State of Louisiana
Coastal Protection and Restoration Authority

2011 Operations, Maintenance, and Monitoring Report

for

Jonathan Davis Wetland Restoration (BA-20)

State Project Number BA-20
Priority Project List 2

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Jefferson Parish

Prepared by:
Melissa K. Hymel
and
Barry J. Richard

Operations Division
New Orleans Field Office
CERM, Suite 309
2045 Lakeshore Drive
New Orleans, LA 70122

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Preface

This report includes monitoring data collected through December 2010, and Annual Maintenance Inspections through April 2011.

The 2011 Operations, Maintenance, & Monitoring (OM&M) Report is the second in a series that includes some monitoring data and analyses presented previously in the 2007 OM&M report (Barmore et al. 2007), plus additional project-specific and CRMS data collected since 2007. For additional information on lessons learned, recommendations and project effectiveness please refer to the 2007 OM&M Report at the following website:
http://sonris.com/direct.asp?path=/sundown/cart_prod/cart_bms_avail_documents_f

I. Introduction

The Jonathan Davis Wetland Restoration (BA-20) project is located in Jefferson Parish within the Barataria Basin. The 7,199-acre (2,880 ha) project area is bounded on the north by the Pailet Canal, on the east by LA Hwy 301, on the south by Bayou Perot and Bayou Rigolettes, and on the west by the Gulf Intracoastal Waterway (GIWW) (Figure 1). Overall, 1,393 ac (557 ha) of land were converted to open water between 1945 and 1989 (Coastal Environments Inc. 1991). The average rate of change from marsh to non-marsh (including loss to both open water and commercial development) has increased since the 1940s. Marsh loss rates were 0.56 %/yr between 1939 and 1956, 0.60 %/yr between 1956 and 1974, and 0.73 %/yr between 1983 and 1990 (Dunbar et al. 1992). In the National Biological Survey (NBS) Geographic Information System (GIS) habitat data from 1956, the majority of the area was characterized as fresh marsh (NBS 1994a). However, the 1978 and 1990 data indicated that the area had become more saline. In 1978, 1988, and 1990, the area was classified as primarily intermediate marsh (NBS 1994b; NBS 1994c; Chabreck and Linscombe 1988).

Large-scale factors influencing degradation in the Barataria Basin included subsidence, lack of sedimentation, and reduced freshwater influx due to the levee system on the Mississippi River and its major distributaries. The subsidence rate based on the U.S. Army Corps of Engineers (USACE) tide gauge readings (1947–78) at Bayou Rigaud, Grand Isle, Louisiana, was 0.80 cm/yr (Penland et al. 1989). Although some sediment entered via the GIWW, there were no substantial sources allowing inorganic sediment into the project area. In addition, the increase in oil field canals led to the exportation of indigenous inorganic and organic sediment during storm surges (U.S. Department of Agriculture, Soil Conservation Service 1994).

Additional factors that influenced wetland loss within the project area were increased water exchange, saltwater intrusion, tidal scour, and shoreline erosion along Bayous Perot and Rigolettes (U.S. Department of Agriculture, Soil Conservation Service 1994). Shoreline erosion from 1945 to 1989, caused primarily by wave action along Bayou

