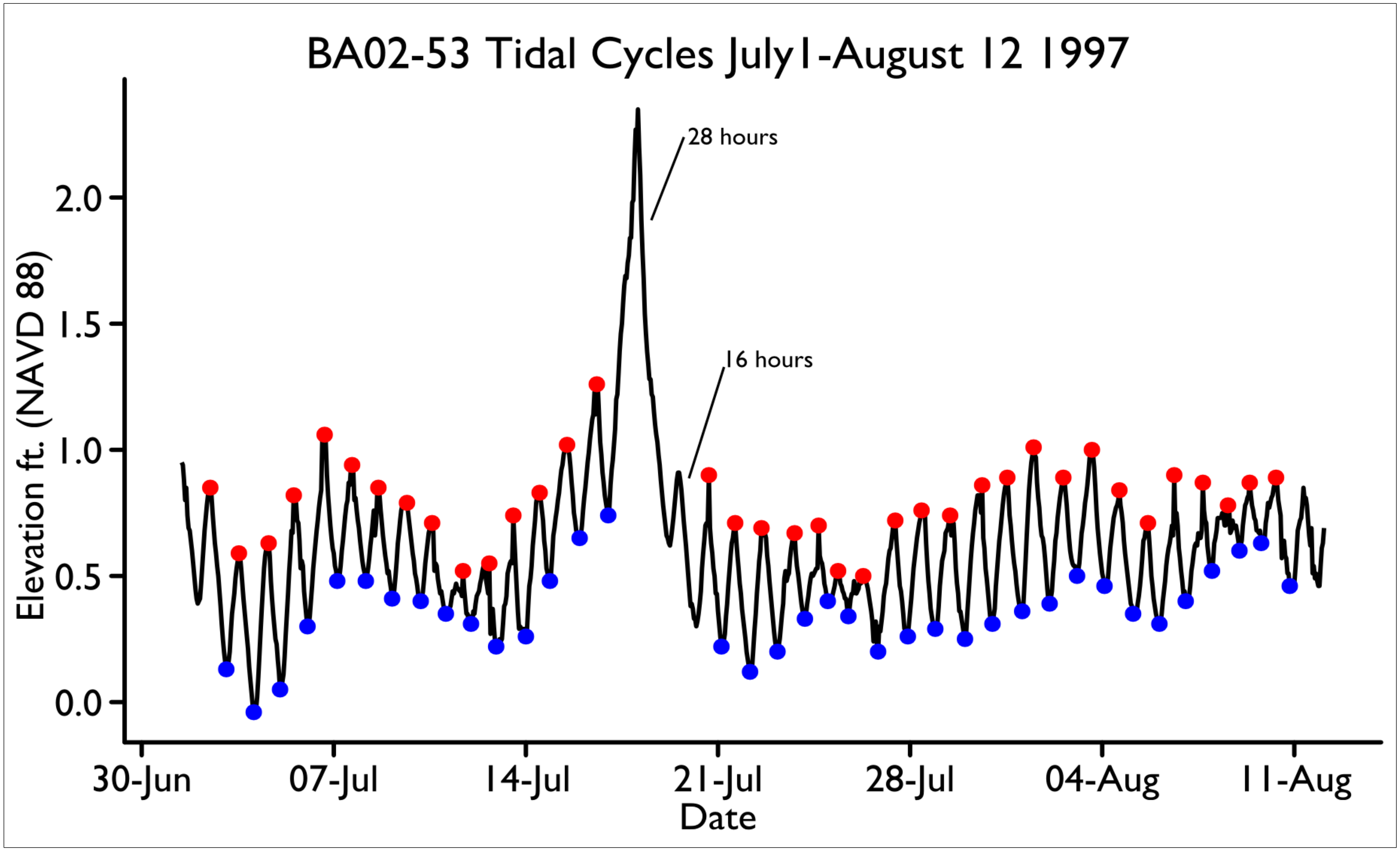



Figure 13. Example of tidal cycle highs and lows for project-specific continuous recorder station BA02-53, for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

that particular maximum; i.e., tidal range is the high tide elevation minus the following low tide elevation. Tidal range was then subjected to an analysis of variance with period as the dependent variable. Thus, the ANOVA tests for variation in tidal range between the three periods: partial, "post 1" and "post 2." There is significant variation in tidal range between these three periods ($F$=38, $P$<2.2×10$^{-16}$). Tukey's post-hoc test examines the difference in means between the various periods and tests for a significant difference in mean. Tukey's test reveals a significant difference between the "post 2" period and both the partial and "post 1" periods; in both cases, "post 2" had significantly lower (0.03 and 0.02 ft, respectively) tidal ranges. Thus, from 2006 to 2010 the tidal range within the project was about 0.03 ft less than during the partial construction phase or from November 1, 2000 to December 31, 2005. The partial and "post 1" periods were not significantly different from one another. This analysis is consistent with the hypothesis that the project reduced tidal range or water level variability; however, the lack of a complete reference data set does not allow exclusion of the hypothesis that these differences represent natural variability.

Comparison of the monthly mean tidal range for the 2006-2010 period ("post 2") suggests that reference sites (dashed lines) tend to have comparably higher tidal ranges (figure 14). An analysis of variance supports this hypothesis, showing that, for the "post 2" period, reference sites have a tidal range that is 0.19 ft. greater than project sites ($F$=1803, $P$<2.2×10$^{-16}$). This is also illustrated in figure 15 which shows that two of the three project sites have the lowest tidal ranges. Again, these results are consistent with the hypothesis that the project reduced tidal range or water level variability, but the conclusion is limited because of a lack of a complete reference data set.

Thus, both analyses are consistent with the hypothesis that the project has had an impact on lowering water level variability. Relative to the partial and "post 1" construction periods, the "post 2" period shows lower tidal ranges. In addition, a comparison of project sites to reference sites for the "post 2" period indicates lower tidal ranges for project sites. Because of the lack of a complete reference data set though, the hypothesis that these differences are due to natural variability cannot be ruled out.

**<u>Salinity</u>**

The same continuous recorder equipment and stations used to collect water level data were used to collect continuous salinity data. Establishment of each continuous recorder setup and the water quality variables collected are described under the "Water Level" data collection section of this report (tables 1 and 2).

<u>Data Analysis Methods for Salinity:</u>

Extensive project-specific data analyses for the GIWW (Gulf Intracoastal Wateway) to Clovelly Hydrologic Restoration (BA-02) project were presented in the 2007 OM&M Report (Lear et al. 2007). Data analysis methods for salinity in this report were conducted in the same

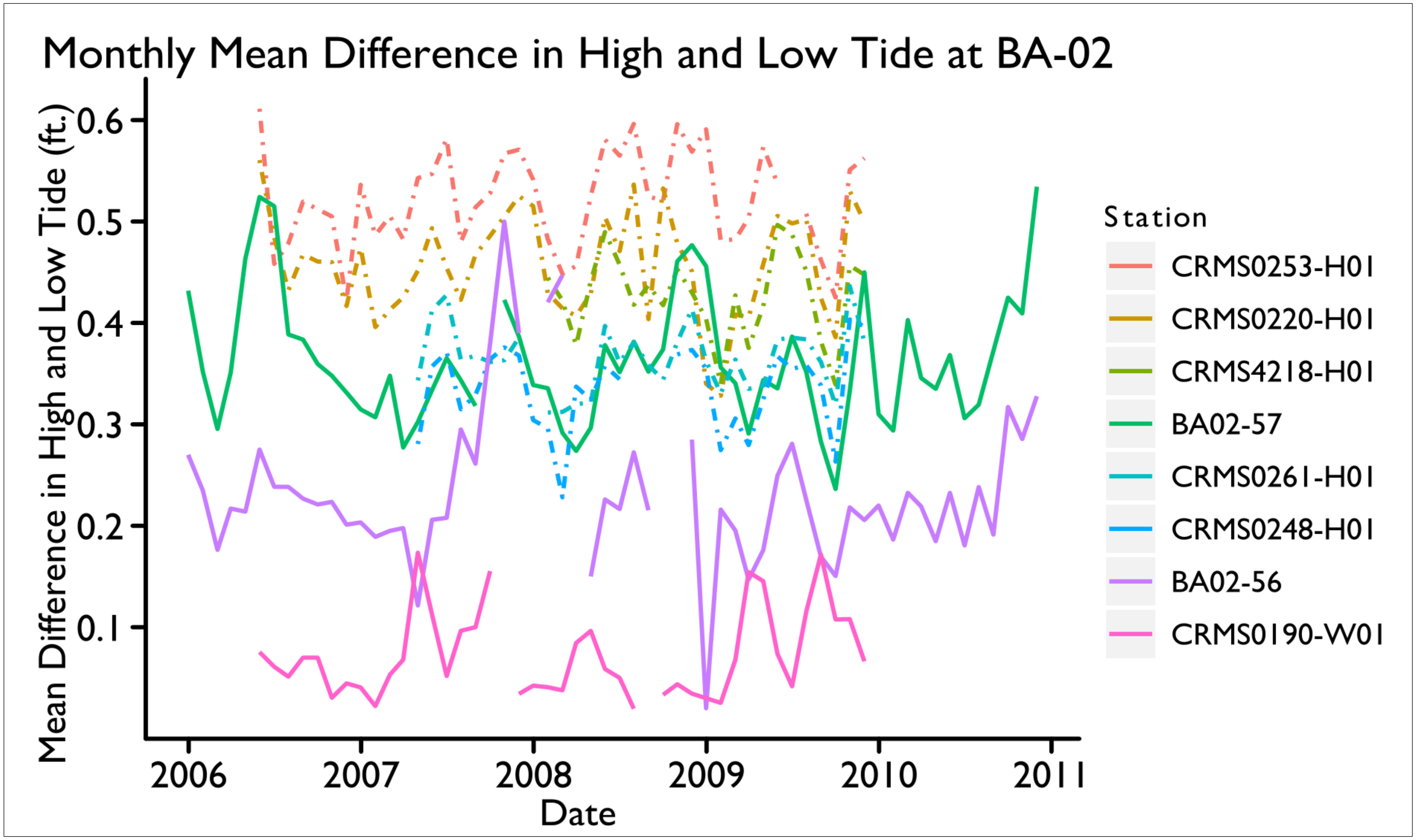



Figure 14. Comparison of the monthly mean tidal range for the 2006-2010 period ("post 2") for project-specific and CRMS-Wetlands continuous recorder stations. For the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

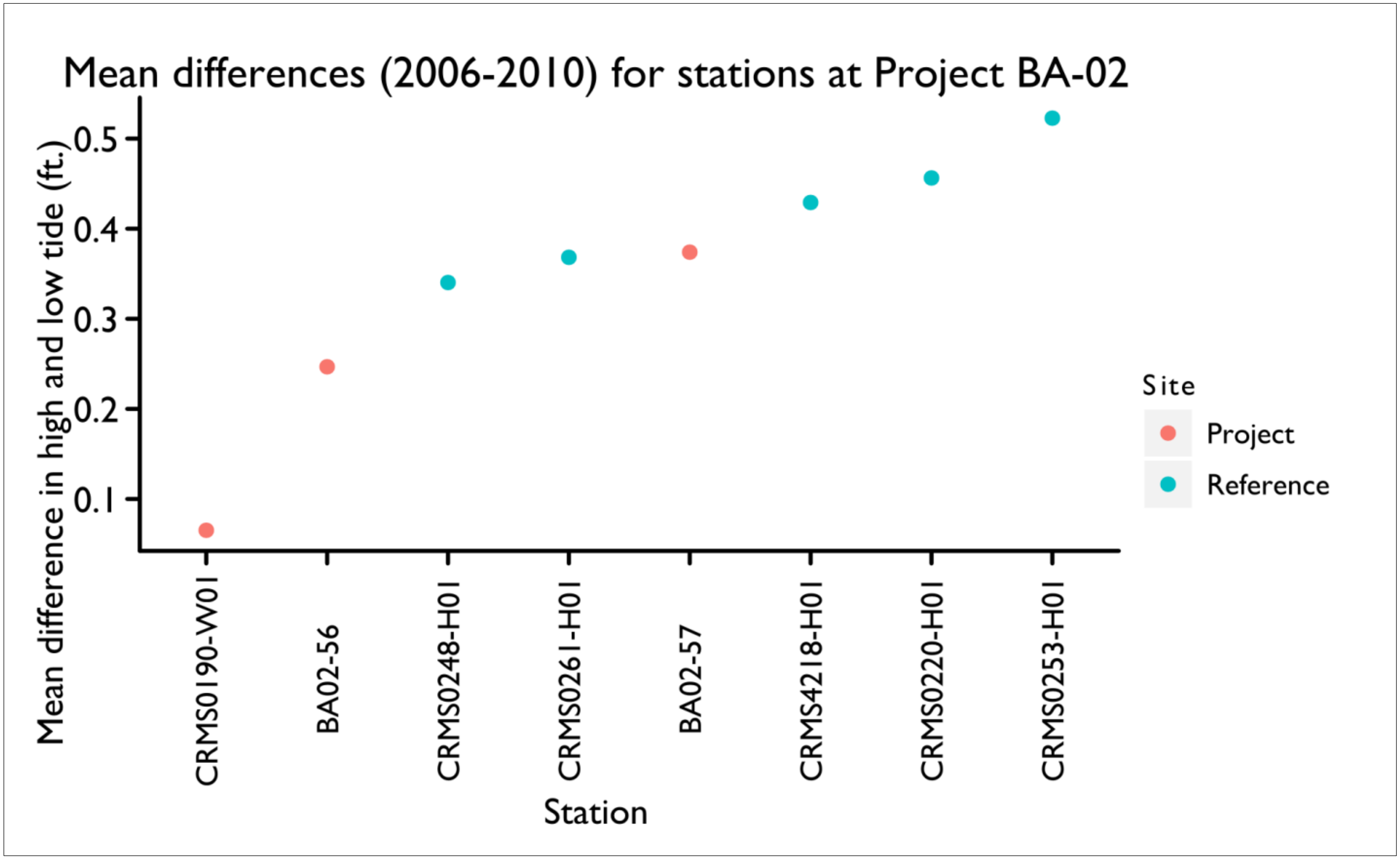



Figure 15. Mean differences between high and low tide for project-specific and CRMS-Wetlands continuous recorder stations. For the GIWW (Gulf Intracoastal Waterway) to Clovellly Hydrologic (BA-02) project.

manner as that used for water level in analysis #1. Also, as with the water level analysis, adjusted salinity data for CRMS0190 continuous marsh well and marsh mat recorders were not included because the data was not comparable to that of the open water continuous recorders from all of the other project-specific and CRMS stations. Data collected from the two remaining project-specific continuous recorders, as well as CRMS reference continuous recorders are presented in figures 16-17.

Salinity Results and Discussions

From 2006 through 2009 project-specific stations BA02-56 and BA02-57 were similar to each other and had generally lower monthly mean adjusted salinities, while stations CRMS0220-H01 and CRMS0253-H01 had higher salinities (figure 13). BA02-57 shows some noticeable differences between March and May with a decidedly upward swing in salinity. Interestingly, in the analysis with additional stations but fewer years of paired data (figure 14) there is a dip in salinities for all stations in the fall months, while the converse is true when 2006 data is included. It is possible that the project may be moderating higher salinities however a longer duration of data collection is needed to verify this trend. Overall, all of the stations in the two scenarios tend to track each other and have standard deviations that show an overlap in variance, which indicates the stations appear to be similar to each other.

**Discrete Salinity Data**

Discrete salinity data were collected at stations throughout the project area from September 1997 through January 2004. Analysis of the data was presented in the 2007 OM&M Report (Lear et al. 2007) for this project.

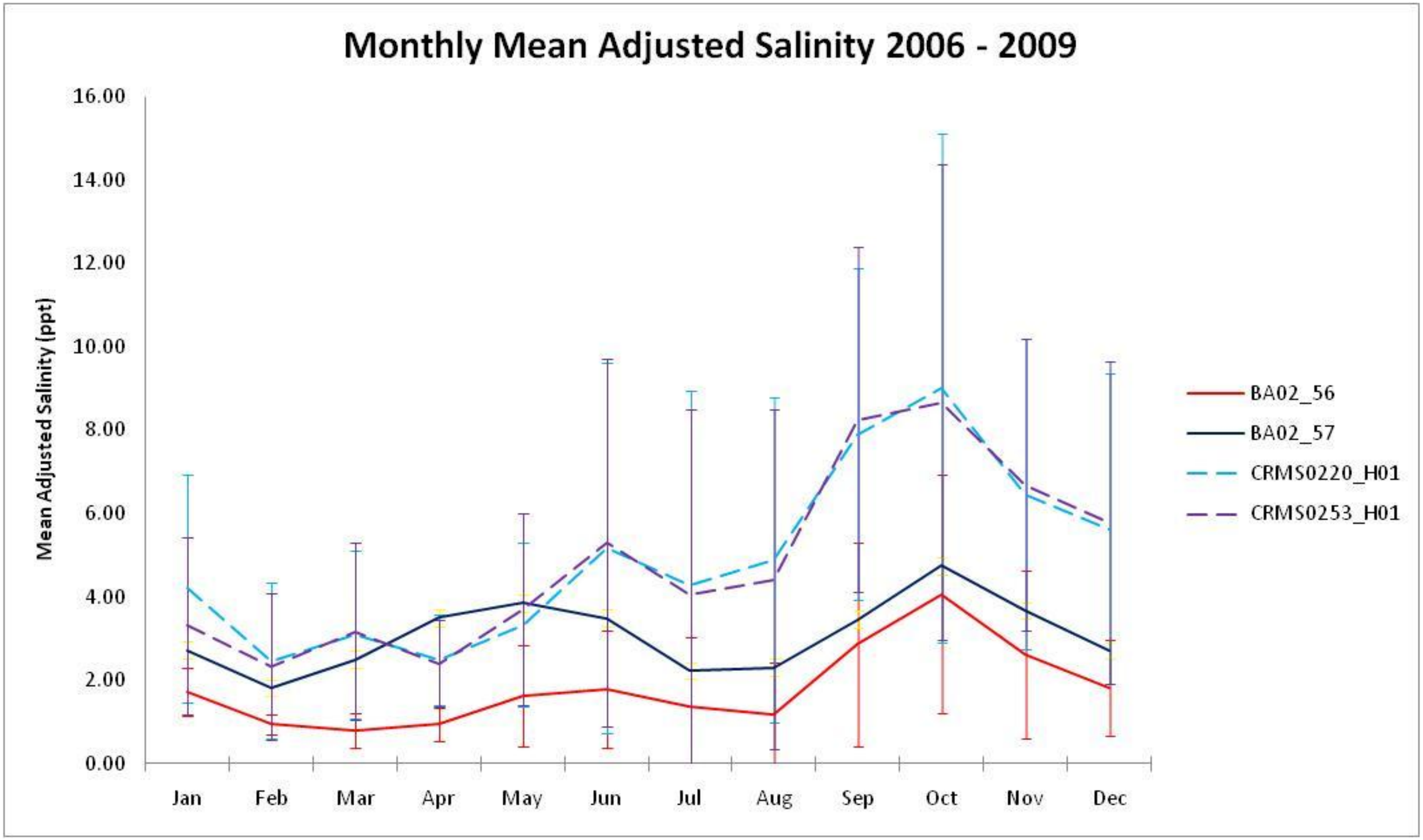



Figure 16. Mean monthly adjusted salinity for 2006-2009 for project-specific and CRMS reference stations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

