State of Louisiana
Coastal Protection and Restoration Authority
Office of Coastal Protection and Restoration

2013 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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Preface

The information presented in this report includes the annual project inspections from April 2013 as well as data collected through December 2012. The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project is sponsored by Natural Resources Conservation Service (NRCS) and Coastal Protection and Restoration Authority of Louisiana (CPRA) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III, Priority List 1).

This is the 4th in a series of possibly six Operations, Maintenance, and Monitoring (OM&M) reports. The 5th report is scheduled for 2016, while a comprehensive closeout report is scheduled for 2021. For more information on lessons learned, recommendations, or project effectiveness please refer to the 2010 OM&M report on the CPRA web site. The end of life for this project was originally projected for 2017 based upon the end of construction date for Construction Unit 1 in November 1997. Monitoring was originally scheduled through 2016. CPRA and NRCS have agreed to extend the life of the project through 2020 based upon the end of construction date for Construction Unit 2 in October 2000.

I. Introduction

The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project is located in Lafourche Parish, Louisiana, southeast of the Gulf Intracoastal Waterway (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). The most recent land-water analysis indicates that between 1993 and 2008 the project area has experienced a loss rate of 6.57% /year (Lear et al. 2010). 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.

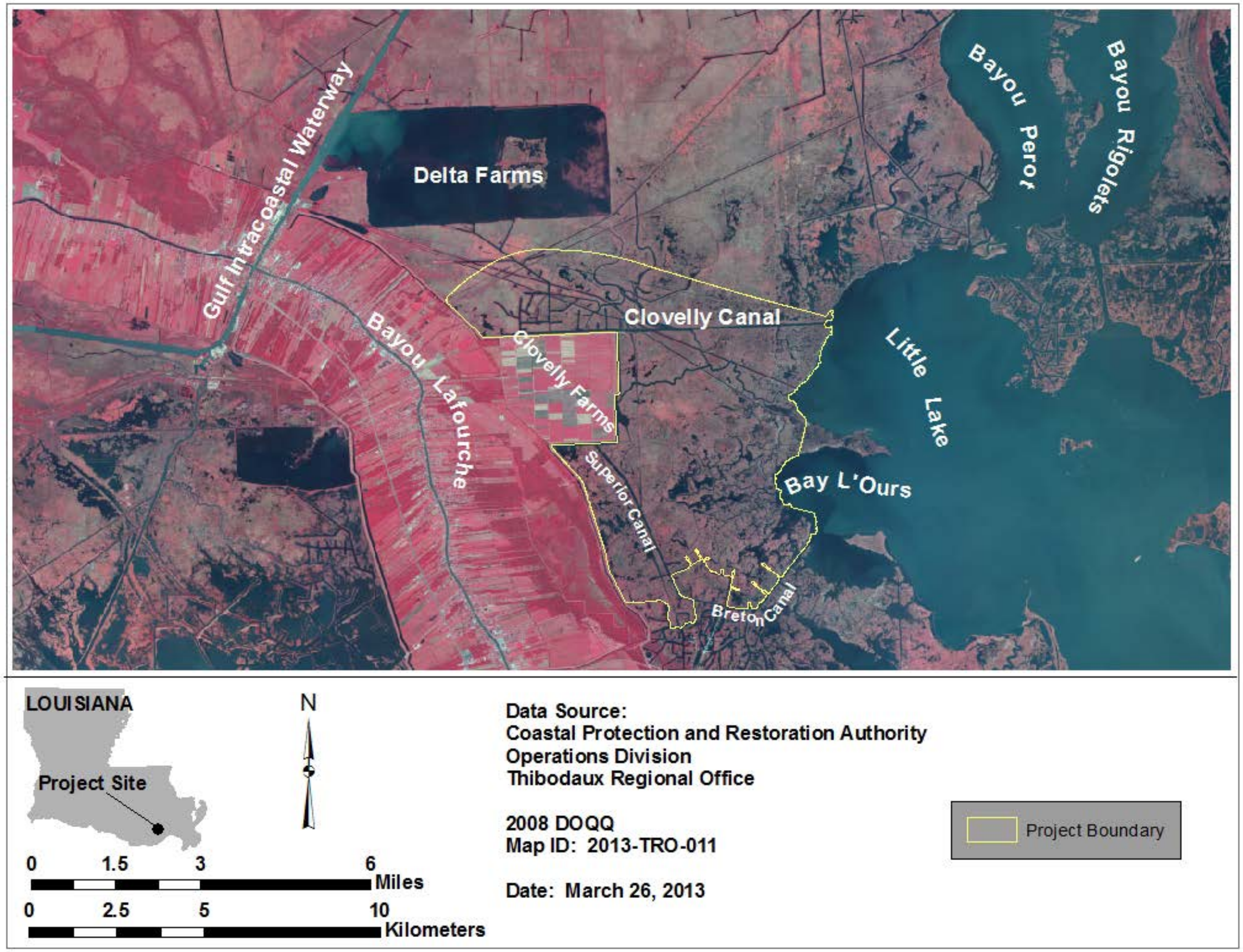

Figure 1. Location map with project boundary for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

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). Beginning in 1968 areas of intermediate and brackish marsh 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. In 2007, the entire project area was intermediate marsh (Sasser et al. 2007). 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 is unclear. 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, raise concerns that the quality of the marsh is declining and marsh will be converted to open water. Based upon the 2012 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 change, 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 was completed in October 1997, and Construction Unit No. 2 was completed in October 2000. CPRA and NCRS have agreed that the twenty-year (20-yr) project life would be based on the end of construction date for Construction Unit 2 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).

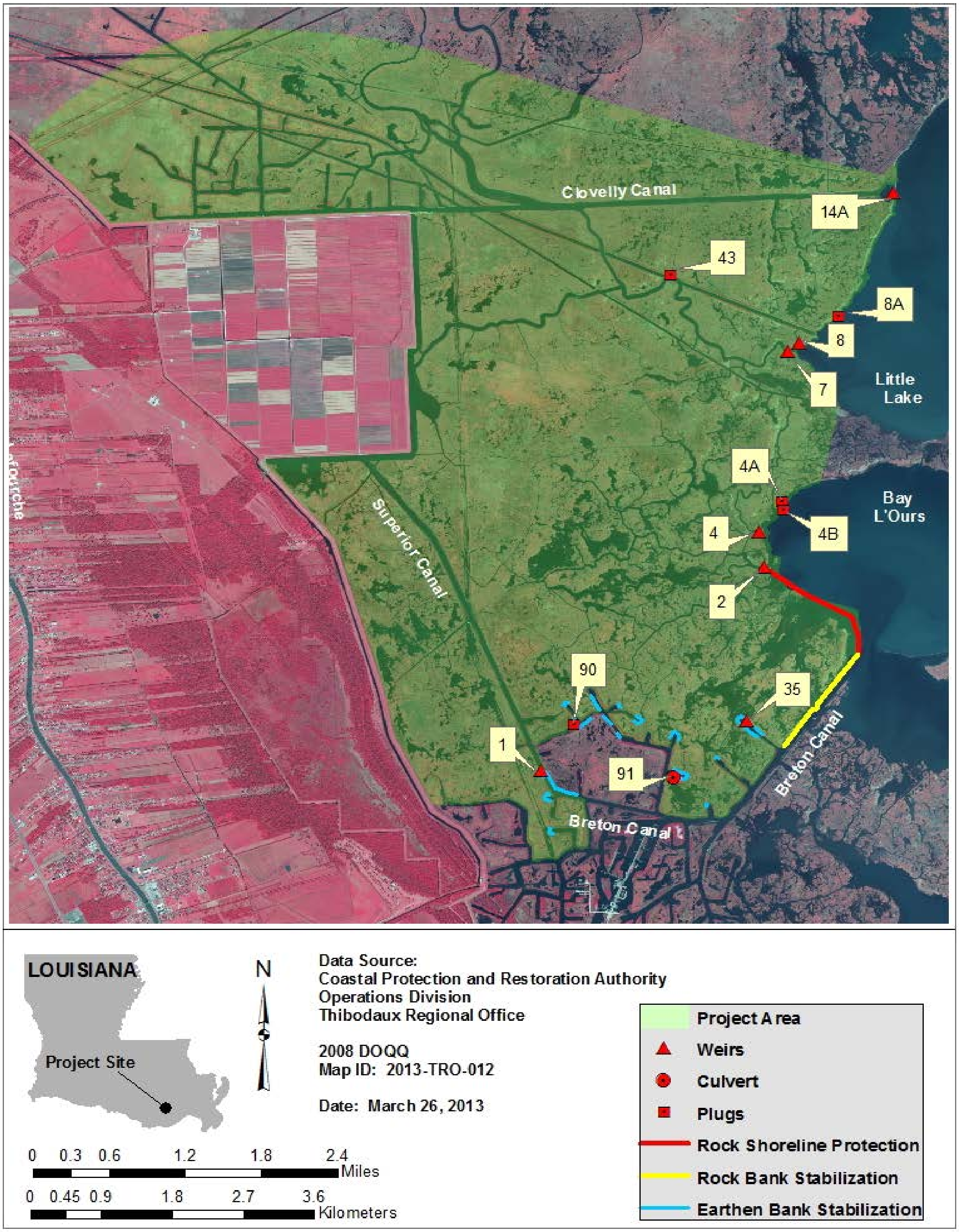

Figure 2. Infrastructure map for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

* 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).
* 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. Project Feature Inspection 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, CPRA shall provide, in report form, a detailed cost estimate for engineering, design, supervision, inspection, construction contingencies, and an assessment of the urgency of such repairs (O&M Plan, 2002). The annual inspection report also contains a summary of maintenance projects undertaken since the constructed features were completed and an estimated project budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year budget projections for operation and maintenance of the GIWW to Clovelly Hydrologic Restoration (BA-02) project are shown in Appendix B. A summary of past operation and maintenance projects undertaken since the completion of the project are outlined in Section II.d of this report.

An inspection of the GIWW to Clovelly Hydrologic Restoration Project (BA-02) was held on April 8th, 2013 under clear skies and windy conditions. In attendance were Adam Ledet and Elaine Lear with CPRA, and Quin Kinler and Warren Blanchard with NRCS. All attendees met at the Clovelly Canal Boat Launch and the inspection began at approximately 9:30am and concluded at 12:00pm. The water level at the time of the inspection was recorded from gauge BA-02-57 located in Superior Canal and was determined to be 1.25’ NAVD88 at 10:00am.

The field inspection included a complete visual inspection of all constructed features within the project area. Photographs of all project features were taken during the field inspection and are shown in Appendix A. Staff gauge readings, where available, were documented and used to estimate approximate water elevations, elevations of rock weirs, earthen embankments, lake-rim dike and other project features.

b. Inspection Results

CONSTRUCTION UNIT NO.1

Structure 2 – Fixed crest rock weir with boat bay

Structure 2 is a three (3) level fixed crest weir constructed of rock riprap material. Previous inspections have shown that settlement has occurred along the structure, in both of the sections between the bank and the boat bay, and also the bottom sill of the boat bay. This structure was recapped with 130# class rip-rap to its original design elevation as part of the 2012

Maintenance Project. By comparing the preconstruction drawings to the as-built drawings, it is shown that the sections between the bank and boat bay have been elevated approximately two (2) feet from +1.0’ NAVD88 to +3.0’ NAVD88 and the bottom sill of the boat bay elevated approximately seven (7) feet from -12.0’ NAVD88 to -5.0’ NAVD88. During the inspection, there were no areas where settlement was observed since the end of construction. The warning signs and navigational aids on Structure 2 are in good condition and do not require maintenance at this time. (See Appendix A, Photos 40 through 44)

Structure 4 – Fixed crest rock weir with boat bay
Structure 4 is also a three (3) level fixed crest weir constructed of rock riprap material. Previous inspections have shown that settlement has occurred along the structure, in both of the sections between the bank and the boat bay, and also the bottom sill of the boat bay. The structure was recapped with 130# class rip-rap to its original design elevation as part of the 2012 Maintenance Project. By comparing the preconstruction drawings to the as-built drawings, it is shown that the sections between the bank and boat bay have been elevated approximately two (2) feet from +1.0’ NAVD88 to +3.0’ NAVD88 on the north side and approximately six (6) feet from -3.5’ NAVD88 to 2.5’ NAVD88 on the south side, and the bottom sill of the boat bay elevated approximately three (3) feet from -7.0’ NAVD88 to -4.0’ NAVD88. During the inspection, there were no areas where settlement was observed since the end of construction. There has been significant erosion observed on the southern end of the structure since the end of the 2012 Maintenance Project. Only a small strip of marsh embankment approximately 30 feet wide is preventing the structure from a full breach on the south side. It is recommended that this strip of mash be protected with riprap material to maintain the hydrologic integrity of the project. The warning sign on the southern end of the structure appears to be partially disconnected from its supports, as the top of the sign remained secure to the support but the bottom of the sign could be observed moving with the wind. It is recommended this warning sign be refastened to the support before it becomes completely detached. The other newly installed warning sign and its support timber are in good condition and do not require maintenance at this time. (See Appendix A, Photos 45 through 48)

As previously reported, there was a breach identified in the western shoreline of Bay L’Ours between Structure 2 and Structure 4. The breach is believed to be caused by the retreating shoreline reaching the edge of an interior pond. It is recommended that this breach be closed with riprap material to maintain the hydrologic integrity of the project.

Structure 7– Fixed crest rock weir w/ boat bay
Structure 7 appeared to be in fair condition with some settlement of the rock riprap material but no visual damage to the weir or erosion around the embankment tie-ins. The original as-built drawings show the weir was constructed to a height of -4.4 NAVD in the boat bay and +2.4’ NAVD on the north and south sides between the bank and boat bay. Observations and data

from previous surveys show this structure has settled uniformly along the entire length of the structure approximately 1.0' to 1.5'. Because the settlement of the Structure 7 has been minor and uniform causing no breaching of the structure, it was not included in the 2012 Maintenance Project, but the structure will continue to be monitored during future inspections. All warning and navigational signs and their supports appear to be in good condition. (See Appendix A, Photos 53 through 55)

Structure 8– Rock rip-rap weir

Structure 8 is a small rock weir with a boat bay located just north of Structure 7. This structure appears to be in fair condition with minimal settlement of the riprap material and no erosion or washouts around the bank tie-ins. This structure was originally constructed with a steel gate to prevent access into the interior marsh, but this gate was destroyed during Hurricanes Gustav and Ike. Since the gate was destroyed, the landowner has installed a series of floating barrels to restrict access, thus there is no need to replace the gate at this time. (See Appendix A, Photos 56 through 57)

Structure 43 – Rock rip-rap channel plug

We were unable to visually inspect Structure 43 due to vegetation blocking the visibility of the structure. There is a small breach that has formed around the eastern end of the rock plug allowing water to flow around the structure. This breach has been identified and will be monitored during future visits to determine the magnitude of its effects to the structure. All warning signs and support structures appear to be in good condition, and at this time, there are no recommendations for maintenance. (See Appendix A, Photos 1 through 2)

Structure 91 – Rock plug with culvert and flap gate

Structure 91 rock plug appeared to be in good overall condition. There were no signs of rock settlement or erosion around the embankment tie-ins. Previous inspections revealed the sheet metal covering the timber piles supporting the corrugated metal pipe were rusted and corroded. As a result, new galvanized timber pile caps were installed as part of the 2012 Maintenance project to prevent the piling from rotting internally. Also, the warning sign for the structure has been damaged by vandals as it appears the sign has endured several shots from a shotgun. Because the sign is still legible, there are no recommendations for maintenance at this time, but it will continue to be monitored on future inspections for further damage. (See Appendix A, Photos 13 through 16)

CONSTRUCTION UNIT NO.2

Structure 1 – Fixed crest rock weir w/ barge bay

Structure 1 appeared to be in good overall condition with no observable settlement or displacement of the rock riprap material. Previous inspections had found considerable damage to the four (4) timber pile dolphins at the opening of the barge bay. This damage was believed to be caused by an oilfield barge navigating the opening of the structure and includes the vertical piles splitting, piles displaced from original position, scarring on the surface of the piles, and the complete destruction of one of the four dolphin structures. Due to the poor condition of the timber dolphins, they were replaced and fitted with new signs as part of the 2012 Maintenance Project. Also, as a precaution, the timber dolphins were installed one (1) foot further apart to allow barges to move more freely through the barge bay without future damage to the structure. At the time of the inspection, the timber pile dolphins appeared to be in good condition with no signs of damage. There are no recommendations for maintenance at this time. (See Appendix A, Photos 3 through 8)

Structure 4A & 4B – Rock rip-rap channel plug

As part of the 2012 Maintenance Project, Structure 4A & 4B was recapped to its original design elevation and extended to Structure 4. The 2008 survey profile showed this structure had settled approximately 1.5’ to 2.0’ along the entire length of the structure. In addition to the settlement, and partially caused by hurricanes Gustav and Ike, the marsh around the plug had suffered extensive erosion. On the south side of the plug there was a very large opening in the shore line approximately 1,000 feet wide. The Maintenance Project recapped the existing structure to an elevation of 3.5’ NAVD88 using 130# class rock riprap and also closed the opening by extending the structure approximately 1,000 linear feet to the embankment tie-in of Structure 4 at an elevation of 3.5’ NAVD88 using 130# class rock riprap. During construction of the extension, a change order allowed the contractor to install two warning signs with timber supports in the location of the fish dips. At the time of inspection, there was no observed settlement or displacement of Structure 4A & 4B or the extension since the end of the 2012 Maintenance Project. There are no recommendations for maintenance at this time. (See Appendix A, Photos 48 through 52)

Structure 14A – Fixed crest rock weir with barge bay

Structure 14A was also rehabilitated during the 2012 Maintenance Project. Observations from previous annual inspections and supporting data from the 2008 survey showed severe settlement and scour near the bottom of the barge bay with depths ranging from the original constructed height of -6.5’ NAVD88 to as low as -15.0’ NAVD88. During the Maintenance Project, the structure was recapped with a heavier 250# class rock riprap to prevent further scouring to the original design elevation of -6.5’ NAVD88 at the bottom of the barge bay and +4.0 at the crest of the weir. At the time of the inspection the structure appears to be in good condition, as there is no observed settlement of the rock since the end of construction. As mentioned in previous inspections, the timber dolphin piles were in poor condition with visible cracks and surface damage. Three of the timber dolphin piles and their navigational aids were replaced as part of the 2012 Maintenance Project. The timber pile on the southeast side of the structure was replaced in 2006 and remains in good condition. There are no recommendations for maintenance at this time. (See Appendix A, Photos 58 through 66)

Structure 35 – Variable crest weir, water control structure

Structure 35 is in overall good condition with some signs of minor corrosion on the bulkhead cap, handrails and deck. The stop logs, cables, signs and supports appear to be in good condition and operable. At the time of inspection the channel from the weir to the interior marsh was open and there appeared to be adequate flow through the interior marsh and structure. The embankment tie-ins also appear to be in good condition with no erosion or washouts. We are not recommending any repairs or corrective actions at this time. (See Appendix A, Photos 29 through 30)

Structure 90 – Rock rip-rap channel plug

Structure 90 appears to be in overall good condition with no rock settlement/ displacement or erosion around the embankment tie-ins. All warning signs and supports are in good condition also. There are no recommended corrective actions at this time. (See Appendix A, Photos 17 through 20)

Lake Rim Restoration

The Lake Rim structure was recapped as part of the 2012 Maintenance Project. As indicated on previous inspections and surveys, the rock dike had displayed minor to moderate settlement along the entire length of the structure. The most notable segments included segments between Stations 7+00 and 13+00, 36+00 and 41+00, and the intersection near the mouth of Breton Canal. As part of the maintenance project, the Lake Rim structure was recapped with 130# class rock riprap to its original design elevation of +3.0’ NAVD88 from the north bank along Breton Canal to southern embankment tie-in of Structure 2. During construction, the Lake Rim structure did not settle from the weight of the extra rock as much as anticipated, which left the contractor with an excess of rock riprap inside of the bid quantity. This additional rock was used to place a second lift of rock along the north bank of Breton Canal, Structure 4, and the Lake Rim structure. The 2012 Maintenance Project as-built drawings show the constructed elevation of the Lake Rim structure to be approximately +3.5’ NAVD88 to +4.0’ NAVD88 after the second lift. At the time of inspection, there appeared to be no further settlement of the structure since the end of maintenance. There are no recommendations for maintenance at this time. (See Appendix A, Photos 31 through 39)

Earthen bank stabilization

There were five (5) breaches included in the 2012 Maintenance Project. Breach 1 was located along the north bank of Breton Canal just southwest of the first location canal from Bay L’ Ours and was approximately 20’ wide. Breach 2 was located along the northeast bank of the second location canal north of Breton Canal and was approximately 10’ wide. Breach 3 was located on the south bank of the same location canal as Breach 2 and was approximately 25' wide. Breach 4 was located on the west bank of an oilfield canal that intersects Breton Canal east of Structure No. 1 and was approximately 30' wide. Another breach, designated as Breach 5, was discovered at the end of a dead end oilfield slip south of Breach 4. The breaches were closed by using in situ material from the adjacent canal bottoms to reconstruct the earthen dike. The material was allowed to dry before it was shaped, seeded, and fertilized. At the time of the inspection all of the breach repairs appeared to be in good condition with full vegetation and no signs of settlement. Breach 1 did show some signs of erosion on its northeast side facing Breton Canal. This is believed to be caused by the heavy boat wake and wave action in this location compared to the other breach repairs. Due to the minor erosion not affecting the overall stability of the breach repair, there are no recommendations for maintenance at this time; however this location will continue to be monitored on future annual inspections. (See Appendix A, Photos 9 through 12 & 21 through 28)

c. Maintenance Recommendations

The GIWW to Clovelly Hydrologic Restoration Project (BA-02) appears to be in good overall condition. However, during the 2013 Annual Inspection, the thinning embankment on the south side of Structure 4 and a breach on the west shoreline of Bay L'Ours between Structure 2 and Structure 4 are areas of concern. Restoration / protection of these areas with riprap material is needed to maintain the hydrologic integrity of the project. CPRA and NCRS have requested an Operation and Maintenance budget increase to address these areas. Other minor deficiencies of the project structures were observed which include the partial detachment of the warning sign from its supports on the south side of Structure 4. It is believed the sign was disconnected due to the high wind and waves of the recent Hurricane Isaac and it is recommended this sign be reattached to the existing supports before it is completely detached and lost due to another high wind event. Other areas of concern are a small breach on the east side of Structure 43. While there are no recommendations for maintenance in these areas at this time, they will continue to be monitored on future annual inspections to determine if any repairs will be needed.

d. Maintenance History

Below is a summary of completed maintenance projects and operation tasks performed since completion of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project (BA-02):

Navigation Aids Maintenance: Below is a short description of repairs, dates and cost associated with the service of the navigational aids located at Structure 14A:

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

12/16/03 – Automatic Power performed maintenance and service to repair navigation lights at Structure 14A. The battery and flash bulbs were replaced in all four (4) navigation lights at a total cost of $2,189.80.

11/4/04 – Automatic Power performed maintenance and service to repair navigation lights at Structure 14A. One (1) lamp changer, one (1) battery and flash bulbs were replaced at a total cost of $922.23.

11/29/06 – CPRA received public bids for a state-wide maintenance contract for inspection, diagnostic testing, and maintenance of twenty-seven (27) navigational aid systems at ten (10) separate locations state-wide. Four (4) of the twenty-seven (27) navigational aid structures included in this contract are located within the GIWW to Clovelly project area at Structure 14A. The state-wide contract was awarded to the lowest bidder, Automatic Power, Inc. of Larose, La., in the amount of $83,424. This contract is a one (1) year contract with an option to extend for another two (2) years. The notice to proceed with inspections, diagnostic testing and maintenance was issued in February 2007. This contract was rebid in 2009 for another three (3) year extension, and was again awarded to the lowest bidder, Automatic Power, Inc. of Larose, LA. The contract bid again in 2013 and has been awarded to Wet Tech Energy, Inc. of Milton, La.

2012 Maintenance Project: This project is the first major maintenance event since the completion of the original project. Since the 2008 Annual Inspection of the GIWW to Clovelly Hydrologic Restoration (BA-02) project, a number of deficiencies had been documented that required corrective actions and/or refurbishment. In February 2010, CPRA initiated maintenance of the GIWW to Clovelly Hydrologic Restoration - 2012 Maintenance Project by contracting MWH Americas, Inc. of Baton Rouge to perform the design. 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. The plans and specifications for the project were completed in May 2011 and were reviewed by both CPRA and NRCS. The modification to the overall maintenance permit obtained in 2007 to include the breach closure between Structures 4A and 4 has been approved and was included the final bid package. The final bid documents were submitted to the Louisiana Office of State Purchase to be bid. The bid process took place in August 2011 and the maintenance project contract along with the bid alternate was awarded to DQSI, Inc. The construction administration and inspection services are being handled by Providence/GSE of Houma, LA. Mobilization of DQSI to the jobsite and work on the breach repairs began in December 2011. Construction of the project was completed in June 2012 and final acceptance was on July 24, 2012. The 2012 Maintenance Project was completed for a total cost of $3,435,923.58. Of this total amount, $2,924,801.23 came from the CWPPRA program and $511,122.35 from FEMA. This total includes construction by DQSI, surveys by John Chance, E&D by MWH, and administration and inspection by Providence/GSE. A summary of the work completed in the 2012 Maintenance Project is found below:

- Four (4) timber pile clusters and navigational aids replaced on Structure 1
- Three (3) timber pile clusters and navigational aids replaced on Structure 14A
- Approximately 10,600 linear feet of the Lake Rim rock dike refurbished
- Approximately 1,000 linear foot rock dike extension created from Structure 4 to Structure 4A & 4B
- Structure 4A & 4B recapped to original design elevation
- Structure 4 and Structure 2 recapped to original design elevation
- Structure 14A barge bay recapped to original design elevation
- Five (5) breach closures along existing oilfield canals in southern section of the project area

III. Operations Activity

In accordance with the operation schedule outlined in the Operations and Maintenance Plan and the special conditions of the permit, Structure 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 due to marsh damage behind the structure following Hurricane Katrina; however, since that time, the marsh material blocking the structure has degraded and settled to the bottom of the channel creating an opening to the interior marsh which enabled structure operations to resume in November 2007.

IV. Monitoring Activity

Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, updates were made to the BA-02 Monitoring Plan to integrate it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There is one CRMS site located in the project area, CRMS0190. This site was established on November 7, 2011 after construction.

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

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

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 CPRA 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 repeated 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. (2012). 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. Water level data is also collected at CRMS0190.

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. (2012).

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 documented once prior to construction in 1996, once in 1999 after Construction Unit No. 1 was completed, and five times after Construction Unit No. 2 was completed in 2000, 2002, 2005, 2008, and 2012. Additional data collection will occur in 2016. Species composition and relative abundance were also evaluated inside the BA-02 project area

CRMS site (CRMS0190) pictured in figure 3. The 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, 2009, 2010, 2011, and 2012.

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. (2012). 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 five times after Construction Unit No. 2 was completed in 2000, 2002, 2005, 2008, and 2012. Additional data collection will occur in 2016. Soil cores were taken at the project CRMS site (CRMS0190) at the time of its establishment in June 2006.

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 CPRA personnel to document marsh edge position using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2012). 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 post-construction in 2000, 2003, 2005, 2008, and 2012. The 2005, 2008, and 2012 surveys were 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 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

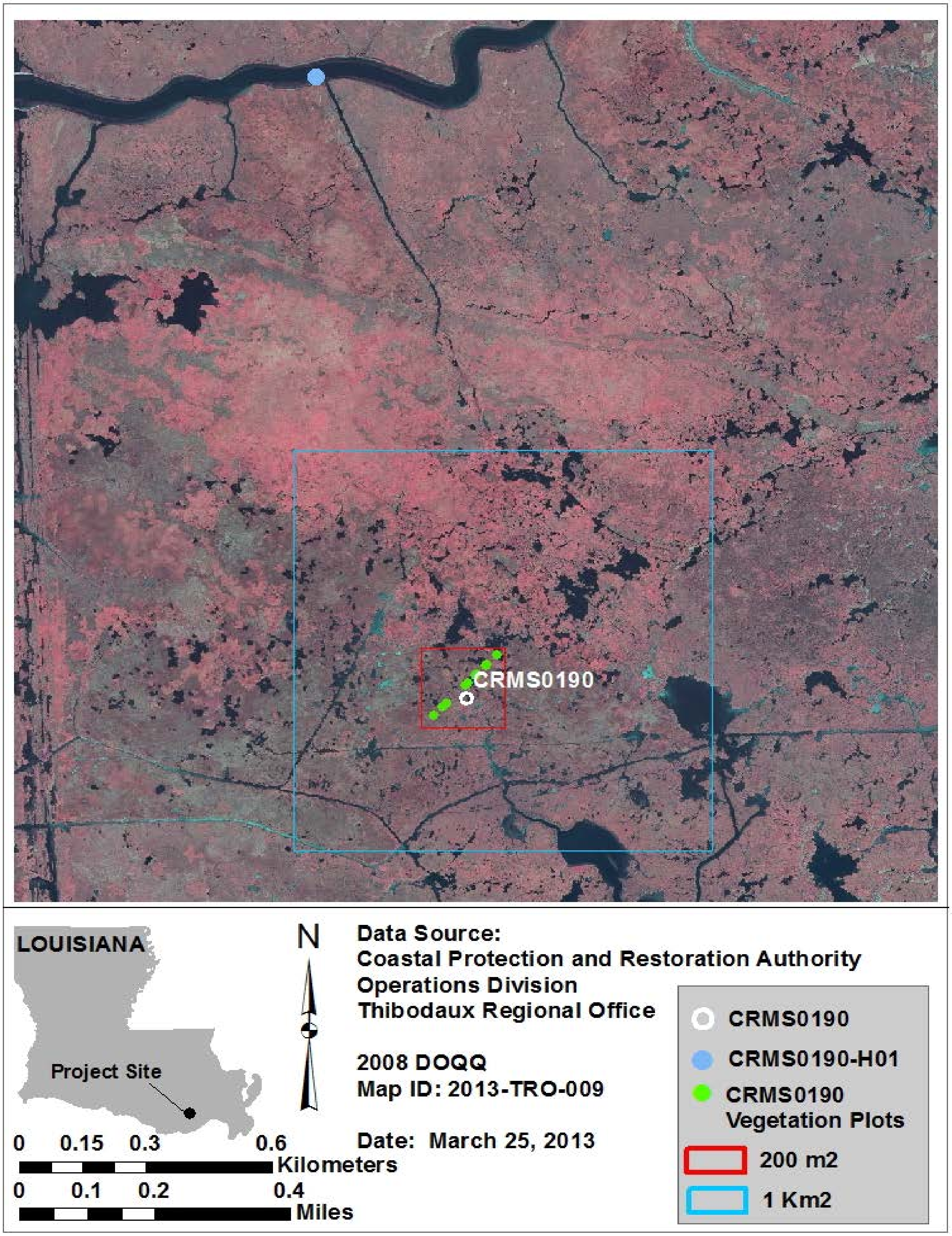

Figure 3. Location of CRMS0190 as well as the continuous hydrographic station CRMS0190-H01 inside the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

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.