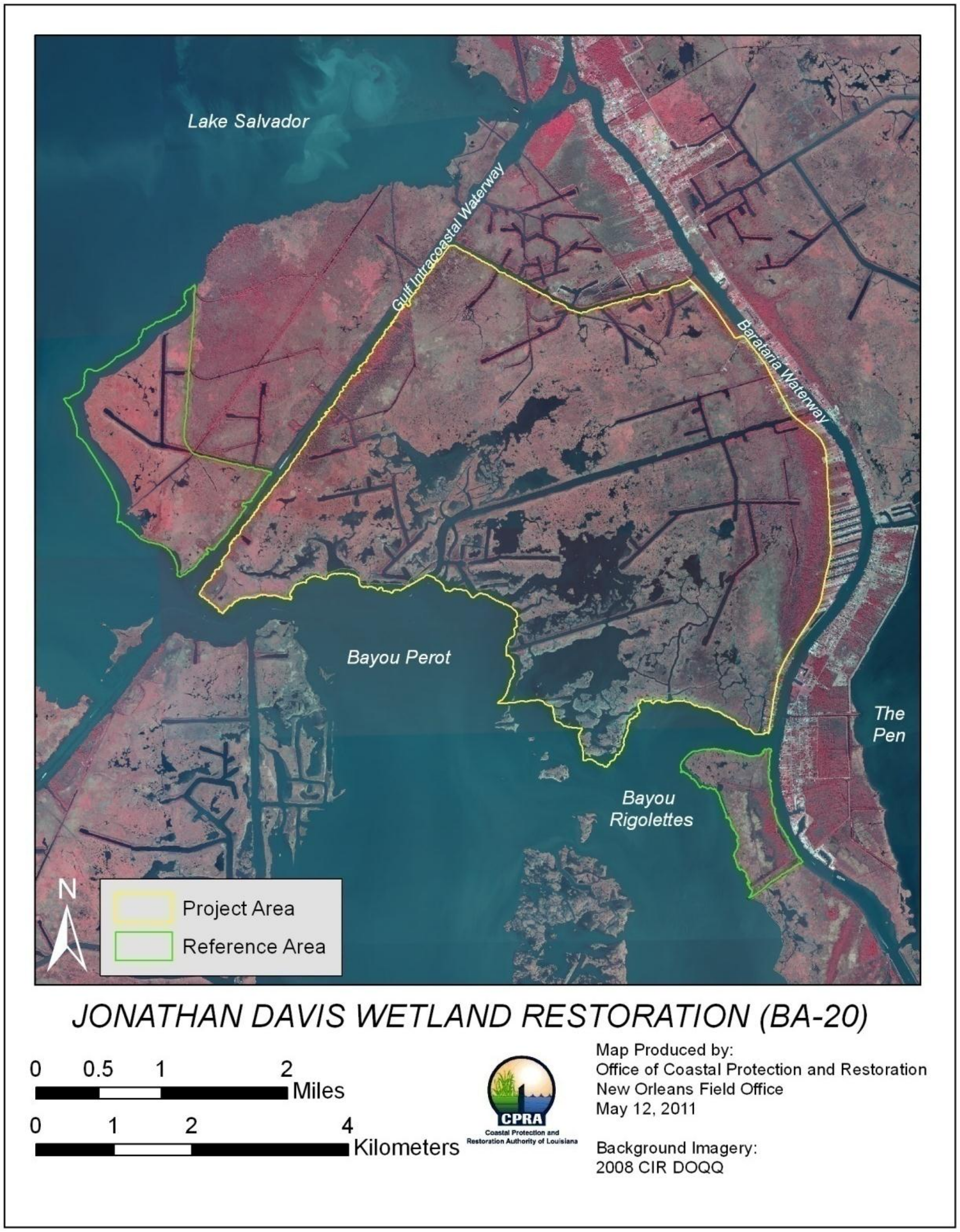


Figure 1. Jonathan Davis Wetland Restoration (BA-20) project and reference areas.

Perot, was measured at 20 ft/yr (6.1 m/yr) (Coastal Environments Inc. 1991). Saltwater intrusion and tidal scour were enhanced during the construction of oil field canals dredged in the 1940s. At the time, oil companies were not responsible for maintaining a continuous spoil bank along canals. The resulting breaches were not repaired and the interior marsh was exposed to increased salinity and tidal flows during storm surges (U.S. Department of Agriculture, Soil Conservation Service 1993).

The objectives of the BA-20 project were to: 1) use structural measures to restore hydrologic conditions that reduce water level and salinity fluctuations (variability) and allow freshwater retention to increase the quantity and quality of emergent vegetation, and 2) reduce wetland loss through hydrologic restoration and reduce erosion through shoreline protection. Constructed project features consist of shoreline protection, rock armored plugs, rock weirs, and sheetpile weirs with boat bays (Figure 2). Construction Unit 1 (CU1), which consists of structures 12, 13, 14, 15, 16, 17, 19, 20, and 21, was completed in September 1998. Construction Unit 2 (CU2), which consists of a weir at site 22 and shoreline protection from structures 20 to 22, was completed in May 2001. Construction Unit 3 (CU3), which consists of shoreline protection from project feature 12 extending west to the Gulf Intracoastal Waterway and a smaller portion extending west from CU2, was completed on July 7, 2003. Construction Unit 4 (CU4), which consists of shoreline protection connecting the eastern and western portions of CU3, is scheduled to be completed in mid to late 2011. Construction of additional breach armor and rock weir features in the northern project area has been deferred because: 1) the Davis Pond diversion may have transformed these sites into avenues for freshwater (including fine-grain sediments and nutrients) to enter the project area marshes from the north; 2) early attempts to secure landrights were unsuccessful; and 3) these sites did not appear to be causing any significant marsh erosion as a result of water exchange.

II. Maintenance Activity

a. Project Feature Inspection Procedures

An inspection of the Jonathan Davis Wetland Restoration (BA-20) project was held on April 21, 2011, by Barry Richard of CPRA and Quin Kinler and Mike Trusclair of NRCS. Photographs of that inspection are included in Appendix A.

The purpose of the annual inspection of the Jonathan Davis Wetland Restoration (BA-20) project is to evaluate the constructed project features, to identify any deficiencies, and to prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, the CPRA shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs (Babin 2002). The annual