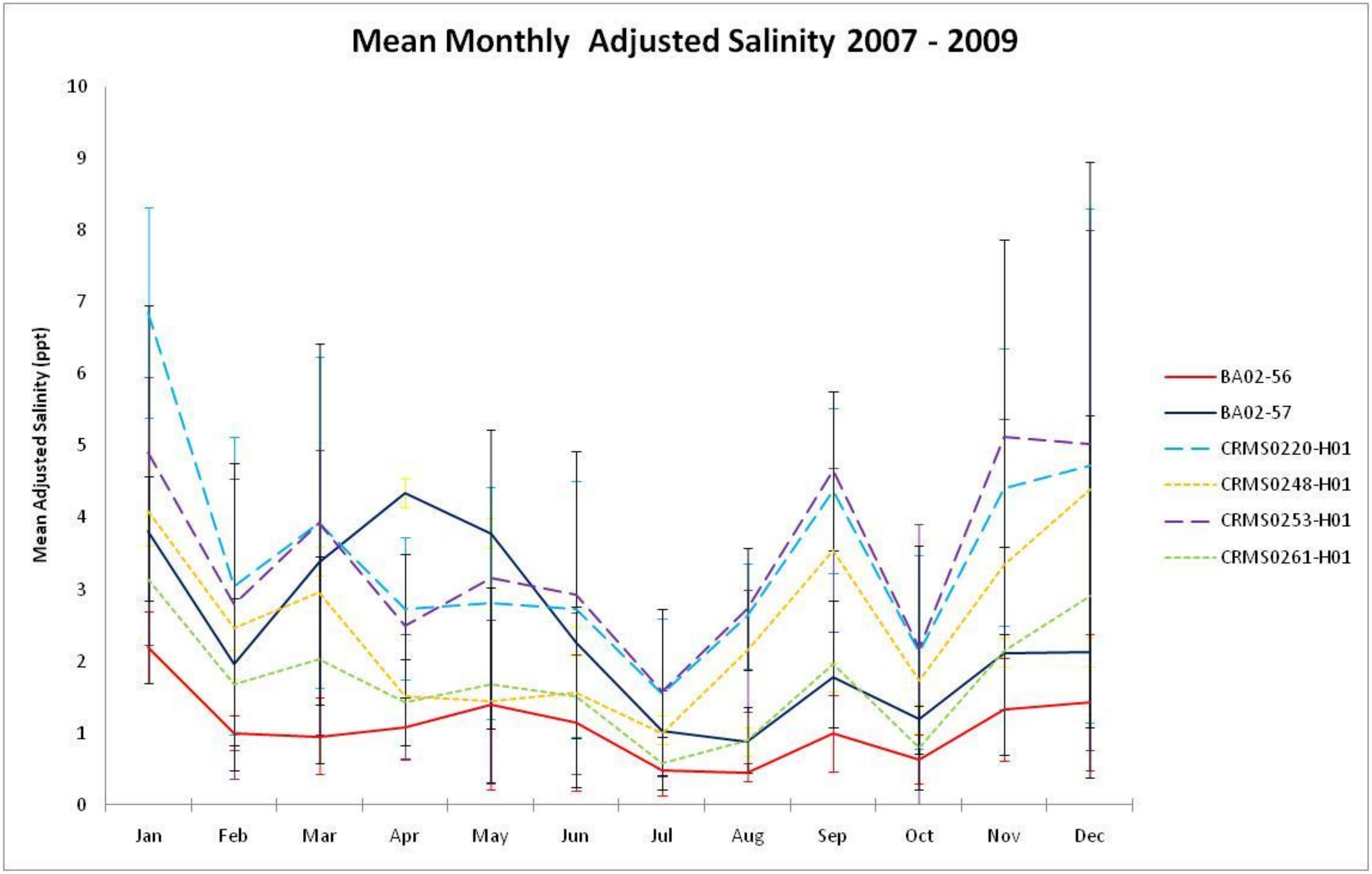



Figure 17. Mean monthly adjusted salinity for project-specific and CRMS reference stations for 2007 through 2009, for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

**Vegetation**

Project-specific vegetation data were collected during the fall of 1996, 1999, 2000, 2002, 2005, and 2008 (table 3; figure 18). Each sampling station was marked with a PVC pole at the southeast corner to mark the plot which allows for data collection on repeat visits unless the station is lost or destroyed by a natural or human disturbance. Station coordinates were collected at the southeast corner pole with a Differential Global Positioning System (DGPS) to facilitate repeat sampling. The corner pole position for each station was recorded in the Universal Transverse Mercator (UTM), North American Datum of 1983 (NAD83), Meters coordinate system. During data collection, a 6.6 ft x 6.6 ft (2 m x 2 m) Braun-Blanquet grid was placed over the southeast corner pole and oriented so that each side faced a cardinal direction. Species composition, percent cover by species and total percent cover data were recorded for the area inside the grid using ocular estimates near the end of the growing season. Total vegetation cover and cover of each layer (tree, shrub, herbaceous, carpet) was estimated between 0 and 100% (Folse et al. 2008). The sum of each vegetation layer could exceed 100 percent because of overlapping canopies. The average height of the dominant (that is, greatest percent cover) species was measured. Plant species nomenclature followed the USDA PLANTS Database (USDA, NRCS, 2008).

For CRMS sites, vegetation data were collected during the fall of 2006, 2007, 2008, and 2009 (table 4; figure 3) inside a 200 $m^2$ data collection area (DCA) within each 1 $km^2$ site. CRMS0190 is located inside the project BA-02 boundary while CRMS0220, CRMS0248, CRMS0253, CRMS0261, and CRMS4218, located to the northeast were selected as reference sites. Each CRMS site has 10 vegetation stations located along a transect which runs diagonally inside the 200 $m^2$ DCA. Station CRMS0190 is an oligohaline spikerush marsh community type (Visser et al. 1998) and all of the reference sites are classified as oligohaline wiregrass. For analytical purposes, OCPR found that the only CRMS reference sites comparative to CRMS0190 which were located within the same watershed in the vicinity of the project were the aforementioned sites. Since all of these sites were intermediate marsh, OCPR felt that they were similar enough for comparisons. Data collection for each site occurred within ten 6.6 ft x 6.6 ft (2 m x 2 m) stations along a 927.8 ft (282.8 m) transect within each 256.2 ft x 256.2 ft (200 m x 200 m) CRMS site (Folse et al. 2008). Data was collected in the same manner as described for project-specific vegetation plots.

Table 3. Project-specific vegetation and soils data collection stations at the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

| Station | 1996 | 1999 | 2000 | 2002 | 2005 | 2008 | Replacement |
|---|---|---|---|---|---|---|---|
| BA02-60 | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-60R | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-61 | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-61R | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-62 | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-62R | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-63 | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-63R | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-64 | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-64R | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-65 | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-65R | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-66 | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-67 | Yes | Dropped | Dropped | Dropped | Dropped | Dropped | None |
| BA02-68 | Yes | Yes | Yes | Yes | No | No | BA02-150 |
| BA02-69 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-70 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-71 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-72 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-73 | Yes | Yes | No | No | No | No | BA02-100 |
| BA02-74 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-75 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-76 | Yes | Yes | Yes | Yes | No | No | BA02-152 |
| BA02-77 | Yes | Yes | Yes | Yes | No | No | BA02-151 |
| BA02-78 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-79 | Yes | Yes | No | No | No | No | BA02-101 |
| BA02-80 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-81 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-82 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-83 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-84 | Yes | Yes | Yes | Yes | Yes | Yes | None |
| BA02-100 | No | No | Yes | Yes | Yes | Yes | None |
| BA02-101 | No | No | Yes | Yes | Yes | Yes | None |
| BA02-150 | No | No | No | No | Yes | Yes | None |
| BA02-151 | No | No | No | No | Yes | Yes | None |
| BA01-152 | No | No | No | No | Yes | Yes | None |

Table 4. Sites and years for CRMS vegetation data collection at the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

| Site | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| CRMS0190 | Yes | Yes | Yes | Yes |
| CRMS0220 | No | Yes | Yes | Yes |
| CRMS0248 | No | Yes | Yes | Yes |
| CRMS0253 | Yes | Yes | Yes | Yes |
| CRMS0261 | Yes | Yes | Yes | Yes |
| CRMS4218 | No | Yes | Yes | Yes |

Note: Soils data were also collected at these stations, but only once during the year of their initial establishment.

Data Analysis Methods for Vegetation:

Six years of project-specific data were entered into an electronic format where OCPR/TFO personnel followed Quality Assurance/Quality Control (QA/QC) procedures prior to data analysis as stated in Folse et al. (2008) and then analyzed for relative cover and Florisitc Quality Index (FQI) following methods described in Cretini et al. (2009). Additionally, CRMS station data were analyzed for FQI. Four years of vegetation cover and composition data from the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project were used to determine the FQI over time for project and reference CRMS sites.

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 (appendix D). 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* 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.

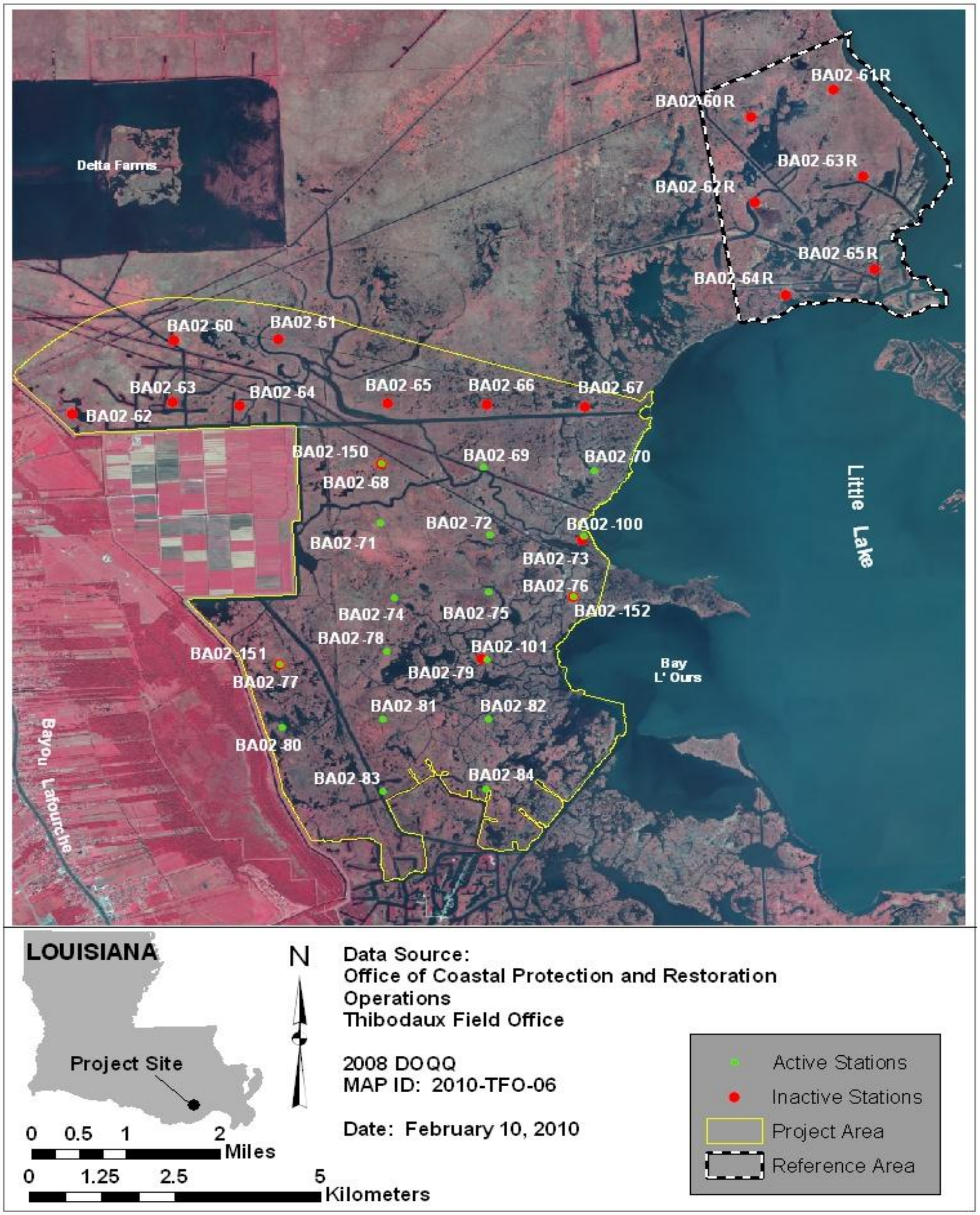



Figure 18. Project-specific vegetation and soils data collection stations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Data Analysis Methods for Project-Specific Vegetation:

The relative mean percent cover of selected species for stations within the BA-02 project and reference areas is presented in figure 16. Reference areas selected to the north and northeast of the project boundary were eliminated due to land rights issues during late spring 1997. For the project-specific stations, SAS® version 9.1.3 software was used to calculate the relative mean percent cover for each species by year for each station. These statistics were entered into Microsoft Office Excel 2007 where overall relative mean cover for each species by project and reference was calculated, ranked, and entered into a chart (figure 16). The relative mean cover for each species across all stations by year sums to 100 percent. In addition to relative mean cover, the FQI for each project-specific project and reference station by year was determined using SAS® version 9.1.3. These values were entered into Microsoft Office Excel 2007 where the mean FQI was calculated for each year for project and reference areas and entered into figure 16. The mean FQI for each sample year is indicated along with a trendline created from these values.

Project-Specific Vegetation Results and Discussions

Discussions pertaining to the analysis of vegetation cover within the project and reference areas were presented in the 2007 OM&M Report and included sampling years 1996, 1999, 2000, 2002, and 2005 (Lear et al. 2007). Additional data collection in 2008 indicates that relative mean cover for dominant species such as *Sp. patens* (Ait.) Muhl. (marshhay cordgrass) and *Spartina alterniflora* Loisel. (smooth cordgrass) increased while species diversity also increased (figure 19). In 2005 data collection occurred two months after Katrina's landfall, while data collection in 2008 occurred approximately two months after hurricanes Rita and Ike. The relative mean percent cover for the dominant species decreased by 50% between the 2002 and 2005 sampling periods. Though still below its 2002 statistic, this species gained an additional 15% relative mean cover by 2008. Relative mean percent cover for drought intolerant species such as *Sagittaria lancifolia* L. (bulltongue) and *Polygonum punctatum* Ell. (dotted smartweed) increased by 2005 despite the drought which lasted from September 1999 through June 2001.

The FQI and the relative mean cover follow a similar trend and appear to track each other between 1996 and 2008. Since the dominant species contributes to a large portion of both, variations in its presence or cover values would likewise be reflected in the results.

Data Analysis Methods for CRMS Vegetation:

For the CRMS stations, SAS® version 9.1.3 software was used to calculate the relative mean percent cover for each species by year for each station. These statistics were entered into Microsoft Office Excel 2007 where overall relative mean cover for each species by project and reference was calculated, ranked, and entered into a chart (figure 20). The relative mean cover

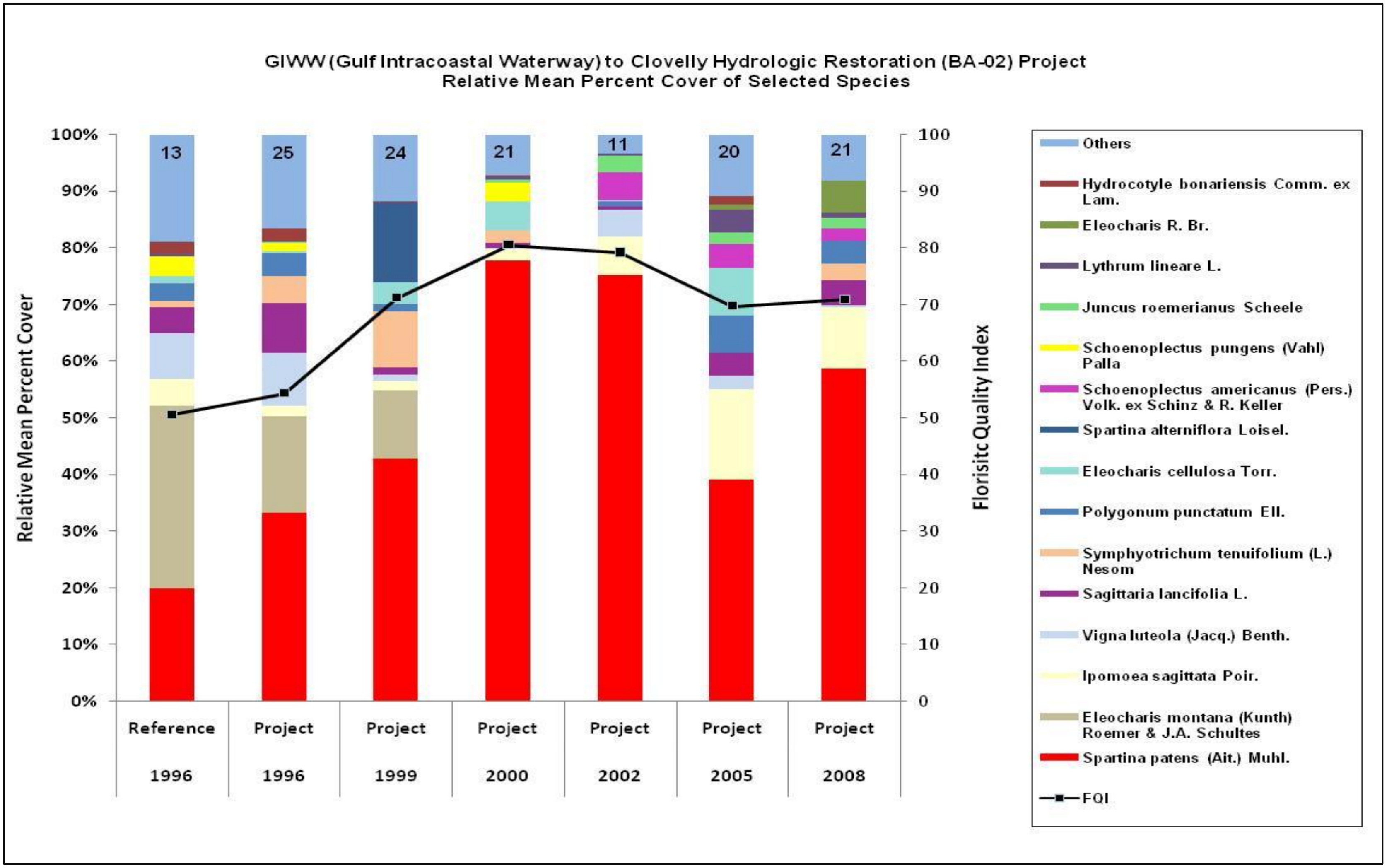



Figure 19. Project – specific relative mean percent cover for selected species by project and reference area by year. The mean FQI is represented for each year by the black line. For the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