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. The CRMS-*Wetlands* program 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). In this report the available data from CRMS0190 as well as CRMS-*Wetlands* sites outside the project boundary will be used as supporting or contextual information for the BA-02 project (figure 4). The trends developed from the available data collected throughout the CRMS-*Wetlands* network now make it possible to report vegetative and hydrologic indices for this project on a site, basin, and coastwide scale.

c. 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. In 2004 upon the request of CPRA personnel, NWRC re-examined the photography from all three flights as well as the most recent vegetation and salinity data available at the time. Revisions were made to the

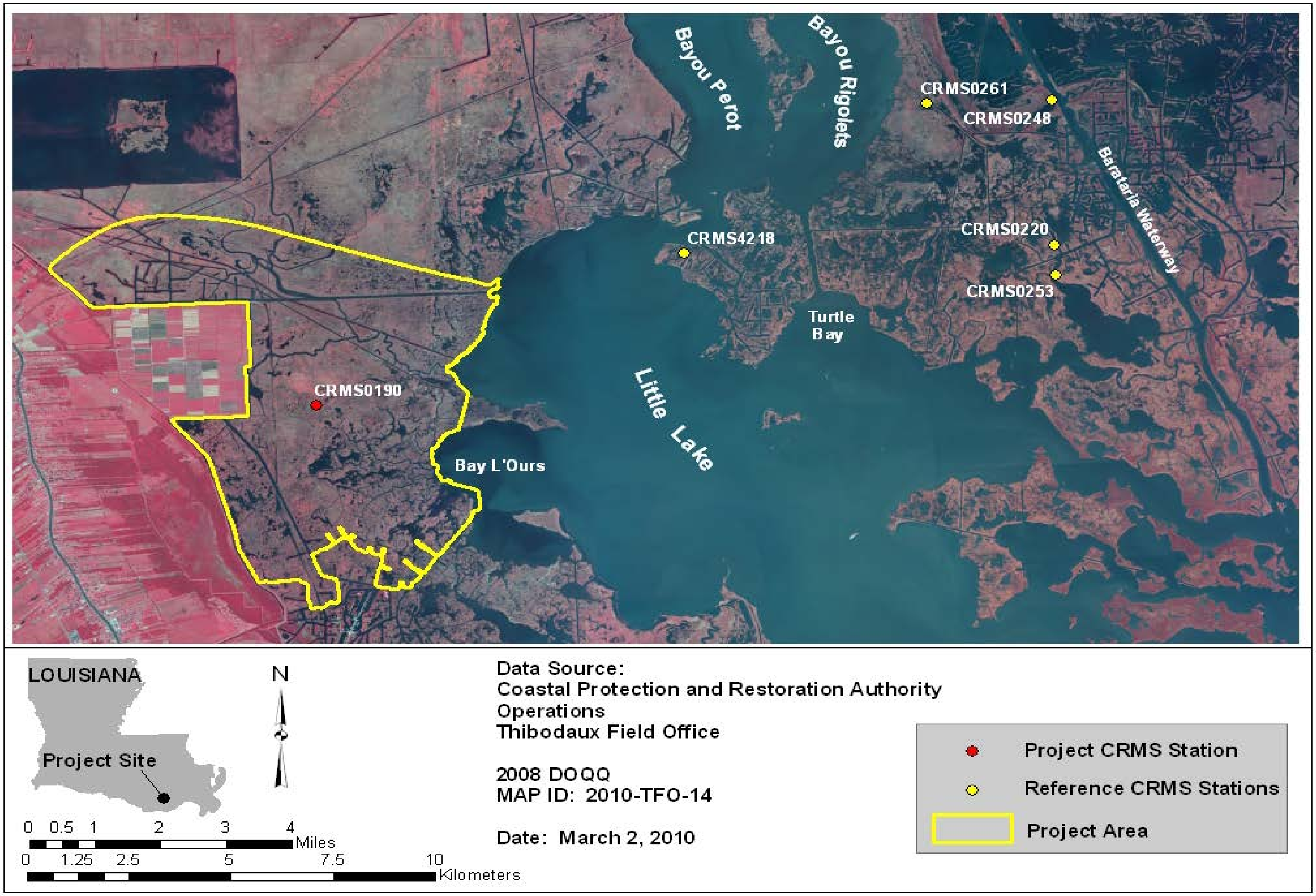

Figure 4. Location map of CRMS-*Wetlands* sites inside and nearest to the BA-02 project in the Barataria basin.

habitat classification data as a result of this review and updated maps were completed in March 2005. All maps are presented in Appendix C of this report.

Habitat Mapping Results and Discussions

Between 1993 and 2002, the land acreage in the project area increased by 28 acres (11.3 hectares) (table 1). Habitat classifications shifted resulting in a project area gain of 31 acres (12.5 hectares) of marsh habitat and 186 acres (75.2 hectares) of wetland forest, to a loss of 112 acres (45.3 hectares) of wetland scrub/shrub and 10 acres (4.04 hectares) of upland forested habitat. By 2002, the project area was comprised of approximately 70% intermediate marsh habitat, approximately 6% fresh marsh, approximately 19% open water, and the remaining 5% of land was a mixture of habitat types (Appendix C, figures 1-3).

Between 1993 and 2002, the land acreage in the reference area increased by 53 acres (21.4 hectares) of land. Habitat classifications shifted resulting in a loss of all 628 acres (254.1 hectares) of fresh marsh and a gain of 548 acres (221 hectares) of intermediate marsh, as well as approximately 9 acres (3.6) of wetland scrub/shrub. By 2002, the reference area was comprised of approximately 67% intermediate marsh, approximately 27% open water, and the remaining 6% of land was a mixture of habitat types (Appendix C, figures 1-3).

Table 1. BA-02 project and reference habitat class acreages and percentages.

	1993				2002			
Habitat Class	Project Acres	Percent	Reference Acres	Percent	Project Acres	Percent	Reference Acres	Percent
Intermediate Marsh	10717	72.2	2122	53.2	10463	70.5	2668	66.9
Fresh Marsh	626	4.2	628	15.75	849	5.72	0	0
Open water	2846	19.17	1014	25.43	2818	18.98	1067	26.76
Mudflat	1	<1	3	<1	2	<1	4	<1
Rocky Shore	1	<1	0	0	4	<1	0	0
Upland Forested	146	<1	68	1.7	136	<1	63	<1
Upland Scrub-shrub	7	<1	1	<1	1	<1	1	<1
Upland Range	8	<1	0	<1	6	<1	0	<1
Upland Urban	6	<1	2	<1	5	<1	2	<1
Wetland Scrub-Shrub	289	1.94	77	1.93	177	1.19	86	2.15
Wetland Forested	193	1.3	72	1.8	379	2.55	96	2.4

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. In addition to this map, land-water acreages were calculated from the habitat analysis maps created by USGS/NWRC in 1993, 1996, and 2002. 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. These acreages were also translated into percentages.

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 5). Inside the project area, small changes occurred from open water to land between 1993 and 1996 (pre-construction), as well as between 1996 to 2002 (construction), while the reference area experienced the opposite. 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.

Water Level

Project construction was completed in two construction units and only a portion of the structures were in place when 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. CRMS0190-W01 was a marsh well station replaced with CRMS0190-H01 at the request of CPRA. The marsh well recorder was replaced because salinity data collected from the marsh well station when water levels fell below the marsh surface represented porewater readings which were not comparable to surface water readings from open water recorders in the project area. 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 and the project CRMS continuous recorder stations where hourly water level data have been collected are found in table 2 (figure 6).

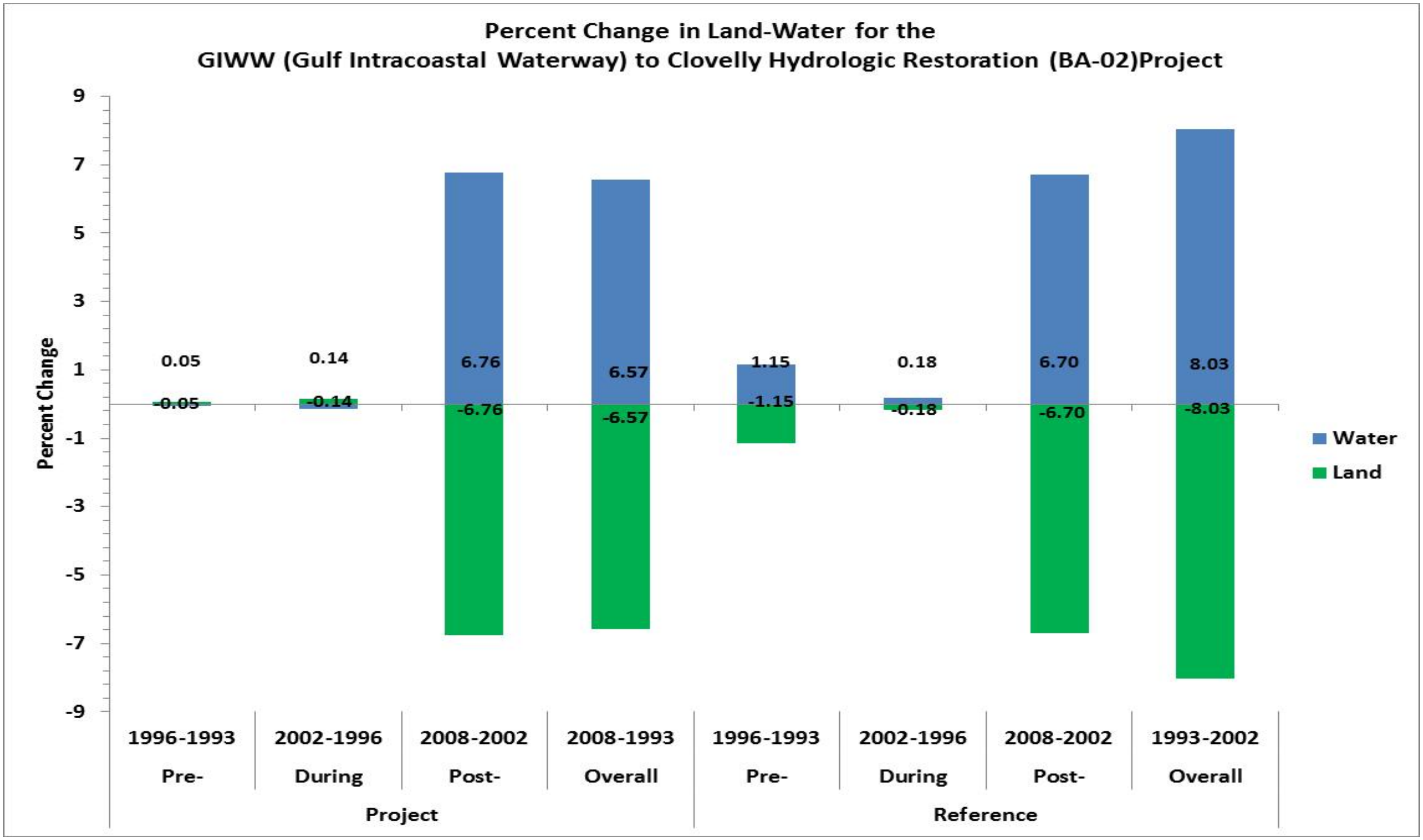

Figure 5. Percent change in Land-Water for pre-construction, construction, post-construction, and overall for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Table 2. Project-specific and project area 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
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
CRMS0190-W01	06/13/2006 - 09/30/2010
CRMS0190-M01	06/13/2006 - Present
CRMS0190-H01	02/26/2010 - Present

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

Changes in water level values were measured on a continuous hourly basis or this project utilizing open water continuous recorders deployed at stations inside of the project boundary and constructed according to CPRA standard operation procedures (Folse et al. 2012).

In addition to the project specific open water recorders, one CRMS-*Wetlands* site (CRMS0190) with a marsh well continuous recorder setup as well as a floating marsh mat continuous recorder setup was inside the project area according to CPRA standard operation procedures (Folse et al. 2012). 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 marsh well station was inactivated and replaced by an open-water recorder in February 2010 in order to acquire more comparable data.

Data Analysis Methods for Water Level:

Assessment of the entire project's impacts is not feasible because full continuous monitoring started only after seven of the water control structures had already been built. The 2007 OM&M Report (Lear et al.) 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. Due to these factors, data presented in the 2010 OM&M Report (Lear et al.) was not as extensive as the 2007 report.

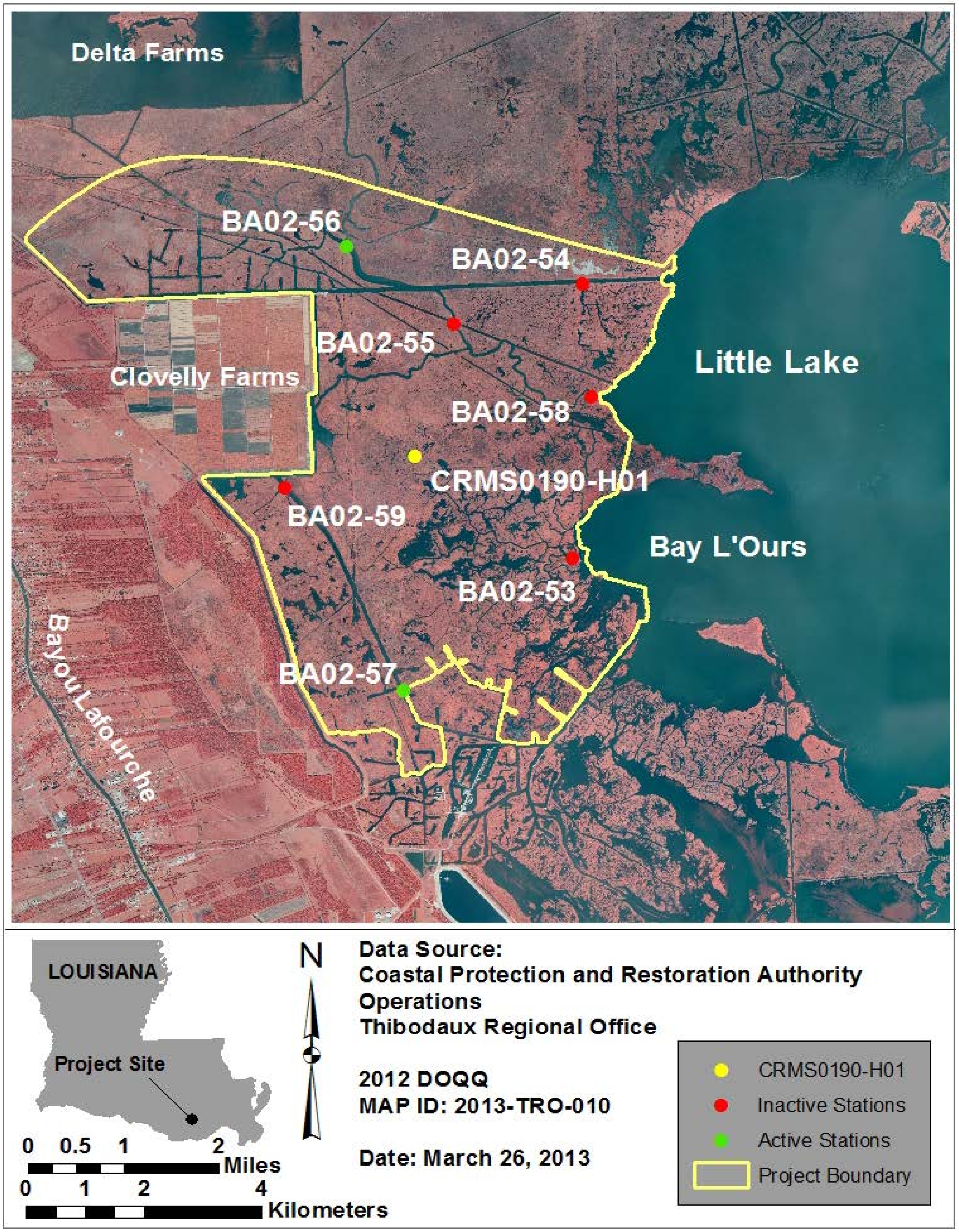

Figure 6. The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project continuous recorder station locations and CRMS0190 continuous recorder station.

Data collected from the two remaining project-specific continuous recorders (BA02-56 and BA02-57), as well as CRMS0190-H01 are presented in figures 7-10. The continuous recorder setup as well as the staff gauge at BA02-56 was completely destroyed by hurricane Isaac. The entire station was replaced, however water level data beyond July 25th 2012 is not corrected to datum. Not all of the CRMS-*Wetlands* stations were established at the same time therefore some do 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 CPRA database for analysis.

In this report the water level data from the two project-specific continuous recorder stations and CRMS0190-H01 were analyzed using several different approaches. The hourly readings were used to get overall means, minimums, and maximums using functions in Microsoft® Excel 2010. The daily means were also analyzed utilizing SAS© Version 9.1.3 and are presented in this report. For CRMS-*Wetlands* data, the Hydrologic Index (HI) score was determined for project, basin, and coast wide scales.

The HI score was developed by CRMS analytical teams based upon parameters collected at CRMS sites from 2006 through 2009 across the Louisiana coast from which they developed a baseline distribution. The index was designed to help better understand the condition of coastal wetlands at various time and spatial scales. A site was classified as good (green) if it's score was greater than 75% of all CRMS site scores calculated during this baseline period, fair (yellow) if it fell within the 25% to 75% range, and poor (red) if did not exceed 25%. The HI score is calculated by year, and requires greater than 70% data completeness for a particular year in order to obtain a score. CRMS0190 has only two years, 2011 and 2012, where the data completeness threshold is met because the open water recorder was not established until late February 2010.

<u>Water Level Results and Discussions</u>

Project Specific Results:

Analysis of all available hourly water level data indicates that the northernmost station (BA02-56) had water elevations which ranged from -0.72 ft (-0.22 m) to 3.94 ft (1.20 m) NAVD 88 (table 3). The average marsh elevation in the vicinity of this station was documented at 1.16 ft (0.35 m) NAVD 88. Since the mean water levels were around 1.10 ft (0.34 m), the marshes in this area were not continuously flooded. For BA02-57, the southernmost station, water elevations ranged from -0.86 ft (-0.26) to 5.95 ft (1.81 m). The average marsh elevation in the vicinity of this station was documented at 0.83 ft (0.25 m) NAVD 88. The mean water levels were around 0.98 ft (0.30 m), which also indicates that the marshes were not continuously flooded in this area. CRMS0190-H01, which is centrally located in the project area, experienced water elevations which ranged from -0.86 ft (-0.26 m) to 5.89 ft (1.80 m). The marsh in the vicinity of CRMS0190-H01 is a floating marsh therefore no average marsh elevation could be measured here.

Table 3. Mean, minimum, and maximum water levels to datum (NAVD 88) for continuous hydrographic stations inside the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project.

*Water Level to Datum (ft) NAVD 88			
	Mean	**Minimum**	**Maximum**
BA02-56	1.10	-0.72	3.94
BA02-57	0.98	-0.86	5.95
CRMS0190-H01	1.14	-0.86	5.89

*Note: Calculations are based upon all available hourly readings at each station through December 31, 2012. For complete date ranges for each recorder, see table 1.

Daily mean water levels are presented in figure 7 for all three continuous recorder stations inside the project area. In this analysis, calculations were made only for the date range where all three recorders had simultaneous data collection periods (February 26, 2010 through December 31, 2012). These daily means ranged from -0.43 ft (-0.13 m) (Jan 2011) to 3.72 ft (1.13 m) (Sep 2011) for BA02-56, from -0.67 ft (-0.20 m) (Dec 2010) to 4.61 ft (1.41 m) (Aug 2012) for BA02-57, and from -0.68 ft (-0.21 m) (Dec 2010) to 4.25 ft (1.30 m) (Aug 2012) for CRMS0190-H01.

CRMS Results:

An examination of CRMS0190 relative to all other CRMS-*Wetlands* sites with the same marsh type (intermediate) gives a brief glimpse of the hydrologic condition of the marsh for years 2011 and 2012 (figure 8). The HI score is important because it helps to assess the relationship of salinity and inundation to the vegetation productivity at a site. Both HI scores were much higher than the comparative sites and there was an increase in the score from 2011 to 2012.

A comparison of CRMS0190 to all other CRMS-*Wetlands* sites within the same basin (Barataria), and of the same marsh type is presented in figure 9 for years 2011 and 2012. Both HI scores are very high, falling into the fair and good categories respectively. CRMS0190 scores were higher than the other CRMS-*Wetlands* project sites and near to or above all reference sites. When CRMS0190 is compared to all CRMS-*Wetlands* sites within all marsh types in the Barataria basin (figure 10) for those same years, HI scores are equal to or above the other sites and they fall into the good and fair categories.

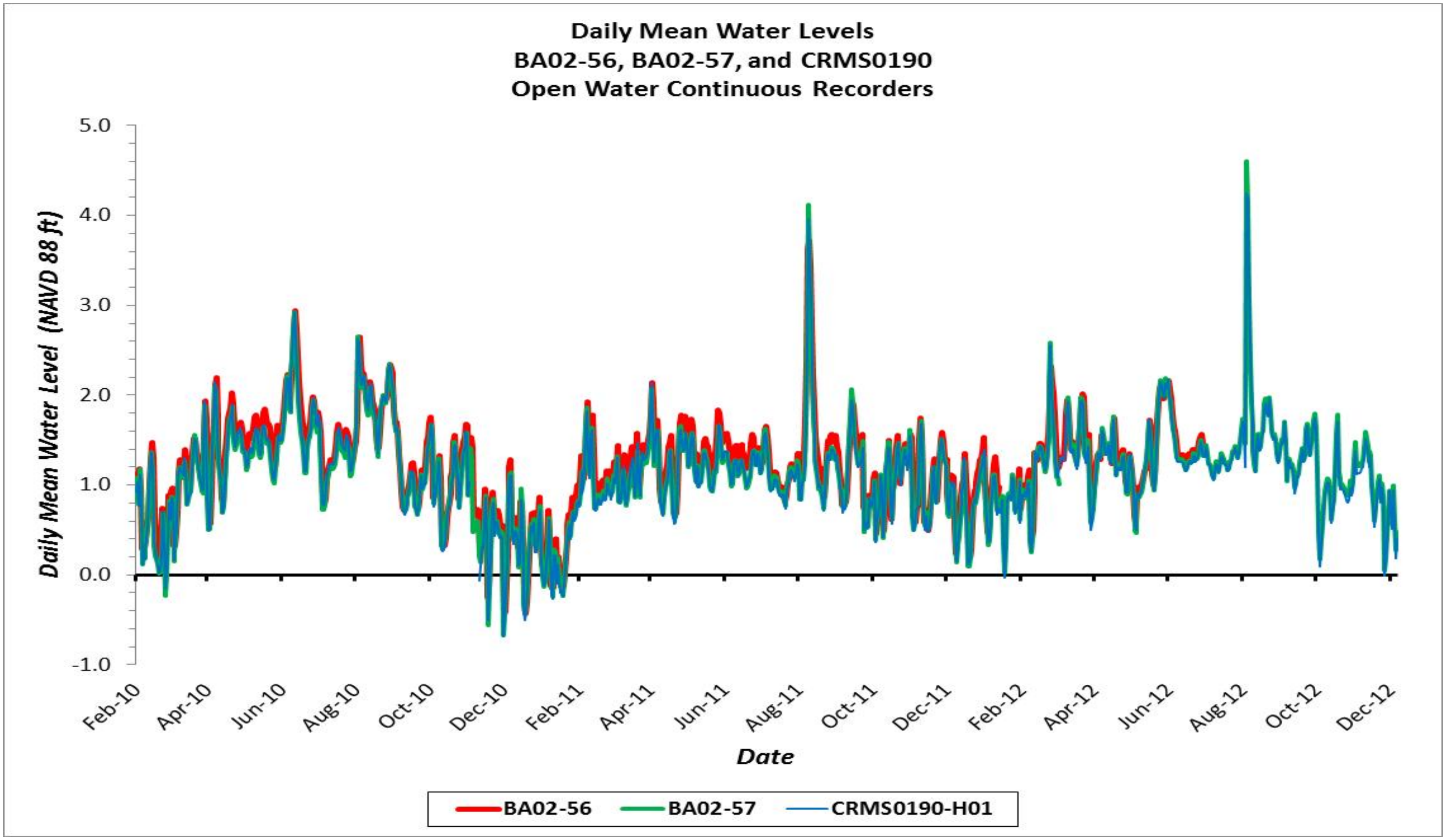

Figure 7. Mean daily water levels (NAVD 88 ft) inside the CRMS0190 1 km square and the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project area.

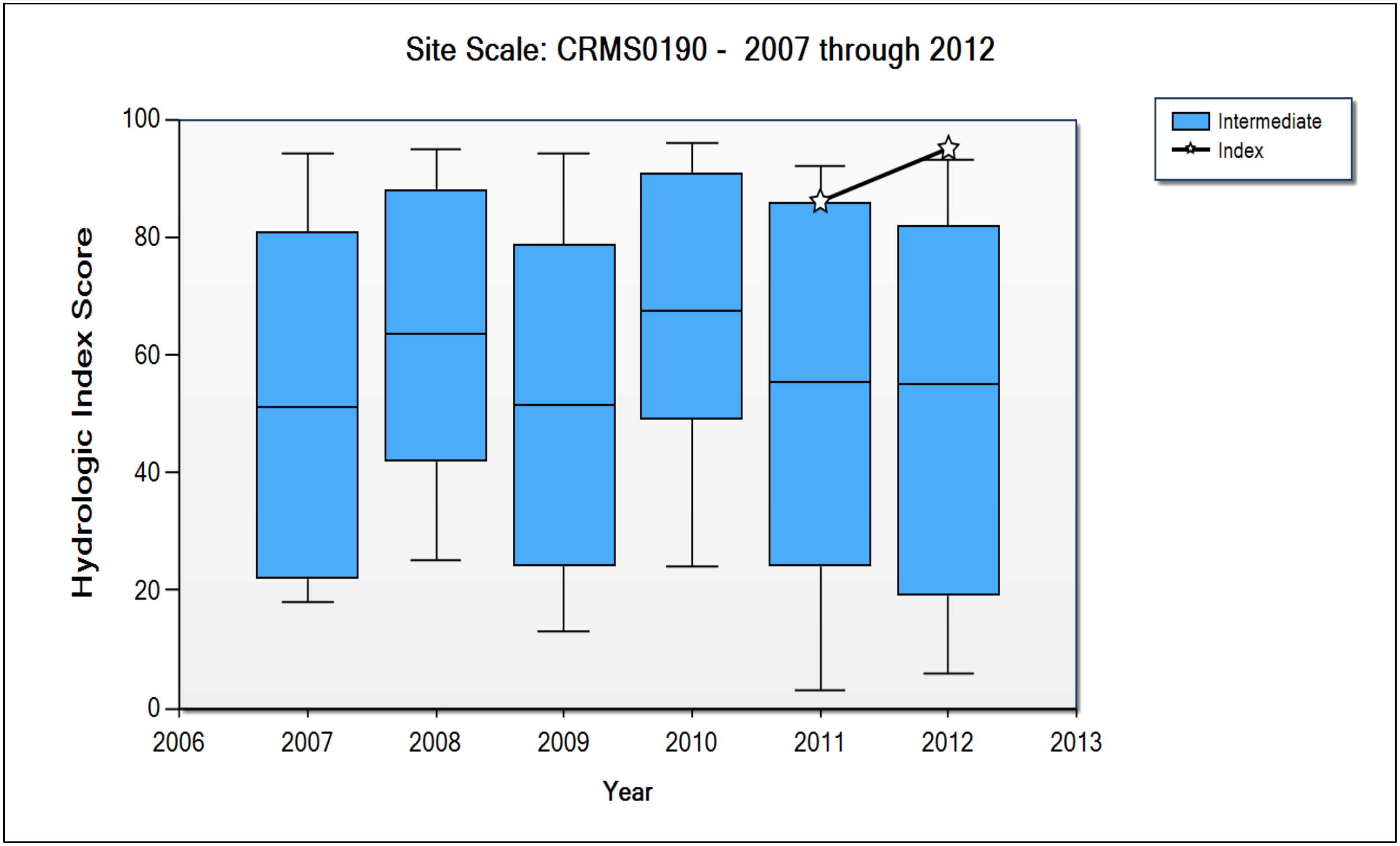

Figure 8. Time series chart of HI scores for CRMS0190 for years 2011 and 2012. HI Scores are represented along the trendline relative to the box plot of scores for all CRMS-*Wetlands* sites within the same marsh type (intermediate) for each year.

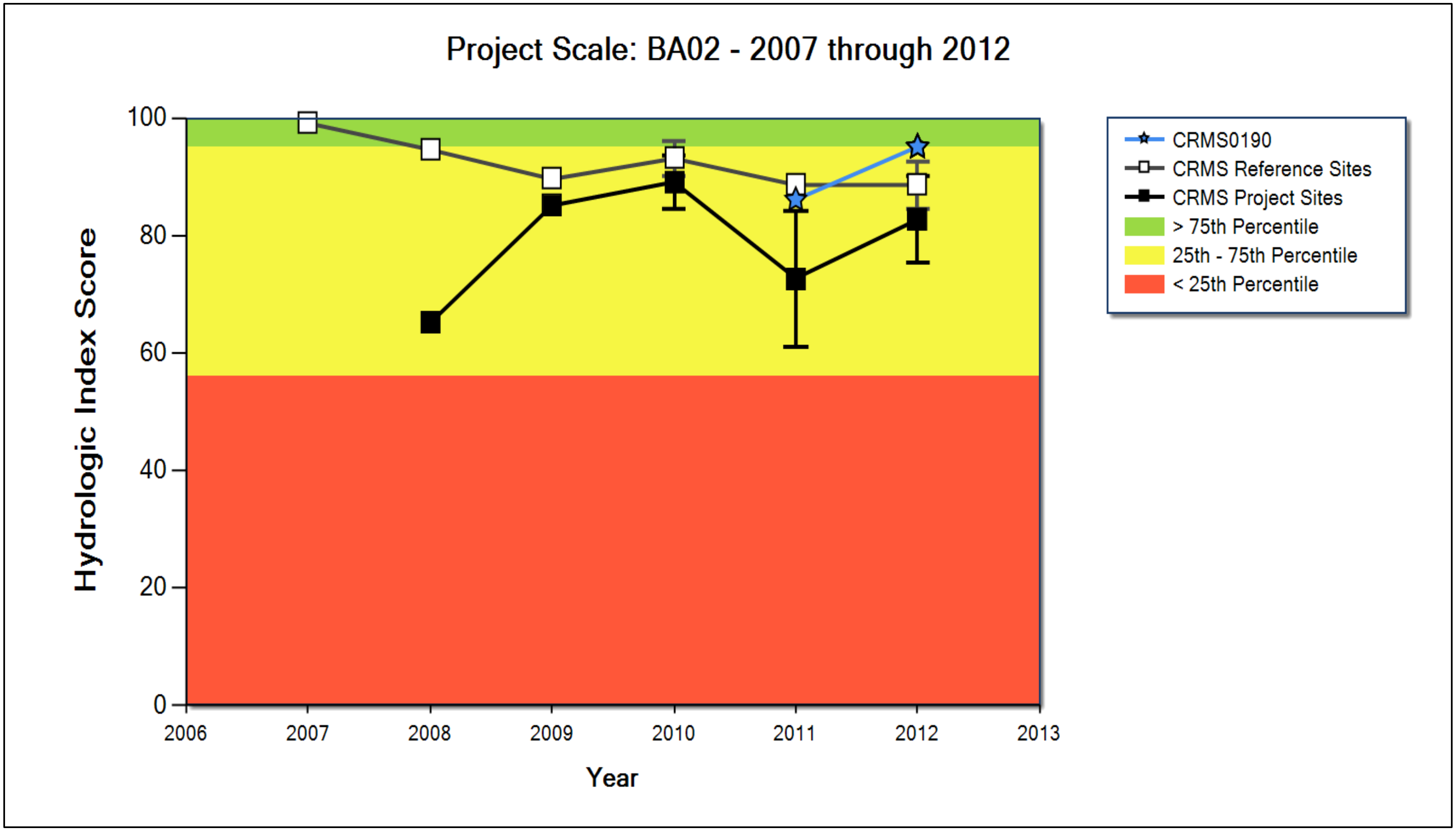

Figure 9. Hydrologic index (HI) scores comparing the CRMS0190 site to other CRMS-*Wetlands* intermediate marsh sites in the Barataria Basin over time [project (n=5) and reference (n=4)]. Note that the HI score for 2010 was not calculated for CRMS0190 because the data completeness did not exceed the 70% threshold.