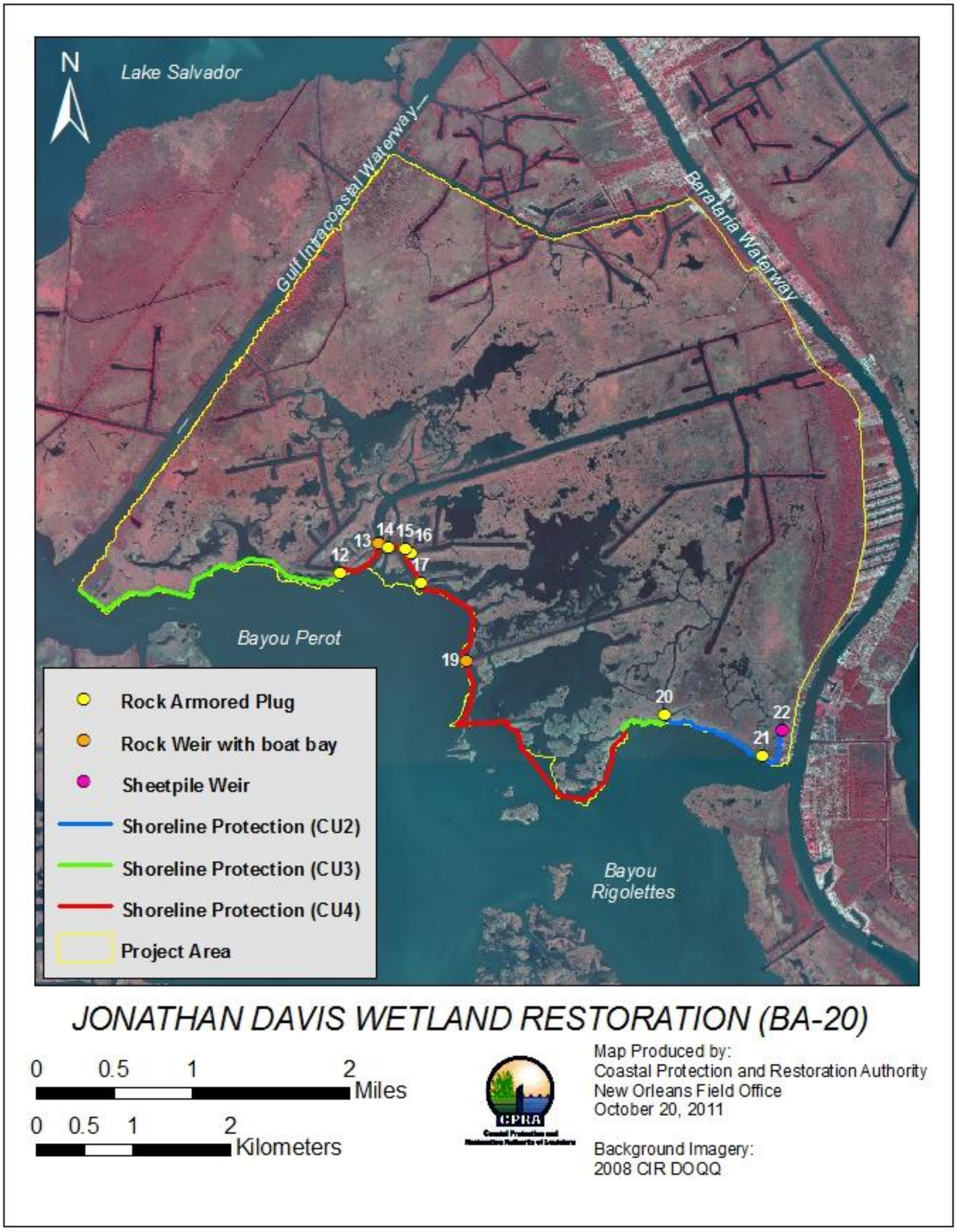


Figure 2. Constructed project features of the Jonathan Davis Wetland Restoration (BA-20) project.

inspection report also contains a summary of maintenance projects and an estimated projected budget for the upcoming three (3) years for operations, maintenance and rehabilitation. The three (3) year projected operations and maintenance budget is shown in Appendix B.

b. Inspection Results

Construction Unit No. 1

Structure No. 12 – Rock rip-rap armored plug
The structure is in good condition. There is some slight settling across the structure. All of the signs and supports were in good condition. At this time there is no need for any maintenance work to be done at this structure.

Structure No. 13 – Rock rip-rap armored weir w/ boat bay
Due to the water level and structure settlement, the structure was not visible. All signs and supports are in good condition. No maintenance will be required at this time.

Structure No. 14 – Rock rip-rap armored plug
Approximately 80% of this structure has been repaired. Two breaches were still present at the time of the inspection (Photo #1). Additional repair of this structure was made during CU4 construction.

Structure No. 15 – Rock rip-rap weir w/ boat bay
All maintenance has been completed on this structure during construction of CU4. The boat bay has been filled, converting this structure to a plug, and everything is in good condition (Photo #2).

Structure No. 16 – Rock rip-rap channel plug

Structure 16 was difficult to inspect due to the amount of vegetation growing on the structure (Photo #3). It is assumed that this structure has stabilized due to the conditions of the channel and the structure signage. The new construction has tied this structure in with the rest of the Construction Units and it is recommended that there be no maintenance work at this time.

Structure No. 17 – Rock rip-rap channel plug

All maintenance work has been completed during construction of CU4 and the structure is in good condition.

Structure No. 19 – Rock rip-rap weir w/ boat bay

Structure 19 appeared to be in good condition. The tides and settlement prevented us from viewing the entire structure. The warning signs and supports were also in good condition. NRCS and CPRA agree that this structure will not require maintenance.

Structure No. 20 – Rock rip-rap armored plug

The structure appeared to be in good condition with no signs of settlement of the rock weir. The warning signs and supports were also in good condition. The structure was heavily vegetated at the time of inspection. NRCS and CPRA agree that this structure will not require maintenance.

Structure No. 21 – Rock rip-rap armored plug

The rock armored plug appeared to be in good condition with slight settlement on the east side of the structure. It was difficult to fully assess the condition due to the amount of vegetation on the structure. CPRA and NRCS agree that the structure will not require maintenance at this time.