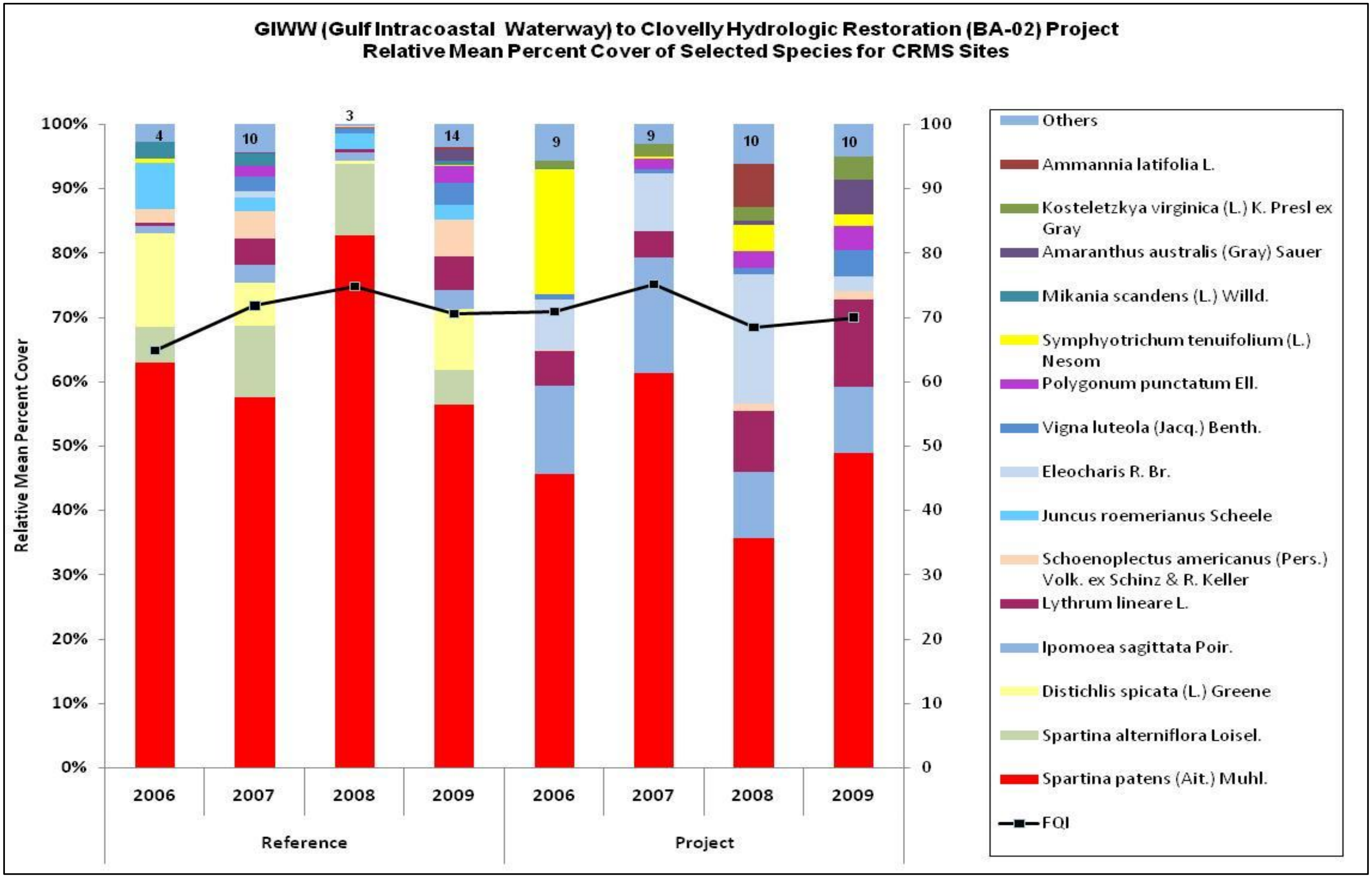



Figure 20. Relative mean percent cover for selected species by project and reference CRMS sites and by year. The mean FQI is represented for each year by the black line.at the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project

for each species across all stations by year sums to 100 percent. FQI analysis was also performed on CRMS vegetation data and is indicated as the solid black line. The data were entered into an electronic format where OCPR/TFO personnel followed QA/QC procedures prior to data analysis as stated in Folse et al. (2008). SAS® version 9.1.3 software was used to determine the FQI for each vegetation station within each CRMS site for each year (2006, 2007, 2008, and 2009). The SAS results were entered into Microsoft Office Excel 2007 where they were sorted and additional calculations made to determine the mean FQI for project versus reference CRMS sites by year. CRMS0248, CRMS0261, and CRMS4218 were not established until after sample year 2006.

<u>CRMS Vegetation Results and Discussions</u>

Within the project CRMS site (CRMS0190) floristic quality showed slight variation between 2006 and 2009, but generally followed the same trend as the relative mean cover of the dominant species (Figure 20). Both the FQI and the relative mean cover slightly increased by 2009. Species diversity also showed variations from year to year.

The reference CRMS sites followed a somewhat different trend than the project CRMS site. While both the FQI and the relative mean cover of the dominant species peaked in 2008 for the reference CRMS sites, the opposite occurred for the project CRMS site. Species diversity remained similar throughout the four year duration of data collection.

## Soils

Project-specific soils data were collected concurrent to vegetation sampling during the fall of 1996, 1999, 2000, 2002, 2005, and 2008. Soils data collection stations as well as sampling years were the same as those used for vegetation monitoring (table 3; figure 18). For the years 1996, 1999, 2000, and 2002 simple grab samples were collected by OCPR personnel just outside of the 6.6 ft x 6.6 ft (2 m x 2 m) vegetation plots and delivered to the Louisiana State University (LSU) agricultural center agronomy department soils lab. One grab sample was taken at each station. Once the spot was selected for the sample, vegetation was clipped back to the marsh surface and all loose detritus was removed. Each sample, approximately 3.9 in (10 cm) deep and approximately 3.9 in (10 cm) in diameter, was taken from the marsh. The samples were placed in plastic Ziploc® bags, labeled, and stored in an ice chest on ice for the duration of the sampling trip. Once delivered to the field office, the samples were held in refrigeration no longer than 48 hours before delivery to the soils lab. The samples were processed in order to determine the $g/cm^3$ bulk density, percent organic matter content, and percent moisture content.

In 2005 and 2008 OCPR contracted with Coastal Estuary Services (CES), LLC in Houma, Louisiana, for project-specific soils data collection and processing. Soil samples were taken with an 11.8 in (30 cm) stainless steel Meriwether corer, with an inside tube diameter of 4 in (10.1 cm) to a depth of 5.9 in (16 cm) using the protocol set forth in Folse et al. (2008). The cores were transferred to individual Ziploc® bags, labeled, and placed in an ice chest on ice for the duration of the sampling trip. Once delivered to the field office, the samples were held in refrigeration no longer than 48 hours before delivery to the soils lab. Soil cores were analyzed for wet pH, dry pH, specific conductance (µS/cm), salinity (ppt), moisture content (%), bulk density (g/cm$^3$), wet volume (cm$^3$), and dry volume (cm$^3$).

In addition to project-specific soils data collection, three baseline soil cores were taken from one CRMS site, CRMS0190 inside the project area as well as reference CRMS sites CRMS0220, CRMS0248, CRMS0253, CRMS0262, and CRMS4218 in the surrounding hydrologic basin (figure 3). The cores were taken only once from each site at the time of their initial establishment (table 4). The cores were taken with an 11.8 in (30 cm) stainless steel Meriwether corer, with an inside tube diameter of 4 in (10.1 cm) to a depth of 11.8 in (30 cm) using the protocol set forth in Folse et al. (2008). Cores were extruded in the field and sliced into 1.57 in (4 cm) increments to a depth of 9.45 in (24 cm). They were placed on ice immediately and sent to the contracted soils lab. Soil cores were analyzed for soil pH, soil salinity (ppt), soil moisture content (%), bulk density (g/cm$^3$), organic matter content (%), wet volume (cm$^3$), and dry volume (cm$^3$).

Project-Specific Data Analysis Methods for Soils:
Soils data were received by OCPR/Operations and individual station results were totaled and divided by the number of stations to determine the mean values for the three (3) variables that were consistently collected. These variables included organic matter content, moisture content, and bulk density.

Project-Specific Soils Results and Discussions
Results and discussions from these analyses were presented in the 2007 Operations, Maintenance, and Monitoring Report (Lear et al.).

CRMS Data Analysis Methods for Soils:
The raw data for bulk density, organic matter content, and moisture content were sorted by station and sample depth. Means were calculated for the three cores at each site by 1.57 in (4 cm) sample depth increments; then an overall mean was calculated by combining project and reference site means. Results for each variable are presented in figures 21 - 23.

CRMS Soils Results and Discussions
All of the CRMS sites selected for data analysis have Lafitte-Clovelly association soil type (U.S. Soil Conservation Service 1984). It is important to note that the project CRMS site (CRMS0190) is located in a floating marsh while all of the reference CRMS sites are in attached marshes. Floating marsh sites have almost entirely organic substrates and are tied together by living plant roots in a peat mat (Sasser et al. 1995). It is the lack of mineral content

which makes them buoyant. Attached marshes have a higher mineral content in their soils due to the influx of suspended sediments over the marsh from nearby water bodies, lowering their buoyancy. Marshes with higher organic matter content in their soils conversely have lower bulk density. Additionally, the buoyancy of an intermediate marsh such as the one in the BA-02 project area is demonstrably variable, as its buoyancy has been shown to oscillate with seasonal variations in water levels in concert with the substrate bulk density (Swarzenski et al. 1991). Intermediate marshes tend to be most buoyant in the late summer and early autumn and least buoyant in the winter.

Mean organic matter content was consistently higher for every 4 cm increment in sample depth within the project's floating marsh CRMS site compared to the reference CRMS sites (figure 21). All project sample depths had above 75% mean organic matter content with the highest occurring at the 12-16 cm sample depth. The highest content for the reference sites occurred at the 8-12 cm sample depth, slightly more than half of the project site content at that depth. The marked differences in mean organic matter content between the project and reference sites illustrate the differences in marsh types.

Mean bulk density for the project CRMS site was consistently and substantially less than the reference CRMS sites across all of the 4 cm sample depth increments (figure 22). Again, this is because it is in a floating marsh with a primarily organic substrate with little to no mineral content. For the project CRMS site the highest bulk density occurred at the 4 cm and 16 cm sample depths. There was slight variability from increment to increment for this site, with no evident trend. The reference CRMS sites had highest bulk density at the 4 cm sample depth with less variability between sample depths.

Mean soil moisture content was consistently near or above 90% for the project CRMS site across all sample depths (figure 23). Also, the moisture content minutely increased with each increase in sample depth. For the reference CRMS sites the mean soil moisture content ranged between near 70% to slightly above 78%. The lowest content was in the top 4 cm increment of sample depth. Interestingly, the moisture content increased with each increase in sample depth except for the last increment.

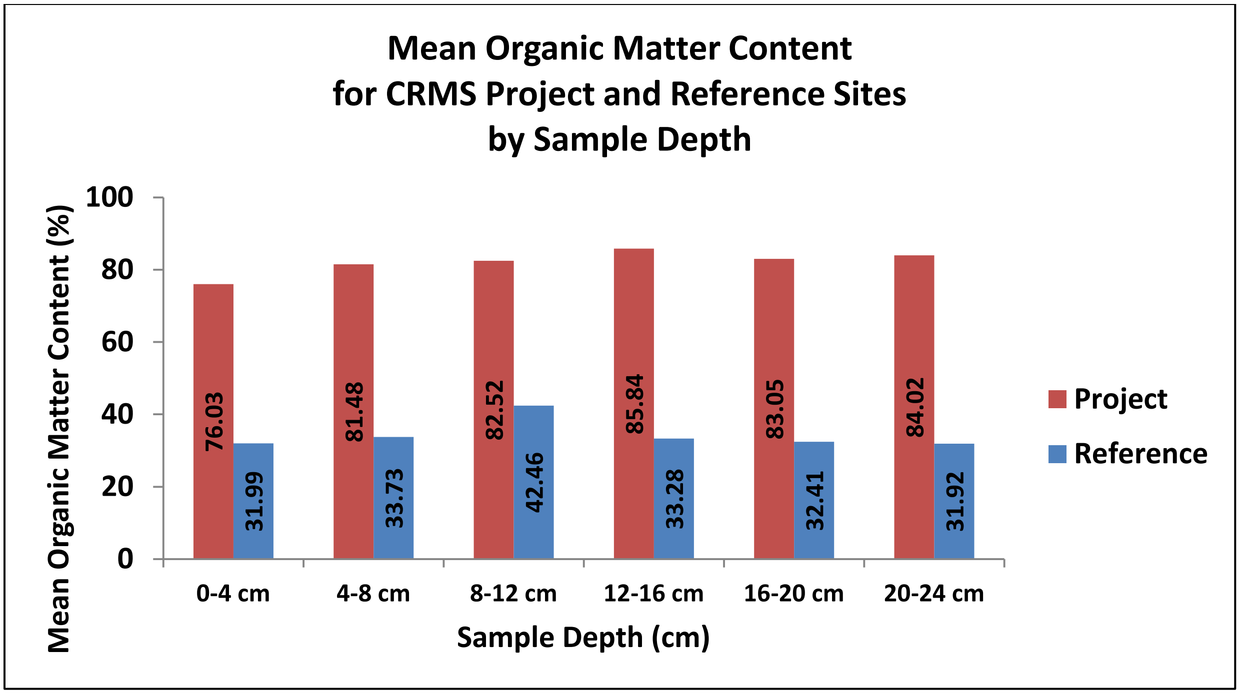



Figure 21. Mean organic matter content for project and reference CRMS sites for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

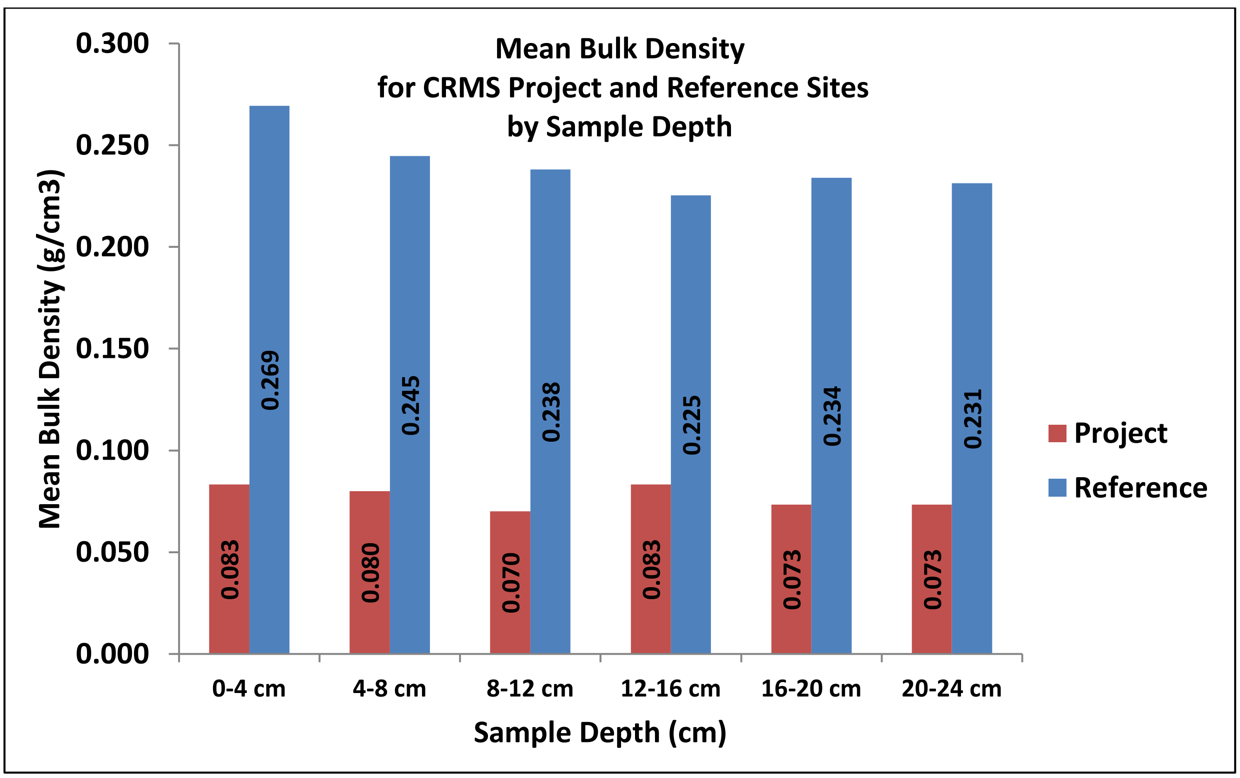



Figure 22. Mean bulk density (g/cm3) for project and reference CRMS sites for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