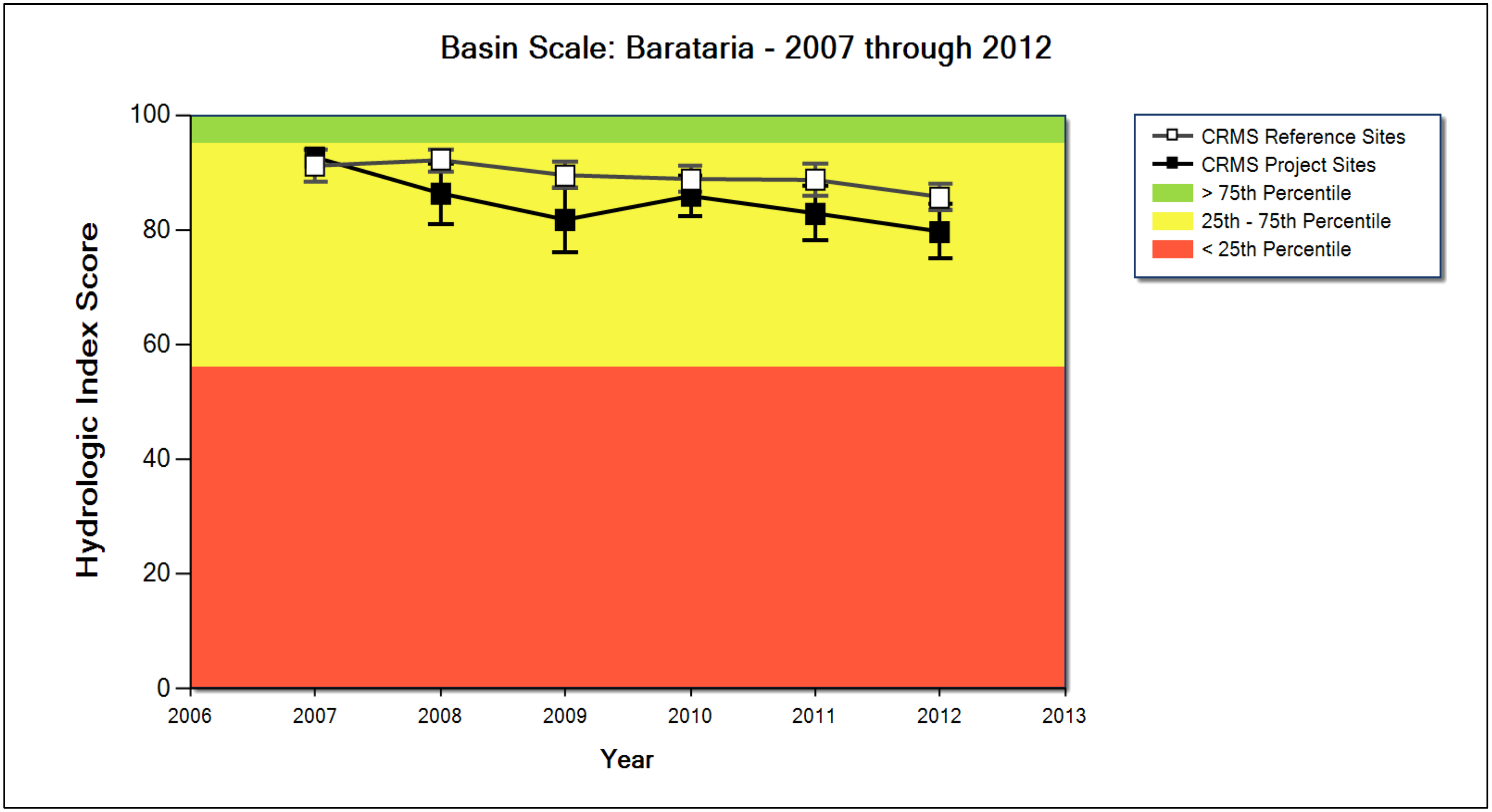

Figure 10. Hydrologic index (HI) scores for all CRMS-*Wetlands* sites within all marsh types within the Barataria Basin [project (n=17) and reference (n=35)] over time. The HI scores as seen in figure 9 for CRMS0190 are equal to or above these sites for 2011 and 2012 respectively.

The HI scores for all CRMS-*Wetlands* sites in the Barataria basin were compared to all CRMS-*Wetlands* sites throughout the Louisiana coastal zone (figure 11). The basin scores were consistently higher than those coastwide.

In order to examine whether the project is meeting the goal of reducing water level variability, analysis was performed on a combination of project-specific and project and reference CRMS-*Wetlands* stations. Figure 12 shows an analysis of water level elevation data from the 1st of January to the 11th of February in 2011 at station BA02-56. This analysis clearly identifies high (in red) and low (in blue) tides for each cycle; cycles greater than 15 hours in length are excluded. 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 that particular maximum; i.e., tidal range is the high tide elevation minus the following low tide elevation.

Previous analyses showed that project sites have a significantly lower tidal range than do reference sites (Lear et al. 2010). Comparison of the monthly mean tidal range for the January 1, 2011-2013 period suggests that reference sites (dashed lines) tend to have comparably higher tidal ranges (figure 13). An analysis of variance supports this hypothesis, showing that, for this period, reference sites have a tidal range that is 0.1 ft. greater than project sites (F=306.9, $P<2.2\times10^{-16}$). This is also illustrated in figure 14 which shows that two of the three project sites have the lowest tidal range, and the remaining project site has a range slightly less than average. 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 preconstruction data at reference CRMS sites.

Thus, this analysis is consistent with the hypothesis that the project has had an impact on lowering water level variability. As shown previously, a comparison of project sites to reference sites for the January 1, 2011-2013 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.

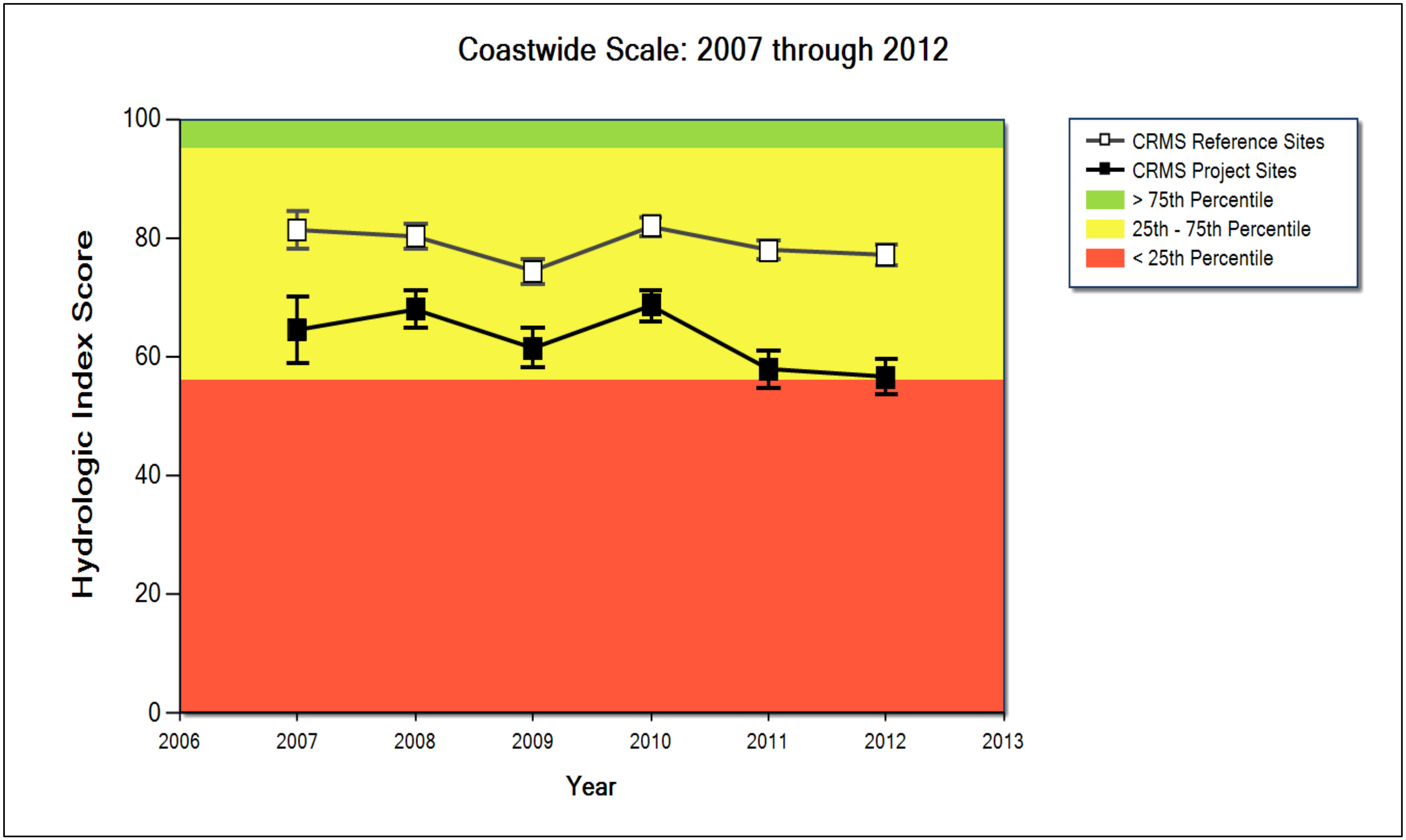

Figure 11. Hydrologic index (HI) scores for all CRMS sites in coastal Louisiana [project (n=123) and reference (n=211)] over time. Note that the HI scores for the Barataria Basin are slightly higher than the coastwide averages.

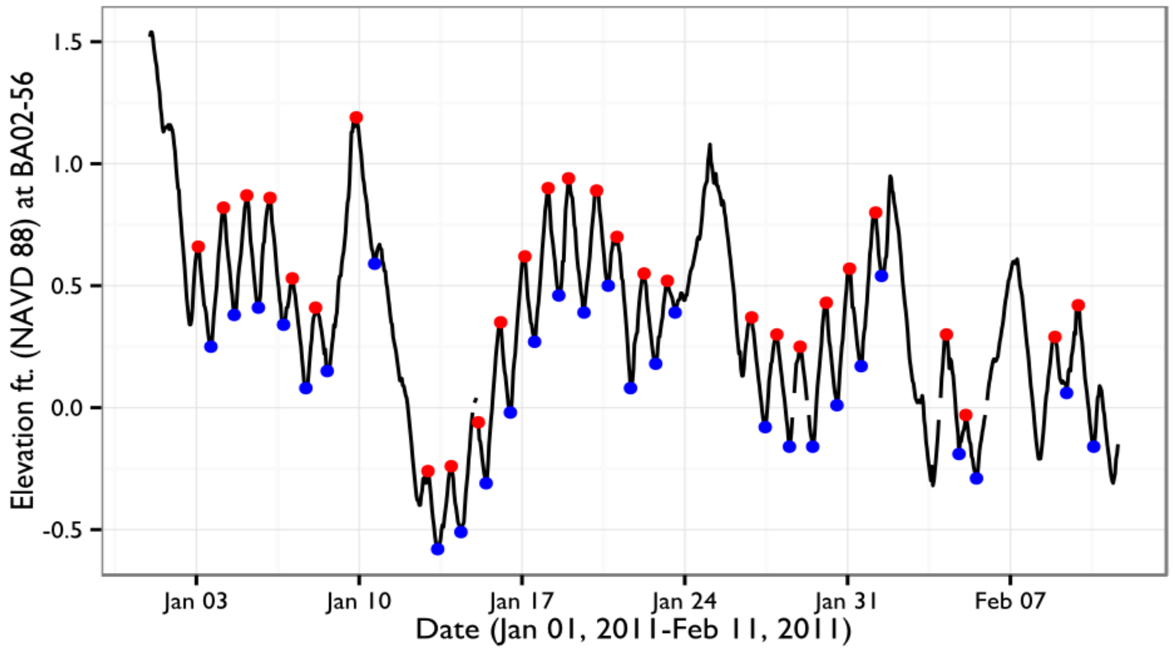

Figure 12. Hourly water levels at BA02-56 and the identified high (red points) and low (blue points) tides.

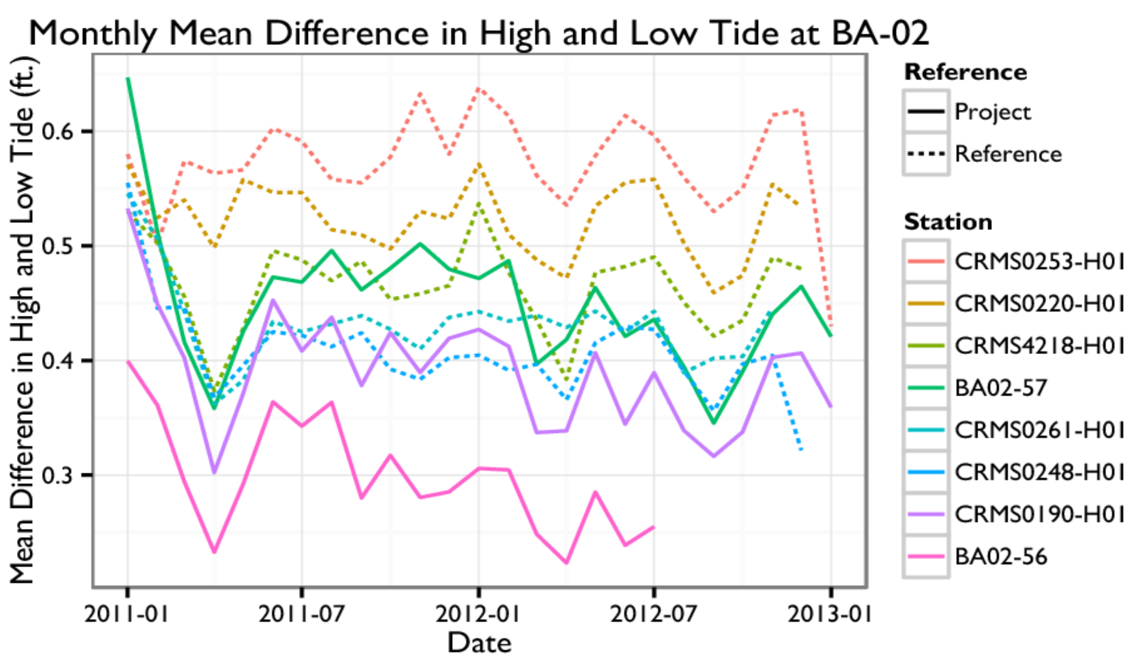

Figure 13. Weekly mean difference in high and low tides for BA-02 project and reference stations (see station location map in figure 4).

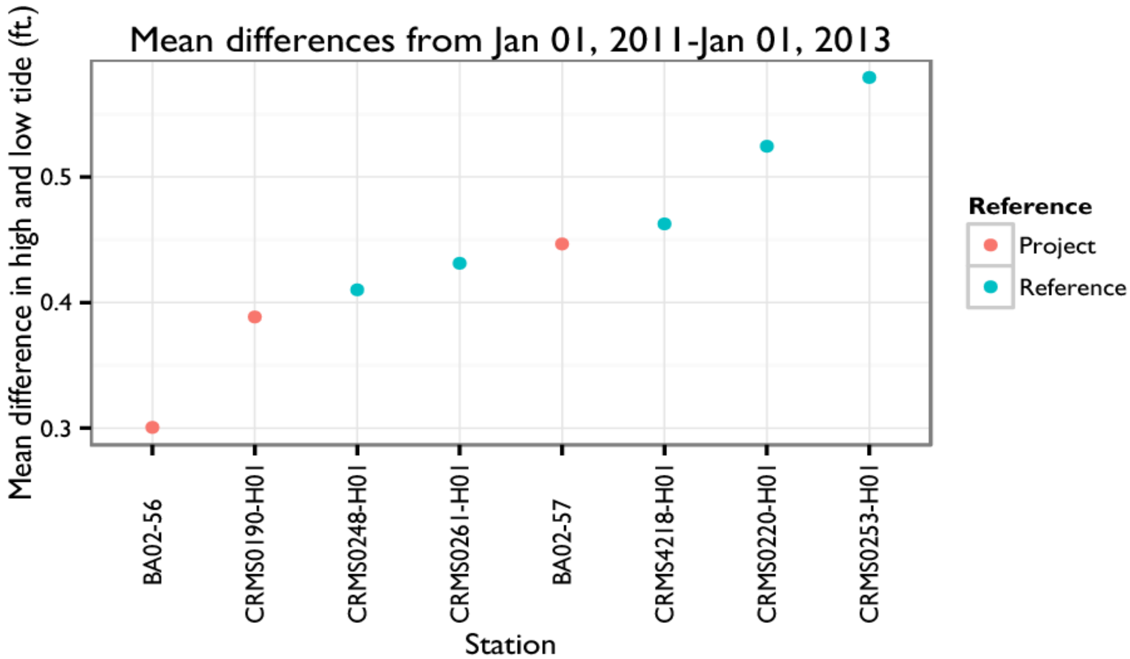

Figure 14. Overall means of difference in high and low tides for the BA-02 project.

Salinity

A location map of the discrete salinity stations for the BA-02 project and reference areas is located in Appendix C, figure 4.

The same continuous recorder equipment and stations used to collect water level data were used to collect continuous salinity data (table 2).

Data Analysis Methods for Salinity:

Analysis was performed on discrete salinity data colleted from January 1993 through January 2004. Discrete salinity data collection was discontinued in January 2004 due to recommendations based upon the CRMS-*Wetlands* project review. All field data were entered to an electronic format where LDNR/CRD personnel followed quality assurance/quality control (QA/QC) procedures prior to data analysis as stated in Folse and West (2005).

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 the two remaining project-specific stations as well as CRMS0190. Data analysis methods for salinity in this report were conducted in the same manner as that used for water level. The hourly readings were used to get overall means, minimums, and maximums using functions in Microsoft® Excel 2010. The daily means were also analyzed utilizing SAS© Version 9.1.3 and are presented in this report.

Salinity Results and Discussions

Project Specific Data:

Discrete salinity data for pre-construction, partial construction (phase 1) and post-construction (phase 2) are graphed in figure 15. The graphic depicts the mean bottom salinity readings for each time period. Of the fifty-two (52) stations, only nine (9) stations had data for all three time periods, and those nine were in the project area. Results show that five (5) stations during the pre-construction time period (n=21) had a mean of less than 0.5 ppt, which is the salinity concentration for freshwater marshes. All stations during the partial and post-construction time period (n=27-34 and 18-24, respectively) had a mean salinity (2.1-4.0 ppt) in the oligohaline marsh type, which is 0.5-5.0 ppt. The higher mean salinity readings were attributed to stations spatially distributed closest to Little Lake while the lower salinity stations were farthest away in the northwest portion of the project area.

Analysis of all available hourly adjusted salinity data indicates that all three continuous recorders inside of the project area had mean salinities within the normal range for a healthy intermediate marsh community (table 4). The southernmost station (BA02-57) had a higher mean adjusted salinity than BA02-56 in the north of the project and CRMS0190 in the center of the project. This is due to the greater tidal influences in the southern reaches of the project.

Table 4. Mean, minimum, and maximum adjusted salinities (ppt) for continuous hydrographic stations inside the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project.

Adjusted Salinity (ppt)			
	Mean	**Minimum**	**Maximum**
BA02-56	1.96	0.14	20.71
BA02-57	2.82	0.2	17.78
CRMS0190-H01	1.37	0.2	6.52

*Note: Calculations are based upon all available hourly readings at each station through December 31, 2012. For complete date ranges for each recorder, see table 2.

Daily mean adjusted salinities are presented in figure 16 for all three continuous recorder stations inside the project area. In this analysis, calculations were made only for the date range where all three recorders had simultaneous data collection periods (February 26, 2010 through December 31, 2012). This is a much smaller data set compared to the previous one using hourly means analysis. BA02-57 generally experienced the highest daily mean adjusted salinity of 2.30 ppt and a range of 0.36 ppt to 7.76 ppt. BA02-56 and CRMS0190 had the same daily mean adjusted salinity at 1.37 ppt. The range for BA02-56 was 0.25 ppt to 8.14 ppt, while CRMS0190 experienced a range of 0.24 ppt to 7.76 ppt. Salinities spiked in the spring and fall for all stations, particularly during the spring of 2011. Though salinities spiked above 7 ppt the yearly means at all three stations remained below 3 ppt.

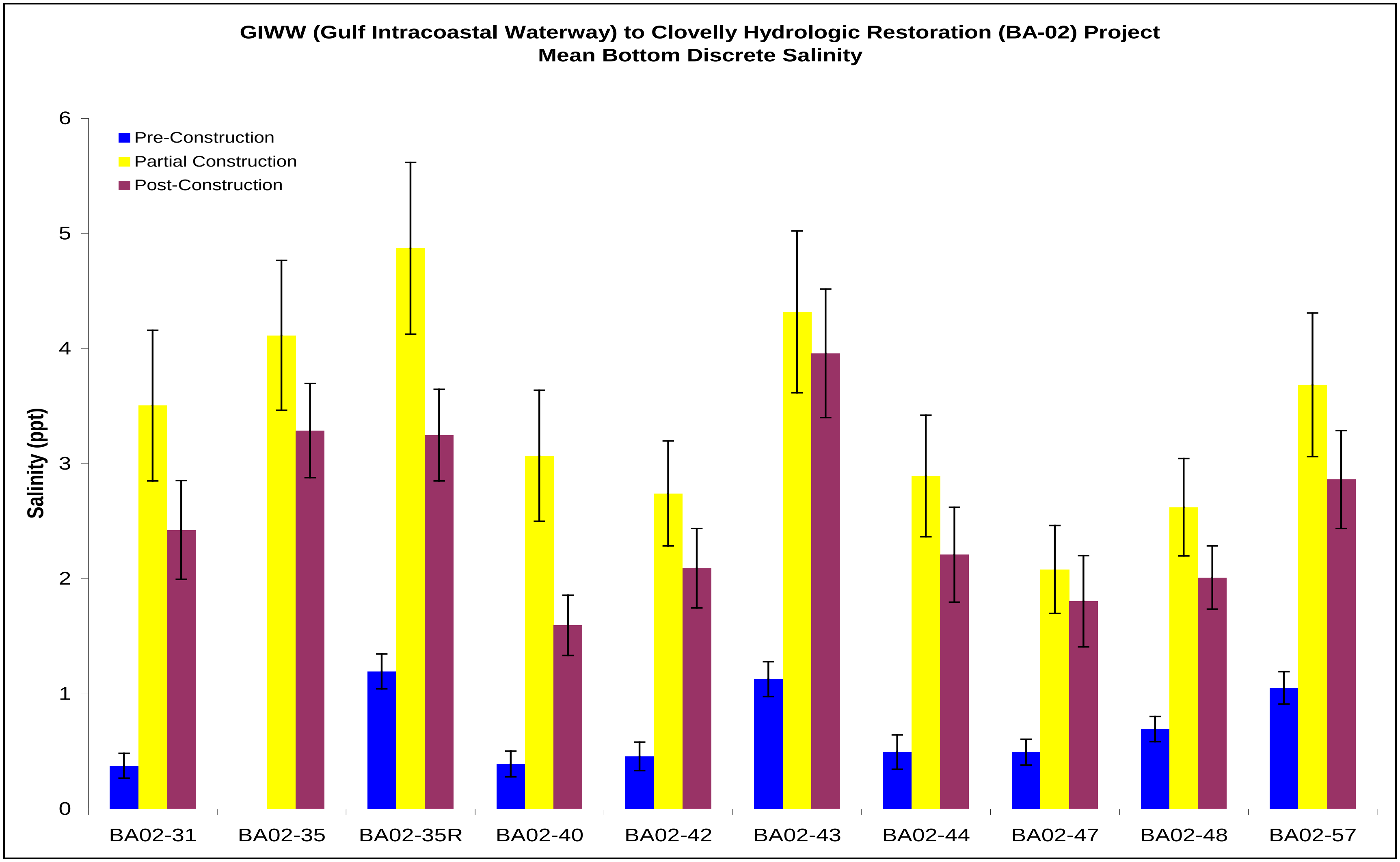

Figure 15. Mean monthly discrete data from pre-construction, partial construction, and post-construction time periods for the BA-02 project.

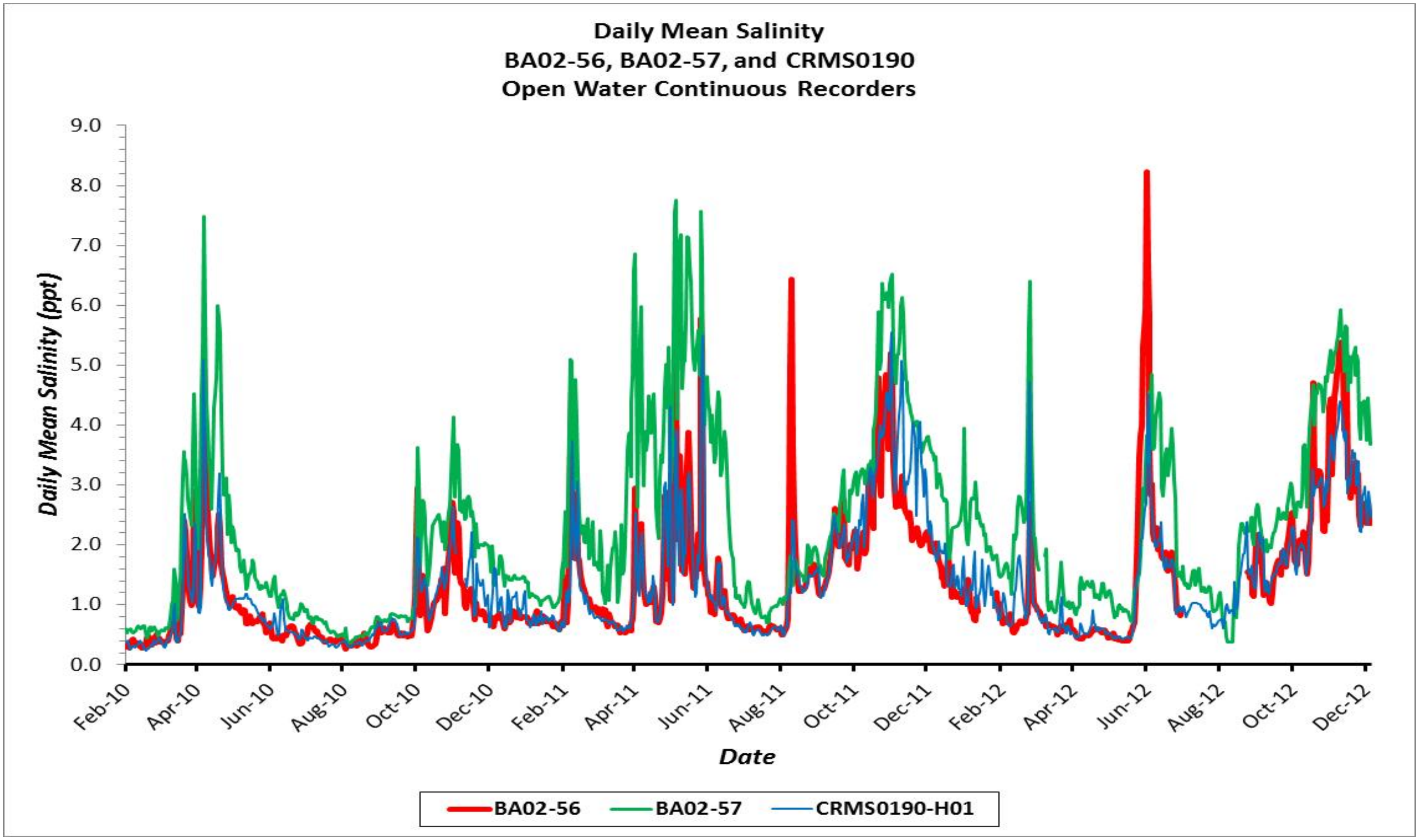

Figure 16. Mean daily salinities inside the CRMS0190 1 km square and the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project area.

Vegetation

Project-specific vegetation data were collected during the fall of 1996, 1999, 2000, 2002, 2005, 2008, and 2012 (figure 17). Each sampling station was marked with a PVC pole at the southeast corner to mark the plot which allows for data collection on repeated 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 repeated 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. 2012). 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 CRMS0190, vegetation data were collected during the fall of 2006, 2007, 2008, 2009, 2010, 2011, and 2012 (figure 3) inside a 200 m^2 data collection area (DCA) within the 1 km^2 site. As with all CRMS-*Wetlands* sites, CRMS0190 has 10 vegetation stations located along a transect which runs diagonally inside the 200 m^2 DCA. This site is an oligohaline spikerush marsh community type (Visser et al. 1998). Data collection 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 the 256.2 ft x 256.2 ft (200 m x 200 m) CRMS site (Folse et al. 2012) in the same manner as described for project-specific vegetation plots. In addition, vegetation data was collected from CRMS-*Wetlands* sites outside the project area (figure 4).

Data Analysis Methods for Vegetation:

The project-specific and project CRMS data were entered into an electronic format where CPRA/TRO personnel followed Quality Assurance/Quality Control (QA/QC) procedures prior to data analysis as stated in Folse et al. (2012) and then analyzed for mean cover, species composition, and Florisitc Quality Index (FQI) following methods described in Cretini et al. (2009). Salinity categories were assigned to the vegetation data based upon what marsh type the individual species were most commonly found. Categories included fresh, intermediate, brackish, and saline, as well as transitional categories such as fresh-intermediate, intermediate-brackish, and brackish-saline using Visser classifications. Seven years of vegetation cover and composition data from the BA-02 project were used to determine the FQI over time for project stations as well as CRMS0190 inside the project area. In addition to mean cover, FQI, and salinity, a Vegetation Volume (VV) was calculated to provide not just the quality of the vegetation, but to get an idea of the productivity of the marsh.