Construction Unit No.2

Structure No. 22 A – Canal bank stabilization

The structure looked to be in good condition. The structure is becoming more vegetated and there are little to no signs of settlement. CPRA and NRCS agree that maintenance of this structure is not needed at this time.

Structure No.22 – Steel sheet pile weir

The structure appears to be in good condition along with the signs, supports, and sheet pile caps. CPRA and NRCS agree that this structure will require no maintenance at this time.

Bayou Rigolettes Bank Stabilization

The rock dike along the northern shore of Bayou Rigolettes appears to be in good condition. There is some noticeable settlement near the western end of this feature (Photo #4). Any maintenance work required will be completed in a future maintenance event.

Construction Unit No.3

Bayou Perot Bank Stabilization

The Bayou Perot Bank Stabilization appears to be in good condition. There was some erosion observed at the westernmost portion of the structure, which will continue to be monitored. Some settlement was also observed. It was agreed by CPRA and NRCS that some maintenance work is needed for this structure during a future maintenance event.

c. Maintenance Recommendations

There is no need for any maintenance activity at this time.

i. **Immediate/ Emergency Repairs**
None at this time.

ii. **Programmatic/ Routine Repairs**
Continue to monitor the condition of all structures.

d. Maintenance History

On January 30, 2002, Stone Energy Corporation was issued a Coastal Use Permit to plug and abandon existing wells within the Jonathan Davis Wetland Restoration project. This work was completed on 7/18/02 and consisted of removing and replacing structures 13 & 19 and to plug and abandon several existing wells located behind these structures. The cost associated with removing and replacing these structures was incurred entirely by Stone Energy Corporation. However, at the request of NRCS, CPRA was required to provide inspection services for this project. CPRA obtained the services of GSE Associates, Inc. to inspect construction activities and prepare a project completion report and as-built drawings. These services were performed for a total cost of $9,394.13.

As part of the construction documents prepared by NRCS for this project, Stone Energy Corporation was required to reconstruct structure 13, increasing the boat bay crest from 50' to 100' in width and raising the crest elevation from -5.0' NGVD to -2.5' NGVD.

As part of work for Construction Unit 4, maintenance was performed on structures 14, 15, and 17. Due to the location and activity of a pipeline in the vicinity of Structure 16, no work was performed there. However, due to the location and infilling in front of Structure 16, no work was required.

III. Operation Activity

There are no operations activities associated with the BA-20 project.

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-20 Monitoring Plan to merge it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There are two CRMS sites located in the BA-20 project area, CRMS3985 and CRMS4245, which will be used to supplement existing project-specific data to further evaluate the effectiveness of the project.

a. Monitoring Goals

The following measurable goals were established to evaluate the effectiveness of the project:

1. Reduce rate of emergent marsh loss.

2. Decrease variability in salinity within the project area.

3. Decrease variability in water level within the project area.

4. Stabilize or increase relative abundance of intermediate-to-fresh marsh plant species.

5. Reduce marsh edge erosion rate along southern project boundary.

b. Monitoring Elements

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

<u>Habitat Mapping</u>

Near-vertical, color-infrared aerial photography (1:12,000 scale, with ground control markers) was used to document marsh to open-water ratios and changes in vegetative community type within the project and reference areas in 1994, 1997, and 2002. Aerial photography was checked for flight accuracy, color correctness and clarity, and was scanned, mosaicked, and geo-rectified by USGS/NWRC personnel according to standard operating procedures (Steyer et al. 1995, revised 2000). A closeout land/water analysis will be performed on photography to be obtained in 2014.

Salinity

Salinity was sampled hourly using continuous recorders at three locations within the project area and at three reference sites (Figure 3) using methods described in Folse et al. 2008. The continuous recorder at each site was mounted on a wooden post in open water with sufficient water depths to inundate the recorder year round. Each continuous recorder station was serviced approximately once every month to clean and calibrate the recorder and to download the data. During processing, the data were examined for accuracy and loaded to the CPRA database, and are available for download from the CRMS website (http://www.lacoast.gov/crms2).

Salinity was also sampled monthly at 17 discrete stations using a salinometer (Figure 4). Discrete data were used in concert with continuous salinity data to characterize the spatial variation of salinity throughout the project and reference areas. Salinity monitoring began in December 1995 and ended in January 2005 at most of the continuous recorder sites. A decision was made in September 2002 not to rebuild the northern reference station, BA20-91R, after it was damaged because the northern project features were not being constructed. Salinity monitoring also ended prematurely at BA20-90R in November 2003 because the station was destroyed. Hourly salinity data has also been collected at two Coastwide Reference Monitoring System (CRMS) stations, CRMS3985 and CRMS4245, from May 2008 to present (Figure 3).

Water Level

Water levels were measured hourly using the same continuous recorders that were used for salinity monitoring (Figure 3). A staff gauge was installed next to each continuous recorder to compare recorded water levels to a known datum (NAVD88). Water level (ft NAVD88) is available from November 1997 to January 2005 at the sites within the project area. Water level data are not available past 2003 at BA20-90R and BA20-98R due to station damage and survey issues, which affected the length of post-construction analysis period. Hourly water level data has also been collected at two Coastwide Reference Monitoring System (CRMS) stations, CRMS3985 and CRMS4245, from May 2008 to present (Figure 3).