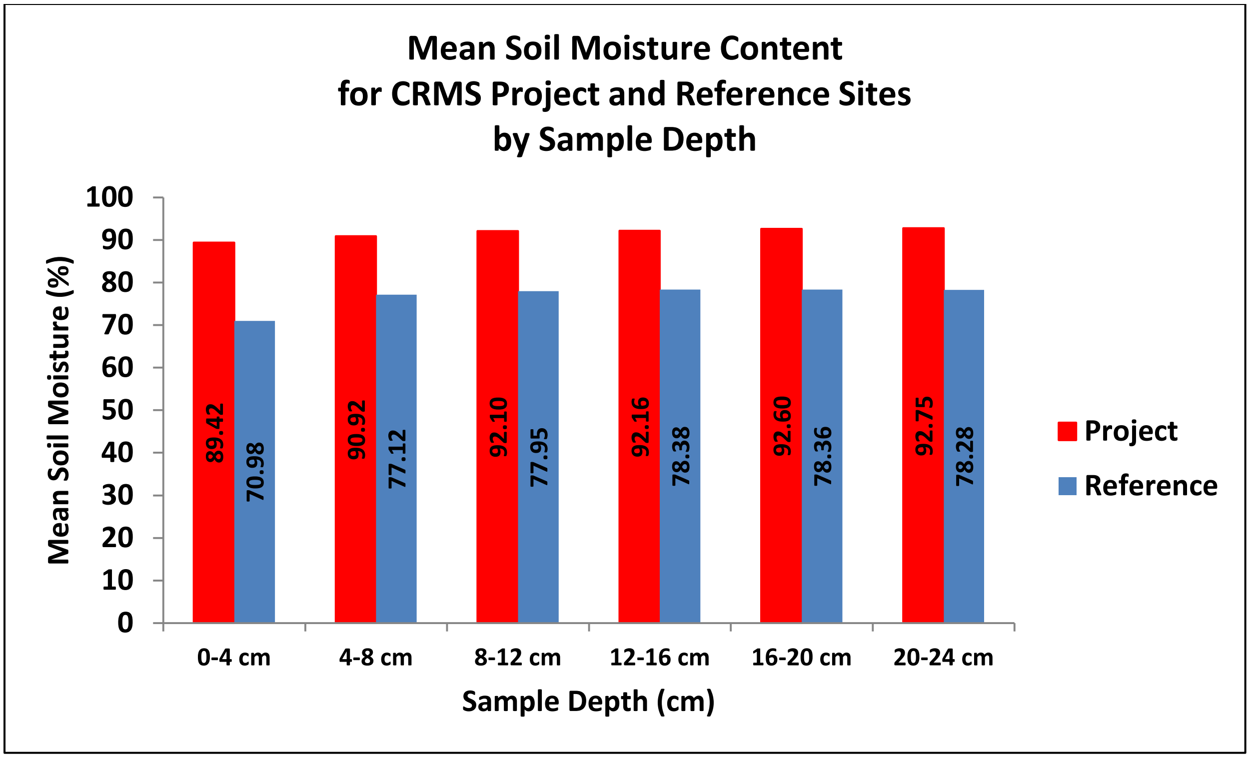



Figure 23. Mean soil moisture content for project and reference CRMS sites for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

**<u>Shoreline Change</u>**

Shoreline position data for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project was collected pre-construction by OCPR personnel in 1993, and 1998, as well as 2000 and 2003 post-construction. OCPR personnel utilized sub-meter accurate DGPS equipment to collect the shoreline points along 21 randomly selected 300 ft (91.4 m) segments (figures 24-29). The same segments were revisited for each subsequent survey. Shaw Coastal, Inc. was contracted by OCPR to document shoreline position data in 2005. Shaw Coastal, Inc. personnel utilized a Trimble 5700 RTK base station with a Trimble 5800 rover unit; the data stored in a Trimble TSCe data collector (Shaw Coastal, Inc. 2005). Bayou Country Surveying , LLC was contracted in 2008 to revisit the same segments. Bayou Country Surveying, LLC utilized a Thales Z-Max base station with a Thales Z-Max rover unit; the data stored in a Carlson Explorer I data collector (Bayou Country Surveying, LLC 2008).

<u>Data Analysis Methods for Shoreline Change:</u>

Georectified DGPS shoreline segments from each survey year were entered into ArcView GIS® Version 3.2 and converted to shapefiles. Polygons were created from these segments in order to have a pre-existing standardized area from which to calculate area and linear changes with polygons created from each data collection year. Shoreline segments for each year were

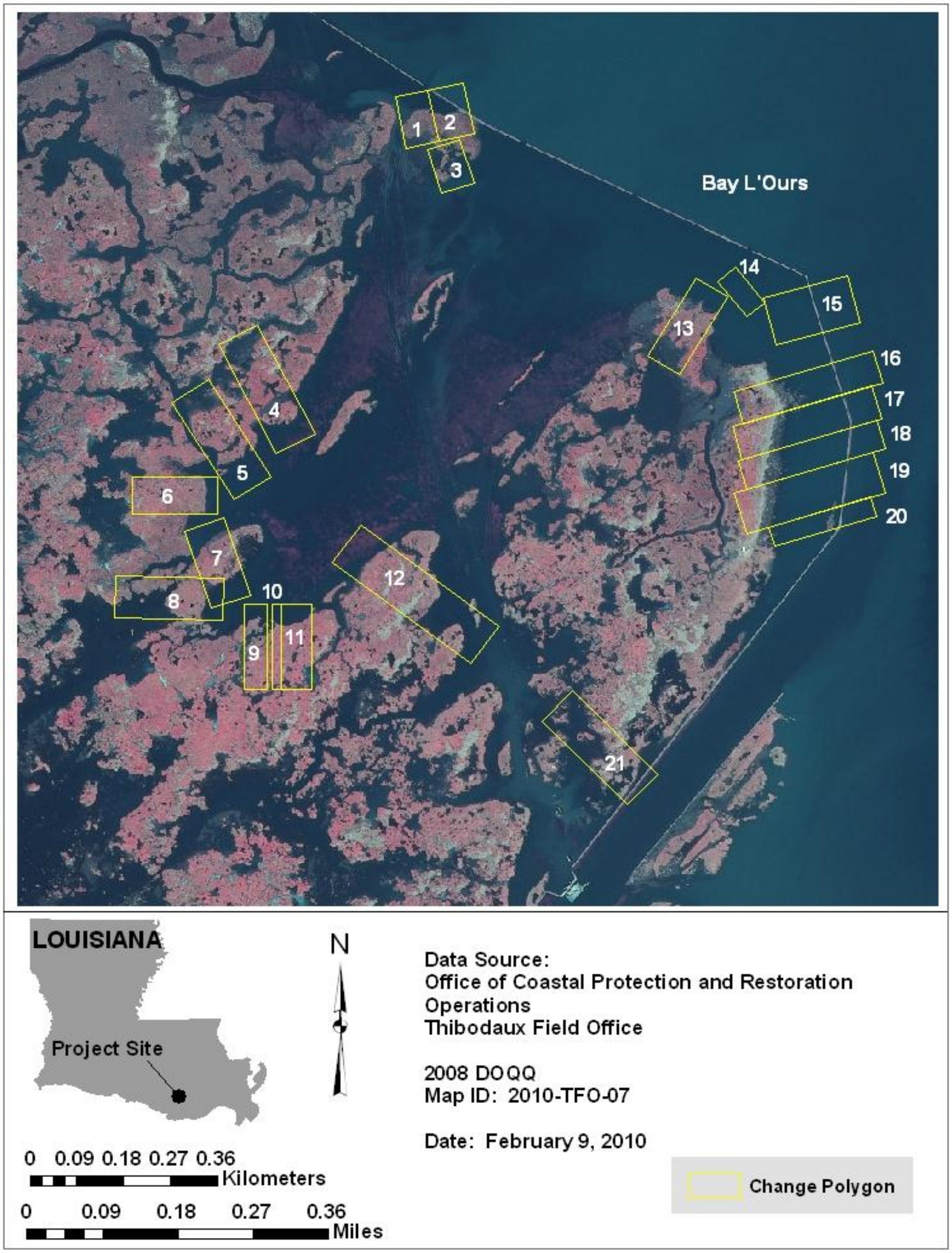



Figure 24. Change polygons for randomly selected shoreline segments 1-21 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project. Construction for the shoreline protection rock dike was completed in October 2000.

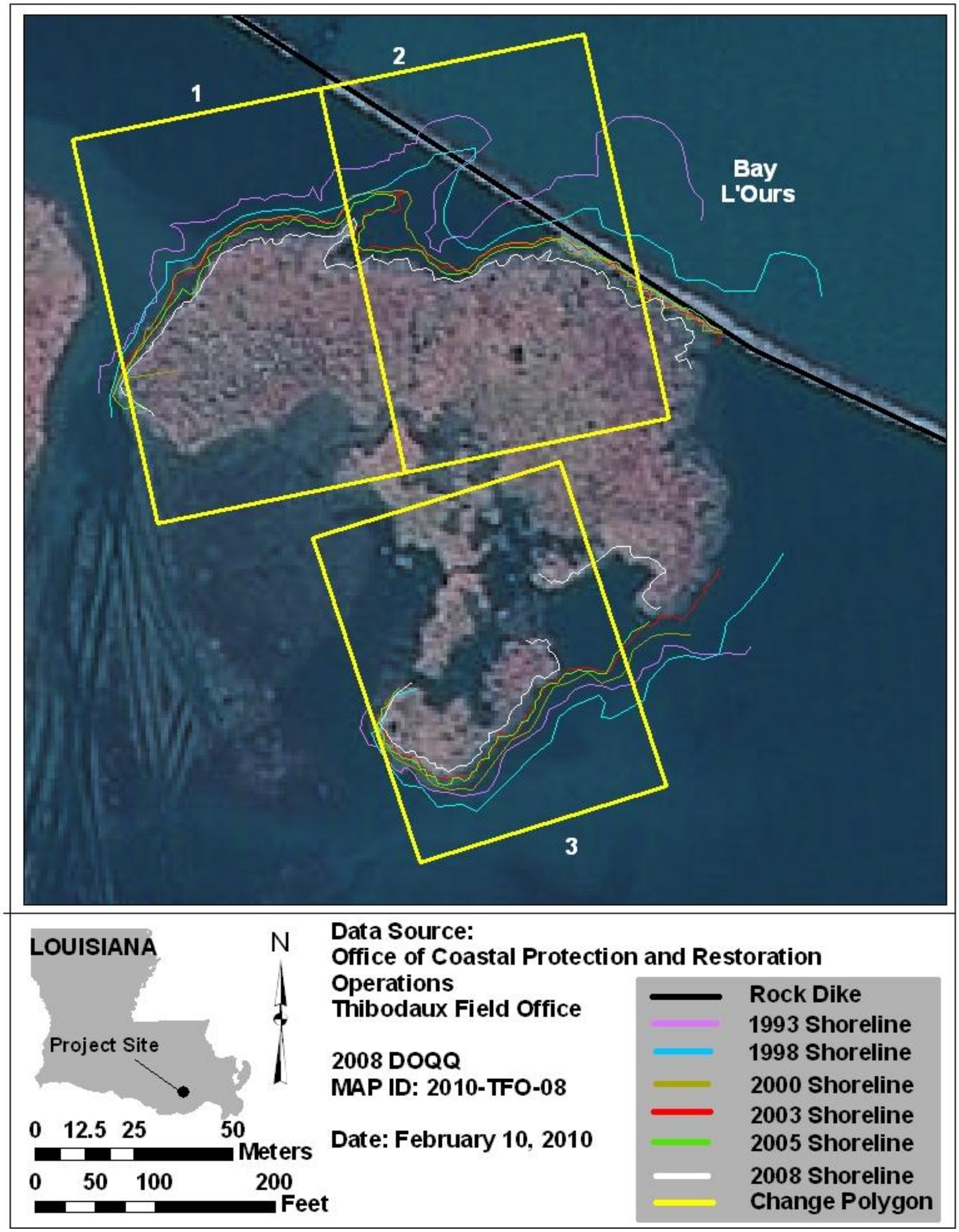



Figure 25. Location of 1993, 1998, 2000, 2003, 2005, and 2008 shoreline segments 1-3 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project. Construction for the shoreline protection rock dike was completed in October 2000.

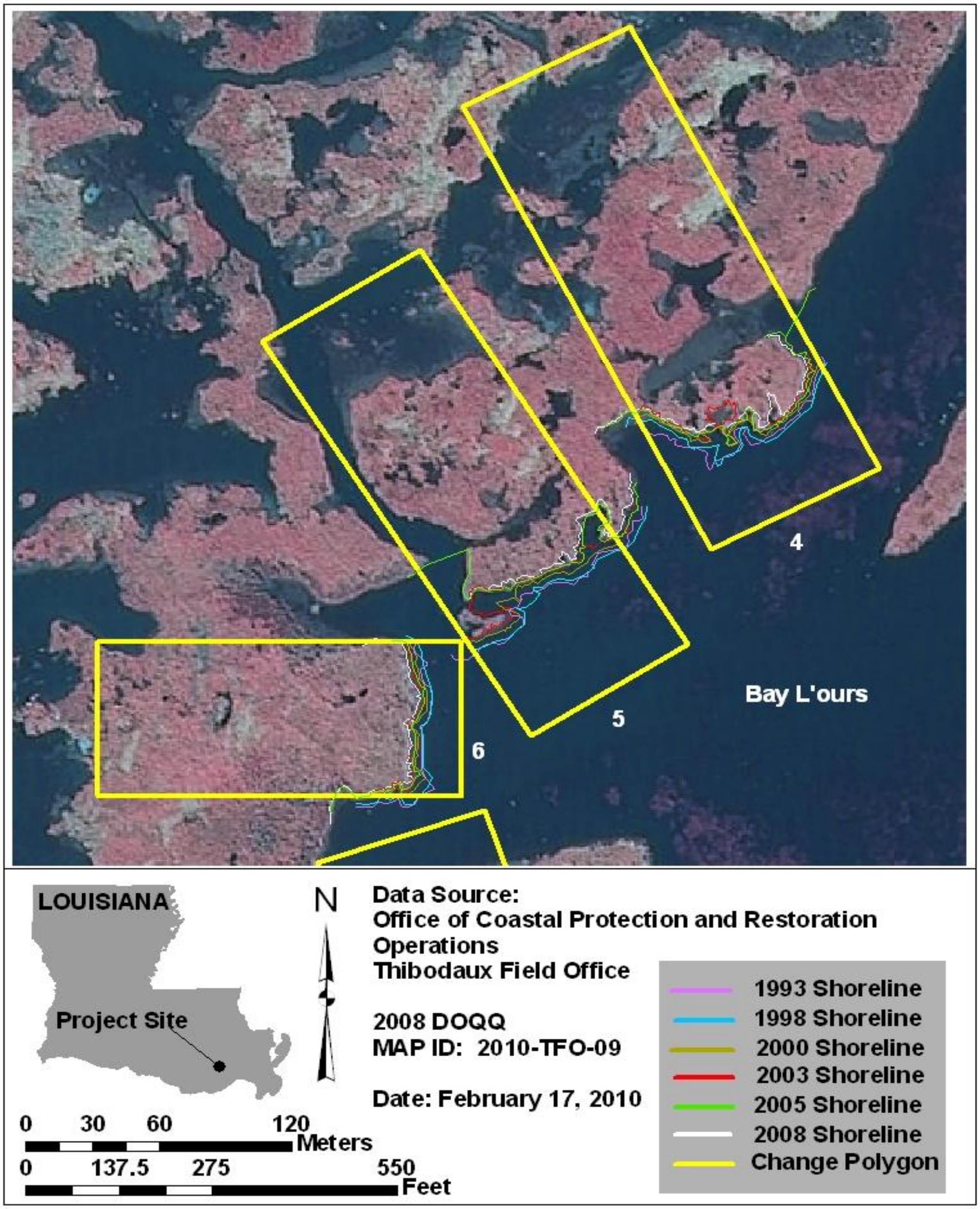



Figure 26. Location of 1993, 1998, 2000, 2003, 2005, and 2008 shoreline segments 4-6 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project. Construction for the shoreline protection rock dike was completed in October 2000.

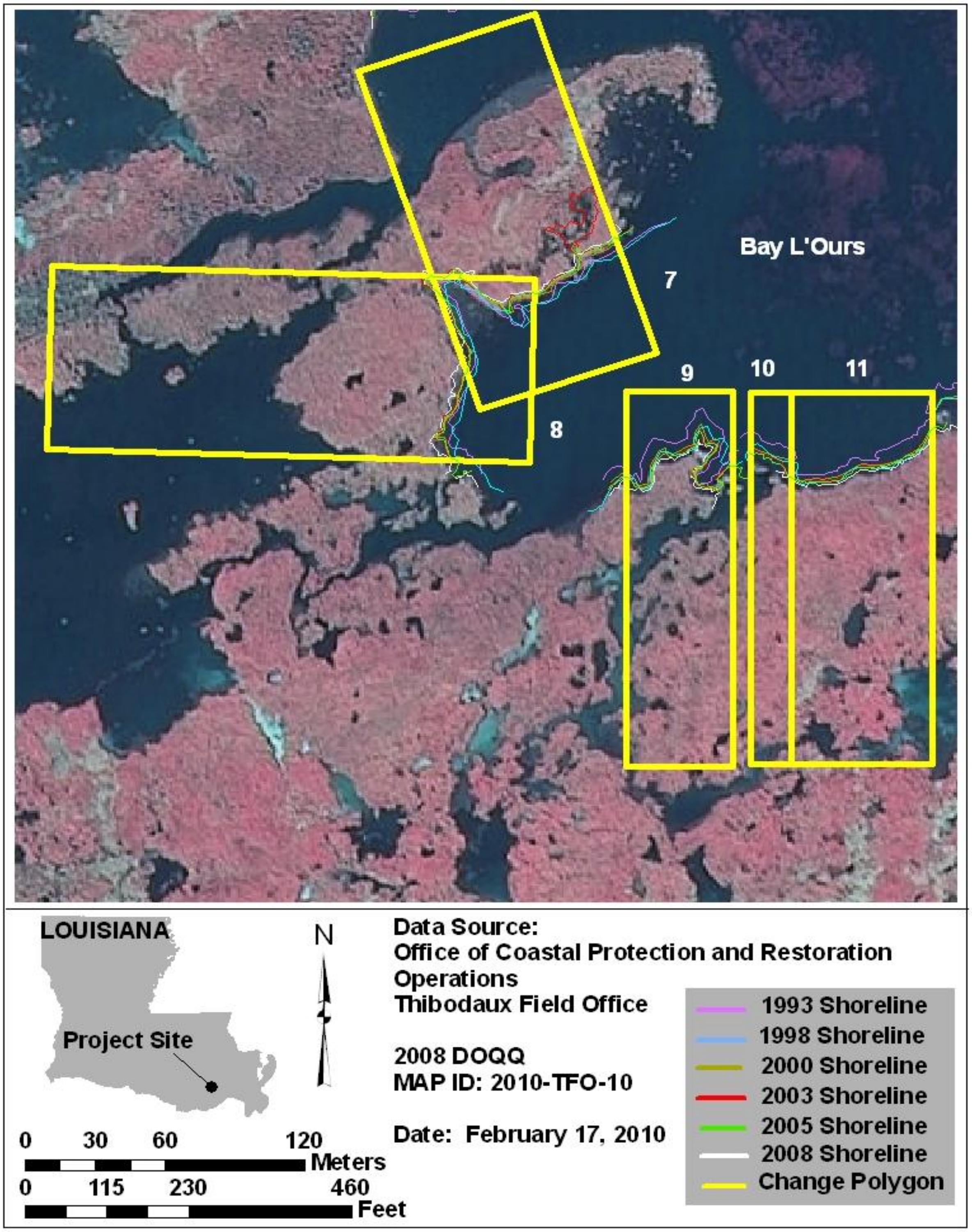



Figure 27. Location of 1993, 1998, 2000, 2003, 2005 and 2008 shoreline segments 7-11 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project. Construction for the shoreline protection rock dike was completed in October 2000.