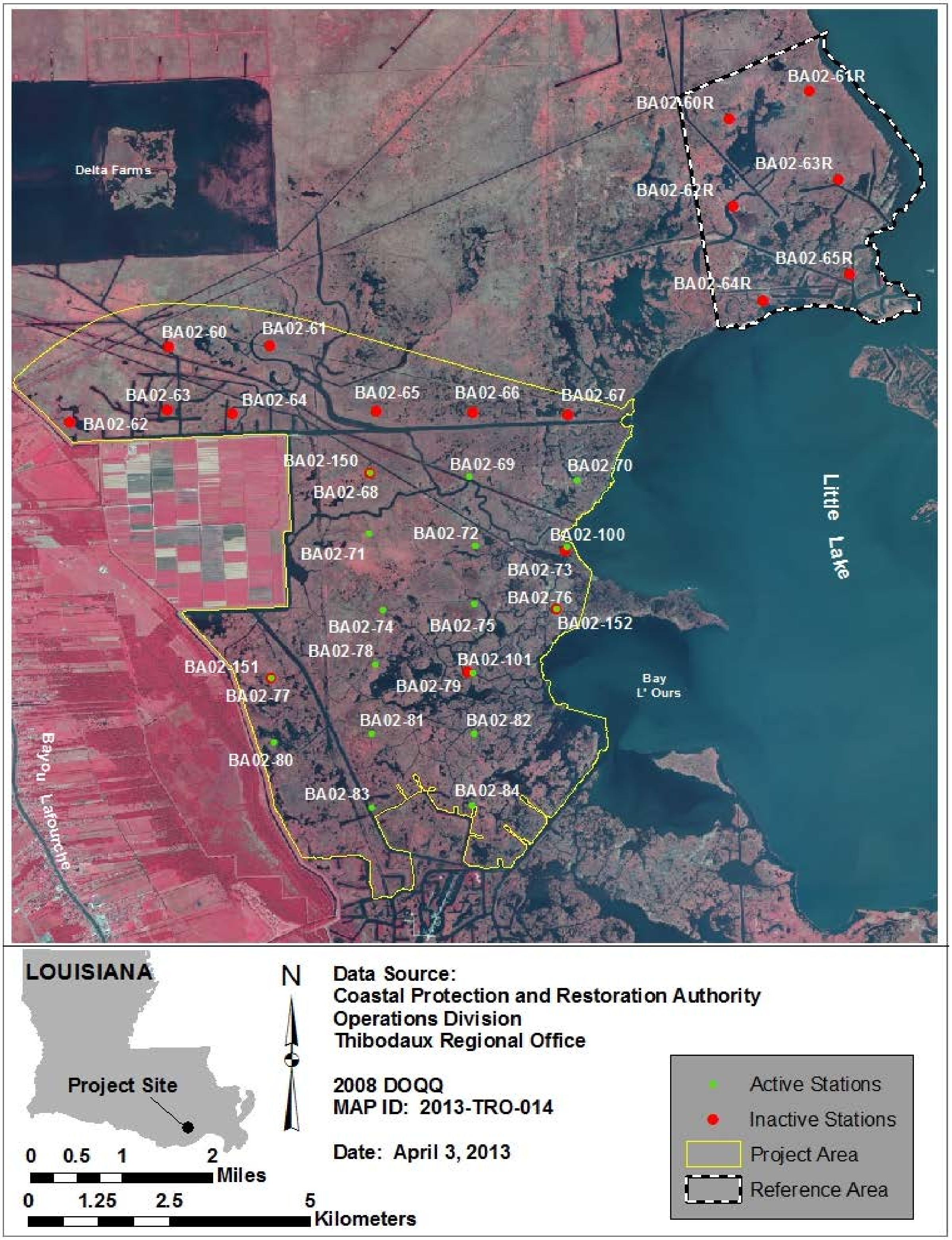

Figure 17. Project-specific vegetation and soils data collection stations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

FQI is not a metric which entirely captures the project's goal to increase or maintain the relative abundance of intermediate marsh plants. It is not intended as a definitive tool towards this goal, but it may add some depth to the information gleaned from mean cover, species composition, and Vegetation Volume (VV) data. 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.

The Vegetation Volume is used to quantify the volume of vegetation layers at project or CRMS marsh sites. Unlike the FQI, which is an indicator of quality, the VV is useful in determining if vegetation cover has been maintained, increased, or decreased throughout the years. The VV incorporates cover data as well as height data (m^3) at each vegetation layer (e.g. tree, shrub, herbaceous, carpet). To calculate the VV, the percent cover (m^2) and height (m) were multiplied for each of the four vegetative layers at a station. Then the layer volumes (m^3) were added together.

Data Analysis Methods for Project-Specific Vegetation:

The mean percent cover of selected species for stations within the BA-02 project and reference areas is presented in figure 18 as well as the FQI for each sample year. Reference areas selected to the north and northeast of the project boundary were eliminated due to land rights issues during late spring 1997. The FQI for each project-specific project and reference station by year was estimated using the Cretini and Steyer protocol (2011). The mean FQI for each sample year is indicated along with a trendline created from these values. Salinity categories

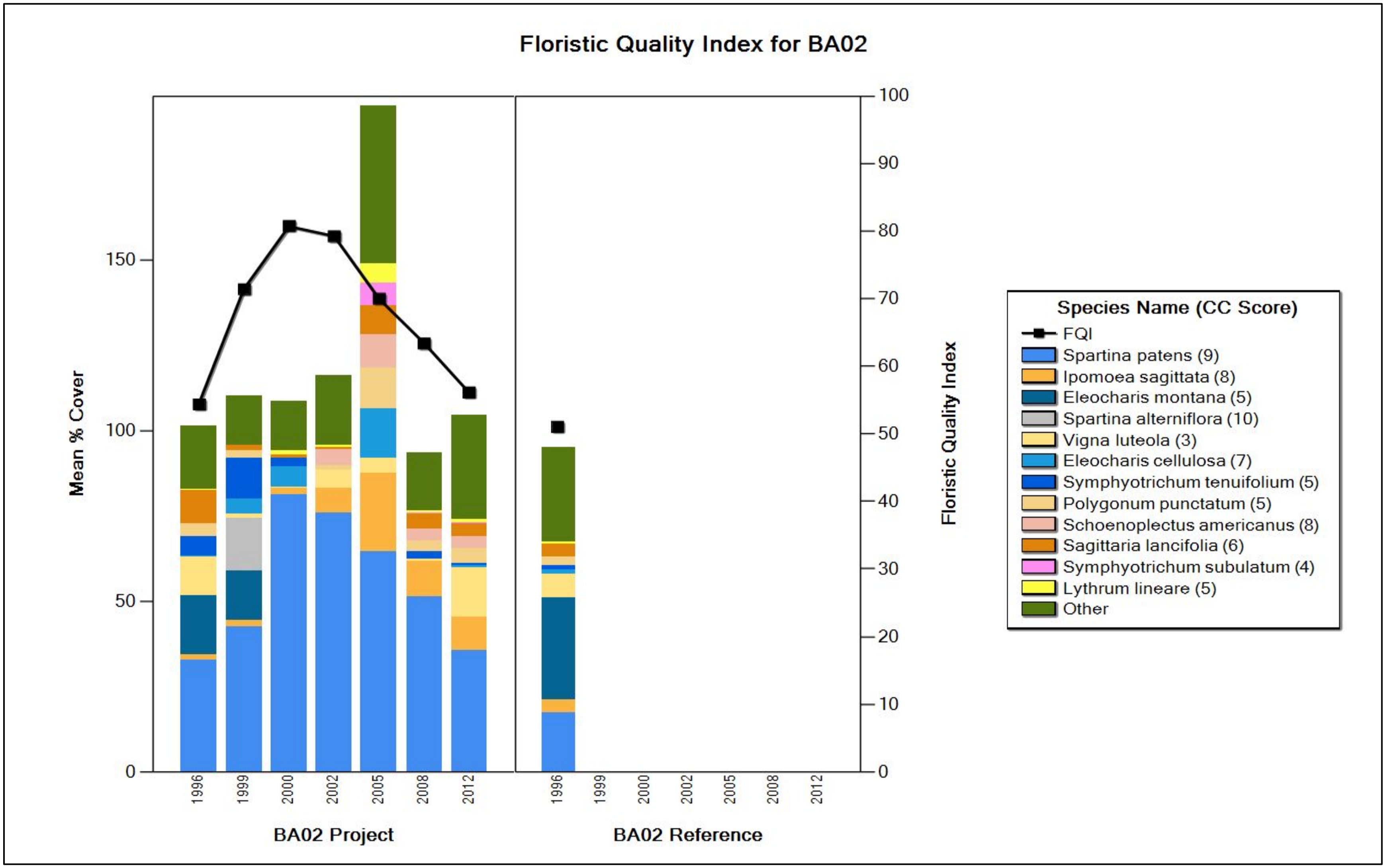

Figure 18. Project-specific mean percent cover for selected species by project and reference area by year. The yearly mean FQI scores are represented by the markers along the black trend line.

from Visser marsh vegetation types based upon mean cover of species as well as the VV for the project area were determined for each year of available data.

Project-Specific Vegetation Results and Discussions

Discussions pertaining to the analysis of vegetation cover within the project and reference areas include sampling years 1996, 1999, 2000, 2002, 2005, 2008, and 2012. Although the mean cover of the dominant species *S. patens* (Ait.) Muhl. (marshhay cordgrass) has dropped by 45% since construction, its cover value was still slightly higher in 2012 (twelve years post-construction) than in 1996 (four years pre-construction) when monitoring began (figure 18). Peak mean cover of this species occurred just prior to construction completion in 2000 after a steady increase which began in 1996. Mean cover values of *Sp. patens* have remained above those in 1996, with the highest values occurring post-construction. Species diversity varied throughout the years. The highest diversity occurred during preconstruction years 1996 and 1999 and the lowest occurred in 2002, two years post-construction. In 2005 data collection occurred two months after hurricane Katrina's landfall and diversity greatly increased as well as the mean cover of important intermediate marsh species such as *Spartina alterniflora* Loisel.(smooth cordgrass) and *Eleocharis* R. Br. (spikerush). Data collection in 2008 occurred approximately two months after hurricanes Rita and Ike and diversity remained high. Mean percent cover for drought intolerant species such as *Sagittaria lancifolia* L. (bulltongue) and *Polygonum punctatum* Ell. (dotted smartweed) increased by 2005 despite a severe drought which lasted from September 1999 through June 2001 in southeastern Louisiana.

The FQI and the mean cover follow a similar trend and appear to track each other between 1996 and 2012. This is because *S. patens*, the species with the greatest cover, has a high cc score and, therefore, has a large impact on the FQI value.

The breakdown of vegetation into salinity categories using mean cover values of species present provides an idea of how the project area marshes have fluctuated through the years (figure 19). In 1996, the project and reference areas were similar. Both contained predominately fresh to intermediate marsh types, as well as some intermediate-brackish marsh, and very little brackish-saline marsh. By the time of construction in 2000, the project marshes shifted to predominately intermediate-brackish, however by 2005 (five years post-construction) they were mainly fresh to intermediate with some intermediate-brackish. In 2008 the project area marshes were again predominately intermediate-brackish, however by 2012 they fluctuated again to more fresh and intermediate marsh types.

The VV within the BA-02 project area has declined since construction in 2000 (figure 20). In 2012 the VV was less than half of its pre-construction metric. There was a dramatic decrease in 2005 which points to possible effects from hurricane Katrina as well as other powerful tropical systems which impacted the area in the following years. A slight recovery occurred between 2008 and 2012. The VV and FQI followed a similar pattern.

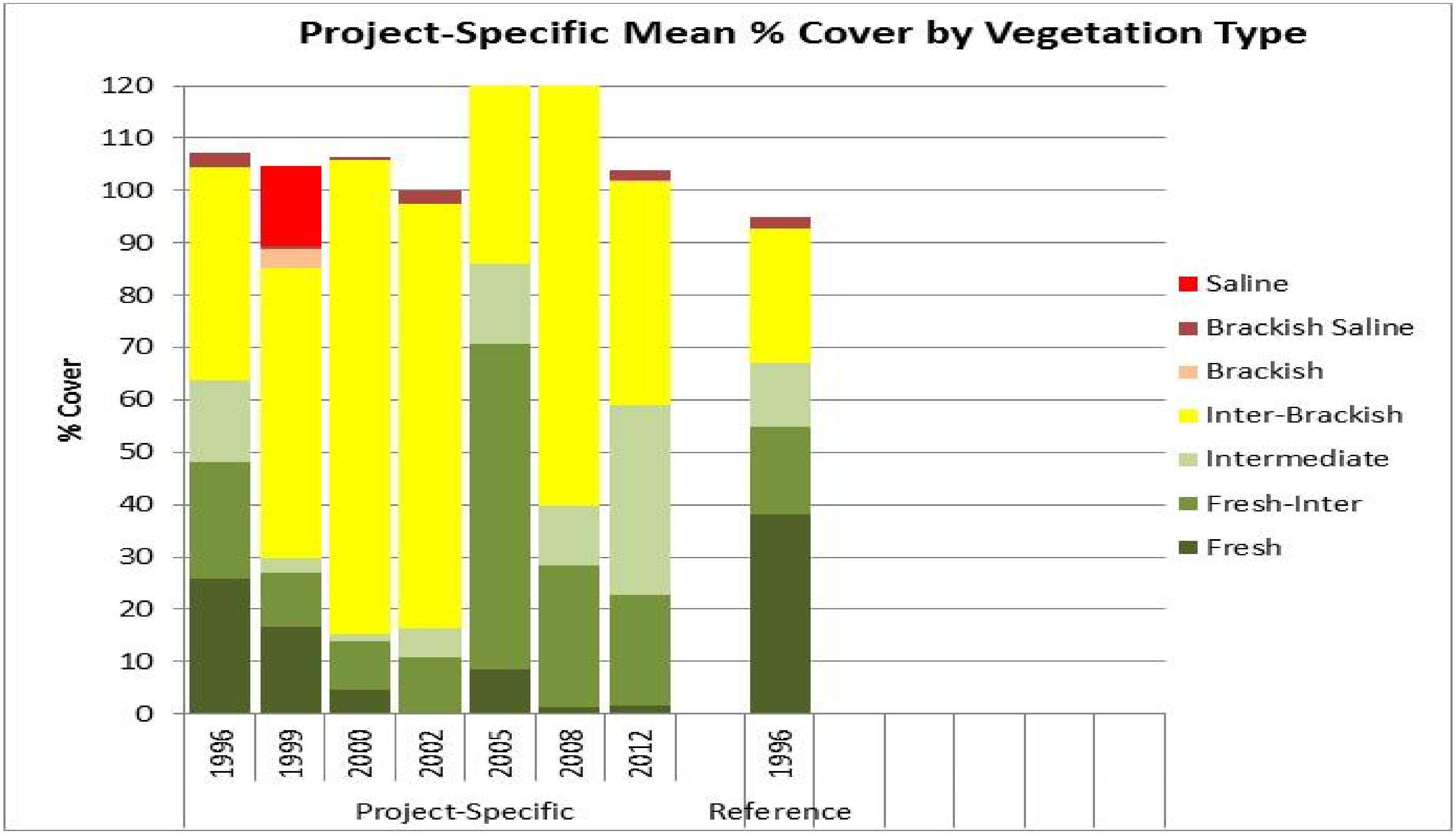

Figure 19. Distribution of salinity categories by sample year based upon mean percent cover of species found inside of $4m^2$ project-specific and project reference vegetation plots for the BA-02 project.

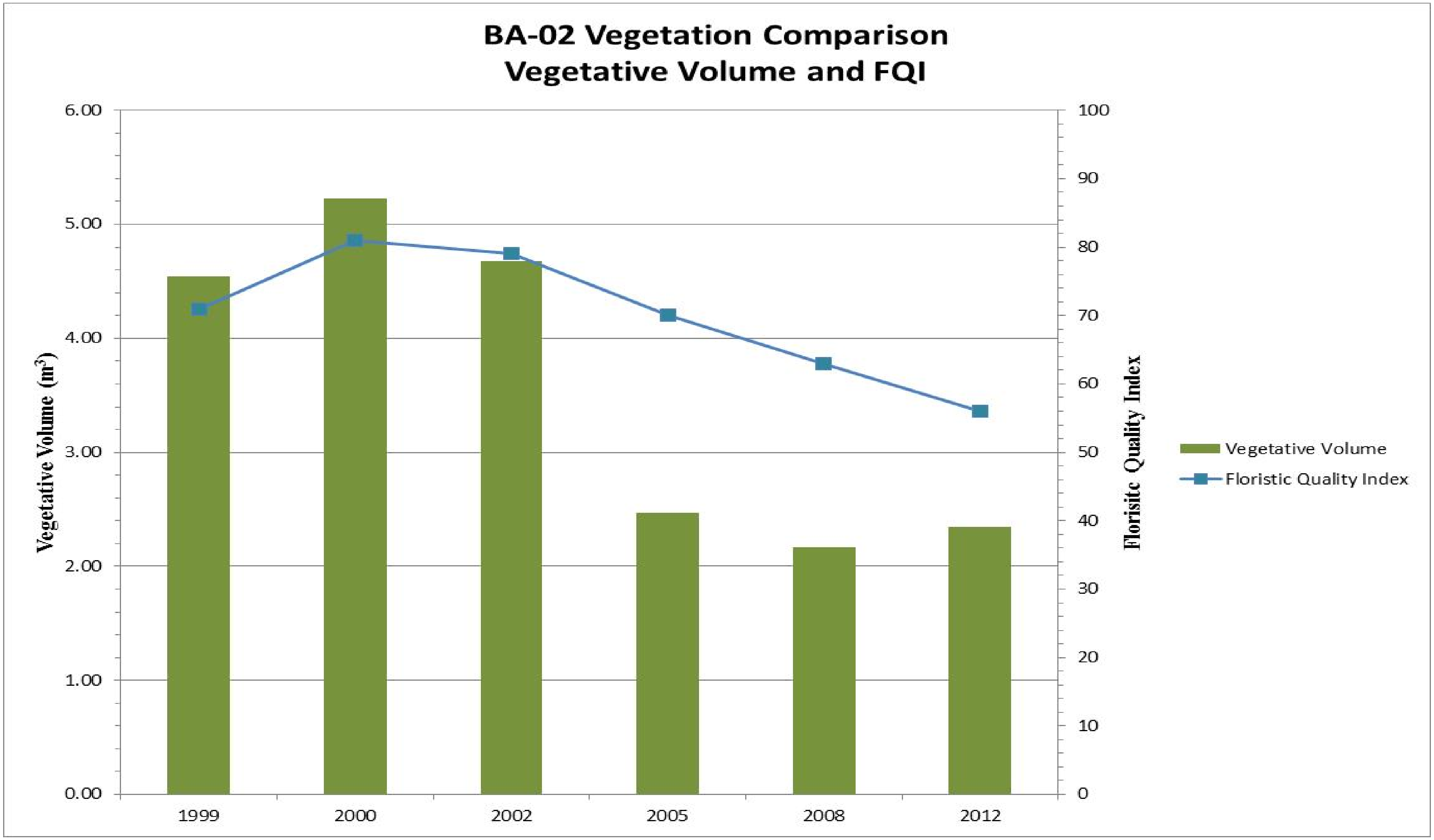

Figure 20. Vegetative Volume (VV) and FQI by year for the project-specific vegetation stations inside of the BA-02 project.

Data Analysis Methods for CRMS Vegetation:

For the project and reference CRMS sites, the data were entered into an electronic format where CPRA/TRO personnel followed QA/QC procedures and saved to the Louisiana Department of Natural Resources (LDNR) database prior to data analysis as stated in Folse et al. (2012). The charting tool from the CRMS website, based upon the Cretini and Steyer protocol (2011) was utilized to determine mean percent cover, species composition, and FQI within these sites for each year of data collection. As with the project-specific analysis, salinity categories were assigned to the CRMS vegetation data based upon what marsh type the individual species were most commonly found.

CRMS Vegetation Results and Discussions

Within the project CRMS site (CRMS0190) there has been an overall downward trend from 2006-2012 for the mean percent cover and the FQI with some variations in between (Figures 21 & 22). Peak mean percent cover occurred in 2007 while the lowest cover occurred in 2011, though it rebounded in 2012. FQI followed the same trend as the mean percent cover for the dominant species, *S. patens*. Despite this trend, and with the exception of year 2011, all years have fallen within the good and fair categories for wetland quality when comparing the project CRMS site to all other CRMS sites within the same vegetation (intermediate marsh) type and hydrologic basin (Barataria) (figure 23).

The CRMS0190 scores are similar to basin-wide FQI scores from 2006 to 2009 when all Barataria Basin CRMS-*Wetlands* sites, which encompass all vegetation types are included in FQI determinations (figure 24). The CRMS0190 scores fall below the basin-wide scores from 2010 to 2012, however all scores fall within the good to fair categories with the exception of year 2011.

Whenever CRMS0190 FQI scores are compared to all CRMS-*Wetlands* sites within the entire Louisiana coastal zone, all scores are higher or equal to the coast-wide scores with the exception of year 2011 (figure 25).

Mean cover and FQI were calculated for five reference CRMS-*Wetlands* sites outside the project area (figure 26). Three of the sites were not established until 2007. As with the project site, *S. patens* was the dominant species. Of the five stations, CRMS0248 and CRMS0253 had some of the highest FQI scores due mainly to the high cover values attributed to high value intermediate marsh species such as *S. patens* and *S. alterniflora.* Mean cover of *S. patens*, as well as FQI fluctuated throughout the years for all stations. By 2012 the project CRMS site as well as all of the reference sites, with the exception of CRMS0253, experienced an upswing in FQI. The upswing was more dramatic inside the project area at the CRMS0190 site. Interestingly, though the 2012 FQI for CRMS0190 was on the rebound, it was much lower than in 2006. Overall, the FQI either increased or slightly decreased between 2006 and 2012 for all the CRMS reference sites.

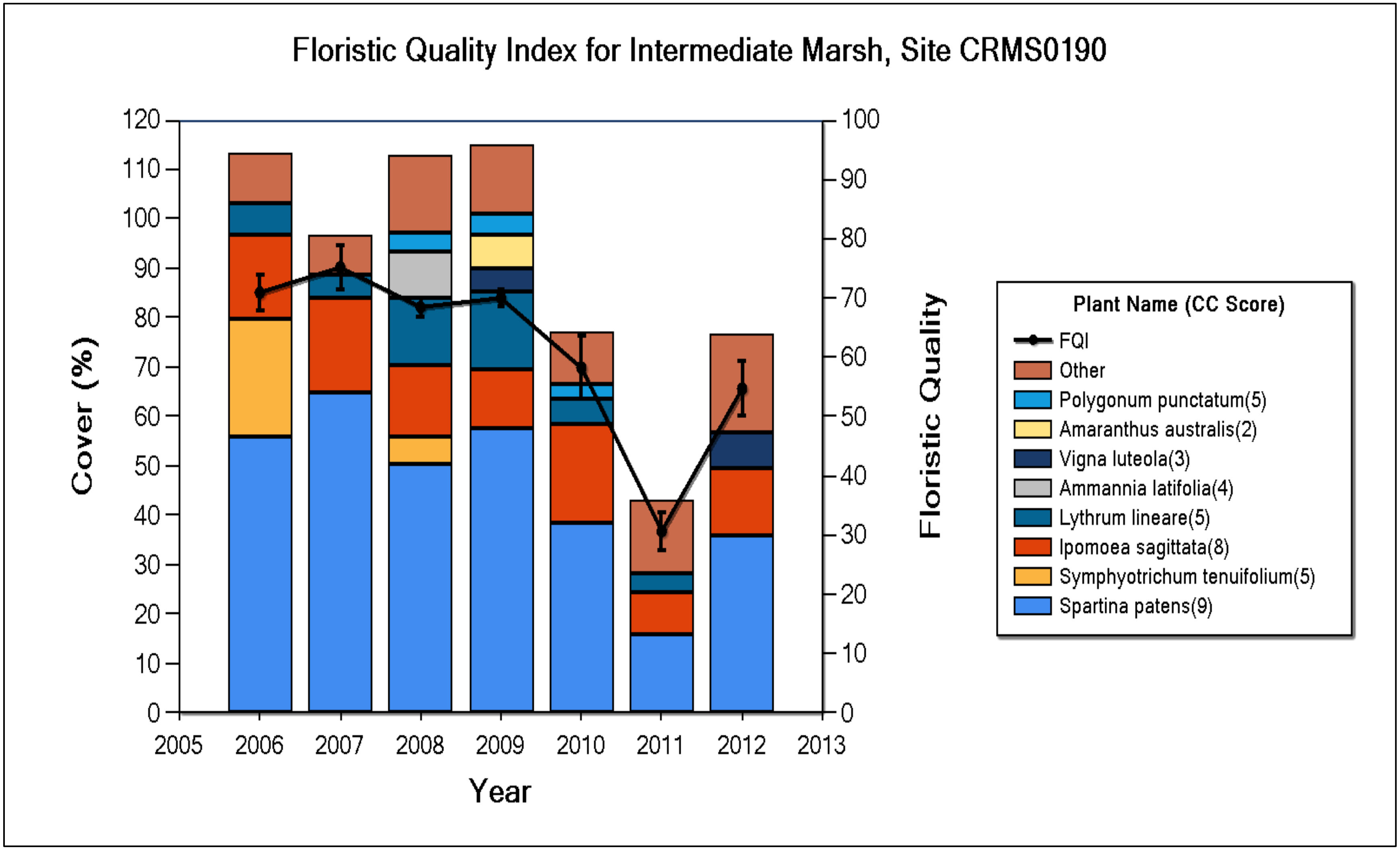

Figure 21. Mean percent cover for selected species at CRMS0190 by sample year. The mean FQI is represented for each year along the trendline.

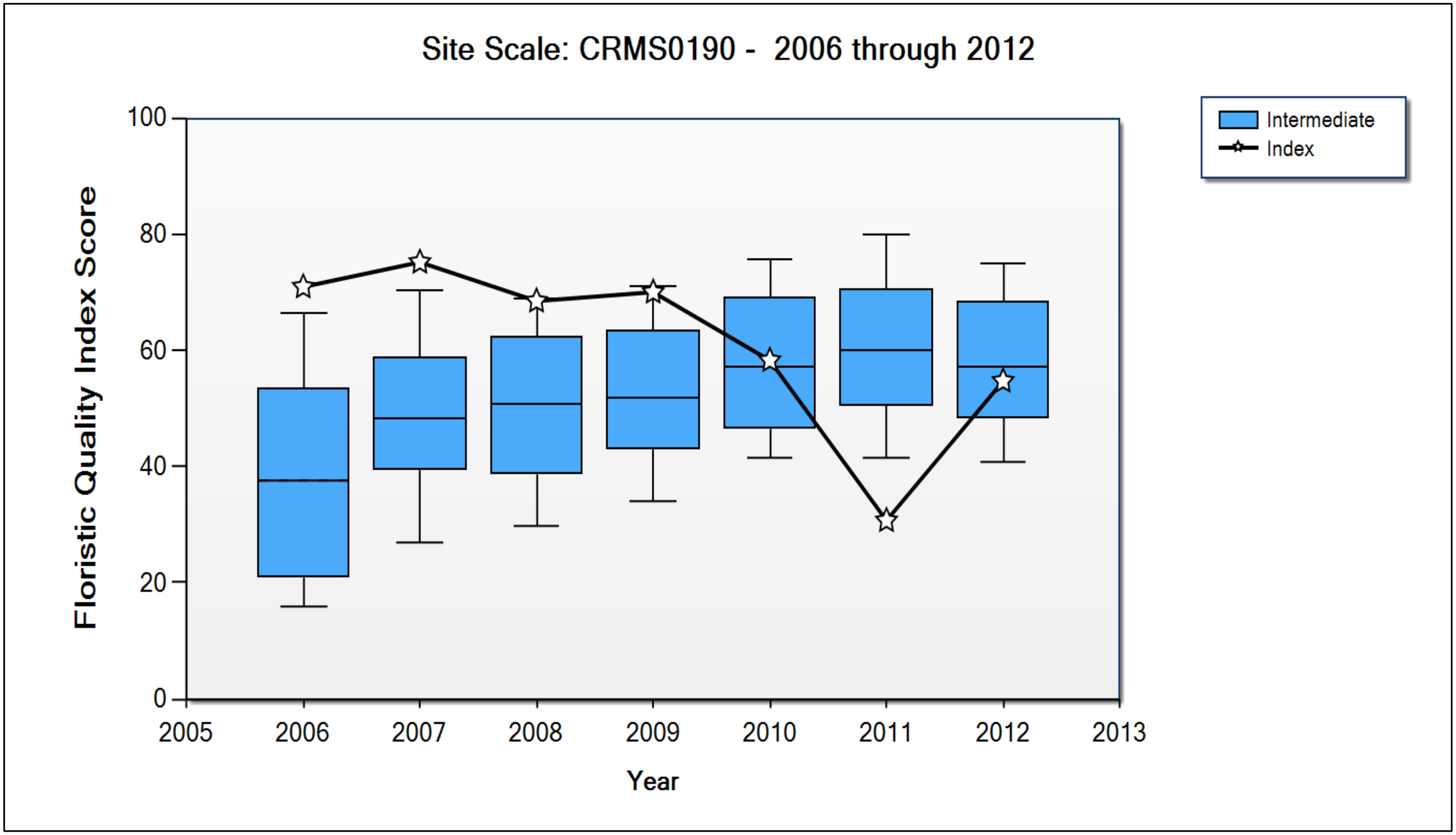

Figure 22. Time series chart of FQI scores for CRMS0190 indicating that it has been consistently characterized as an intermediate marsh. FQI Scores are represented along the trendline relative to a box plot of scores for all CRMS-*Wetlands* sites within the same marsh type for each year. Marsh type classification for each year was based upon the species composition at CRMS0190 at that year.

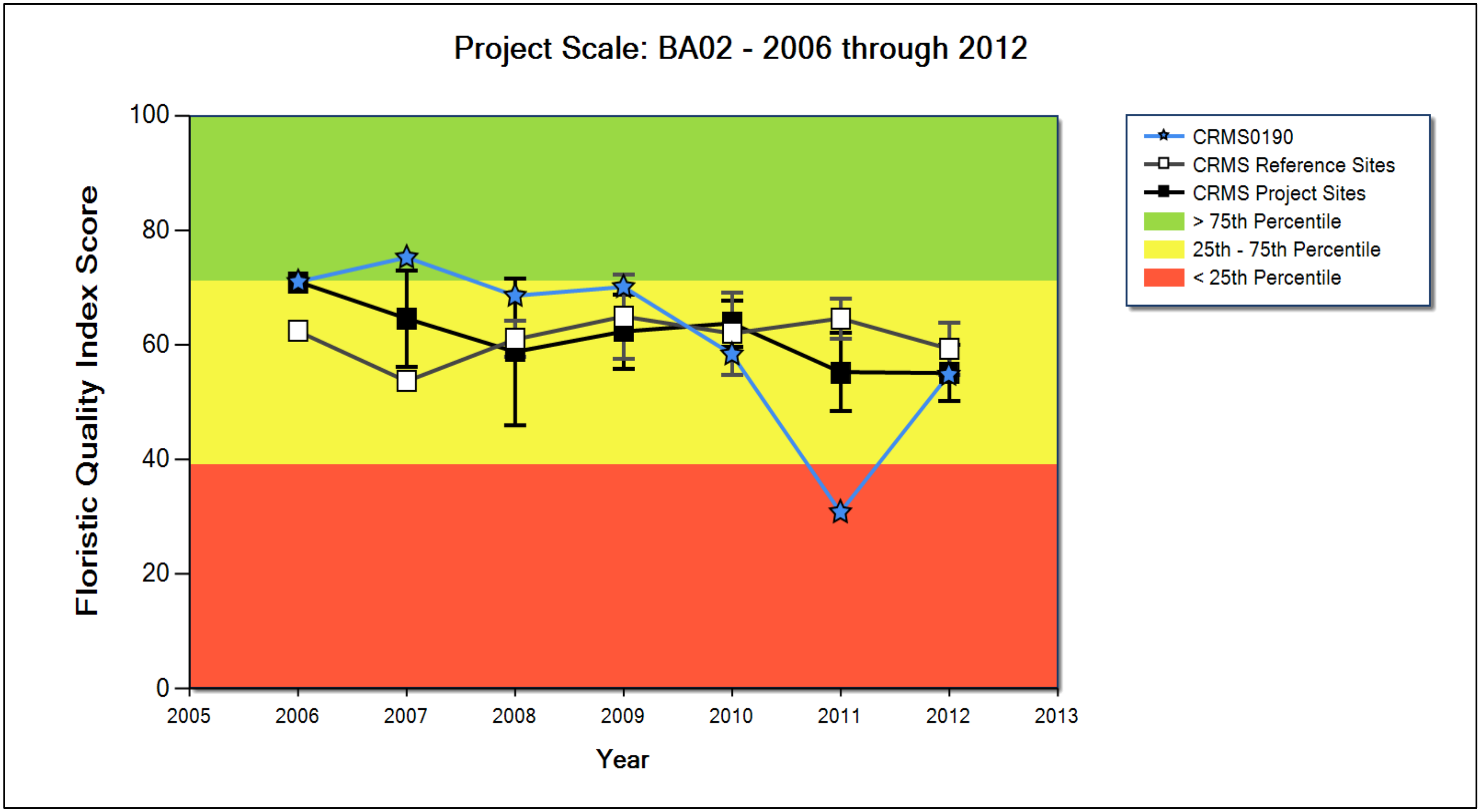

Figure 23. FQI scores comparing the CRMS0190 site to other CRMS-wetlands intermediate marsh sites in the Barataria Basin over time. Note that the FQI scores for CRMS0190 are higher than or similar to the other sites in this basin with the exception of year 2011.