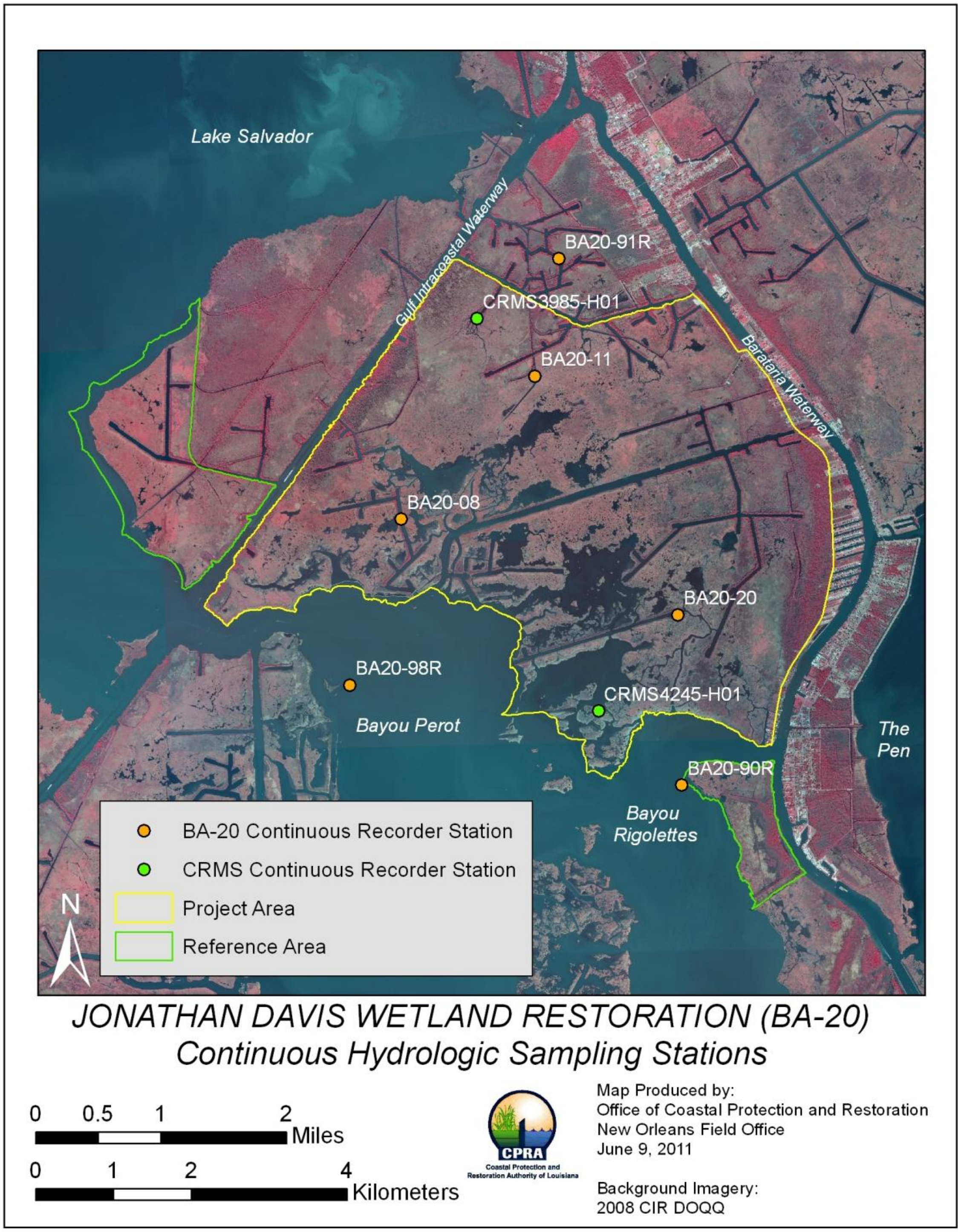


Figure 3. Continuous hydrologic recorder stations associated with the Jonathan Davis Wetland Restoration (BA-20) project.