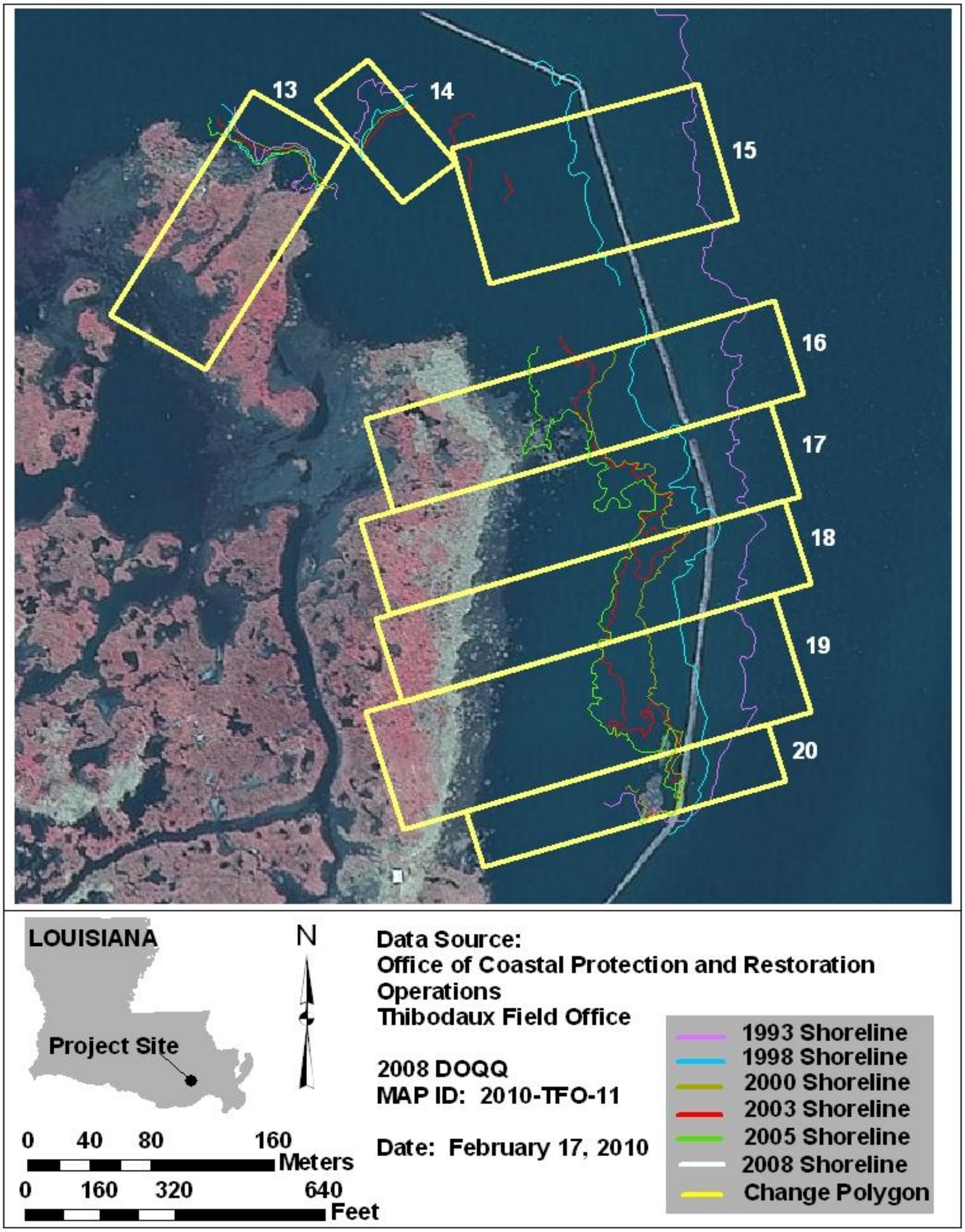



Figure 28. Location of 1993, 1998, 2000, 2003, 2005, and 2008 shoreline segments 13-20 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project. Construction for the rock dike was completed in October 2000.

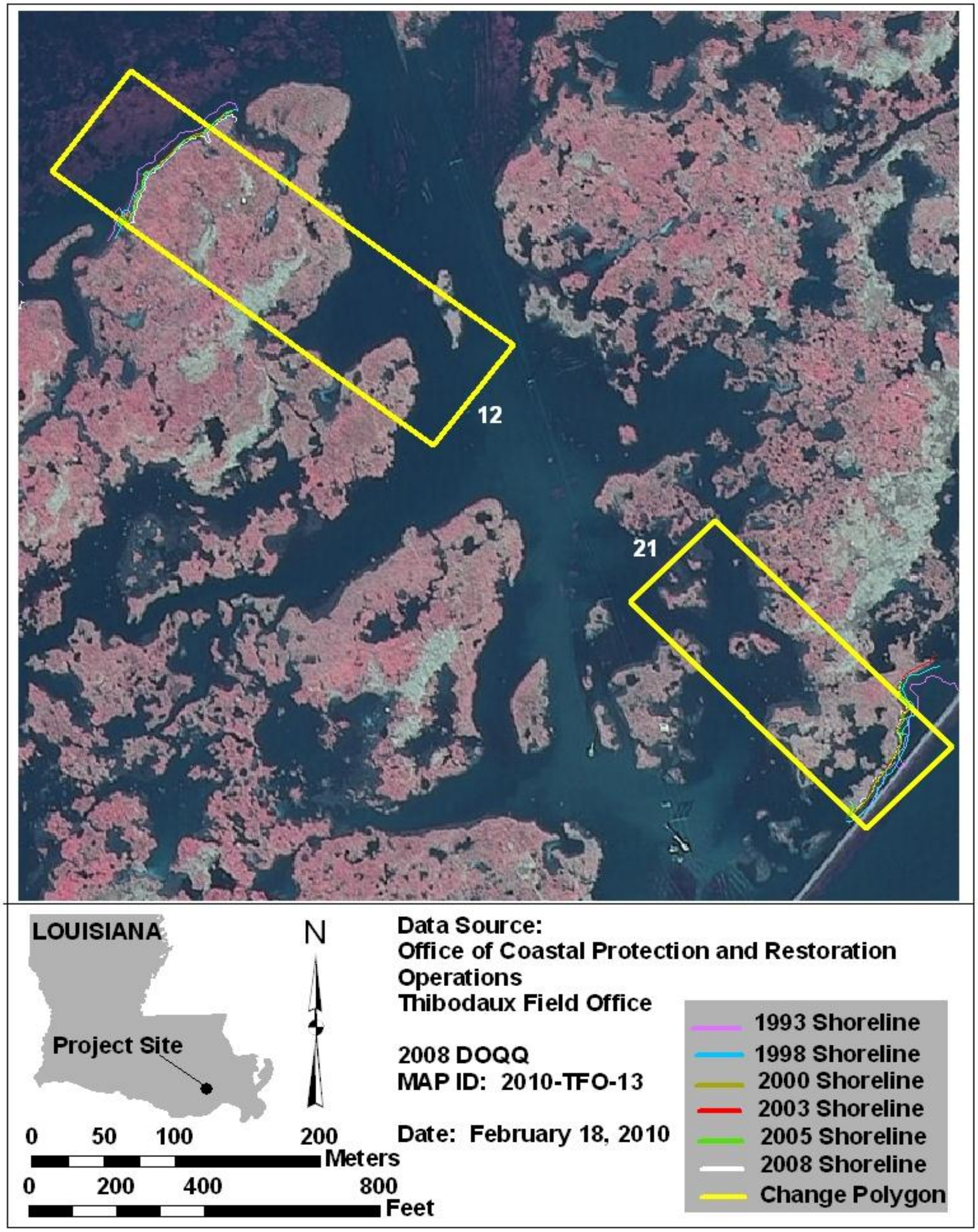



Figure 29. Location of 1993, 1998, 2000, 2003, 2005, and 2008 shoreline segments 12 and 21 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project. Construction for the shoreline protection rock dike was completed in October 2000.

also entered into ArcView GIS® Version 3.2 as shapefiles. Each shapefile was entered into Autodesk Map © 2004 where polygons were created for the segments. Area and distance calculations were made between the polygons and segments for each year using the area command function in Autodesk Map© 2004. Data generated from these calculations were entered into a Microsoft Office Excel 2007 worksheet and additional calculations were performed to determine the change rate per year for each shoreline segment. A bar chart was created for graphic representation of the data (figure 30).

The methods used to determine shoreline position from survey to survey allowed personnel to determine changes occurring between a five year pre-construction time range and an eight year post-construction time range to determine project effects. Also, because the DGPS equipment used for these surveys was sub-meter accurate, the shoreline segments could be georectified to aerial photography, which made it possible to generate data and produce images showing the shoreline changes.

In order to calculate the change rate per year for a given span of years, the land area inside the standardized polygon created for each shoreline segment was first determined for each survey year. The difference between the areas inside the polygon for a given span of years represented the change in the area.

$$\text{Year 2000 Area } (m^2) - \text{Year 2008 Area } (m^2) = \text{Area Change } (m^2)$$

Next, an average change rate was calculated by taking the area change inside the shoreline segment polygon and dividing it by the shoreline segment length.

$$\text{Area Change } (m^2) \div \text{Shoreline Segment Length (m)} = \text{Avg Change Rate (m)}$$

Finally, the average change rate was divided by the number of days within the span of the two surveys being compared, and then multiplied by 365.25 days to determine the change rate per year.

$$(\text{Avg Change Rate (m)} \div \text{\# of Days between surveys}) \times 365.25 \text{ days} = \text{Change Rate/Year } (m/yr^{-1})$$

Note: The 365.25 day count was used to make allowances for leap years.

For comparison purposes a separate shoreline change analysis was also undertaken. This second shoreline change protocol included both project and reference areas (figure 31). The same project area shoreline reaches were utilized, and 3 reference areas were established. The first reference area (reference area 1) was established along an unprotected shoreline reach located south of the Clovelly Canal (figure 31). Reference area 2 was established on the northern shoreline of the Bay L'Ours Peninsula, and reference area 3 was established on the southern shoreline of the Bay L'Ours Peninsula directly north of the rock dike (figure 31). Shoreline position data were analyzed to estimate shoreline changes in the BA-02 project and reference areas using the Digital Shoreline Analysis System (DSAS version 2.1.1) extension of ArcView® GIS (Thieler et al. 2003). Shoreline positions were determined by digitizing aerial photographs at a 1:1000 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 an eleven year period to discern the rock dike's effect on shoreline erosion rates. Pre-construction aerial photographs were collected on February 4, 1998 while post-construction aerial photographs were captured on November 1, 2005 (5 years post-construction) and October 29, 2008 (8 years post-construction). All images were georectified using UTM NAD 83 horizontal datum.

The February 1998, November 2005, and October 2008 shorelines were created in ArcView® GIS software to establish shoreline change rates. Secondly, offshore baselines were drawn and labeled. Thirdly, the DSAS attribute editor was populated by identifying and dating shorelines. Next, simple transects were cast from the baseline at 25 m (82 ft) intervals producing shoreline change, intersect, and transect shapefiles. Then, these shapefiles were edited by eliminating transects that intersect the shorelines at irregular angles. Finally, 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-November 2005 and November 2005-October 2008 for the project and reference areas.

Shoreline Change Results and Discussions

Results from the first analysis indicate a reduction in the rate of erosion for segments 1, 2, 9, 11, 12, and 16 located behind the project's constructed rock dike (figure 30). The erosion rate increased for all other segments. Segments 14 and 15 disappeared between 2003 and 2005. Segment 3 partially eroded away between 2005 and 2008 which left broken marsh in place of a continuous shoreline, and segment 20 eroded beyond the change polygon used to calculate loss rate. The average shoreline change rate from 1993-1998 was -3.19 $m/yr^{-1}$. From 2000-2008 (post-construction), the average shoreline change rate was -4.04 $m/yr^{-1}$. The average rate of erosion increased by 0.85 $m/yr^{-1}$ during post-construction. Several factors may attribute to the increase and decrease of erosion rates, which include, but are not limited to, orientation along the shoreline, proximity to the rock dike, powerful storms, and the amount of open water causing more frequent and larger wave action.

The outcome of the DSAS investigation reveals that the project area shorelines eroded at a faster rate than the reference area shorelines during the period of shoreline assessment (figure 32). The project area shorelines transgressed at a rate of -1.88 $m/yr^{-1}$ from February 1998 to

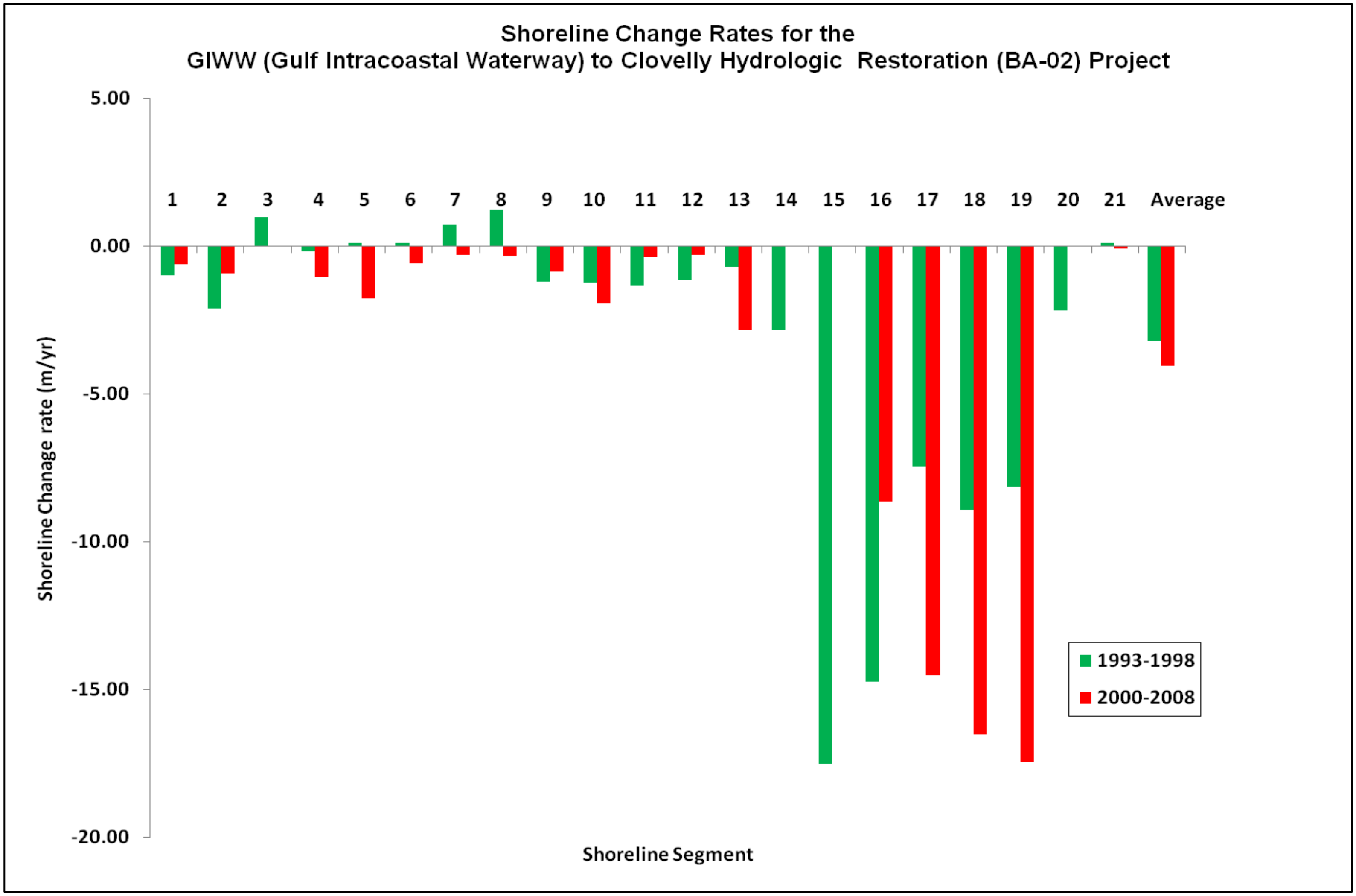



Figure 30. Shoreline change rates and the average shoreline change rate for each randomly selected shoreline segment pre- and post-construction. Note: Construction ended October 31, 2000. Segments 14 and 15 were not calculated into the "Average" change rate because they eroded completely away.