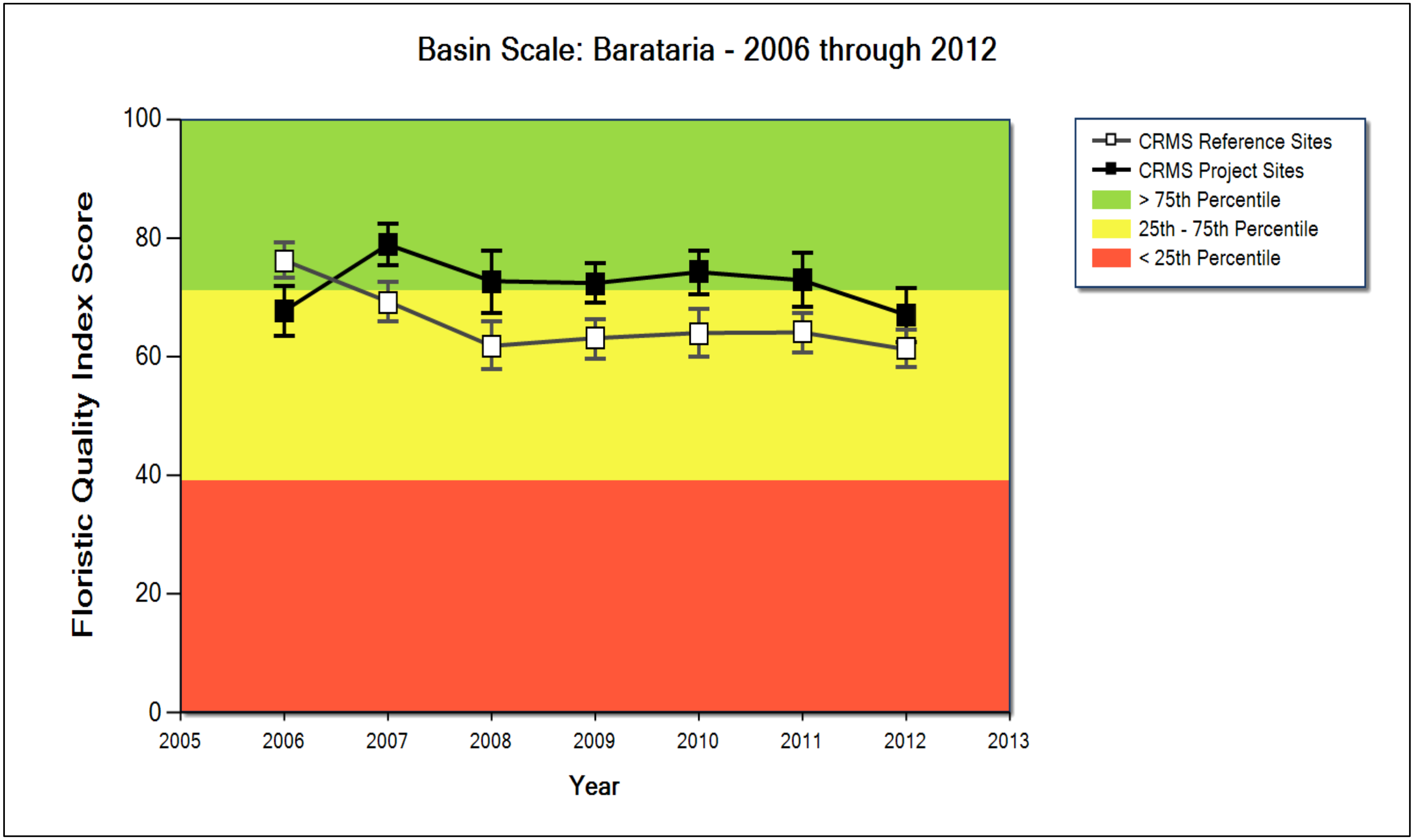

Figure 24. FQI scores for all CRMS-*Wetlands* sites within the Barataria Basin in a time series chart. These scores include all marsh types within the basin and not just intermediate marsh sites like CRMS0190.

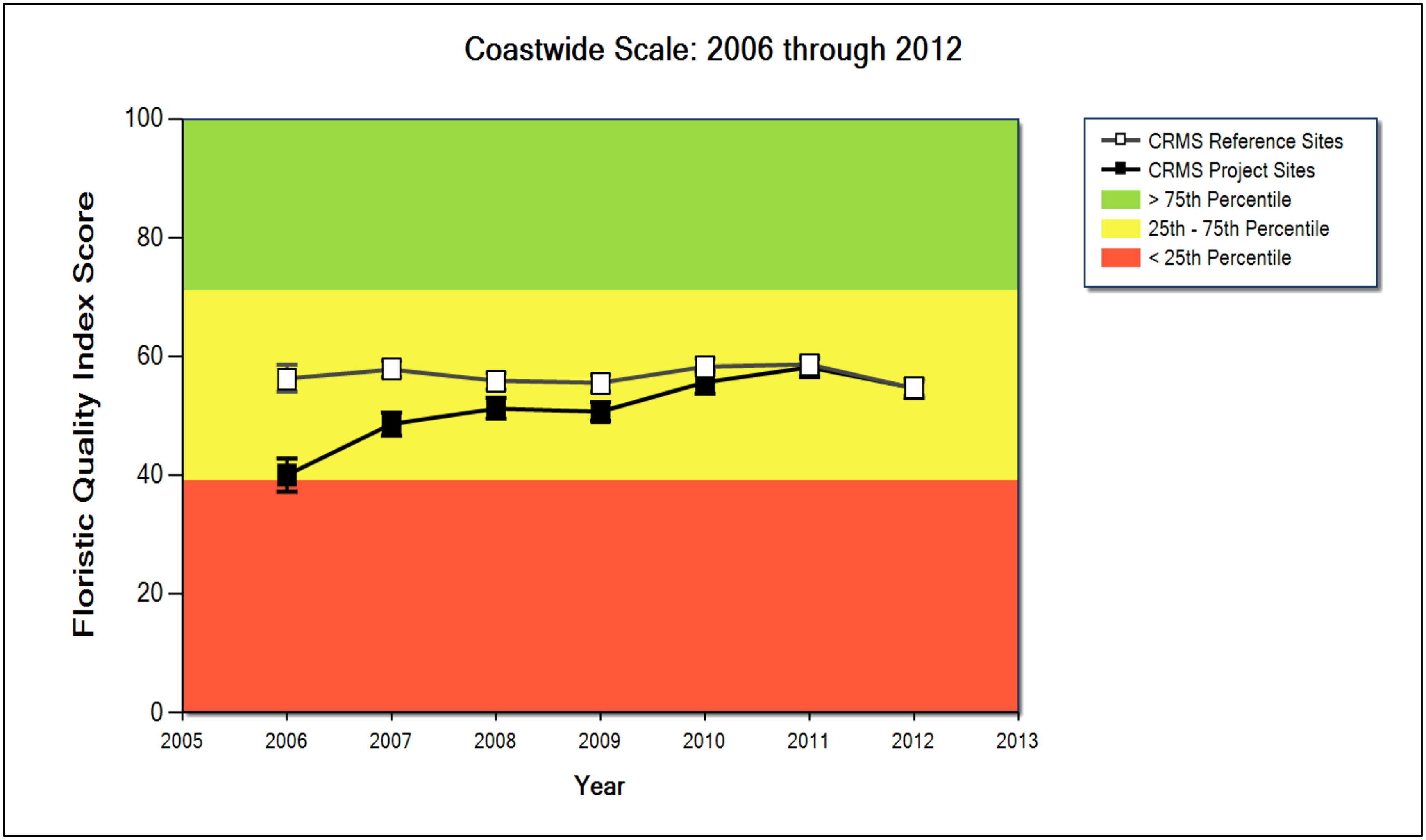

Figure 25. FQI scores for all CRMS-*Wetlands* sites within the Louisiana coastal zone in a time series chart. These scores include all sites regardless of their marsh type.

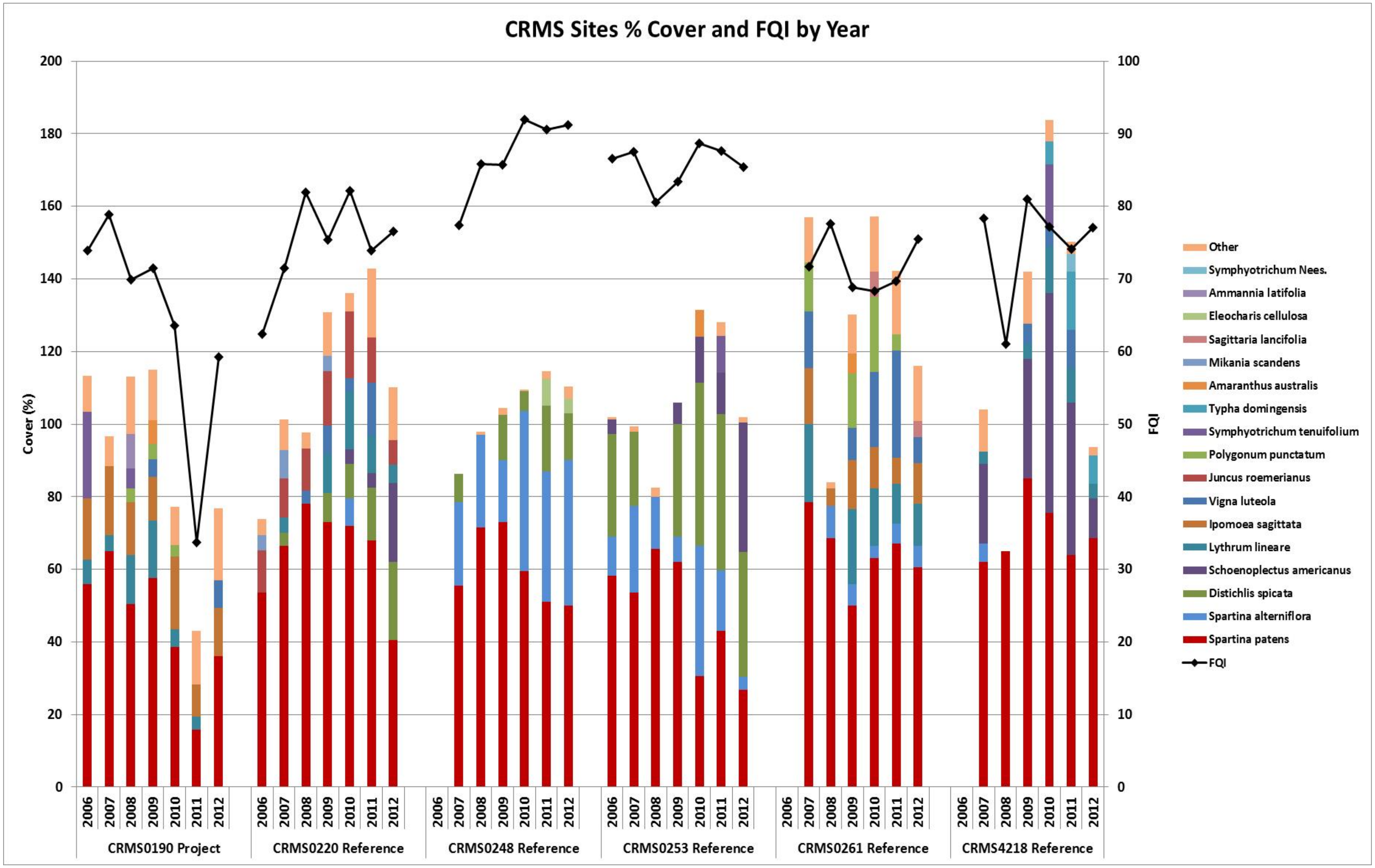

Figure 26. Project and reference CRMS site mean percent cover for selected species by year. The yearly mean FQI scores are represented by the markers along the black trend lines.

In a separate analysis, salinity categories were assigned to the CRMS vegetation data based upon the marsh types in which the individual species were most commonly found. Figure 27 indicates the salinity categories for the project and reference CRMS sites based upon their mean percent cover for years 2006 through 2012. Overall, the project site had more fresh to intermediate marsh types than the reference CRMS sites. In 2008 brackish-saline marsh vegetation began to show up in the project area, however the fresh to intermediate marsh types increased in cover. The intermediate-brackish marsh type increased inside the project area while the brackish and brackish-saline marsh types increased in the reference sites. Though the small metric for brackish-saline marsh type remained in the project area by 2012, the fresh to intermediate marsh types increased to much greater levels than in 2006. Conversely, in the reference CRMS sites, the fresh to intermediate marsh types substantially decreased by 2012 while the brackish-saline and saline marsh types increased.

The VV was calculated and compared to the FQI for each project and reference CRMS site for years 2006 through 2012 (figure 28). The VV at CRMS0190 followed the FQI pattern from year to year. Unlike the FQI, by 2012 it increased to a higher level than in 2006. This means that though there was an overall slight decrease in cover and presence of the more important intermediate marsh vegetation species at CRMS0190, there was an increase in the volume of vegetation produced. The CRMS0190 VV metrics were comparative to the CRMS reference sites, with the exception of CRMS0261 and CRMS4218, which had some of the highest VV values. Also, though the FQI values were highest at CRMS0220, CRMS0248, and CRMS0253, the VV values were more comparable to the project CRMS0190 site. The VV patterns for the CRMS reference sites did not necessarily follow their FQI score patterns from one year to the next as with CRMS0190.

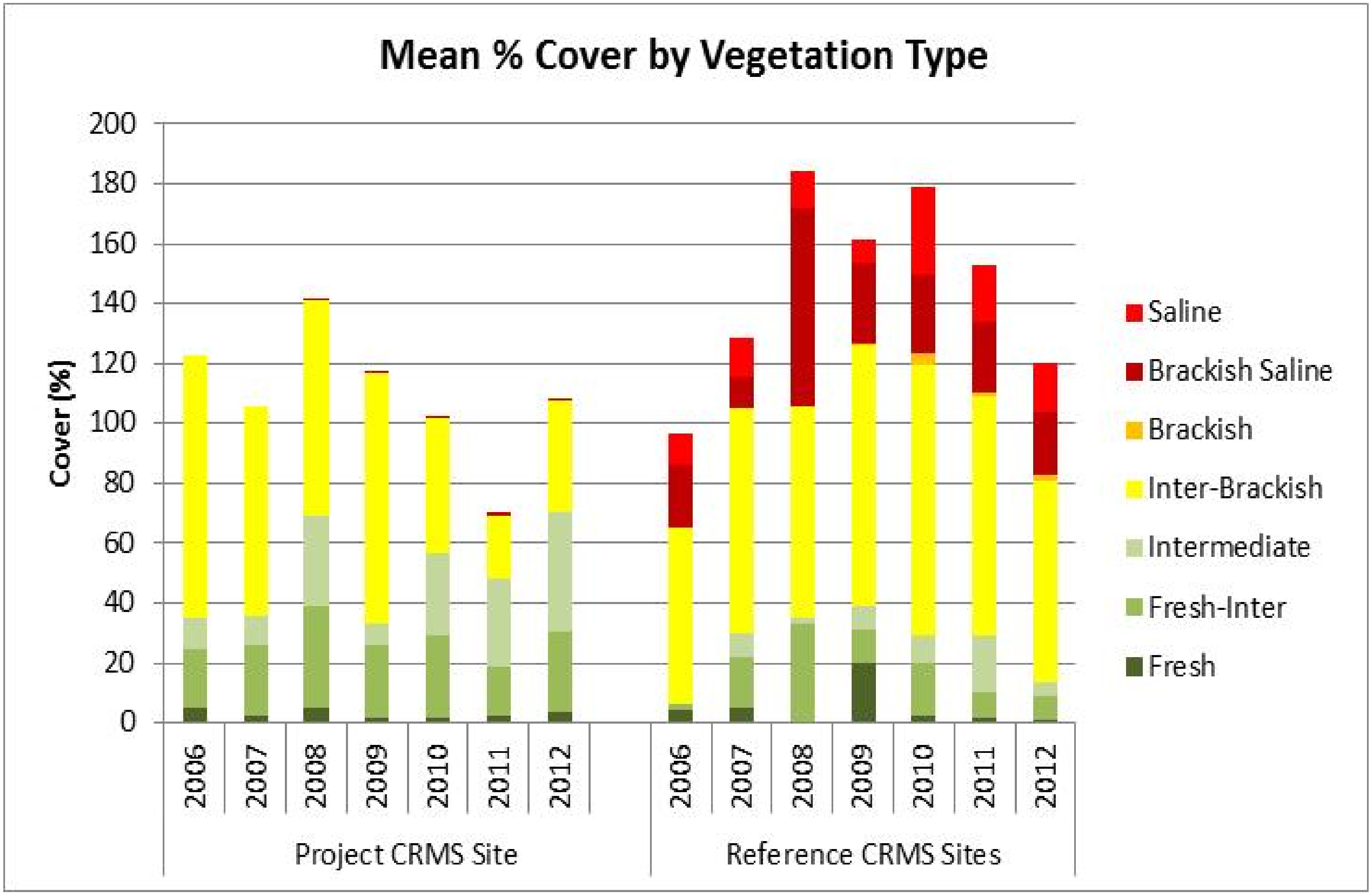

Figure 27. Distribution of salinity categories by sample year based upon mean percent cover of species found inside of $4m^2$ CRMS project and reference vegetation plots for the BA-02 project.

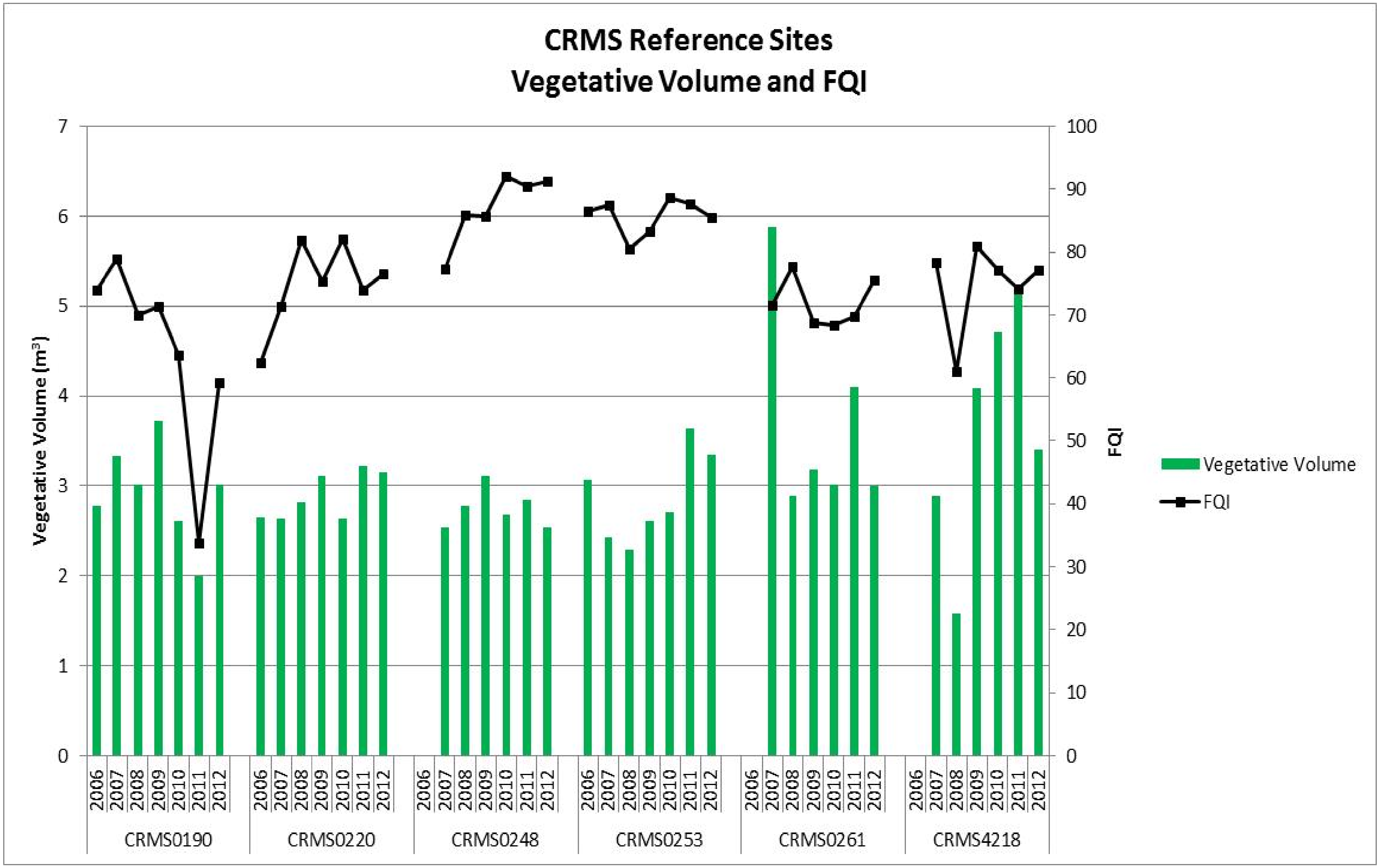

Figure 28. Vegetative Volume and FQI for CRMS-*Wetlands* project and reference sites for the BA-02 project.

Soils

Project-specific soils data were collected concurrent to vegetation sampling during the fall of 1996, 1999, 2000, 2002, 2005, 2008, and 2012. Soils data collection stations as well as sampling years were the same as those used for vegetation monitoring (figure 17). For the years 1996, 1999, 2000, and 2002 simple grab samples were collected by CPRA 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, 2008, and 2012 CPRA 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. (2012). 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 2012, CPRA requested that CES resume the collection of grab samples in order to have comparative data to previous years when this protocol was used.

In addition to project-specific soils data collection, three baseline soil cores were taken from CRMS0190 inside the project area. The cores were taken only once from the site at the time of its initial establishment. 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. (2012). 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). Core samples are taken at all CRMS-*Wetlands* sites using this methodology at the time of establishment, therefore comparisons can be made between CRMS0190 and similar sites throughout the coastal zone.

Project-Specific Data Analysis Methods for Soils:

Soils data were received by CPRA/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, soil moisture content, and bulk density.

Project-Specific Soils Results and Discussions

The BA-02 project area is primarily floating marsh. Floating marsh sites have almost entirely organic substrates and are tied together by living plant roots in a peat mat (Sasser et al. 1995). Also, organic soils such as those found in the BA-02 project area generally have a bulk density of 0.2 to 0.3 g/cm^3 but can be as low as 0.04 g/cm^3 in a peatland soil (Mitsch and Gosselink 2000). It is the lack of mineral content which makes floating marshes 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.

Note: The 2002 samples had values that were so low for all soil properties tested, that they are considered to be outliers, possibly due to an error during analysis.

Soil organic matter: The data indicates that the project has maintained highly organic soils typical of a floating marsh system.

Grab Samples: Four of the five sample years had a mean soil organic matter content greater than 60%, as well as the 1996 sample year for the reference sites (figure 29). The values peaked in 1999 and 2000 and slightly dropped by 2012. Despite this drop, the mean soil organic matter content was 2% higher in 2012 than in 1996 when monitoring began within the project area.

Core samples: All three sample years had mean soil organic matter content greater than 60% (figure 30). There was a slight drop in 2008. The core sample data supported the grab sample data, revealing a 66% mean organic matter content by 2012.

Soil moisture content: The data indicates that the project has experienced a slight drop in mean soil moisture content since monitoring began in 1996, one year pre-construction. The lowest values occurred in 2000 and 2002, with 2002 considered an outlier. Despite the drop, the overall soil moisture content is indicative of a healthy floating marsh system.

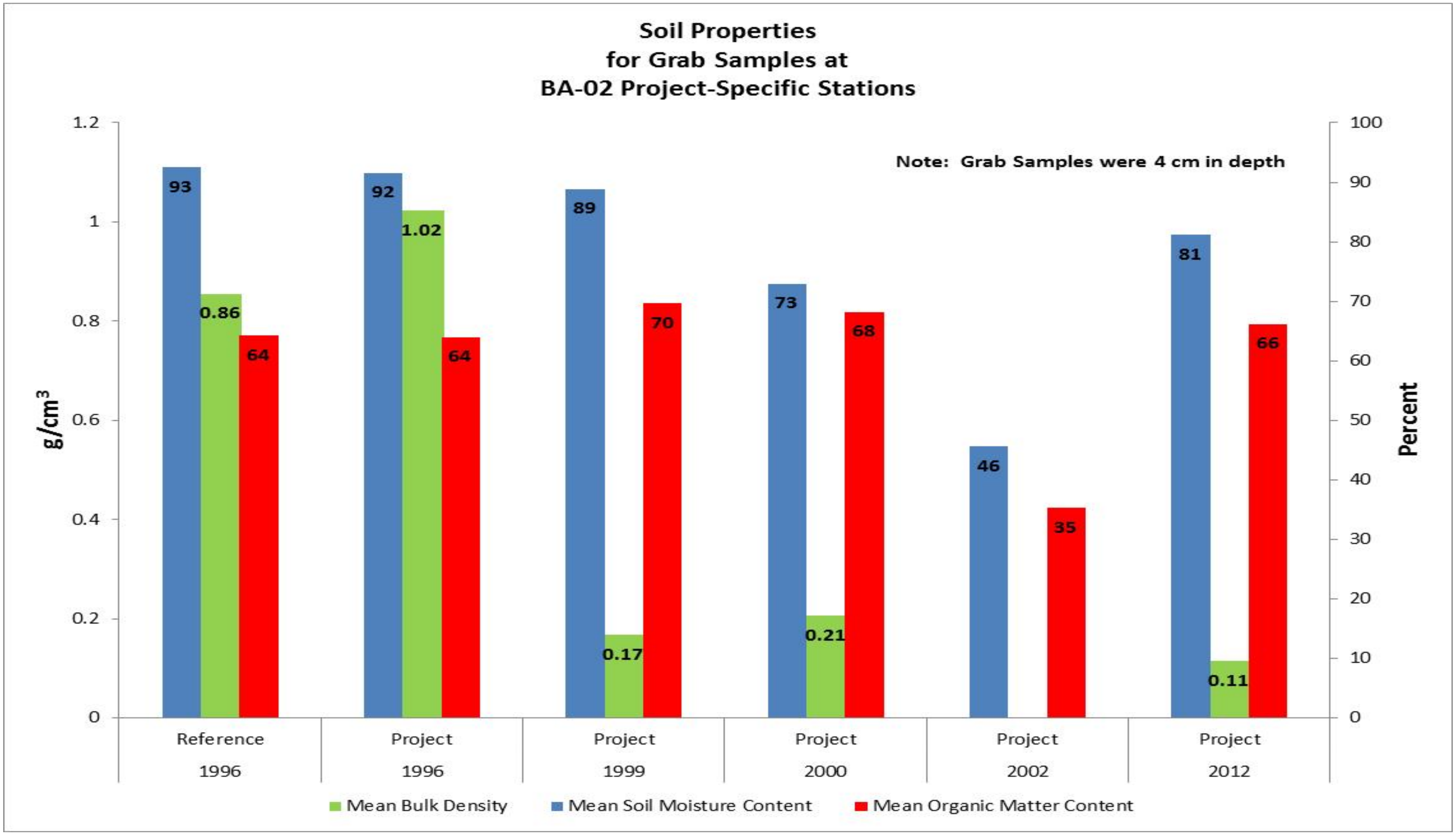

Figure 29. Mean bulk density, Mean soil moisture content, and mean organic matter content for grab samples collected at all BA-02 project-specific stations and reference stations.

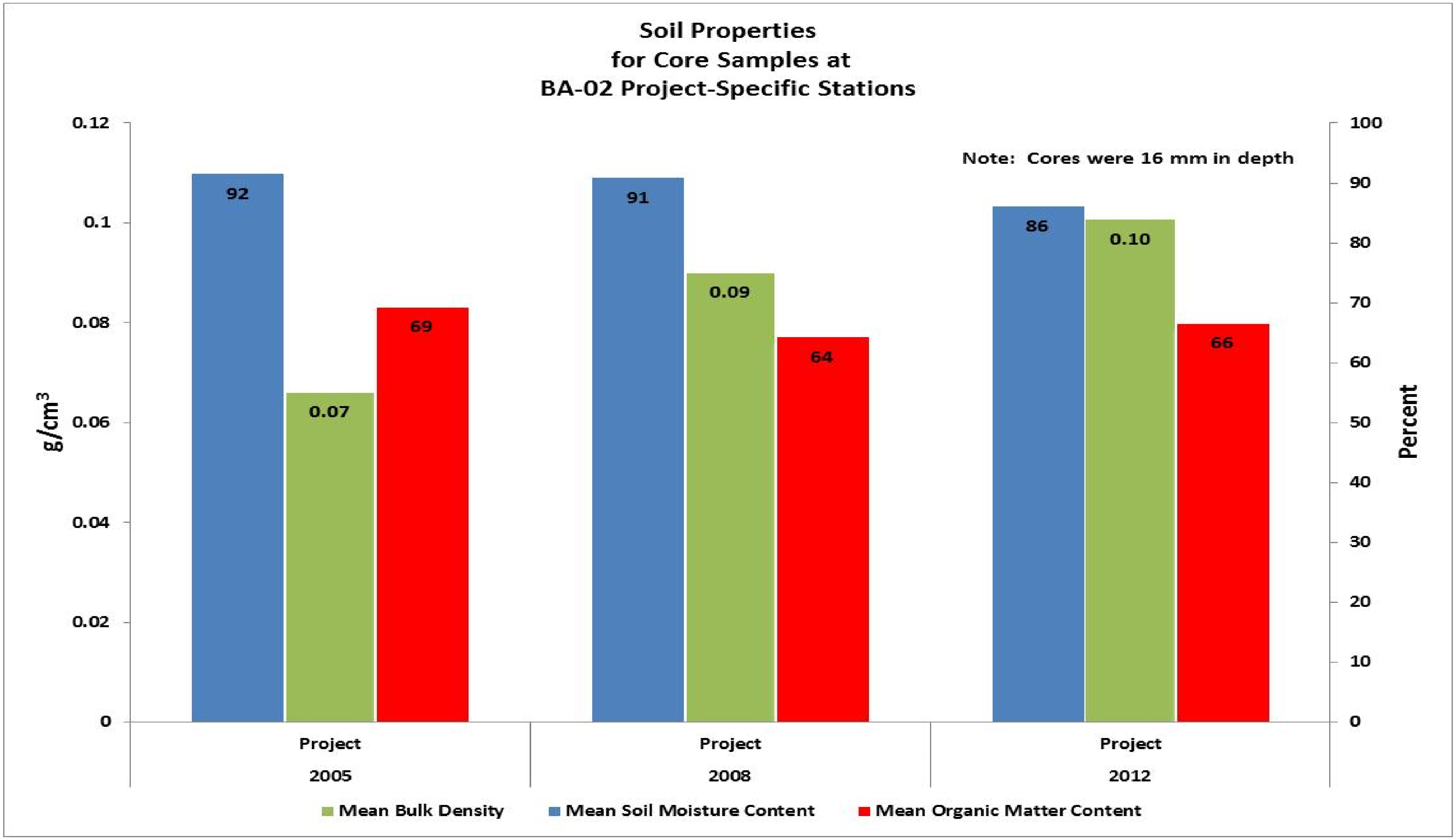

Figure 30. Mean bulk density, mean soil moisture content, and mean organic matter content for soil core samples collected at all BA-02 project-specific stations and reference stations.

Grab Samples: The mean soil moisture content for 3 of the 5 sample years was above 80%, while years 2000 and 2002 dropped to 73% and 46% respectively (figure 29).