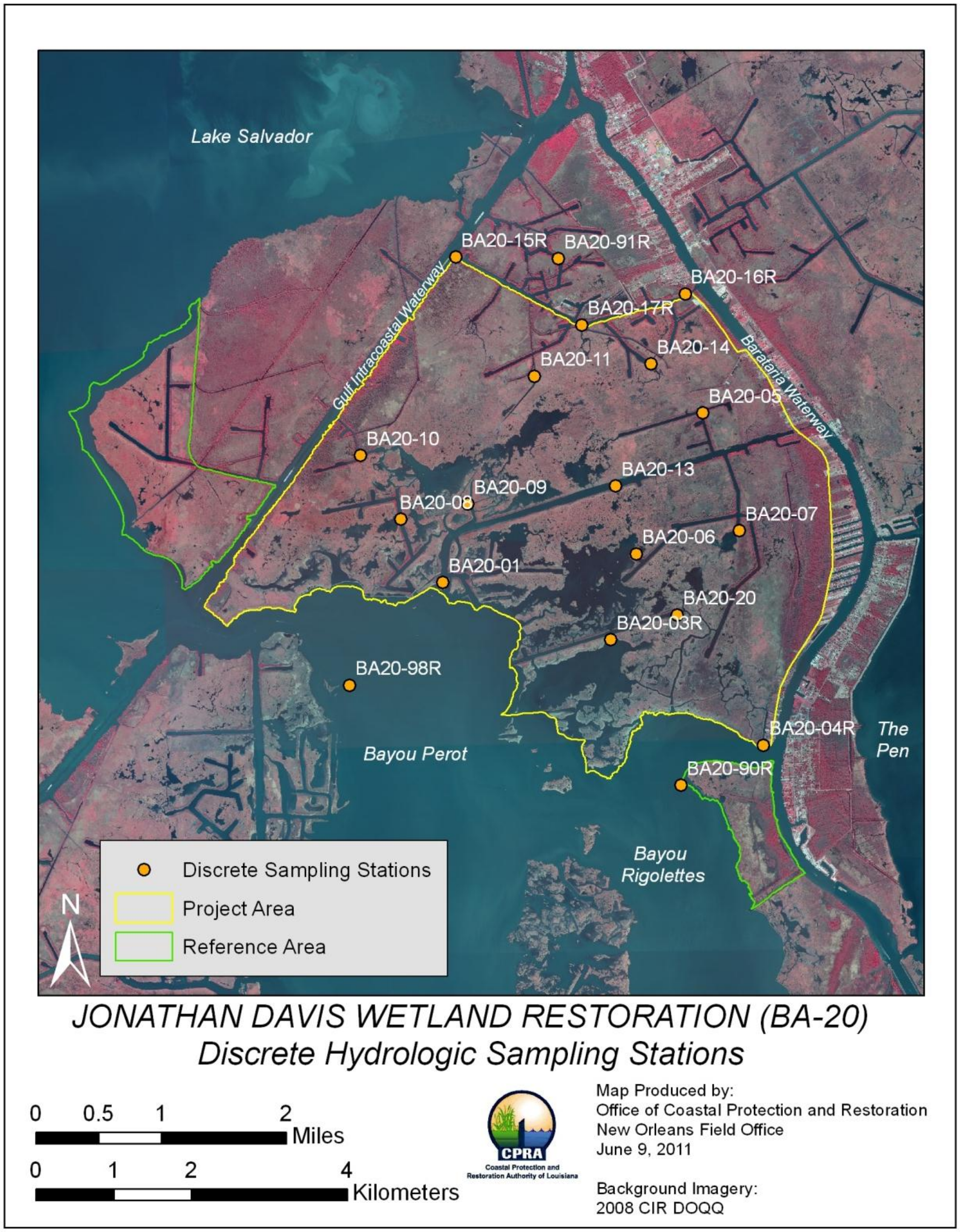


Figure 4. Discrete hydrologic sampling stations associated with the Jonathan Davis Wetland Restoration (BA-20) project.

Shoreline Change

To evaluate shoreline change, a Differential Global Positional Satellite (DGPS) system was used to document the position of the vegetated marsh edge in 2001, 2004, and 2010. The shoreline position was documented by manually taking a DGPS point every 5 to 10 feet along the shorelines of CU2 (as-built) and the eastern reference area in 2001 and of CU2 and CU3 (as-built) in 2004. In 2010, the CU2 and CU3 shorelines were surveyed by collecting a point every two feet in a continuous logging pattern along the shoreline. GPS receiver settings were configured to use real time correction, and data were post-processed in order to achieve sub-meter accuracy. The eastern reference area has not been resurveyed since 2001 because it is now part of the Barataria Landbridge Shoreline Protection Project, Phase 4 (BA-27d) and has been protected with rock revetment since 2006. An as-built survey will be conducted of the CU4 shoreline upon completion of construction in 2011. Surveys will continue to be conducted approximately every three years over the duration of the 20 year monitoring period.

Vegetation

Emergent marsh vegetation sampling stations were established in the project area along five transects running parallel to the GIWW (Figure 5). Stations were located along these transects at 0.8-km increments for a total of 27 stations within the project area. Four transects were established in the two reference areas yielding ten reference stations. Species composition, percent cover, and relative abundance were evaluated within 4-m^2 plots using a modified Braun-Blanquet sampling method (Mueller-Dombois and Ellenberg 1974) in 1996, 1999, and 2002. Emergent marsh vegetation was also sampled at two CRMS sites (CRMS3985 and CRMS4245) within the project area in 2008, 2009, and 2010, and will continue to be sampled annually. At each CRMS site, ten 2-m^2 sampling plots were randomly located along a 288-m transect and were sampled using the same method described above.

Percent coverage data from the BA-20 stations and CRMS stations were summarized according to the Floristic Quality Index (FQI) method utilized by CRMS (Cretini et al. 2011), where cover is qualified by scoring species according to their tolerance to disturbance and stability within specific habitat types.

CRMS Supplemental

Additional data were collected at CRMS-*Wetlands* stations, which can be used as supporting or contextual information for this project. Data types collected at CRMS sites include hydrologic, emergent vegetation, physical soil characteristics, discrete porewater salinity, marsh surface elevation change, vertical accretion, and land:water analysis of the 1-km^2 area encompassing the station (Folse et al. 2008).