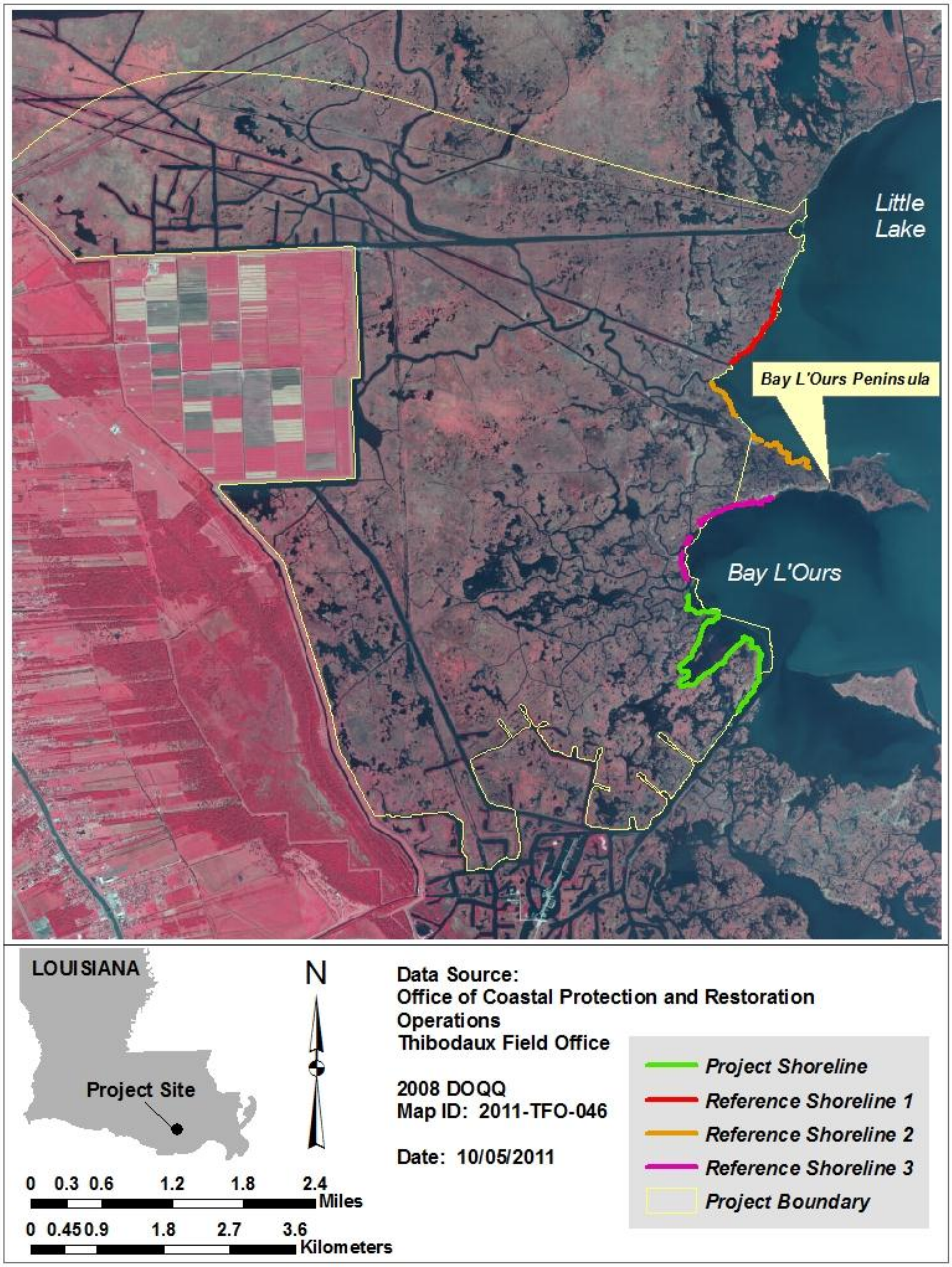



Figure 31. Location of project and reference shoreline segments. For the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

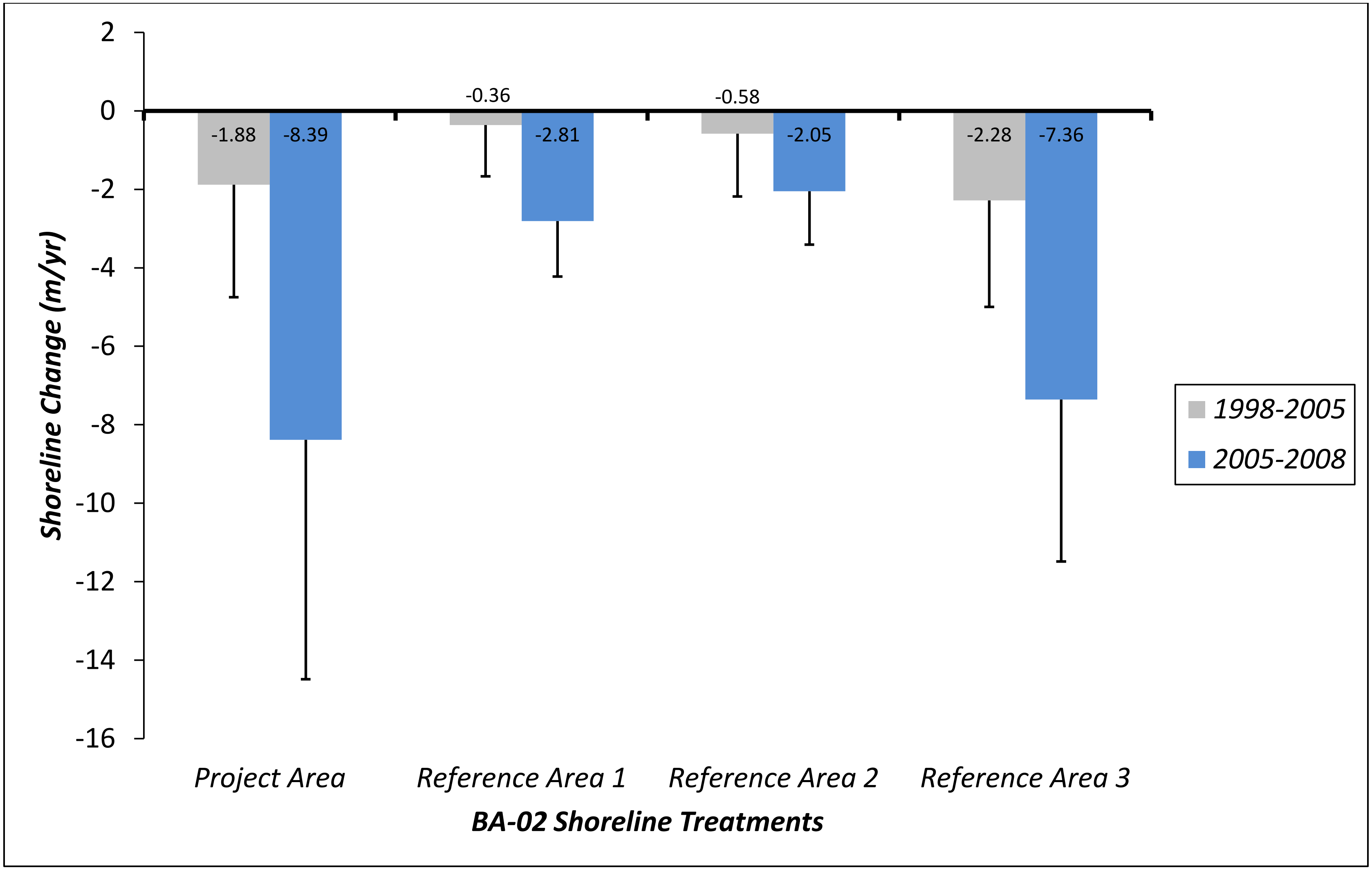



Figure 32. Shoreline change rate for the project and reference areas during two separate time periods, for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

November 2005 and -8.39 $m/yr^{-1}$ from November 2005 to October 2008. In contrast, the reference area 1 shorelines transgressed at -0.36 $m/yr^{-1}$ (1998-2005) and -2.81 $m/yr^{-1}$ (2005-2008) rates, and reference area 2 shorelines transgressed at -0.58 $m/yr^{-1}$ (1998-2005) and -2.05 $m/yr^{-1}$ (2005-2008) rates. Alternatively, reference area 3 shorelines transgressed at -2.28 $m/yr^{-1}$ (1998-2005) and -7.36 $m/yr^{-1}$ (2005-2008) rates. Within the project area the northeast corner of the protected area experienced the greatest shoreline change while other shoreline segments incurred milder rates of shoreline erosion. This area which lies at the junction of Bay L'Ours and the Breton Canal transgressed at a considerably faster rate than the other shoreline segments during both intervals (1998-2005 and 2005-2008). The reference area 1 shorelines are largely continuous unlike the fragmented marshes found behind the rock dike and possibly form a more mineral shoreline. These factors likely contribute to the lower erosion rate found in the reference area because they render the shoreline less susceptible to erosion. While the reference area 2 shorelines are extensively fragmented, reference areas 1 and 2 transgressed at similar rates. It is possible that the orientation of reference area 2 and the position of reference areas 1 and 2 on the northern side of the Bay L'Ours Peninsula aided in protecting these shorelines from marsh edge erosion because the reference area 3 shorelines transgressed at a rate comparable to the project area. Moreover, the reference area 3 shorelines are oriented in the same direction as the project area shorelines that experienced the highest rates of marsh edge erosion. The rate of erosion expanded in both the project and reference areas during the 2005-2008 interval. This increased erosion rate in the BA-02 project and reference areas was probably initiated by the 2005 (Cindy, Katrina, and Rita) and 2008 (Gustav and Ike) hurricane seasons (figure 33). Of these storms Hurricane Gustav seems to have had the largest influence on the BA-02 shorelines. The increased post-construction shoreline erosion rate in the project and reference areas area is probably an effect of Hurricane Gustav, which impacted the Louisiana coast in September 2008 (figure 33). Although hurricanes have been found to erode coastal marshes (Guntenspergen et al. 1995; Stone et al. 1997; Watzke 2004), cold fronts (Watzke 2004) and wind generated waves (Stone et al. 1999; Curole et al. 2002; Watzke 2004) have also been shown to cause marsh edge erosion. Therefore, it is not unequivocally defined what caused the high erosion rates behind the BA-02 rock dike. However, it seems that it is highly likely that hurricane activity was the major force reshaping these shorelines. Furthermore, the shoreline position data suggest that the Bay L'Ours Peninsula seems to be buffering the effects of the hurricanes from the shorelines in its immediate lee while the marshes south of the peninaula are subject to the full force of these storms. Future shoreline position data should clarify if the erosion rates behind the structure were induced by the frequent occurrence of hurricane activity in the area. Currently, the goal to reduce the marsh edge erosion rate has not been attained to date because the project area shoreline is retreating and this is probably a direct result of increased rate of hurricane incidence.

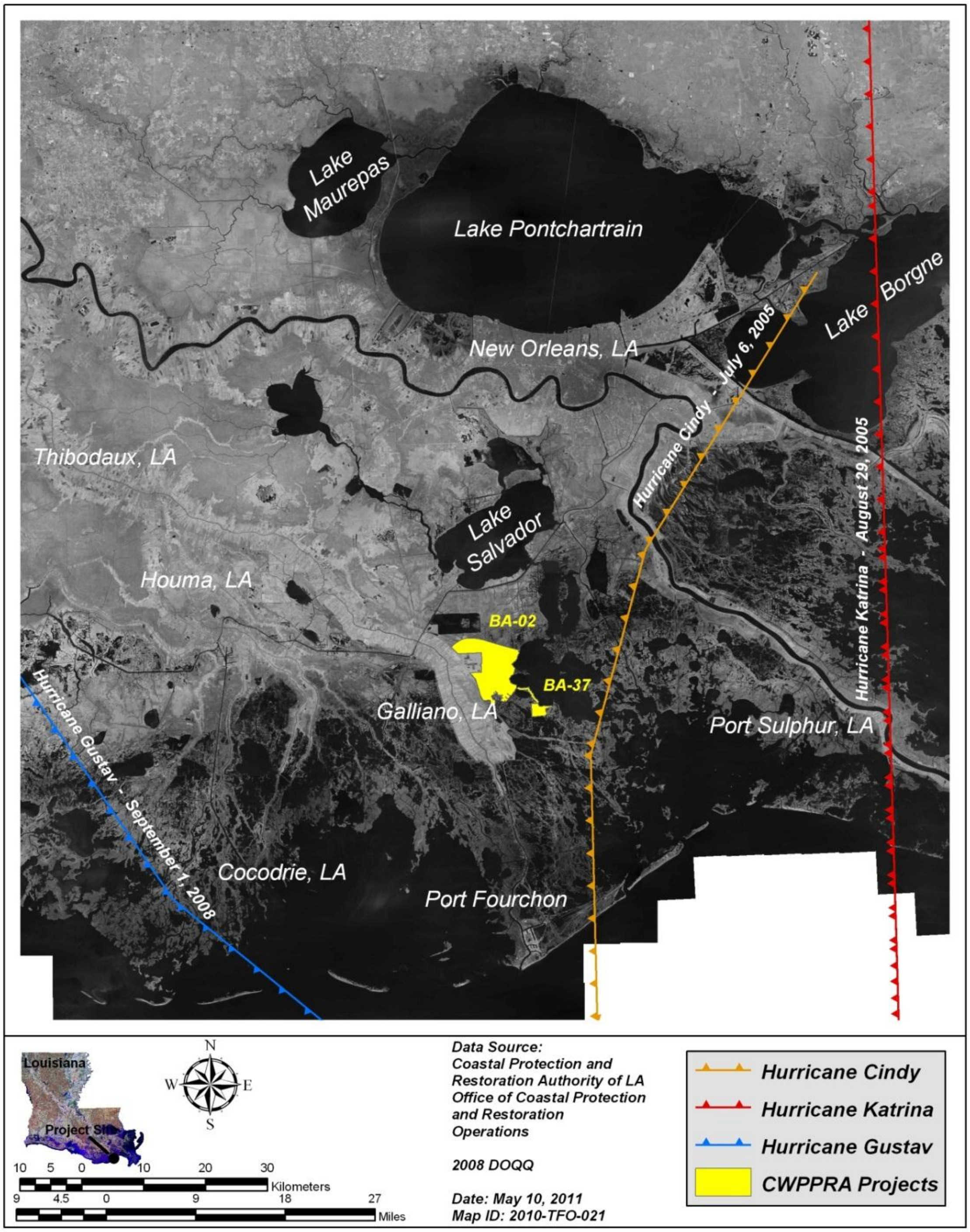



Figure 33. Tracks of hurricanes which have impacted the (BA-02) project area shoreline. For the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project. Hurricanes Ivan (2004), Rita (2005), and Ike (2008) are not shown because the eye wall of these storms traveled further to the south (off the map).

**Submerged Aquatic Vegetation (SAV)**

SAV data were collected during the fall of 1996, 1999, 2000, 2002, and 2005. Analysis of this data was presented in the 2007 OM&M Report for this project (Lear et al. 2007).

## V. Conclusions

### a. Project Effectiveness

Land water analysis indicates that between 1996 and 2008 there has been a trend from land to open water in both the project and reference areas. There have been some variations in change which could be attributed to project effects. One variation would be the slight change from open water to land in the project area but not in the reference area between 1996 and 2002 during construction. Another variation would be a slightly lower shift from land to open water in the project area than in the reference area despite large shifts in both between 2002 and 2008. It is possible the effects from powerful hurricanes which have impacted the coast between these years may have been moderated inside the project area.

Short term analysis using monthly means for the years where paired project and CRMS data is available indicates an overlap in variance, which points to similarities between the project-specific and CRMS reference stations in both water levels and salinities. Though the project-specific stations had higher mean water levels than the CRMS reference stations, they shared similar patterns and tracked each other. Monthly mean adjusted salinities were lower at project-specific stations than at reference CRMS stations outside the project area, with the exception of project-specific station BA02-57 where mean adjusted salinities were higher between March and May. Additional years of comparative data from the reference CRMS stations may help to determine if there are any project effects on both water levels and salinity.

Tidal cycle analysis used to determine project effects on water level variability indicate that the project has had an impact on lowering water level variability. Relative to the partial and "post 1" construction periods, the "post 2" period showed lower tidal ranges. In addition, a comparison of project sites to reference sites for the "post 2" period indicates lower tidal ranges for project sites. Because of the lack of a complete reference data set though, the hypothesis that these differences were due to natural variability could not be ruled out.

Analysis of vegetation data collected at project-specific sites in 2008 indicates that the project area continued to maintain itself as an intermediate marsh with *Sp. patens* (Ait.) Muhl. (marshhay cordgrass) as the dominant species. There was a substantial increase in relative mean cover of the dominant species between 2005 and 2008 despite the appearance of hurricanes Katrina, Gustav, and Ike on the Louisiana coast, while species diversity slightly increased. The FQI and the relative mean cover followed similar trends between 1996 and 2008.

Vegetation patterns differed slightly between the project and reference CRMS sites between 2006 and 2009. While both the FQI and the relative mean cover of the dominant species peaked in 2008 for the reference CRMS sites, the project CRMS site experienced a substantial decrease in relative mean cover and a slight decrease in the FQI. Species diversity varied from year to year at the project CRMS site while it remained similar from year to year for the reference CRMS sites.

Differences in mean organic matter content, mean bulk density, and soil moisture content between the project site and the CRMS reference sites illustrated the differences in marsh types. The project's floating marsh site had consistently higher mean organic matter content, higher percent soil moisture, and lower bulk density than the attached marshes at the reference CRMS sites.

In the first shoreline analysis, the average rate of shoreline erosion increased by 0.85 $m/yr^{-1}$ during post-construction. Four of the twenty one shoreline segments have eroded beyond the point of data collection efforts. There was however a reduction in the rate of erosion for six of the shoreline segments during post-construction, while the average change rate increased for the remaining eleven segments. The highest average erosion rates occurred along the easternmost segments which jut out into Bay L'Ours. The lowest rates occurred along the interior shorelines to the west.

The DSAS shoreline analysis indicated that the project area shorelines eroded at a faster rate than the reference area shorelines during the period of shoreline assessment. The reference area 1 and 2 shorelines eroded at a slower rate than the project area and reference area 3 shorelines which was likely due to the orientation and position of these shorelines on the northern side of the Bay L'Ours Peninsula. The rate of erosion expanded in both the project and reference areas during the 2005-2008 interval, probably initiated by the 2005 (Cindy, Katrina, and Rita) and 2008 (Gustav and Ike) hurricane seasons. Of these storms Hurricane Gustav seems to have had the largest influence on the BA-02 shorelines. Currently, the goal to reduce the marsh edge erosion rate has not been attained to date because the project area shoreline is retreating and this is probably a direct result of increased rate of hurricane incidence.

### b. Maintenance Recommendations

Since the 2008 Annual Inspections of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project, a number of deficiencies have been documented that will require corrective actions and/or refurbishment. In February 2010, OCPR initiated maintenance of the GIWW to Clovelly Hydrologic Restoration - 2010 Maintenance Project by contracting MWH Americas, Inc. of Baton Rouge to perform the design and plan preparations for the deficiencies outline in Section V of this report. This project will be the first major maintenance event since the completion of the original project. Prior to beginning the design, John Chance Surveyors, Inc. of Lafayette was contracted to perform the necessary design surveys to supplement the data obtained from the 2008 surveys. This work was completed in mid July 2010. OCPR anticipates that the construction documents for the 2010 Maintenance Project will be completed by March 2011 and receipt of bids for the project by May 2011. Maps showing the work plan for the proposed 2010 Maintenance Project can be found under Appendix C.

Below is a summary of the identified deficiencies and recommended methods of repair that are included in the 2010 Maintenance Project:

**Structure No.1**

The deficiencies at Structure No.1 were limited to the four (4) timber cluster piles near the entrance of the barge bay. The timber structure on the southwest side of the barge bay was completely destroyed and not longer exits and the other three (3) cluster piles were severely damaged with large splits down the middle of the piles, the batter piles were off center and the surface of all the timbers were worn or scarred from marine vessels rubbing the timbers while accessing the barge bay. Under the 2010 Maintenance Project, all four (4) timber pile clusters will be removed and replaced with new material including hardware, cables and signage. With concurrence from NRCS, we are also recommending that the new structures be relocated slightly outwards (6" to 1') to allow additional clearance for barge vessels to move through the barge opening without interference.