Core Samples: The mean soil moisture content dropped slightly from 92% to 86% from 2005 to 2012. This drop is not considered unusual for a healthy floating marsh system which is in constant flux (figure 30).

<u>Soil bulk density</u>: Soil bulk density is the dry weight of soil material per unit of volume.

Grab Samples: In 1996, the reference area soils averaged 0.85 g/cm^3, and project area soils averaged 1.02 g/cm^3, which is more characteristic of mineral soils (figure 29). The remaining samples had mean soil bulk densities which fell within the range for a healthy floating marsh. The soils laboratory did not perform bulk density measurements in 2002.

Core Samples: Mean bulk density increased steadily between 2005 and 2012. All three mean values fell within the healthy range for highly organic floating marsh (figure 30).

<u>CRMS Data Analysis Methods for Soils:</u>
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 CRMS0190 at 1.57 in (4 cm) sample depth increments. Results for each variable are presented in figure 31.

<u>CRMS Soils Results and Discussions</u>
The mineral substrate beneath the CRMS0190 floating marsh consists of the Lafitte-Clovelly association soil type (U.S. Soil Conservation Service 1984). The soils data analysis of this site illustrates that the marsh is highly organic with very low bulk density which indicates little to no mineral content.

Mean organic matter content was consistently high (>75 %) for each of the 4 cm sample depth increments within the project's floating marsh CRMS site (figure 31). Peak content occurred at the 12-16 cm sample depth.

Mean bulk density for CRMS0190 was consistently low across all of the 4 cm sample depth increments (figure 31). There was slight variability from increment to increment of soil depth for this site. The highest mean bulk densities occurred at the 4 cm and 16 cm sample depths, though they were both indicative of a highly organic floating marsh.

Mean soil moisture content was consistently near or above 90% for CRMS0190 across all sample depths (figure 31). Also, the moisture content slightly increased with each increase in sample depth.

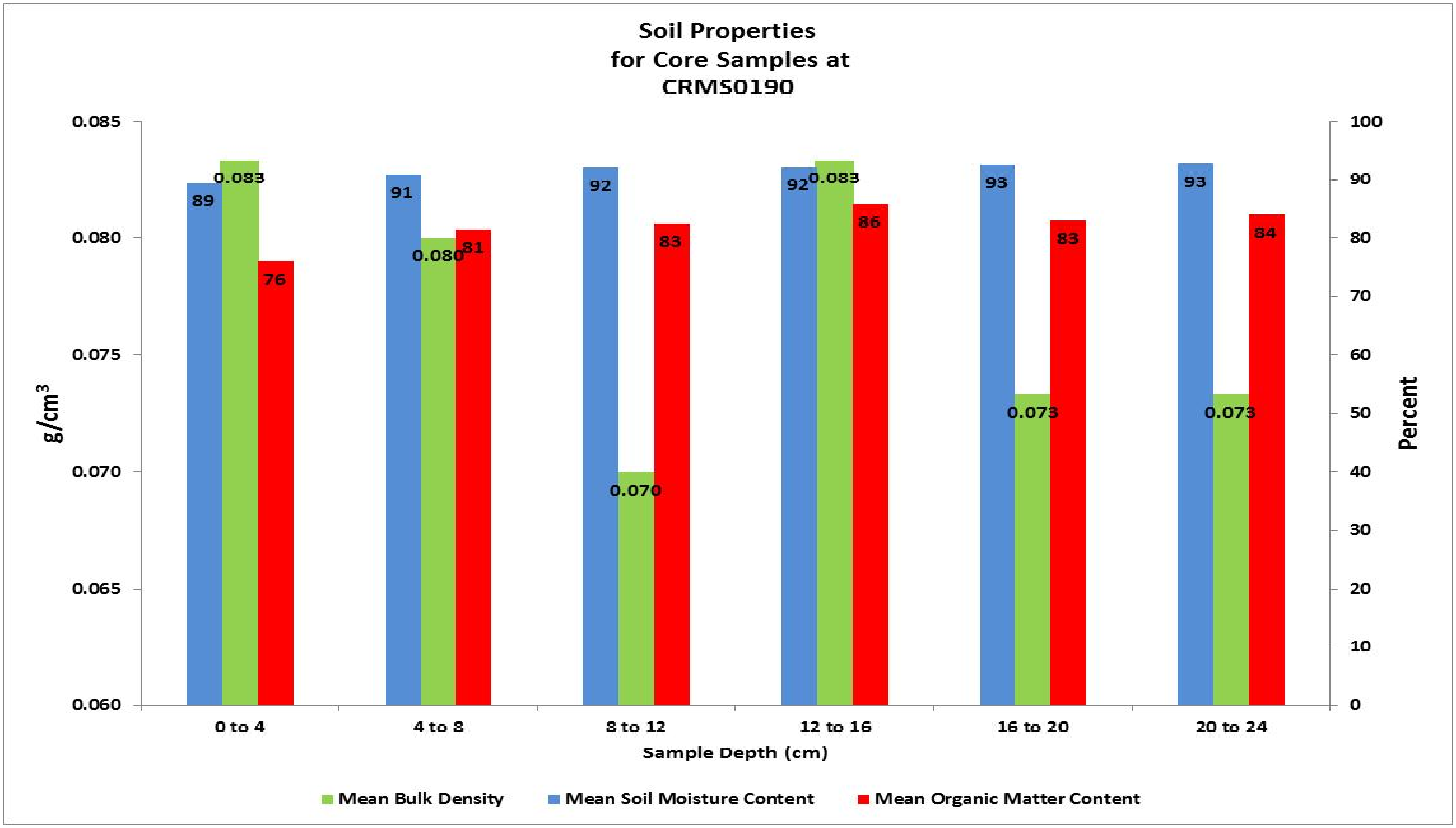

Figure 31. Mean bulk density, mean soil moisture content, and mean organic matter content for soil core samples collected at CRMS0190.

Shoreline Change

Shoreline position data for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project was collected pre-construction by CPRA personnel in 1993 and 1998, as well as 2000 and 2003 post-construction. CPRA personnel utilized sub-meter accurate DGPS equipment to collect the shoreline points along 21 randomly selected 300 ft (91.4 m) segments (figures 32-37). Shaw Coastal, Inc. was contracted by CPRA to document shoreline position along the same segments in 2005, 2008 and 2012. Shaw Coastal, Inc. personnel utilized a Trimble 5700 RTK base station with a Trimble 5800 rover unit; the data was stored in a Trimble TSCe data collector (Shaw Coastal, Inc. 2005).

Data Analysis Methods for Shoreline Change:

Analysis1: 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 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 39).

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.

(m^2)

Year 2000 Area (m^2) - Year 2012 Area (m^2) = Area Change

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.

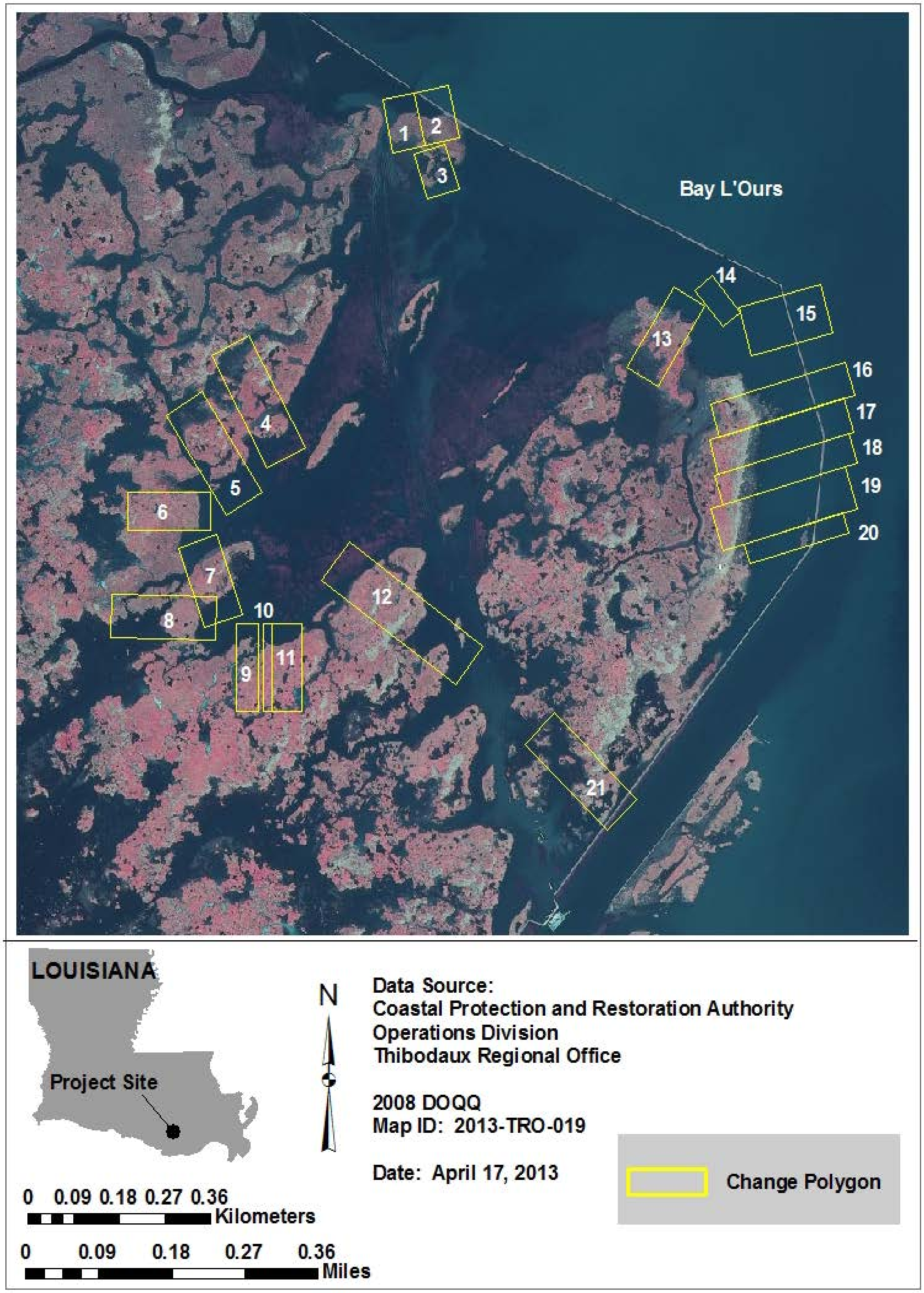

Figure 32. Change polygons for randomly selected shoreline segments 1-21 for the BA-02 project. Construction for the shoreline protection rock dike was completed in October 2000.

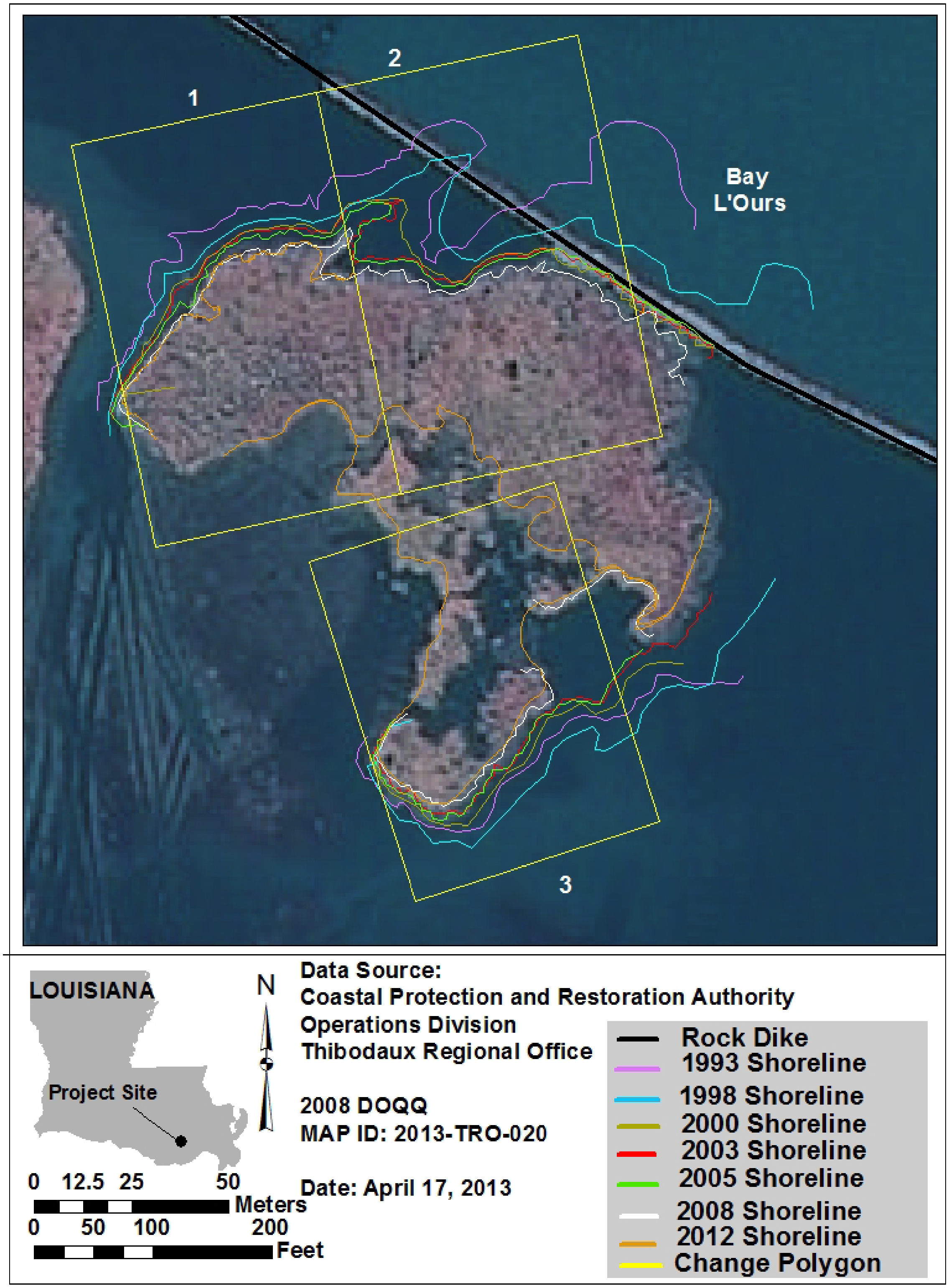

Figure 33. Location of 1993, 1998, 2000, 2003, 2005, 2008, and 2012 shoreline segments 1-3 for BA-02. Construction for the shoreline protection rock dike was completed in October 2000.

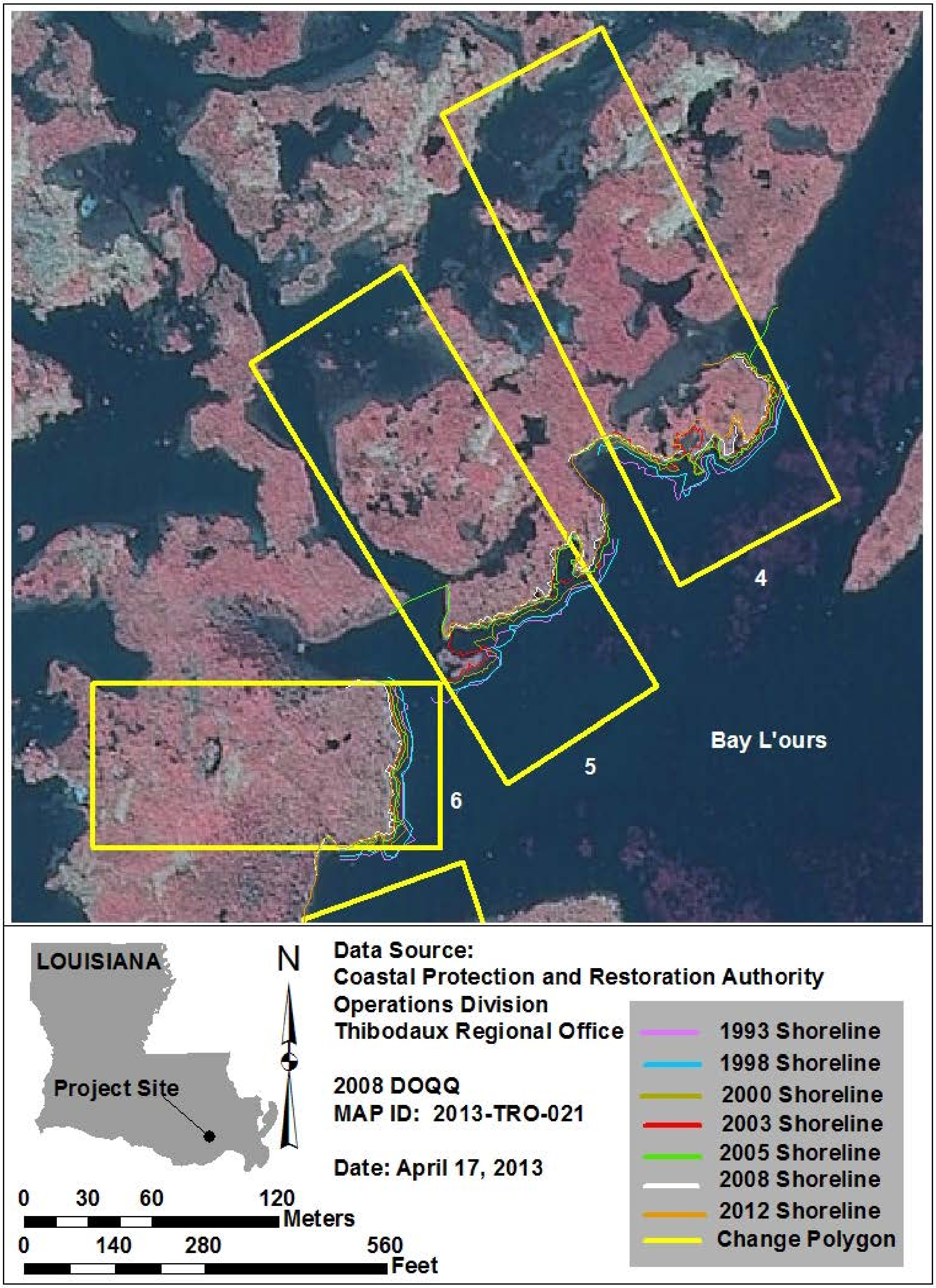

Figure 34. Location of 1993, 1998, 2000, 2003, 2005, 2008, and 2012 shoreline segments 4-6 for BA-02. Construction for the shoreline protection rock dike was completed in October 2000.

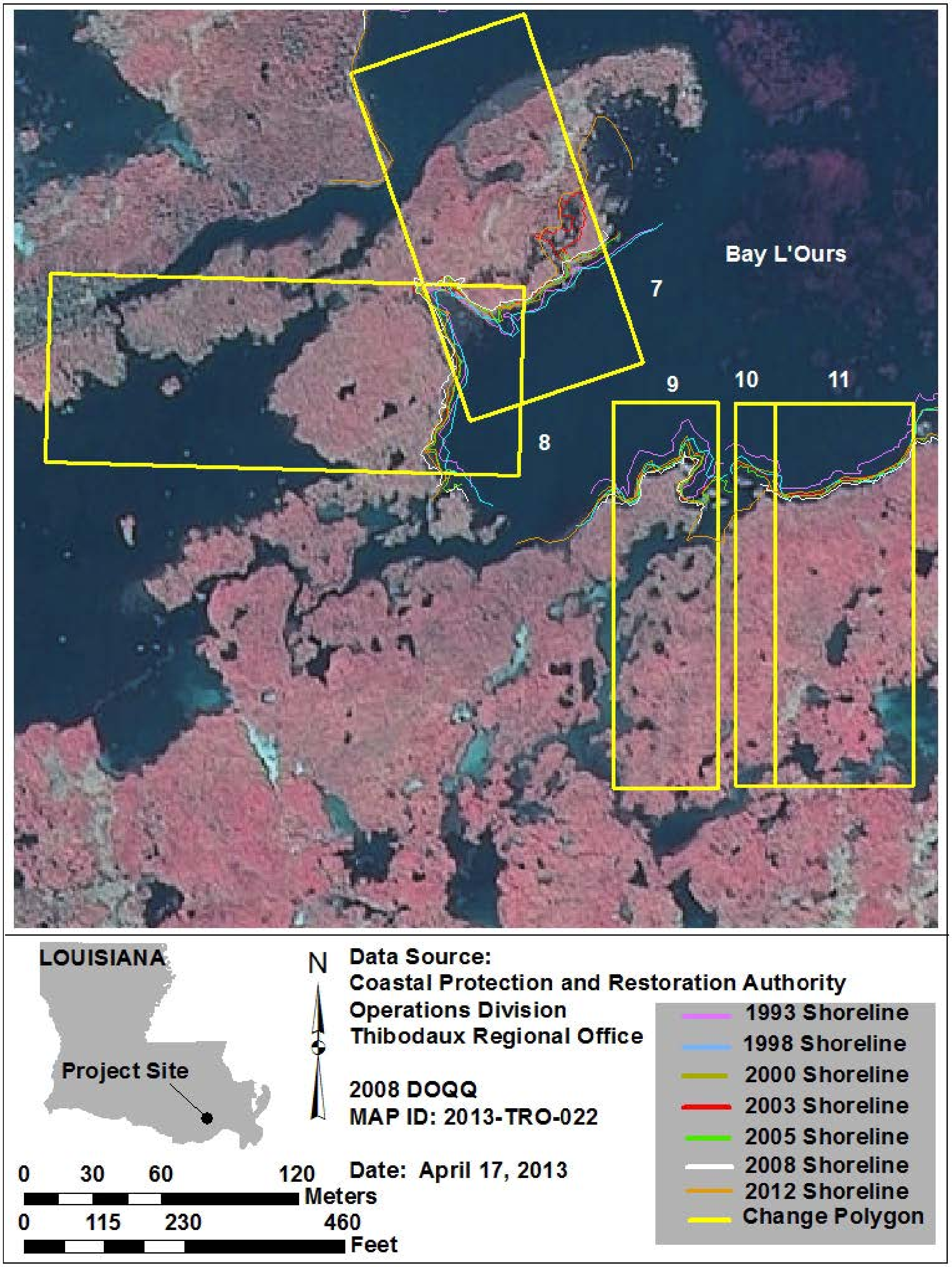

Figure 35. Location of 1993, 1998, 2000, 2003, 2005 2008, and 2012 shoreline segments 7-11 for BA-02. Construction for the shoreline protection rock dike was completed in October 2000.

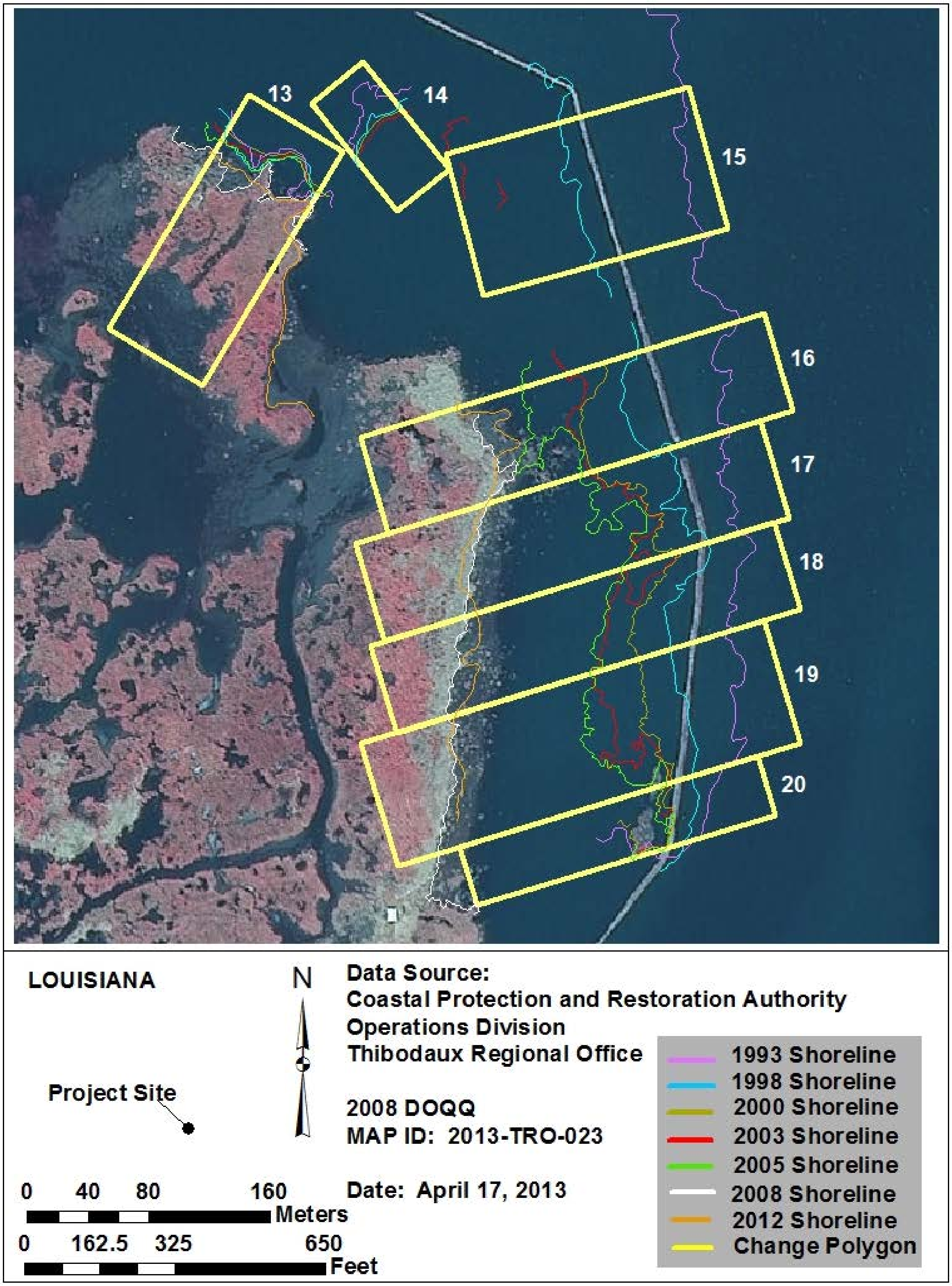

Figure 36. Location of 1993, 1998, 2000, 2003, 2005, 2008, and 2012 shoreline segments 13-20 for BA-02. Construction for the rock dike was completed in October 2000.

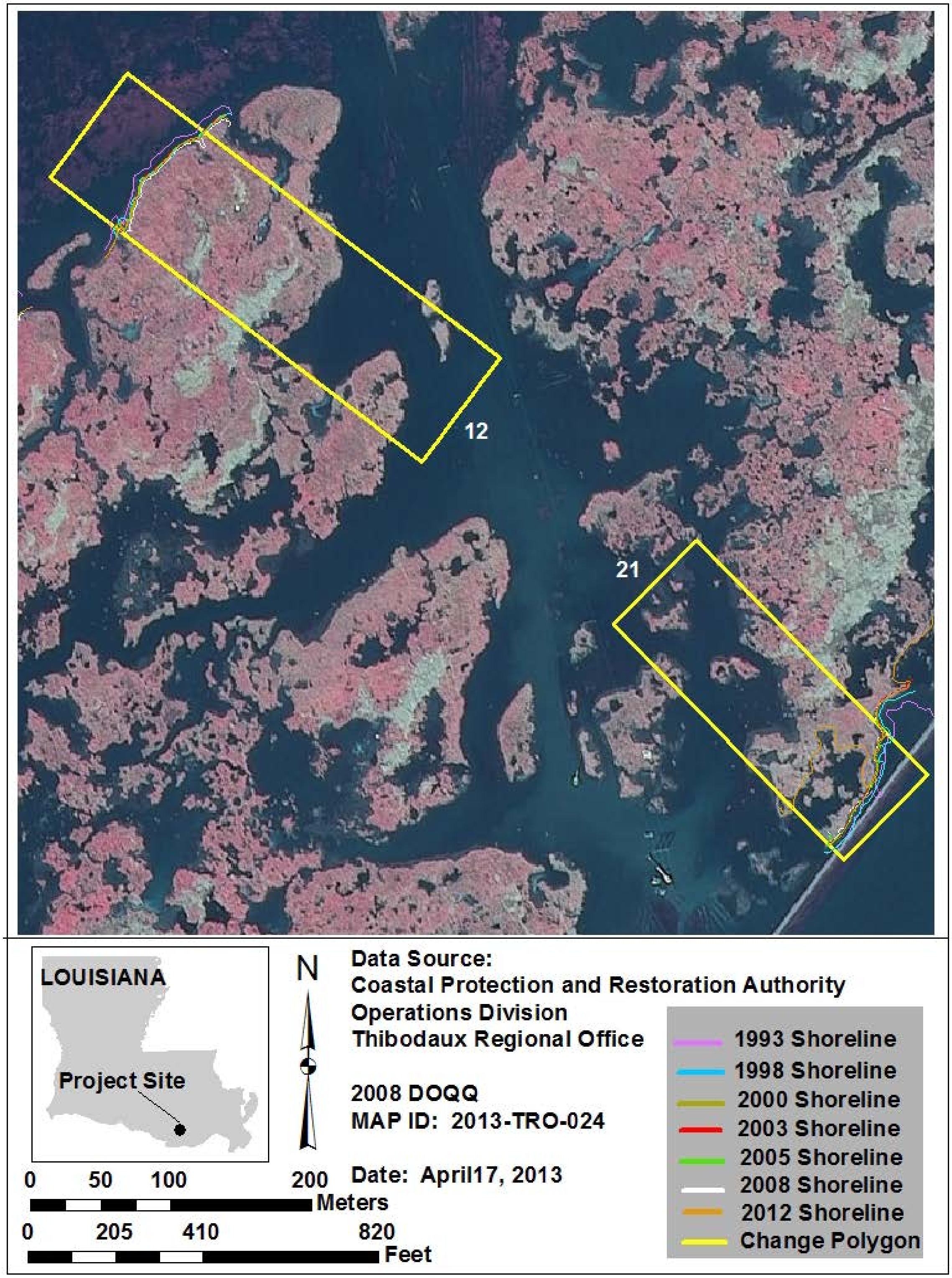

Figure 37. Location of 1993, 1998, 2000, 2003, 2005, 2008 and 2012 shoreline segments 12 and 21 for BA-02. Construction for the shoreline protection rock dike was completed in October 2000.

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

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.

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

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

Analysis 2: This second shoreline change protocol included both project and reference areas. During this analysis, the project area shoreline was not partitioned into 300 ft (91.4 m) segments. The entire shoreline behind the rock closure was analyzed as in the procedure listed below, and 3 reference areas were also established (figure 38). The first reference area (reference area 1) was established along an unprotected shoreline reach located south of the Clovelly Canal. 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 (figure 38). 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), October 29, 2008 (8 years post-construction), and November 1, 2012 (12 years post-construction). The scale of all Digital Ortho Quarter Quad (DOQQ) images was 1:16,000 and georectified using the UTM NAD 83 horizontal datum.

The February 1998, November 2005, and October 2008, and November 2012 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, November 2005-October 2008, and October 2008-November 2012 for the project and reference areas.