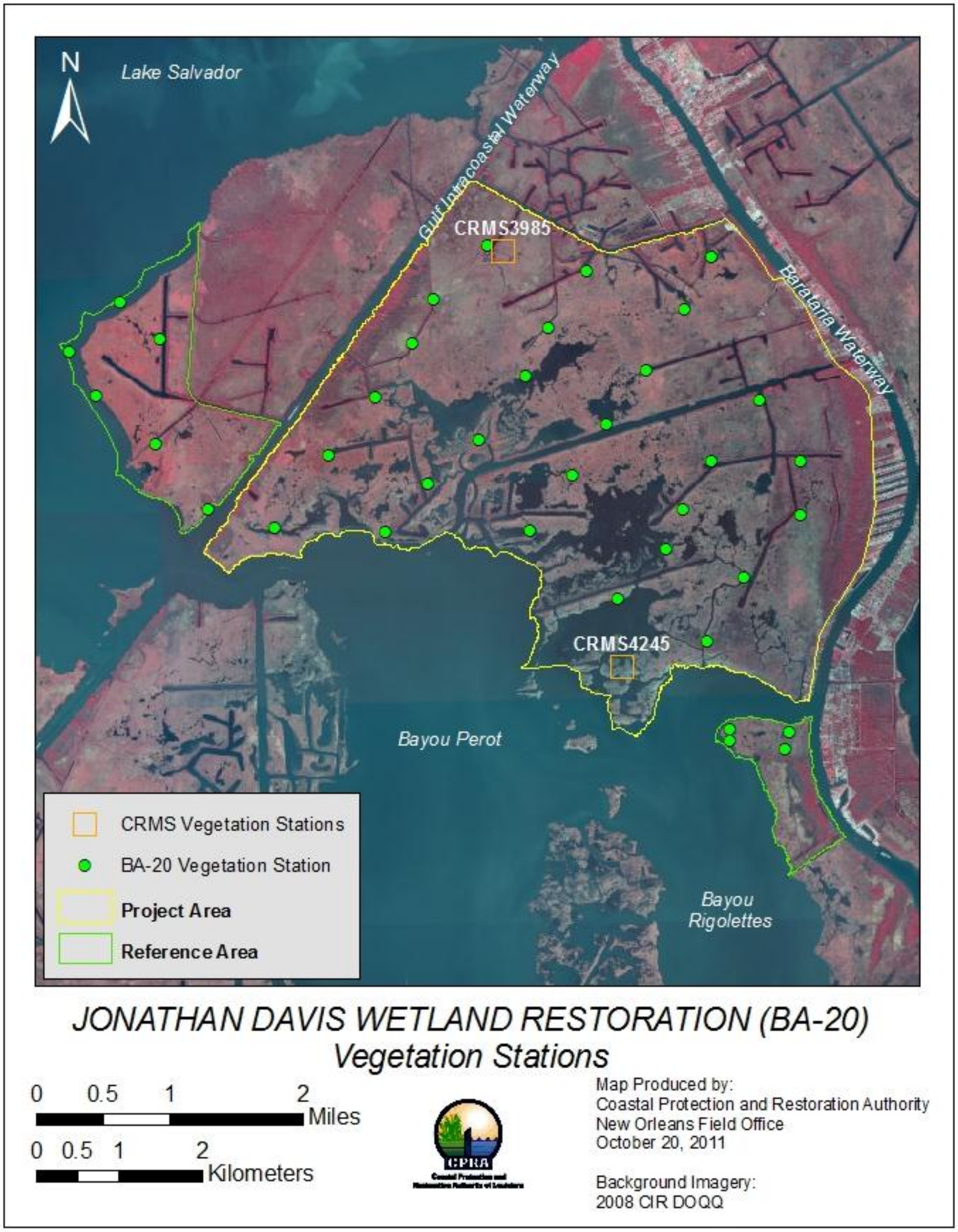


Figure 5. Vegetation stations within the Jonathan Davis Wetland Restoration (BA-20) project and reference areas.

For this report, hydrologic and vegetation data from the two CRMS sites inside the project area (CRMS3985 and CRMS4245) were used to assess project goals in years after project specific monitoring had ended.