**Structure No.2**

The documented deficiencies at Structure No.2 were primarily due to settlement of the rock weir with the most severe settlement on the south side of the structure between the boat bay and existing bank. Under the 2010 Maintenance Project, the boat bay section and fixed crest sections be raised to the original constructed elevations using rock riprap. To facilitate repairs to Structure 2, access dredging from the lake to the structure will be required due to shallow conditions at the mouth of the channel.

**Structure No.4**

Structure No.4 was found to be in fair to poor condition with severe settlement and/or displacement of the rock material on the south side of the structure and moderate settlement of the rock lining the boat bay and rock weir section on the north side. The warning sign on the north side of the structure was also missing. Under the upcoming 2010 Maintenance Project, Structure No. 4 will be refurbished with rock riprap to restore the structure to the original design elevation. The missing warning will also be replaced. As in the case of Structure No.2, access dredging from the bay to the structure is likely. In anticipation of possible access dredging, the water bottom along the lake rim was recently surveyed by John Chance.

**Structure No. 4A & 4B**

The rock plug structures appeared to be in poor condition with substantial settlement ranging between 1.5' to 2.0'. The critical area of concern associated with this structure is large breach that has developed on the south side of the structure resulting from the 2008 storms. The marsh on the south side of the structure is completely gone with very little shoreline remaining to facilitate a breach closure by extending the structure. Considering the size of the breach and the vulnerability of the interior marsh in this area, we have included a rock dike extension in the 2010 Maintenance Project that consist of refurbishing Structures 4A & 4B to the original design elevation and extending the rock plug across the breach opening and along the existing shoreline approximately 1,500 linear feet, creating a closure with Structure 4.

**Structure 14A**

Structure No.14A was in fair to good condition with significant damage to the timber cluster piles supporting the navigational aids and severe settlement and scour of the rock pad below the barge bay opening. We believe that the strong currents moving through the barge bay opening may be responsible for the excessive scour of the rock pad beneath the barge bay. To reduce the scour, we are recommending that the existing scour pad be replaced with a larger stone under the 2010 Maintenance Project. We will also be replacing three (3) of the four (4) timber pile clusters supports for the navigational aid lights as well.

**Structure 91**

The rock plug was in good condition with no obvious settlement or erosion around the bank tie-ins. However, we did identify minor maintenance which included severe corrosion of the metal caps covering the butts of the timber piles supporting the culver and flap gate. To prevent rotting of the timber pile heads, the metal sheeting on the top the timber piles will be replaced. As preventative maintenance, we will also be removing the flap gate attached to the culvert for inspection and cleaning, if required.

**Lake Rim Restoration**

As indicated in the inspection results and on previous inspections, a large portion of the rock dike along the lake rim has settled below the constructed crest elevation. To rehabilitate the structure, we will be recapping the entire lake rim with rock riprap under the 2010 Maintenance Project.

Project from Structure 2 to the termination point along the north bank of Breton Canal: Depending on the depth of the lake bottom, it is likely that construction will require access dredging adjacent to the dike structure. In anticipation of possible access dredging, the water bottom along the lake rim was recently surveyed by John Chance.

**Earthen bank stabilization**

In all, five (5) breaches ranging from 10' to 30' wide were identified within the southern portion of the project area that is included in the 2010 Maintenance Project. Breach locations are shown in the Work Plan Map of Appendix D. The method of repair for breach closures consist of utilizing in situ material from adjacent channel bottoms to reconstruct the earthen dike.

### c. Lessons Learned

The lessons learned since the inception of this project were presented in the 2007 OM&M report (Lear et al. 2007). No additional lessons learned have been added to this report.

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# Appendix A

# Three Year Budget Projections

## GIWW TO CLOVELLY, PHASES 1 & 2 / BAO2 / PPL1

## Three-Year Operations & Maintenance Budgets 07/01/2010 - 06/30/13

| Project Manager | O & M Manager | Federal Sponsor | Prepared By |
|---|---|---|---|
| | B. Babin | NRCS | B. Babin |

| | 2010/2011 | 2011/2012 | 2012/2013 |
|---|---|---|---|
| **Maintenance Inspection** | $ 5,908.00 | $ 6,085.00 | $ 6,267.00 |
| **Structure Operation** | $ 12,000.00 | $ 12,000.00 | $ 12,000.00 |
| **Administration** | $ 5,500.00 | $ 5,500.00 | $ 5,500.00 |
| **COE Administration** | $ 1,240.00 | $ 1,257.00 | $ 1,275.00 |

**Maintenance/Rehabilitation**

10/11 Description — Routine maintenance of navigational aids and structure operations

| | 2010/2011 |
|---|---|
| E&D | |
| Construction | $ 4,000.00 |
| Construction Oversight | |
| Sub Total - Maint. And Rehab. | $ 4,000.00 |

11/12 Description: — Routine Maintenance: navigation aid maintenace and structure operations

| | 2011/2012 |
|---|---|
| E&D | $ - |
| Construction | $ 4,000.00 |
| Construction Oversight | $ - |
| Sub Total - Maint. And Rehab. | $ 4,000.00 |

12/13 Description: — Routine Maintenance: navigation aid maintenance and structure operations

| | 2012/2013 |
|---|---|
| E&D | $ - |
| Construction | $ 4,000.00 |
| Construction Oversight | $ - |
| Sub Total - Maint. And Rehab. | $ 4,000.00 |

| | 2010/2011 | 2011/2012 | 2012/2013 |
|---|---|---|---|
| **Total O&M Budgets** | $ 28,648.00 | $ 28,842.00 | $ 29,042.00 |
| **Total O&M Budget 2009 through 2012** | | | $ 86,532.00 |
| **Unexpended O&M Budget** | | | $ 1,595,152.00 |
| **Remaining O&M Budget (Projected)** | | | $ 1,508,620.00 |

Note: 2009-2012 Unexpeded O&M budgets includes a deduction of $86,456 for MIPR O&M funds allocated for NRCS (see attached worksheet for 10-13 accounting)

**OPERATIONS & MAINTENANCE BUDGET WORKSHEET**

**Project: BA-02 GIWW to Clovelly Hydrologic Restoration Ph. 1 &2**

**FY 10/11 –**

| | | |
|---|---|---|
| OCPR Administration | | $ 3,500* |
| NRCS Administration | | $ 2,000** |
| COE Administration | | $ 1,240 |
| O&M Inspection & Report | | $ 5,908 |
| Structure Operations: | | $ 12,000*** |
| Maintenance: | | $ 4,000 |
| E&D and Surveying: | $ | |
| Construction: | $ | |
| Construction Oversight: | $ | |
| General Maintenance: | $ 4,000***** | |
| **Total O&M FY10/11** | | **$ 28,648** |

Operation and Maintenance Assumptions:
$6,000 per operation. (2)($6,000) = $12,000*** plus ($2,000 for OCPR administration.)*
General Maintenance: Water control structure, navigation aids repair. (Construction: $4,000)*****. (Administration: $1,500)*
Structure Operations: water control structure operated twice annually for a total of
NRCS Administration (Annual Inspections): $2,000**

**FY 11/12 –**

| | | |
|---|---|---|
| OCPR Administration | | $ 3,500* |
| NRCS Administration | | $ 2,000** |
| COE Administration | | $ 1,257 |
| O&M Inspection & Report | | $ 6,085 |
| Structure Operations: | | $ 12,000*** |
| Maintenance: | | $ 4,000 |
| E&D and Surveying: | $ | |
| Construction: | $ | |
| Construction Oversight: | $ | |
| General Maintenance: | $ 4,000***** | |
| **Total O&M FY11/12** | | **$ 28,842** |

Operation and Maintenance Assumptions:
$6,000 per operation. (2)($6,000) = $12,000*** plus ($2,000 for OCPR administration.)*
General Maintenance: Water control structure, navigation aids repair. (Construction: $4,000)*****. (Administration: $1,500)*

Structure Operations: water control structure operated twice annually for a total of
NRCS Administration (Annual Inspections): $2,000**

**FY 12/13 –**

| | | |
|---|---|---|
| OCPR Administration | | $ 3,500* |
| NRCS Administration | | $ 2,000** |
| COE Administration | | $ 1,275 |
| O&M Inspection & Report | | $ 6,267 |
| Structure Operations: | | $ 12,000*** |
| Maintenance: | | $ 4,000 |
| E&D and Surveying: | $ | |
| Construction: | $ | |
| Construction Oversight: | $ | |
| General Maintenance: | $ 4,000***** | |
| **Total O&M FY12/13** | | **$ 29,042** |

Operation and Maintenance Assumptions:

Structure Operations: water control structure operated twice annually for a total of $6,000 per operation. (2)($6,000) = $12,000*** plus ($2,000 for OCPR administration.)*

General Maintenance: Water control structure, navigation aids repair. (Construction: $4,000)*****. (Administration: $1,500)*

NRCS Administration (Annual Inspections): $2,000**

**2010-2013 Accounting**

| | |
|---|---|
| Total Unexpended Funds (Lana Report through Feb 10): | $1,707,210.20 |
| OCPR Expenditures (Feb 10 through June 10) | $ -25,602.51 |
| | $ 1,681,607.69 |
| Total NRCS Expenditures: | $ 86,456.00 |
| **Unexpended O&M Funds:** | **$ 1,595,151.69** |

# Appendix B

# Inspection Photos


Photo No.1 – view of rock weir with boat bay (Structure No.2) looking southwest.


Photo No.2 – view of rock weir with boat bay (Structure No.2) looking south.


Photo No.3 – view of southeast bank tie-in of the rock weir (Structure No.2).


Photo No.4 – view of northwest bank tie-in of the rock weir (Structure No.2) looking northwest.


Photo No.5 – view of the rock weir with boat bay (Structure No.4) looking west.


Photo No.6 – view of the north side tie-in of the rock weir with boat bay at Structure No.4.


Photo No.7 – view of the rock weir with boat bay (Structure No.4) looking east into Little Lake.


Photo No.8 – view of the rock weir with boat bay (Structure No.4) looking east into Little Lake.


Photo No.9 – view of rock weir with boat bay (Structure No.7) from the Little Lake side.


Photo No.10 – view of smaller rock weir (Structure No.8) with boat bay on the north side of Structure No7.


Photo No. 11 – view of rock plug (Structure No. 43) on the interior marsh along Bayou Des Amoreux.


Photo No. 12 – view of rock plug (Structure 91) with corrugated culvert and flap gate through the embankment.


Photo No.13 – view of the rock dike section and bank tie-in on the east side of Structure No.1 looking south.


Photo No. 14 – view of the rock dike section and bank tie-in on the west side of Structure No.1 looking north.


Photo No.15 – view of timber pile dolphin on the northeast side of the barge bay entrance of Structure No.1.


Photo No. 16 – another view of damaged timber dolphin structure at the barge bay entrance of Structure No.1.


Photo No.17 – view of large open area of eroded marsh between Structures 4 and 4A. The marsh in this area was eroded during Hurricanes Gustave and Ike.


Photo No.18 – view of rock plug (Structures 4A & 4B) along the west shoreline of Bay L' Ours.


Photo No.19– view of the north side of the rock plug (Structures 4A & 4B) and the adjacent marsh tie-in.

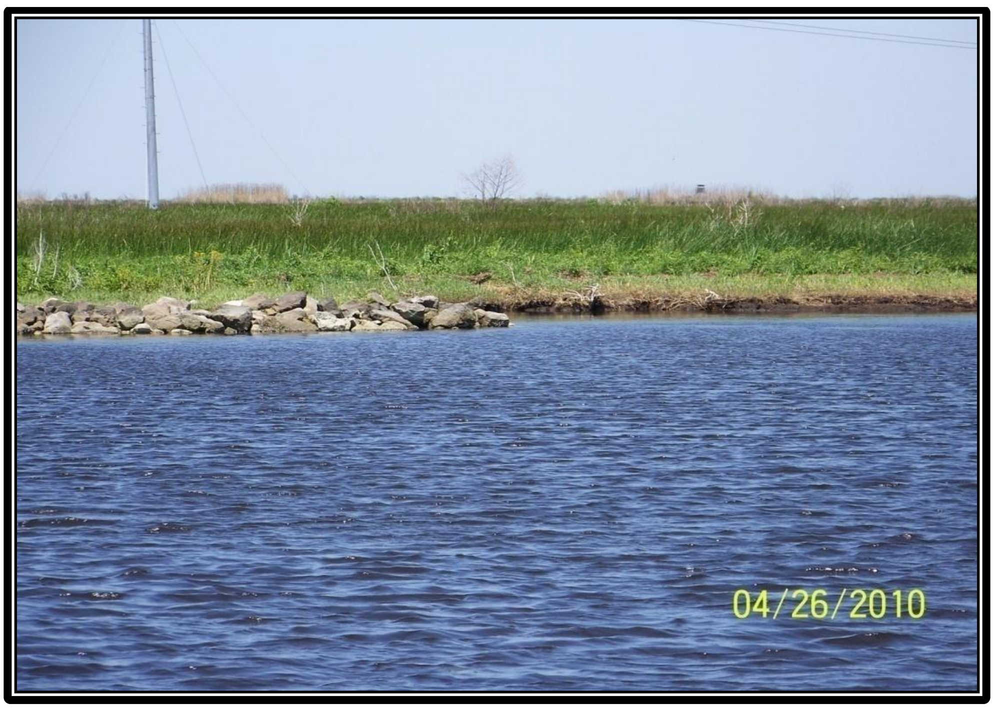



Photo No.20 – view of the north side of the rock plug (Structures 4A & 4B) and the adjacent marsh tie-in.


Photo No.21 – view the existing shoreline on the north side of Structures 4A & 4B.


Photo No.22 – view of timber dolphin support structure and navigational aid on the northwest side of Structure No. 14A.


Photo No.23 – view of rock dike section near the barge bay of Structure 14A looking north.


Photo No.24 – view of rock dike section near the barge bay of Structure 14A looking south.


Photo No.25 – view the timber dolphin support and navigational aid on the southeast side of the barge bay at Structure 14A.


Photo No.26 – view of rock dike section of Structure 14A north of the barge bay.


Photo No. 27 – view of rock dike section along the shoreline north of Structure 14A.


Photo No.28 – view of rock dike section and barge bay of Structure 14A looking northwest.

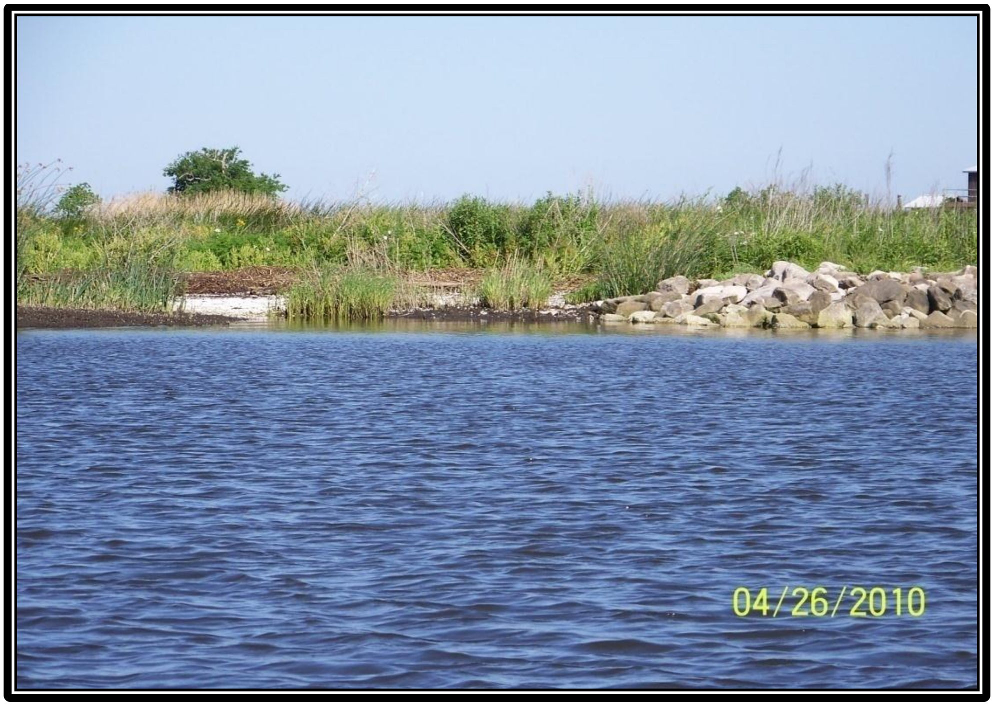



Photo No.29 – view of the rock dike tie-in to the shoreline on the south side of Structure 14A.


Photo No. 30 – view of the rock dike tie-in to the shoreline on the south side of Structure 14A.


Photo No.31 – view of shell mitten along the shoreline of Little Lake south of Structure 14A.


Photo No.32 – view of shell mitten along the shoreline of Little Lake south of Structure 14A


Photo No.33 – view of breach location along the shoreline of Little Lake north of Structure 14A.


Photo No.34 – closer view of breach shown in the previous photograph.


Photo No.35 – view of a second breach in the shoreline of Little Lake south of Structure 14A.


Photo No.36– view of variable crest weir Structure No.35 along north bank of location canal on the east side of Breton Canal.


Photo No.37 – view of steel bulkhead and bank tie-in on the south side of Structure No.35.


Photo No.38 – view of steel bulkhead and bank tie-in on the north side of Structure No.35.

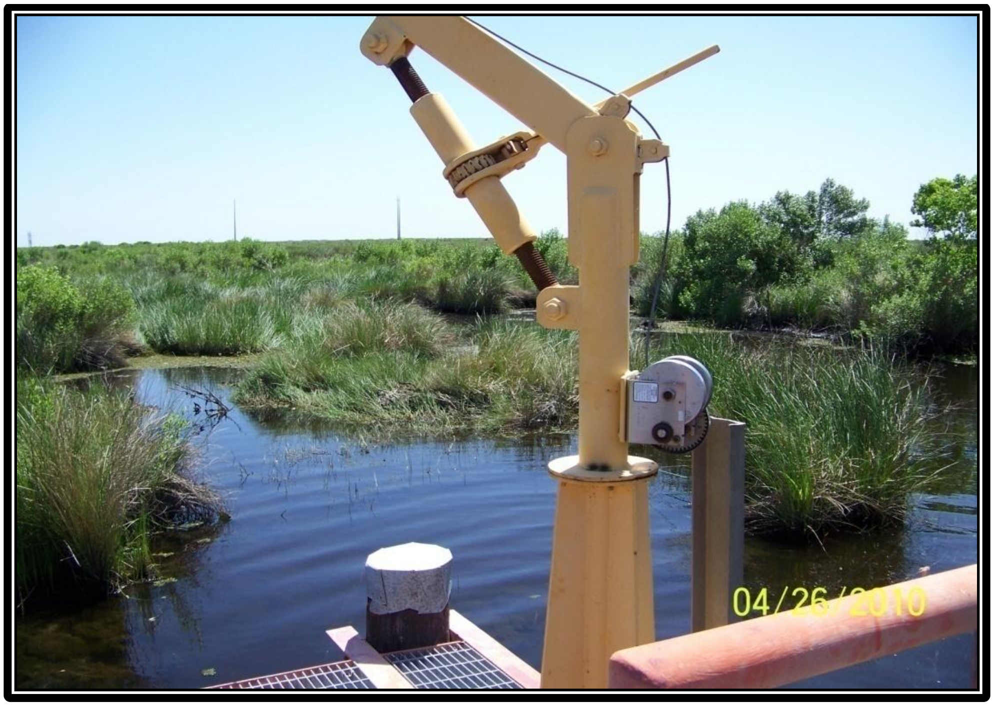



Photo No.39 – view boom structure and interior marsh behind Structure No. 35.