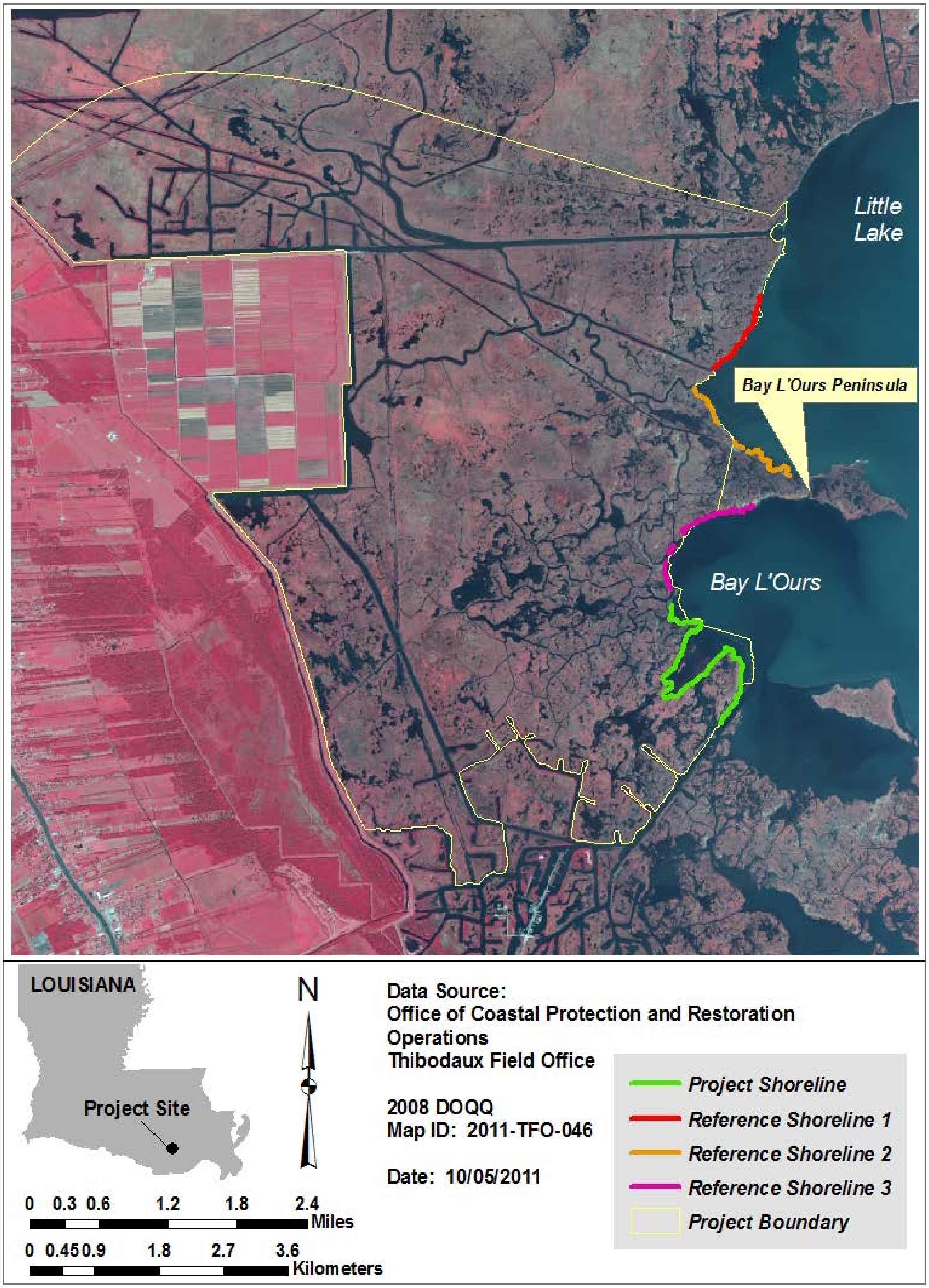

Figure 38. Location of project and reference shoreline segments for shoreline change analysis 2.

Shoreline Change Results and Discussions

Analysis 1: Results indicate that from 1993 through 1998 (pre-construction) all 21 shoreline segments remained intact. Utilizing loss rates for only those 16 segments which remained intact for the entirety of data collection, the average pre-construction shoreline change rate from 1993-1998 was -1.94 m/yr^{-1} (figure 39). By the 2012 survey (12 years post-construction) five of the 21 segments had either completely or partially eroded away to non-continuous broken marsh. Between 2000 and 2012 (post-construction) average shoreline change rate was -1.98 m/yr^{-1} for the remaining 16 shoreline segments. Segments 14 and 15 disappeared between 2003 and 2005. Segment 2 experienced a reduction in shoreline loss based upon the 2008 survey, but by 2012 this segment eroded beyond the point of being a continuous shoreline and only broken marsh remained. Segment 3 was almost completely eroded away leaving heavily broken marsh in place of a continuous shoreline, and by 2008 segment 20 eroded beyond the change polygon used to calculate change rates. Of the remaining 16 shoreline segments in 2012, there was a reduction in the rate of erosion for segments 1, 9, 10, 11, 12, and 16 while the rate increased for all other segments.

A comparison of change rates utilizing the same remaining 16 shoreline segments with various survey date ranges (figure 40) illustrates when some of the more drastic shoreline changes occurred. The greatest changes occurred between the 2005 and 2008 surveys when the shoreline loss reached an average yearly rate of -5.92 m/yr^{-1}. In this time frame some of the most powerful tropical systems impacted the area including hurricanes Cindy, Katrina, Rita, Gustav, and Ike. Conversely, the lowest rate of change (-0.11 m/yr^{-1}) occurred between the 2008 and 2012 surveys. It is interesting to also note that the rate of erosion was reduced after construction between the years 2000 and 2005. Several factors may have contributed to the increase or decrease of erosion rates, which include, but are not limited to, orientation along the shoreline, proximity to the rock shoreline protection structure, the effects of powerful storms, and the increased amount of open water between the structure and the existing shoreline, causing more frequent and larger wave action.

Analysis 2: The DSAS analysis of the project and reference shorelines indicates similar trends to analysis 1. All shoreline segments continue to experience erosion (figure 41). The greatest change rates occurred between the 2005 and 2008 surveys for all segments Overall there is significant variation in change rates among areas ($F=6.0$, $p=5.0\times10^{-4}$) and among time periods ($F=30.1$, $p < 1.0\times10^{-4}$). An analysis of variance indicates that compared with the 1998-2005 and 2008-2012 time periods, the 2005-2008 time period showed significantly greater change rates (3.2 m/yr, p=0 and 3.3 m/yr, p=0 respectively). Erosion rates were very similar for the 1998-2005 and 2008-2012 periods and are not significantly different. Across periods, reference area 3 has significantly greater rates of erosion than either the project area (p=0.01), reference area 1 (p=0.006), or reference area 2 (p=0.0004). Erosion rates for the project area and reference areas 1 and 2 are not significantly different.

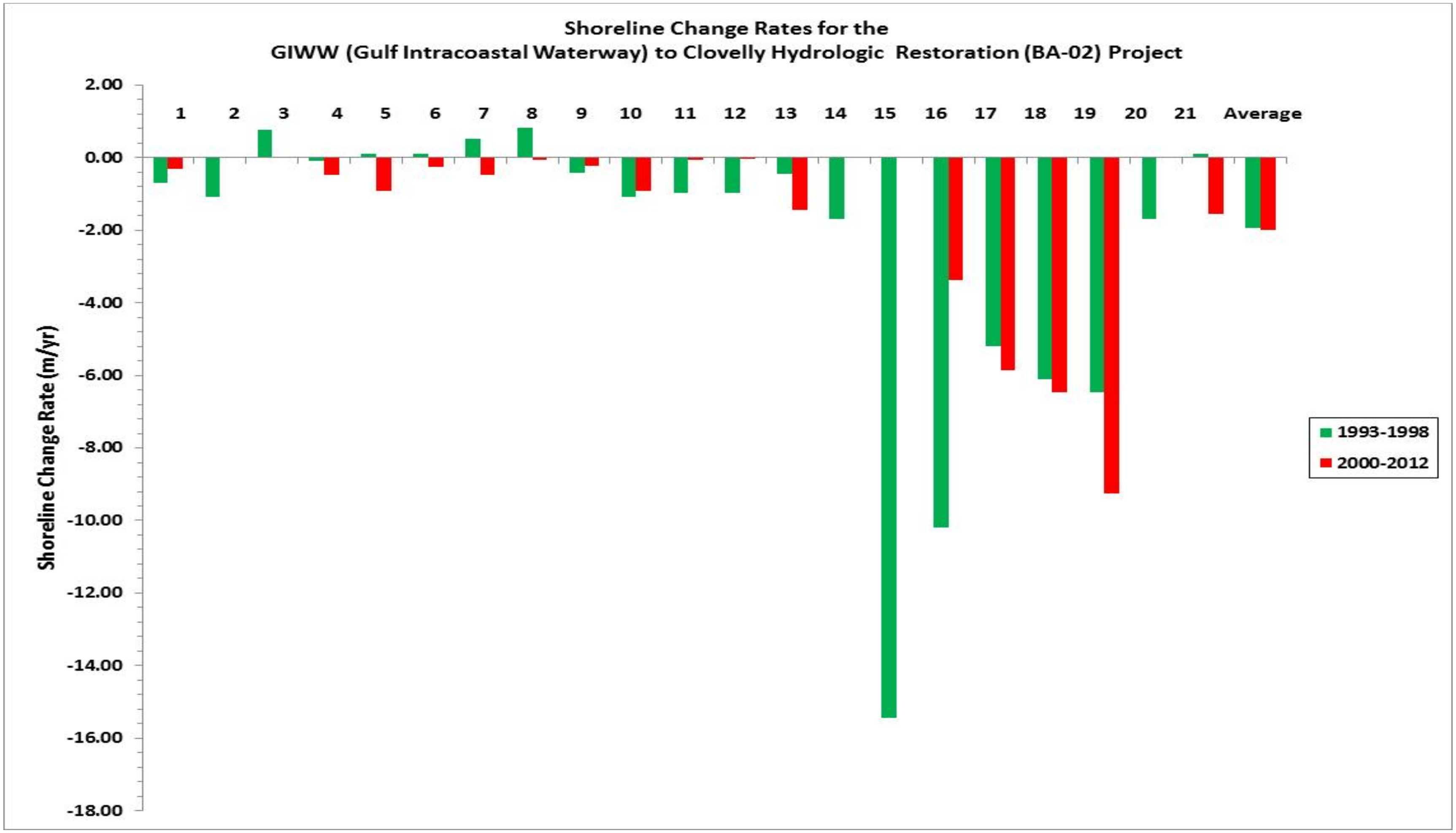

Figure 39. Shoreline change rates for each randomly selected shoreline segment pre- and post-construction, and the average shoreline change rate. Note: Construction ended October 31, 2000. Segments 2, 3, 14, 15, and 20 were not calculated into the "Average" change rate because there was no discernible continuous shoreline.

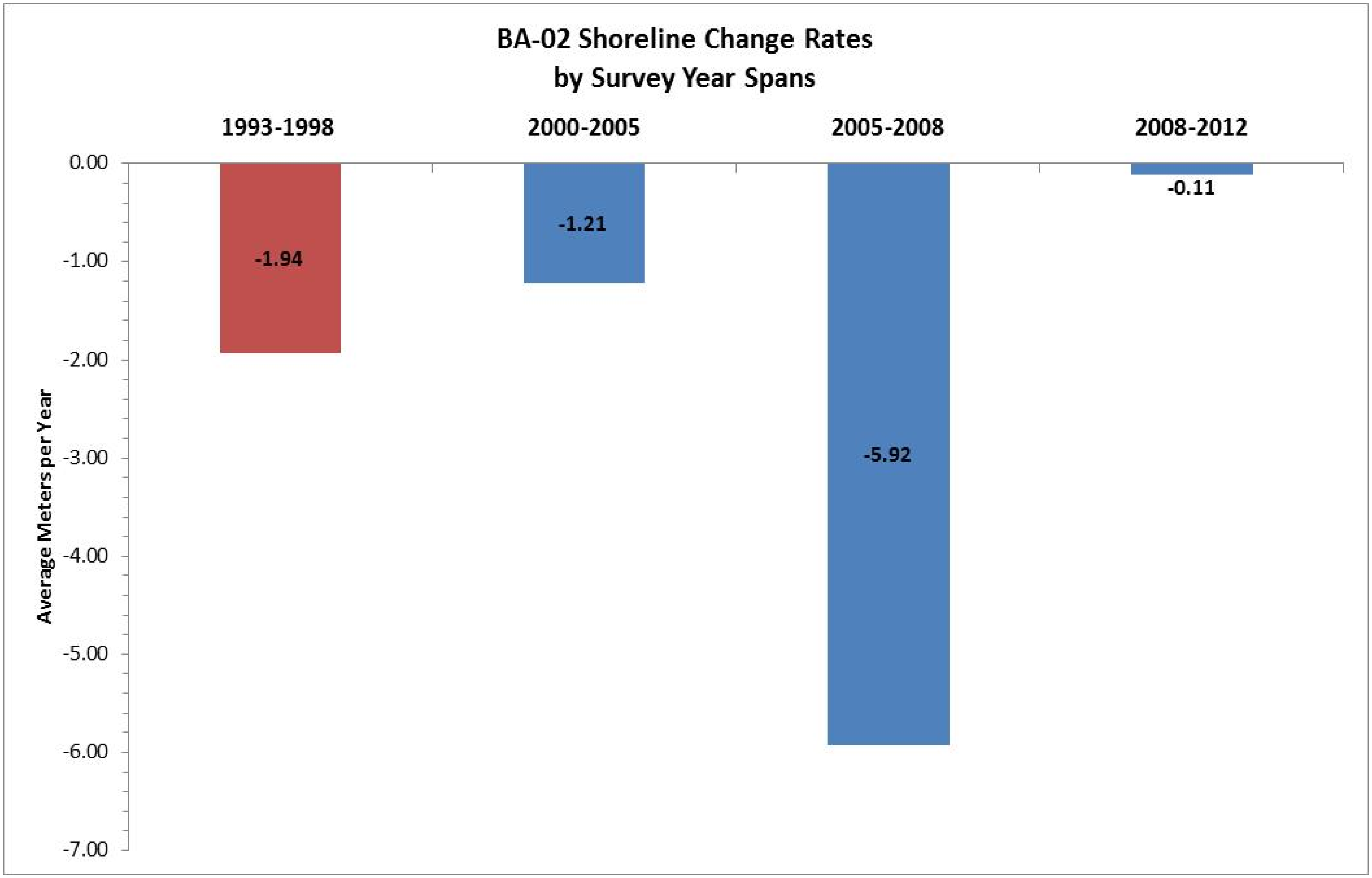

Figure 40. A comparison of average yearly shoreline change rates utilizing various survey year spans for BA-02.

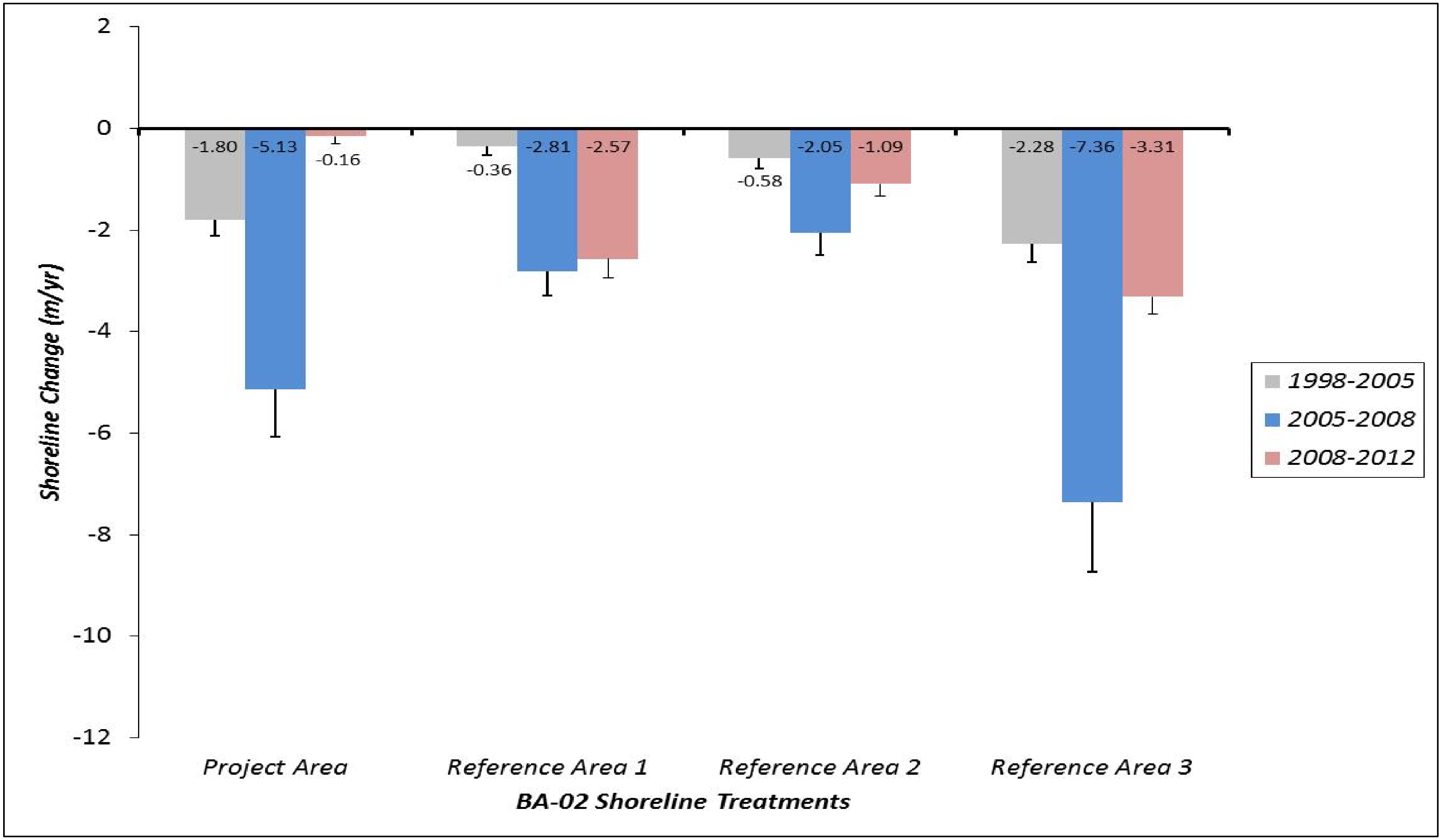

Figure 41. BA-02 shoreline change rates for the project area shoreline segments and selected reference areas utilizing analysis 2.

Submerged Aquatic Vegetation (SAV)

SAV data were collected during the fall of 1996, during the fall and spring of 1999 and 2000, and during the fall of 2002 and 2005. Initially, fifteen (15) ponds were selected for data collection; however, three (3) ponds in the northern portion of the project were dropped due to land rights issues, as well as five (5) reference area ponds, leaving seven (7) ponds for SAV sampling (Appendix C; figure 5). Each pond was sampled at random points along transects using the rake method (Chabreck and Hoffpauir 1962; Nyman and Chabreck 1996). The number of random points and transects was determined based upon the size and configuration of the pond. Frequency of SAV occurrence was determined for each area from the number of points at which SAV occurred and the total number of points sampled.

Data Analysis Methods for SAV:

Field data were entered into an electronic format where LDNR/CRD personnel followed QA/QC procedures prior to data analysis as stated in Folse and West (2012).

SAV Results and Discussions

Submerged aquatic vegetation sampling has occurred seven (7) times in five (5) years. The spring sampling events of 1999 and 2000 showed fewer empty pulls than in the fall (figure 42). The larger difference was between the spring and fall 2000 sampling periods, when the drought may have had an impact on SAV abundance. Salinity was on the rise during the spring sampling period; however, the maximum salinity was recorded after the spring period, which may have affected the vegetation. The 2002 and 2005 results may be attributed to the passing of Hurricanes Lili (2002) and Katrina and Rita (2005).

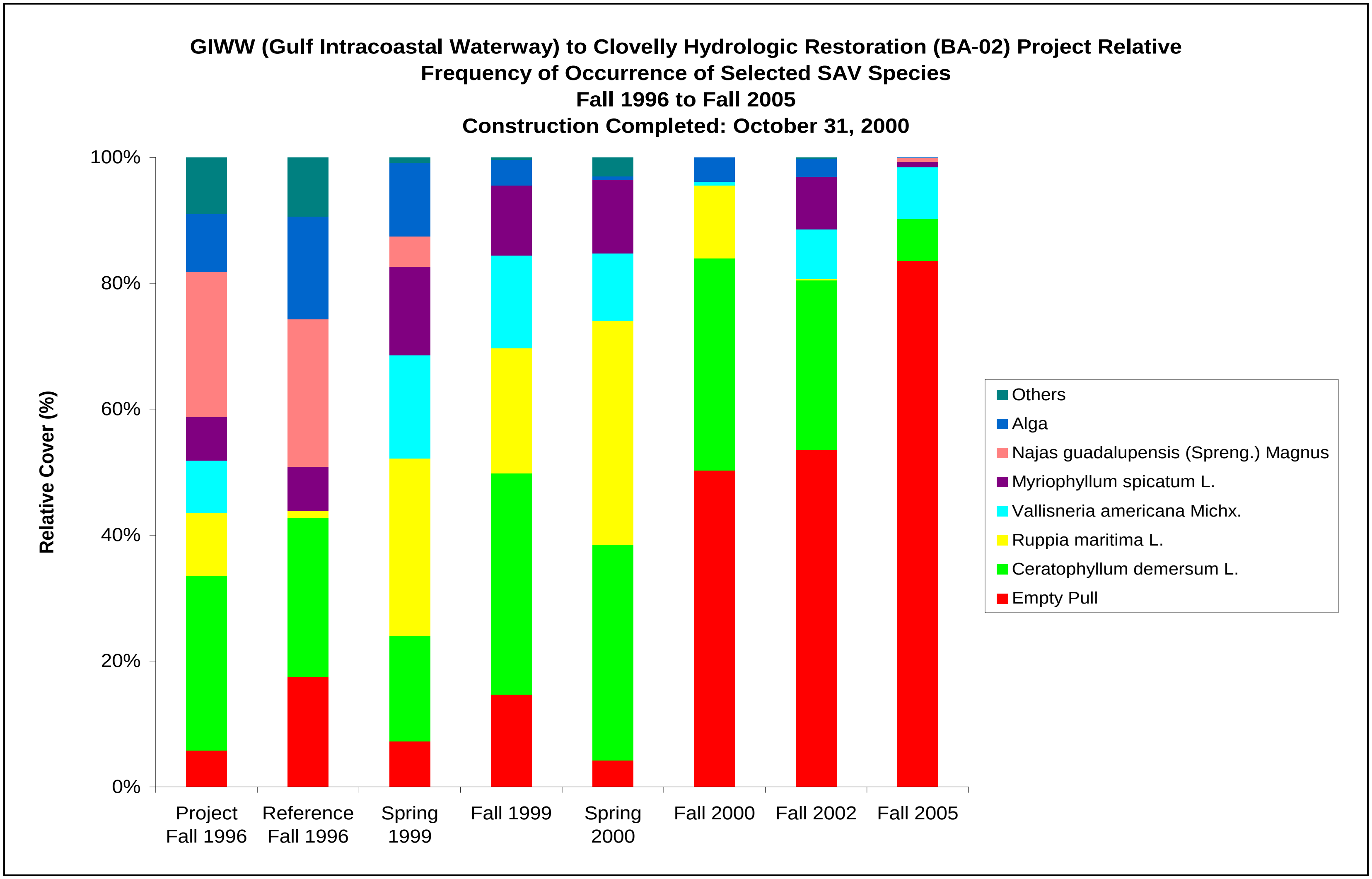

Figure 42. Relative frequency of occurrence of SAV species inside the BA-02 project area.

V. Conclusions

a. Project Effectiveness

The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project, whose objectives are to restore natural hydrologic conditions and reduce shoreline erosion, has met with some success. Based upon the most recent analyses of water level and salinity data, the 2008 Land-Water analysis, mean cover and species composition data, soil properties data, and the 2012 shoreline analysis, the project continues to sustain itself as a healthy intermediate marsh.

1. **Increase or maintain marsh to open water ratio.** Habitat analysis indicated that from 1993 to 2002 there were land acreage changes inside the project and reference areas. There was a shift from intermediate marsh to fresh marsh in the project area, while the reference area lost all of its fresh marsh and gained intermediate marsh. In 2002 the project area consisted of approximately 81% land and approximately 19% water, while the reference area consisted of 73% land and 27% open water.

   Land water analysis presented in the 2010 OM&M report (Lear et al.) indicated that though the overall trend has been a change from land to open water in both the project and reference areas between 1996 and 2008, there were slight variations inside the project area which could possibly be attributed to the project's moderating effects on powerful hurricanes which have impacted the area. The 2015 land-water analysis for this project will provide additional comparative data to help determine if the goal to reduce shoreline erosion has been met.

   Soil properties analysis of project specific sites and the CRMS0190 site showed that the marshes inside of the BA-02 project area are highly organic, highly moist, with very low bulk densities consistently within the range of a healthy floating marsh. Mean soil organic matter content for project specific sites was slightly higher in 2012 than the 1996 pre-construction levels, despite a downward trend. Soil moisture content remained between 80-90% with the exception of 2002 which was considered an outlier. The mean bulk density increased steadily between 2005 and 2012 and all means fell within the healthy range for highly organic floating marsh. CRMS0190 soil properties analysis results were very similar to and supported the results from the project specific analysis.

2. **Decrease salinity variability in the project area, and 5. Promote greater freshwater retention and utilization in the project area.** Salinities within the project area have remained in the normal range for a healthy intermediate marsh. Mean

salinities in the southernmost areas of the project were higher than in the central or northern areas, most likely due to the greater tidal influences. Variation in salinities based upon the minimum and maximum yearly data indicated a wide salinity range. Salinities spiked in the spring and fall for all of these areas, however the yearly means remained below 3 ppt.

3. **Decrease the water level variability in the project area, and 5. Promote greater freshwater retention and utilization in the project area.** Water level analysis showed that the project to date has met the goal of decreasing water level variability in the project area. Tidal ranges in the project area sites have been significantly lower than in the reference sites. Reference sites had a mean tidal range 0.1 ft (0.03 m) greater that project sites. Additionally, when mean marsh elevations at each project-specific site as well as the project's CRMS wetlands site were compared to their mean water elevations, none of the sites were continuously flooded.

   The Hydrologic Index for CRMS0190-H01 inside the project area was equal to or higher than all other CRMS wetlands sites within the same marsh type within the Barataria basin as well as all intermediate marsh types throughout the Louisiana Coastal Zone. The HI was higher than all CRMS wetlands sites within all marsh types throughout the Louisiana Coastal Zone. The high scores indicate that the project area hydrologic conditions have provided a healthy environment for intermediate marsh vegetation to thrive.

4. **Increase or maintain the relative abundance of intermediate marsh plants**. The project has been successful in meeting the goal to increase or maintain the relative abundance of intermediate marsh plants. Project specific data has shown that despite a downward trend in the mean cover of dominant intermediate vegetation species since construction in 2000, the mean cover values in 2012 were still higher than those in 1996 during pre-construction. The Floristic Quality Index and the project specific mean cover data follow a similar trend, with the exception of 2008 (Hurricane Gustav) in which mean cover of the dominant species increased but the FQI decreased. The VV within the BA-02 project area decreased since construction where it dropped to less than half of its pre-construction metric. The decrease began in 2005 following hurricane Katrina, however it slightly recovered in 2012. Species diversity varied throughout the years. The highest diversity occurred during pre-construction, yet despite the powerful hurricanes during post-construction project area diversity was slightly higher than in 1996 when vegetation monitoring first began.

   Mean cover and FQI for the project CRMS site (CRMS0190) experienced an overall downward trend between 2006 and 2012 with some variability in between. Despite the trend, the FQI for all years fell within the good and fair categories for wetland quality compared to all other CRMS wetlands sites within the same vegetation type and hydrologic basin. With the exception of 2011, CRMS0190 FQI scores were within the good to fair categories when compared to CRMS wetlands sites of all vegetation types within the Barataria basin from 2006 to 2012. With the exception of 2011, CRMS0190 FQI scores were higher or equal to all CRMS wetlands sites within the Louisiana Coastal Zone. The VV for this site was comparable to three of the five reference CRMS sites, and after a large dip in 2011 both the FQI and the VV began to recover by 2012.

Three of the reference CRMS sites had generally higher FQI scores than the project CRMS site and the remaining two reference sites. Mean cover of *S. patens*, as well as FQI fluctuated throughout the years for all reference stations. By 2012 the project CRMS site as well as all of the reference sites, with the exception of CRMS0253, experienced an upswing in FQI. The VV patterns for the CRMS reference sites did not necessarily follow their FQI score patterns from one year to the next as with CRMS0190. VV at reference CRMS sites was comparative to the project CRMS site.

6. **Reduce shoreline erosion through shoreline stabilization.** As of this time, the goal to reduce shoreline erosion through shoreline stabilization has had mixed results. In the first analysis, shoreline erosion during post-construction (2000-2012) continued behind the rock shoreline protection structure at a rate similar to that during preconstruction (1993-1998). The average rate of shoreline erosion increased slightly by 0.05 m/yr^{-1} during post-construction (2000-2012). This statistic only includes 16 of the 21 original shoreline segments remaining from which data could still be collected since 1996 in pre-construction. Five of the shoreline segments have fragmented to the point of being non-continuous. Shoreline loss peaked between the 2005 and 2008 surveys when the area was impacted by powerful hurricanes; however, rates markedly decreased between 2008 and 2012, which indicate positive project effects. The highest average erosion rates occurred along the easternmost segments which extend out into Bay L'Ours. The lowest rates occurred along the interior shorelines behind the rock shoreline protection structure.

   A separate analysis which included reference shorelines to the north of the rock shoreline protection structure supports the above analysis. Though both project and reference shoreline segments experienced erosion, there was a reduction in shoreline loss rates behind the project structure in the time between the most recent shoreline surveys (2008-2012). Again, the greatest rate of shoreline loss occurred between 2005 and 2008, a period of intense and frequent hurricane activity.

7. **Increase or maintain the relative abundance of submerged aquatic vegetation (SAV).**
   Based upon the CRMS-*Wetlands* review, SAV data collection was discontinued after 2005. Results to meet the project goal were inconclusive. The SAV in the project area appears to respond to changes in salinity. As salinity increases, the total number of species and the relative frequency of occurrence of species decreases.

b. Recommended Improvements

There are no recommendations for monitoring changes within the project. Discussions were underway at the time of this report between CPRA and NRCS to discuss options for preventative maintenance at structure 4 in order to prevent a breach due to the thinning embankment on the south side of the structure.

c. Lessons Learned

Under the current design criteria for CWPPRA projects, most Hydrologic Restoration (HR) projects are designed with the aid of a hydrodynamic model to actively manage coastal restoration projects. Since the GIWW to Clovelly Hydrologic Restoration (BA-02) project was implemented in the early stages of the CWPPRA program, hydrologic modeling was not performed during the design phase. Evaluation of the initial post-construction data did not result in a conclusive determination regarding project effectiveness; therefore, a post construction hydrodynamic model was developed on a subset of project features to determine if the constructed features were providing the anticipated reduction in salinity and tidal exchange, and to assess whether the project features required design modifications. "The results of the model illustrated that the constructed features reduced salinity in the project area on the order of 3 to 4 ppt on average with no modifications. Modifications to the largest structure along Clovelly Canal revealed that an additional 2 to 3 ppt reduction in salinity levels could be attained by reducing the size of the barge bay opening" (Meselhe et al. 2006). From the limited modeling effort completed on this project, we have learned that biological data collection alone does not always provide the conclusive results in determining project effectiveness, and that biological data collection along with hydrodynamic modeling can be utilized to analyze goals and objectives of HR projects.

Land rights for both the project area and reference area need to be acquired prior to the construction of the project in areas that represent the project area. This was one of the first projects; land rights are currently acquired much earlier in the process than they were at the start when this project started.

Data collection stations need to be located in the proper areas both within the project area and— more importantly—in the reference area. Without a reference area, it is much more difficult to determine the effectiveness of the project features.