Photo No.40 – Breach No.1 located along the north bank of Breton Canal south of the location canal leading to Structure No.35.


Photo No.41 – view of rock plug section and bank tie-in on the south side of Structure No.90.


Photo No. 42 – view of rock plug (Structure No.90) looking southeast.


Photo No.43 – view of rock shoreline along the north bank of Breton Canal.


Photo No.44 – view of rock shoreline along the north bank of Breton Canal.


Photo No.45 – view of rock shoreline along the north bank of Breton Canal.


Photo No.46 – view of rock shoreline along the north bank of Breton Canal.

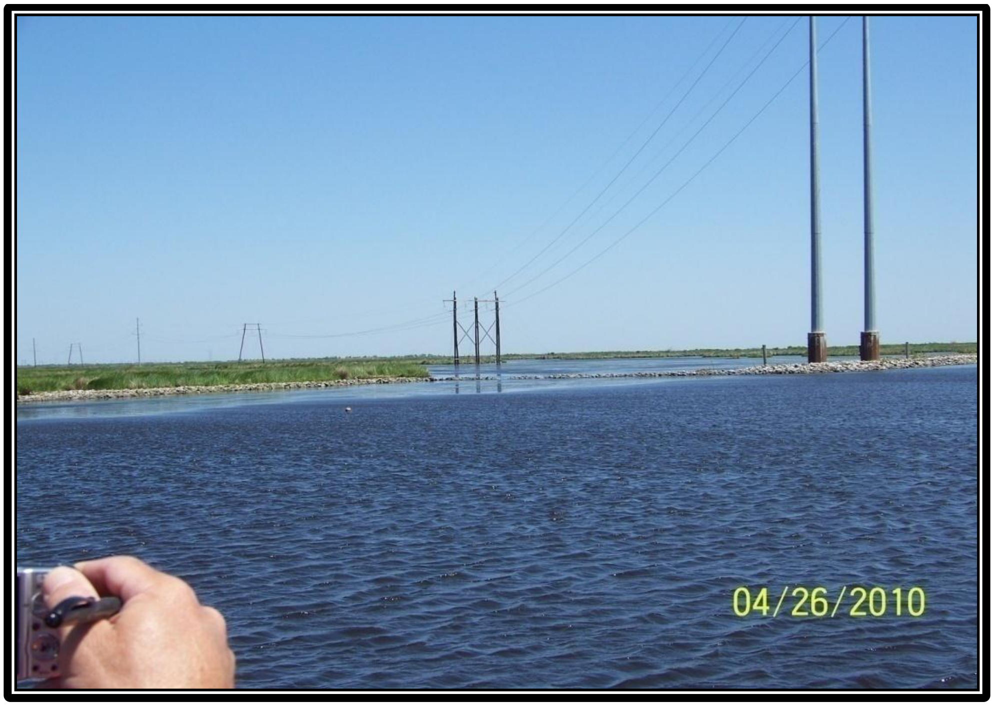



Photo No.47 – view of rock shoreline along the north bank of Breton Canal.


Photo No.48 – view of rock shoreline along the north bank of Breton Canal.


Photo No.49 – view of rock dike along the north bank of Breton Canal looking into Little Lake.


Photo No.50 – view of rock dike along the lake rim of Little Lake near the mouth of Breton Canal.


Photo No.51 – view of the rock dike along the lake rim of Little Lake.


Photo No.52 – view of the rock dike along the lake rim of Little Lake looking north.

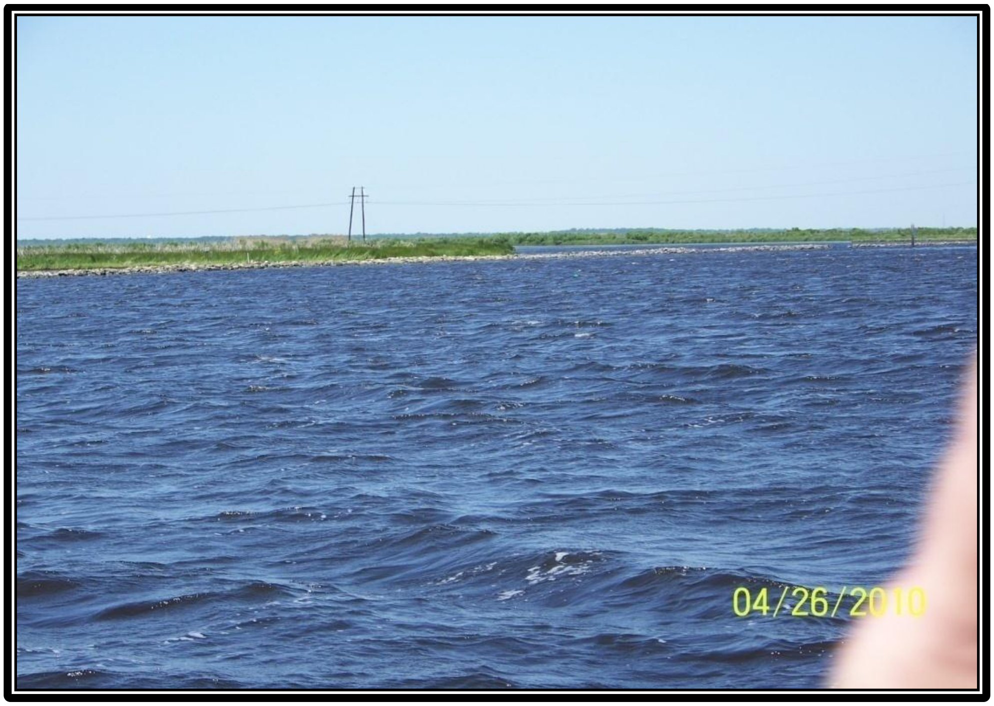



Photo No.53 – view of the rock dike along the lake rim of Little Lake looking west.


Photo No.54 – Breach No.1 located along the north bank of Breton Canal south of the location canal leading to Structure No.35.

Photo No.55 – Breach No.2 located along the north bank of the first oilfield location canal along Brenton Canal across from Breach 3.

Photo No.56 – Breach No.2 located along the north bank of the first oilfield location canal along Breton Canal across from Breach 3.

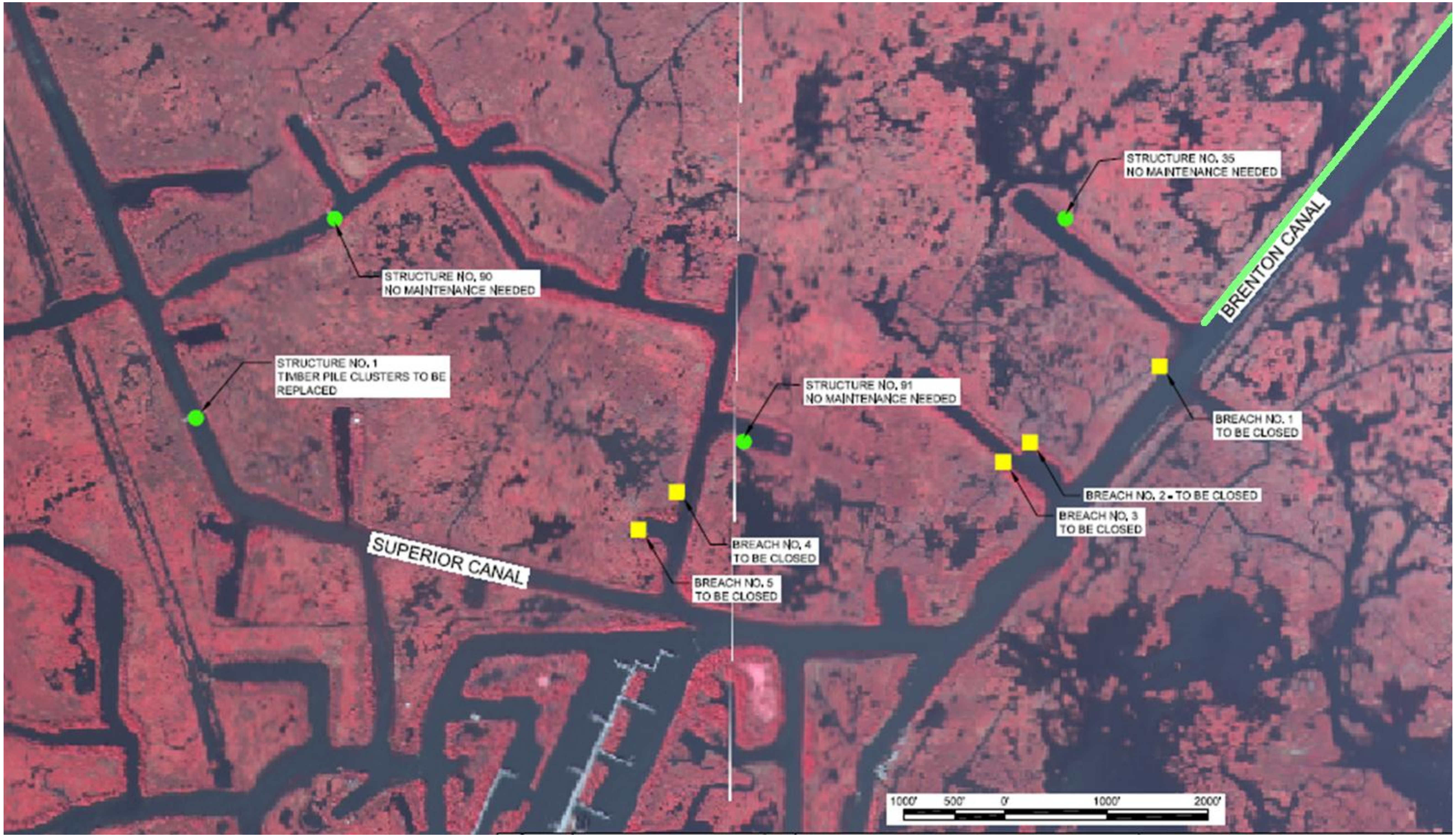

Photo No.57 – Breach No.3 located along the south bank of first oilfield location canal along Breton Canal.


Photo No.58 – Breach No.4 on the west bank of a location canal off of Superior southwest of Structure No.91.


Photo No.59– Breach No. 6 located at the end of an existing pipeline slip just southwest of Breach 4.

# Appendix C

# 2010 Maintenance Work Plan


STRUCTURE NO. 35
NO MAINTENANCE NEEDED
BRENTON CANAL
STRUCTURE NO. 90
NO MAINTENANCE NEEDED
STRUCTURE NO. 1
TIMBER PILE CLUSTERS TO BE
REPLACED
STRUCTURE NO. 91
NO MAINTENANCE NEEDED
BREACH NO. 1
TO BE CLOSED
BREACH NO. 2 - TO BE CLOSED
BREACH NO. 3
TO BE CLOSED
BREACH NO. 4
TO BE CLOSED
BREACH NO. 5
TO BE CLOSED
SUPERIOR CANAL
1000' 500' 0' 1000' 2000'


STRUCTURE NO. 4A & 4B
RECAP TO ORIGINAL DESIGN
ELEVATION
1500' EXTENSION OF ROCK PLUG FROM
4A & 4B TO THE NORTH SIDE OF
STRUCTURE NO. 4
STRUCTURE NO. 4
RECAP TO ORIGINAL DESIGN
ELEVATION
STRUCTURE NO. 2
RECAP TO ORIGINAL DESIGN
ELEVATION
BAY L'OURS
LAKE RIM
REFURBISH DIKE FROM STRUCTURE
NO. 2 TO BRENTON CANAL
BRENTON CANAL
1000' 500' 0' 1000' 2000'

# Appendix D

## Coefficient of Conservatism (CC) Scores

Coefficient of Conservatism (CC) scores for all flora species documented at the BA-02 project-specific vegetation stations as well as the BA-02 project and reference CRMS stations.

| Scientific Name | CC Score |
|---|---|
| Acer rubrum L. | 7 |
| Acer rubrum L. var. drummondii (Hook. & Arn. ex Nutt.) Sarg. | 7 |
| Agalinis heterophylla (Nutt.) Small ex Britt. | 6 |
| Agalinis purpurea (L.) Pennell | 6 |
| Alopecurus carolinianus Walt. | 1 |
| Alternanthera philoxeroides (Mart.) Griseb. | 0 |
| Amaranthus australis (Gray) Sauer | 2 |
| Amaranthus cannabinus (L.) Sauer | 2 |
| Amaranthus L. | 2 |
| Amaranthus tuberculatus (Moq.) Sauer | 2 |
| Ammannia coccinea Rottb. | 4 |
| Ammannia latifolia L. | 4 |
| Andropogon glomeratus (Walt.) B.S.P. | 3 |
| Baccharis halimifolia L. | 4 |
| Bacopa monnieri (L.) Pennell | 5 |
| Bare Ground | |
| Bidens laevis (L.) B.S.P. | 3 |
| Ceratophyllum demersum L. | |
| Cladium mariscus (L.) Pohl | 8 |
| Cladium P. Br. | 8 |
| Crinum americanum L. | 8 |
| Cucumis L. | |
| Cuscuta indecora Choisy | |
| Cuscuta L. | |
| Cynanchum angustifolium Pers. | 6 |
| Cyperus bipartitus Torr. | |
| Cyperus distinctus Steud. | |
| Cyperus erythrorhizos Muhl. | 3 |
| Cyperus esculentus L. | 0 |
| Cyperus filicinus Vahl | 4 |
| Cyperus haspan L. | 5 |
| Cyperus L. | |
| Cyperus odoratus L. | 4 |
| Cyperus oxylepis Nees ex Steud. | 4 |
| Cyperus strigosus L. | 3 |
| Distichlis spicata (L.) Greene | 2 |
| Echinochloa walteri (Pursh) Heller | 5 |
| Eleocharis baldwinii (Torr.) Chapman | 5 |

Coefficient of Conservatism (CC) scores (continued)

| | |
|---|---|
| Eleocharis cellulosa Torr. | 7 |
| Eleocharis flavescens (Poir.) Urban | 6 |
| Eleocharis montana (Kunth) Roemer & J.A. Schultes | 5 |
| Eleocharis parvula (Roemer & J.A. Schultes) Link ex Bluff | 3 |
| Eleocharis R. Br. | |
| Eriochloa contracta A.S. Hitchc. | 2 |
| Eupatorium capillifolium (Lam.) Small | 1 |
| Fimbristylis Vahl | |
| Galium L. | 2 |
| Galium tinctorium L. | 2 |
| Hydrocotyle bonariensis Comm. ex Lam. | 4 |
| Hydrocotyle umbellata L. | 3 |
| Hypericum L. | |
| Ipomoea sagittata Poir. | 8 |
| Iris L. | |
| Iva frutescens L. | 4 |
| Juncus roemerianus Scheele | 9 |
| Kosteletzkya virginica (L.) K. Presl ex Gray | 7 |
| Ludwigia octovalvis (Jacq.) Raven | 3 |
| Lythrum L. | 5 |
| Lythrum lineare L. | 5 |
| Mikania scandens (L.) Willd. | 3 |
| Mitreola petiolata (J.F. Gmel.) Torr. & Gray | 5 |
| Morella cerifera (L.) Small | 6 |
| Osmunda regalis L. | 8 |
| Panicum hemitomon J.A. Schultes | 10 |
| Panicum L. | |
| Pennisetum glaucum (L.) R. Br. | 0 |
| Phragmites australis (Cav.) Trin. ex Steud. | 6 |
| Phyla lanceolata (Michx.) Greene | 3 |
| Phyla nodiflora (L.) Greene | 4 |
| Pluchea camphorata (L.) DC. | 2 |
| Pluchea odorata (L.) Cass. | 2 |
| Pluchea odorata (L.) Cass. var. odorata | 2 |
| Polygonum hydropiperoides Michx. | 4 |
| Polygonum punctatum Ell. | 5 |
| Rhynchospora colorata (L.) H. Pfeiffer | 6 |
| Rumex obovatus Danser | |
| Sabatia calycina (Lam.) Heller | 6 |
| Sabatia stellaris Pursh | 6 |

Coefficient of Conservatism (CC) scores (continued)

| | |
|---|---|
| Sacciolepis striata (L.) Nash | 6 |
| Sagittaria lancifolia L. | 6 |
| Salvinia minima Baker | |
| Schoenoplectus (Reichenb.) Palla | 7 |
| Schoenoplectus americanus (Pers.) Volk. ex Schinz & R. Keller | 8 |
| Schoenoplectus californicus (C.A. Mey.) Palla | 7 |
| Schoenoplectus pungens (Vahl) Palla | 7 |
| Schoenoplectus robustus (Pursh) M.T. Strong | 7 |
| Sesbania herbacea (P. Mill.) McVaugh | 2 |
| Setaria Beauv. | |
| Setaria faberi Herrm. | 0 |
| Setaria italica (L.) Beauv. | 0 |
| Setaria parviflora (Poir.) Kerguelen | 3 |
| Setaria pumila (Poir.) Roemer & J.A. Schultes ssp. pallidifusca (Schumacher) B.K. Simon | 0 |
| Solidago sempervirens L. | 4 |
| Spartina alterniflora Loisel. | 10 |
| Spartina patens (Ait.) Muhl. | 9 |
| Symphyotrichum subulatum (Michx.) Nesom | 4 |
| Symphyotrichum tenuifolium (L.) Nesom | 5 |
| Symphyotrichum turbinellum (Lindl.) Nesom | 4 |
| Thelypteris palustris Schott | 7 |
| Typha domingensis Pers. | 3 |
| Typha L. | 2 |
| Vigna luteola (Jacq.) Benth. | 3 |
| Websteria confervoides (Poir.) S. Hooper | |