Data collection stations should not be inactivated until substitute stations are established and active. As with the CRMS-*Wetlands* project the anticipated timeline for station construction and activation was delayed due to several external factors. Project-specific stations should have remained active until the CRMS-*Wetlands* were active so there would be no data gaps.

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Appendix A

Inspection Photos

Photo 1: View of small breach around the east side of Structure 43

Photo 2: View of Structure 43 looking north. The rock plug is not visible through the vegetation.

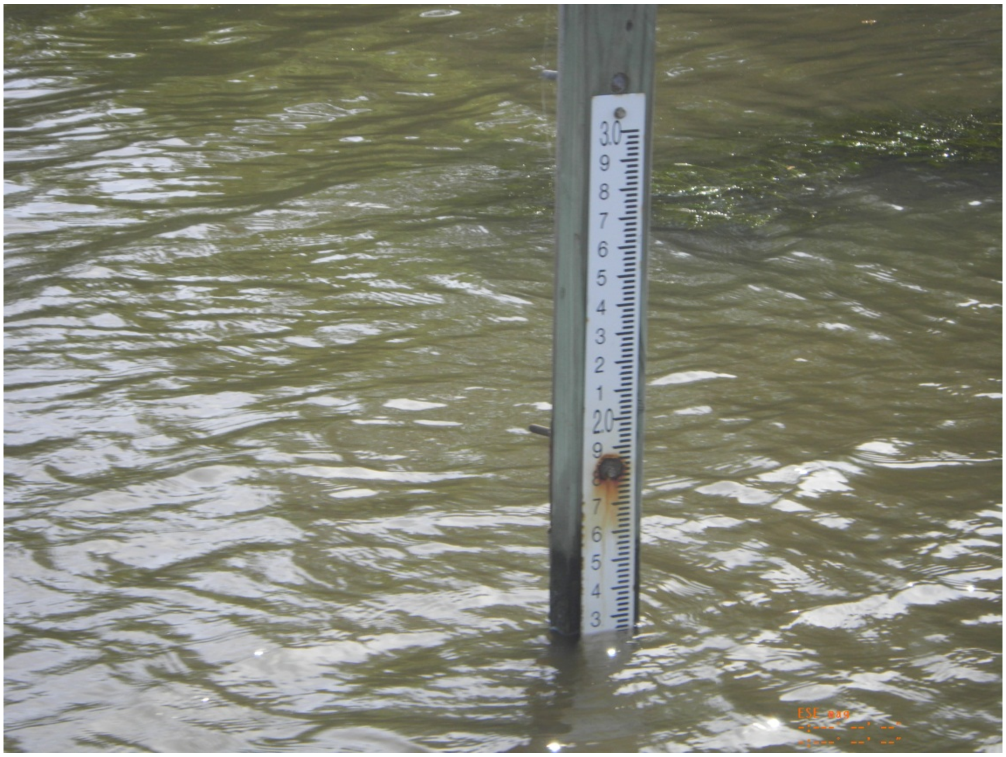


Photo 3: A tide reading of 1.25' NAVD88 was taken near Structure 1 at approximately 10:00am

Photo 4: Overall view of Structure 1 rock riprap weir, looking southwest

Photo 5: Close up view of the embankment tie-ins on the east side of Structure 1

Photo 6: Close up view of the embankment tie-ins on the west side of Structure 1

Photo 7: View of the newly installed timber pile clusters and signs on the north side of Structure 1

Photo 8: View of the newly installed timber pile clusters and signs on the south side of Structure 1

Photo 9: View of Breach Closure No. 5 which was part of the 2012 Maintenance Project

Photo 10: View of Breach Closure No. 5 which was part of the 2012 Maintenance Project

Photo 11: View of Breach Closure No. 4 which was part of the 2012 Maintenance Project

Photo 12: View of Breach Closure No. 4 which was part of the 2012 Maintenance Project

Photo 13: Overall view of Structure 91 rock plug with culvert and flap gate, looking south

Photo 14: Close up view of Structure 91 warning sign damaged by vandals

Photo 15: Galvanized pile caps installed on canal side of Structure 91 as part of 2012 Maintenance Project

Photo 16: Galvanized pile caps installed on marsh side Structure 91 as part of 2012 Maintenance Project

Photo 17: Overall view of Structure 90 rock plug, looking southwest

Photo 18: Close up view of the embankment tie-in on the southeast side of Structure 90

Photo 19: Close up view of the embankment tie-in on the northwest side of Structure 90

Photo 20: Close of view of the warning signs and supports of Structure 90

Photo 21: View of Breach Closure No. 2 which was part of the 2012 Maintenance Project

Photo 22: View of Breach Closure No. 2 which was part of the 2012 Maintenance Project

Photo 23: View of Breach Closure No. 2 which was part of the 2012 Maintenance Project

Photo 24: View of Breach Closure No. 3 which was part of the 2012 Maintenance Project

Photo 25: View of Breach Closure No. 3 which was part of the 2012 Maintenance Project

Photo 26: View of Breach Closure No. 3 which was part of the 2012 Maintenance Project

Photo 27: View of Breach Closure No. 1 which was part of the 2012 Maintenance Project

Photo 28: View of Breach Closure No. 1 which was part of the 2012 Maintenance Project

Photo 29: Overall view of Structure 35 variable crest weir, looking northeast

Photo 30: Close up view of Structure 35 warning signs, railings, steel bulkhead, and operating crane

Photo 31: View of the southernmost end of the Lake Rim rock dike refurbishment in Breton Canal

Photo 32: View of the Lake Rim rock dike refurbishment from Breton Canal, looking north

Photo 33: View of the Lake Rim rock dike refurbishment from Breton Canal, looking northwest

Photo 34: View of the Lake Rim rock dike refurbishment from Breton Canal, looking northwest

Photo 35: View of the Lake Rim rock dike refurbishment from Breton Canal, looking northwest

Photo 36: View of the Lake Rim rock dike refurbishment from Breton Canal, looking north

Photo 37: View of Lake Rim fish dip and warning sign from Little Lake, looking west

Photo 38: View along the Lake Rim rock dike refurbishment from Little Lake, looking west

Photo 39: View of Lake Rim fish dip and warning sign from Little Lake, looking southwest

Photo 40: Overall view of Structure 2 fixed crest rock weir with boat bay, looking southwest

Photo 41: View of warning sign and rock recap on the southern side of Structure 2

Photo 42: View of the embankment tie-in on the southern side of Structure 2

Photo 43: View of warning sign and rock recap on the northern side of Structure 2

Photo 44: View of the embankment tie-in on the northern side of Structure 2

Photo 45: View of the warning sign and embankment tie-in on the south side of Structure 4

Photo 46: View along the rock recap of Structure 4, looking northwest

Photo 47: Overall view of Structure 4 fixed crest rock weir with boat bay, looking west

Photo 48: View of new warning sign and transition between Structure 4 and Rock Dike Extension

Photo 49: View of Rock Dike Extension from Little Lake, looking north

Photo 50: View of new warning sign and transition from Rock Dike Extension to Structure 4A&4B

Photo 51: View of Structure 4A&4B rock recap along Little Lake, looking north

Photo 52: View of the northernmost end of Structure 4A&4B, looking west

Photo 53: Overall View of Structure 7 fixed crest rock weir with boat bay, looking west

Photo 54: View of the warning sign and embankment tie-in on the southern end of Structure 7

Photo 55: View of the warning sign and embankment tie-in on the northern end of Structure 7

Photo 56: View of Structure 8 rock riprap channel plug, looking north

Photo 57: View of Structure 8 rock riprap channel plug, looking north

Photo 58: Overall view of Structure 14 fixed crest rock weir with barge bay from Little Lake looking west

Photo 59: View of the rock recap on the northern side of Structure 14 from Little Lake, looking northwest

Photo 60: View of navigational light installed on the timber pile cluster at Structure 14

Photo 61: View along the rock recap on the northern side of Structure 14 from the barge bay, looking north

Photo 62: View along the northern side of Structure 14 from Clovelly Canal, looking northeast

Photo 63: View of newly installed timber pile cluster and sign on northwest side of Structure 14

Photo 64: View of the rock recap on the southern side of Structure 14, looking south east

Photo 65: View along the southern side of Structure 14 from Clovelly Canal, looking southeast

Photo 66: Overall view of Structure 14 fixed crest rock weir with barge bay from Clovelly Canal looking east

Appendix B

Three Year Budget Projections

WW TO CLOVELLY, ASES 1 & 2 / BAO2 / PPL1

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

Project Manager	O & M Manager	Federal Sponsor	Prepared By
	A. Ledet	*NRCS*	*A. Ledet*

	2013/2014	2014/2015	2015/2016
Maintenance Inspection	$ 6,456.00	$ 6,650.00	$ 6,850.00
Nav. Aid Inspection/Maint.	$ 3,000.00	$ 5,000.00	$ 5,000.00
Structure Operation	$ 9,000.00	$ 10,000.00	$ 10,000.00
State Administration	$ 3,090.00	$ 3,188.00	$ 3,284.00
Federal Administration	$ -	$ -	
Maintenance/Rehabilitation			

13/14 Description	Routine Maintenance: Navigational aid and structure operations

E&D	$ -
Construction	$ -

Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

14/15 Description:	Routine Maintenance: navigation aid maintenance and structure operations

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

15/16 Description:	Routine Maintenance: navigation aid maintenance and structure operations

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

	2013/2014	2014/2015	2015/2016
Total O&M Budgets	**$ 21,546.00**	**$ 24,838.00**	**$ 25,134.00**
Total O&M Budget 2013 through 2016			**$ 71,518.00**
Unexpended O&M Budget			**$ 168,589.00**
Remaining O&M Budget (Projected)			**$ 97,071.00**

Unexpended budget includes a deduction for NRCS M IPR in the amount of $86,456

OPERATIONS & MAINTENANCE BUDGET WORKSHEET

Project: <u>BA-02 GIWW to Clovelly Hydrologic Restoration Ph. 1 &2</u>

FY 13/14 –

CPRA Administration		$ 3,090*
O&M Inspection & Report		$ 6,456
Structure Operations:		$ 9,000
Maintenance:		$ 3,000
E&D:	$ 0	
Construction:	$ 0	
Construction Oversight:	$ 0	
General Maintenance:	$ 3,000	

Operation and Maintenance Assumptions:

Structure Operations: water control structure operated twice annually for a total of $4,500 per operation. (2)($4,500) = $9,000 plus $2,000* for CPRA administration.

General Maintenance: Water control structure, navigation aids repair. Construction: $3,000. Administration: $1,090*

FY 14/15 –

CPRA Administration		$ 3,188*
O&M Inspection & Report		$ 6,650
Structure Operations:		$ 10,000
Maintenance:		$ 4,000
E&D:	$ 0	
Construction:	$ 0	
Construction Oversight:	$ 0	
General Maintenance:	$ 5,000	

Operation and Maintenance Assumptions:

Structure Operations: water control structure operated twice annually for a total of $5,000 per operation. (2)($5,000) = $10,000 plus $2,000* for CPRA administration.

General Maintenance: Water control structure, navigation aids repair. Construction: $4,000. Administration: $1,188*

FY 15/16 –

CPRA Administration	$ 3,284*
O&M Inspection & Report	$ 6,850
Structure Operations:	$ 10,000
Maintenance:	$ 4,000

E&D:	$ 0
Construction:	$ 0
Construction Oversight:	$ 0
General Maintenance:	$ 4,000

Operation and Maintenance Assumptions:

Structure Operations: water control structure operated twice annually for a total of $5,000 per operation. (2)($5,000) = $10,000 plus $2,000* for CPRA administration.

General Maintenance: Water control structure, navigation aids repair. Construction: $4,000. Administration: $1,284*

<u>2013-2016 Accounting</u>

Current O&M Funding (Lana Report)	$3,460,557.00
Expenditures from DNR Accounting	$3,047,671.00
NRCS MIPR	$ 86,456.00
2012 Maintenance Project (balance remaining)	$ 152,841.00
CPRA Administration (Jan 1 thru to date) est.	$ 5,000.00
Unexpended O&M Budget:	**$168,589**

Appendix C

Habitat Analysis Maps

and

Discrete Salinity Map

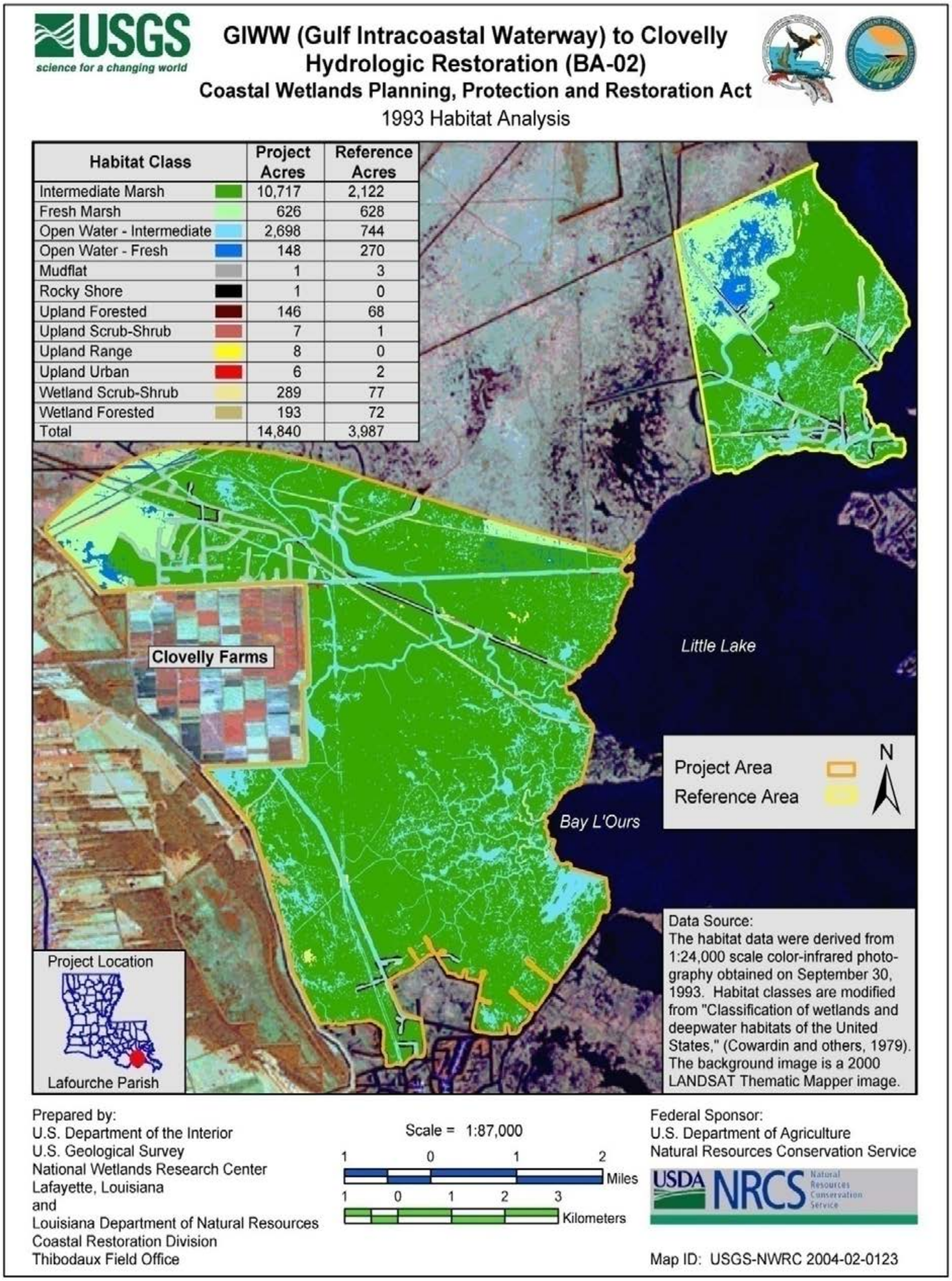
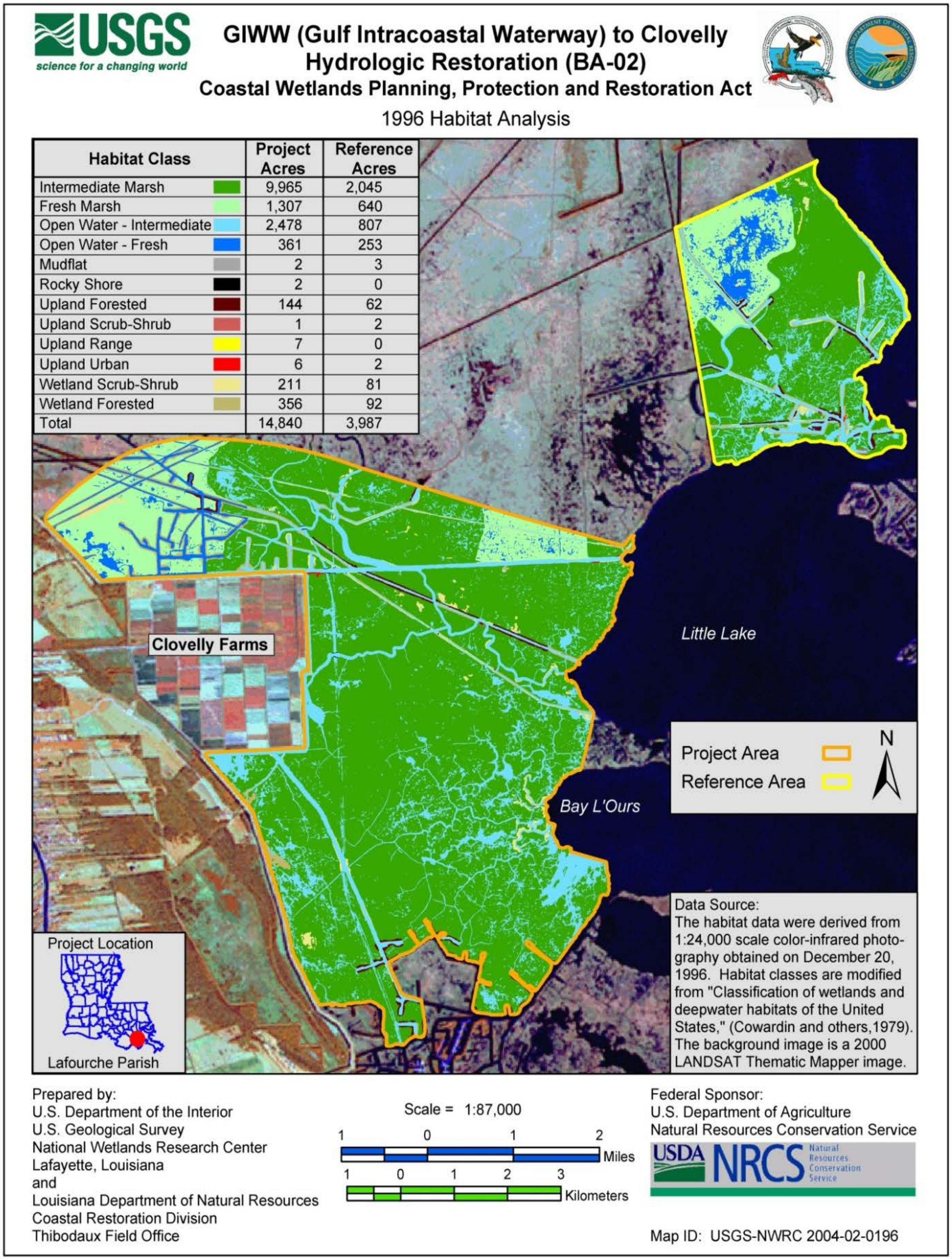
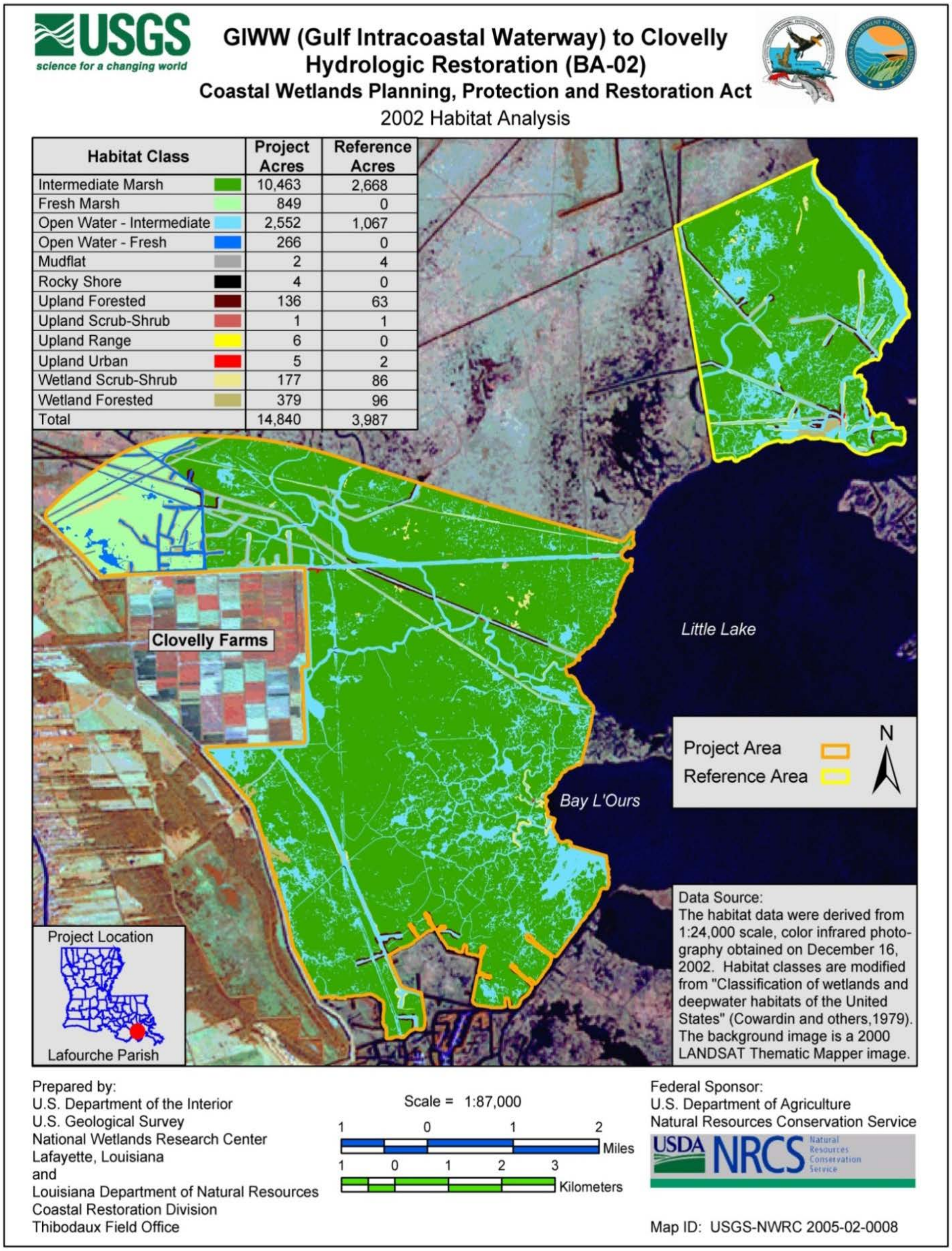


Figure 1. 1993 Habitat Analysis Map for the BA-02 Project and reference areas.



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 2. 1996 habitat analysis map for the BA-02 project and reference areas.



Habitat Class	Project Acres	Reference Acres
Intermediate Marsh	10,463	2,668
Fresh Marsh	849	0
Open Water - Intermediate	2,552	1,067
Open Water - Fresh	266	0
Mudflat	2	4
Rocky Shore	4	0
Upland Forested	136	63
Upland Scrub-Shrub	1	1
Upland Range	6	0
Upland Urban	5	2
Wetland Scrub-Shrub	177	86
Wetland Forested	379	96
Total	14,840	3,987

Figure 3. 2002 habitat analysis map for the BA-02 project and reference areas.

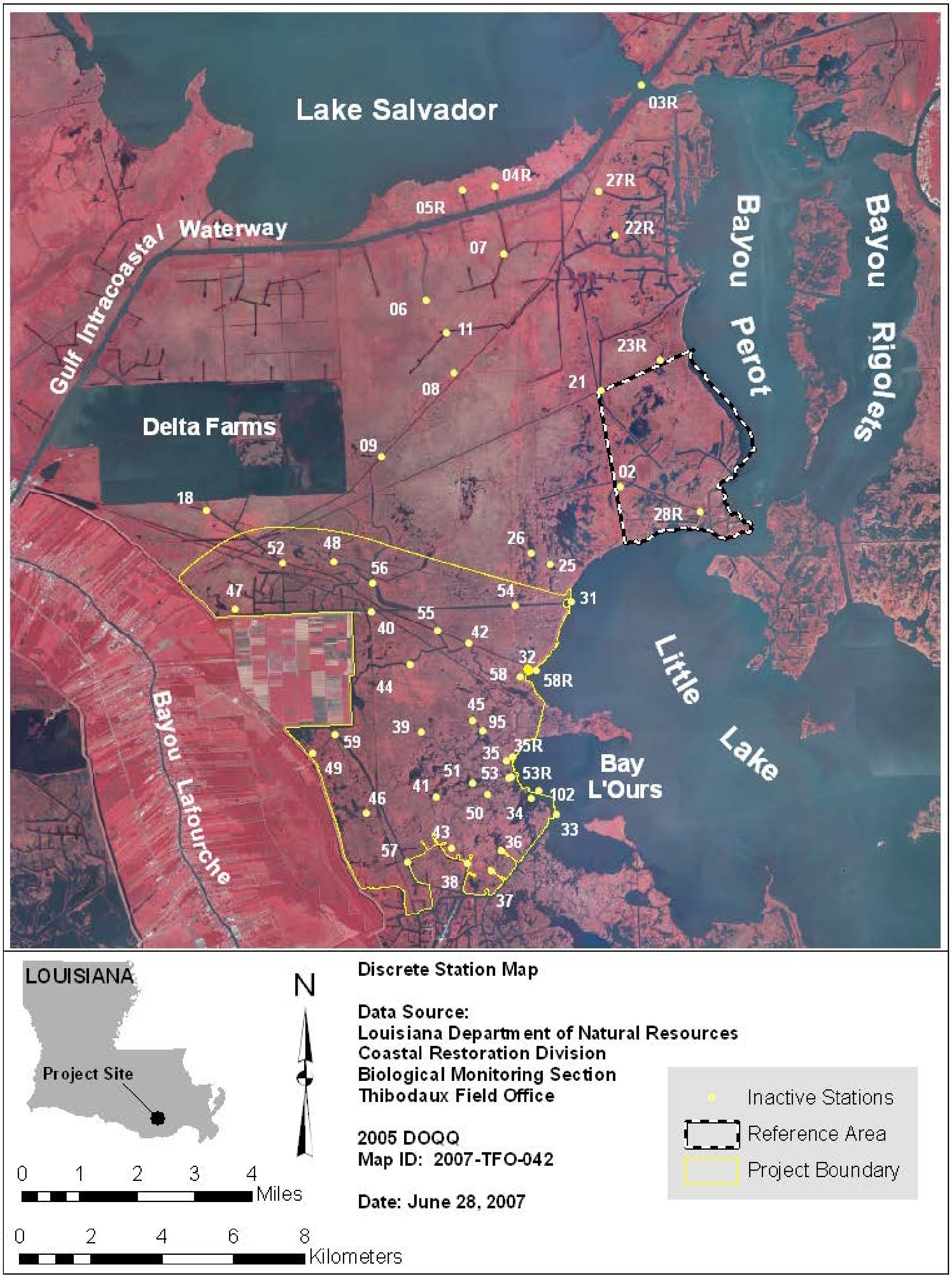


Figure 3. Location map of discrete salinity stations inside the BA-02 project and reference areas.

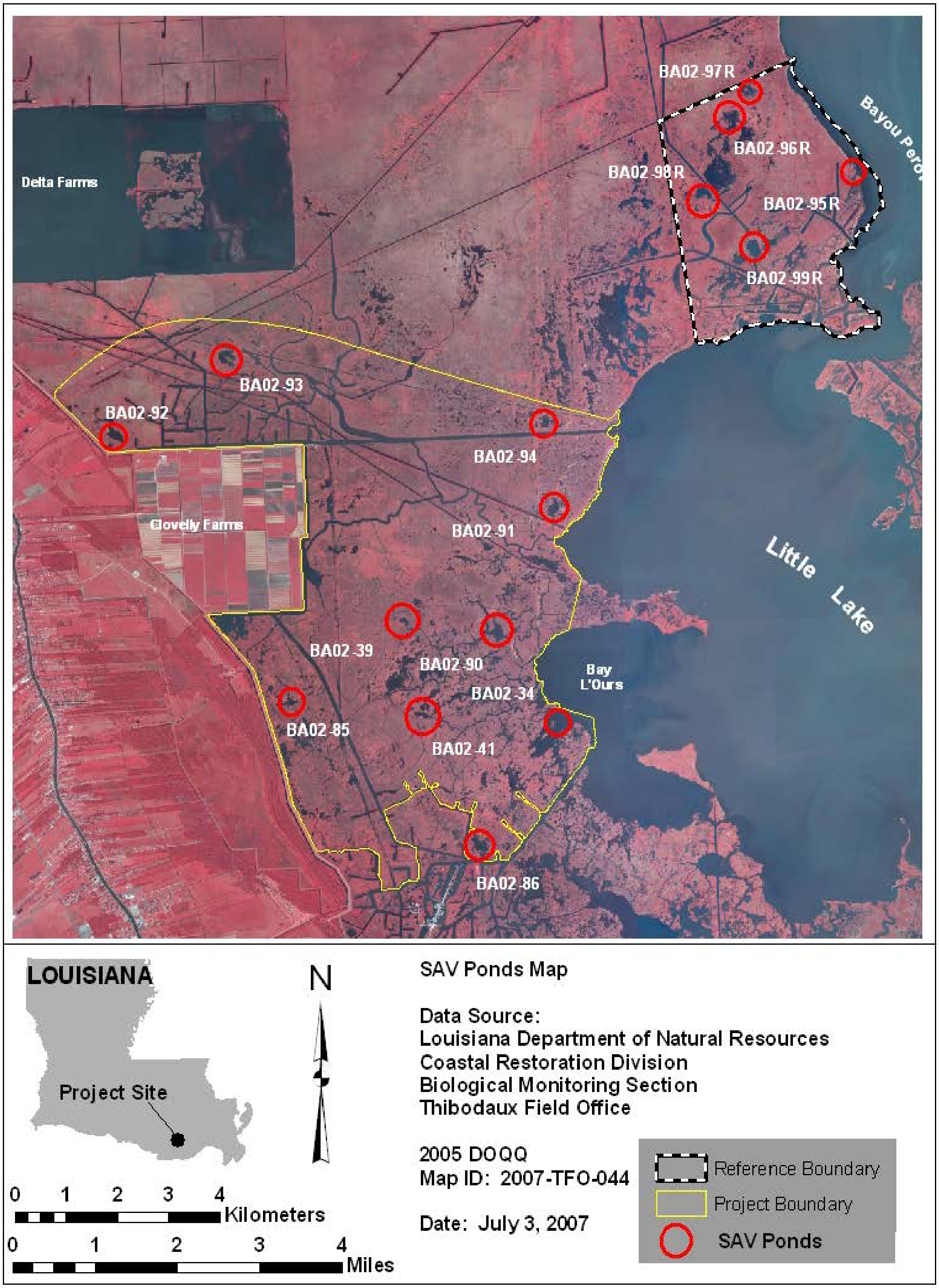


Figure 4. Location map of SAV ponds inside the BA-02 project and reference areas.

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	