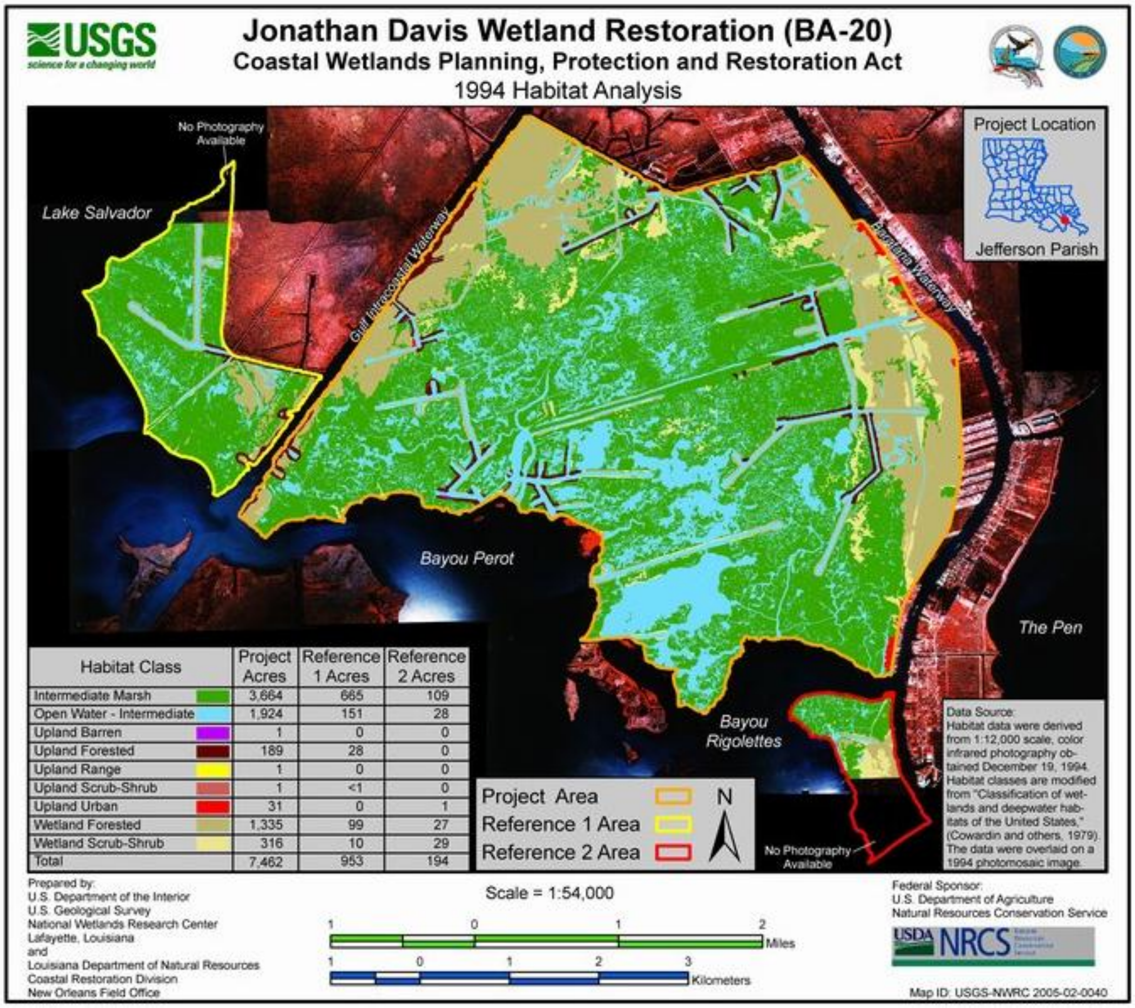
c. Preliminary Monitoring Results

Habitat Mapping

Habitat analyses from 1994, 1997, and 2002 are presented in Figures 6 through 8 with the caveat that the analysis should be used only for predicting trends. Recent and ongoing work by the U.S. Geological Survey (USGS) (John Barras and others) has revealed considerable variability in habitat and land:water classifications due to 1) clarity of image; 2) water level at time image was taken; 3) seasonality; 4) difficulty in distinguishing submerged, floating, and emergent vegetation; and 5) in the case of floating marshes, variable mat buoyancy and frequent vegetative changes. Photography was acquired in mid-December for each analysis year which adjusts for some seasonality differences. However, floating marsh has been confirmed to exist in the BA-20 project area, particularly in the southern project area around CRMS4245, which may introduce additional error in acreage calculations.

One of the specific monitoring goals of the project was to reduce the rate of emergent marsh loss within the project area. Because of the staggered timeline of the various construction units, the only construction unit which may have affected the outcome of the habitat analysis was CU1, which was constructed in September 1998. All three habitat analyses show that the project area consisted primarily of intermediate marsh and open water, along with areas of wetland forest (swamp) and wetland scrub-shrub concentrated along the eastern and northwestern boundaries (Table 1). While it appears that 199 acres or 2.7% of the intermediate marsh in the project area is lost from 1994-1997, there are significant gains in acreage in the wetland forested and wetland scrub-shrub categories. Therefore, these changes may be attributed to reclassification of vegetation types and not a reflection of land loss within the project area. There was an overall gain of 151 acres of land, or 2% of the project area between 1994 and 1997. The 1994 analysis of the reference areas can not be compared because the entire area was not included in the analysis.

There was little change in intermediate marsh acreage (<0.1%) in the project area from 1997 to 2002 and an overall land loss of 56 acres (0.8%) of land. This equates to a loss rate of 11.2 acres/yr during the five year period. The overall land loss from 1997 to 2002 was mainly attributable to loss within the wetland scrub-shrub habitat class, and was relatively smaller than the total land loss in the reference areas (5.7% and 2.8%) during that same period. CU1 construction may have reduced the land loss rate in the project area as compared to the reference



Habitat Class	Project Acres	Reference 1 Acres	Reference 2 Acres
Intermediate Marsh	3,664	665	109
Open Water - Intermediate	1,924	151	28
Upland Barren	1	0	0
Upland Forested	189	28	0
Upland Range	1	0	0
Upland Scrub-Shrub	1	<1	0
Upland Urban	31	0	1
Wetland Forested	1,335	99	27
Wetland Scrub-Shrub	316	10	29
Total	7,462	953	194

Figure 6. 1994 habitat analysis of the Jonathan Davis Wetland Restoration (BA-20) project and reference areas.

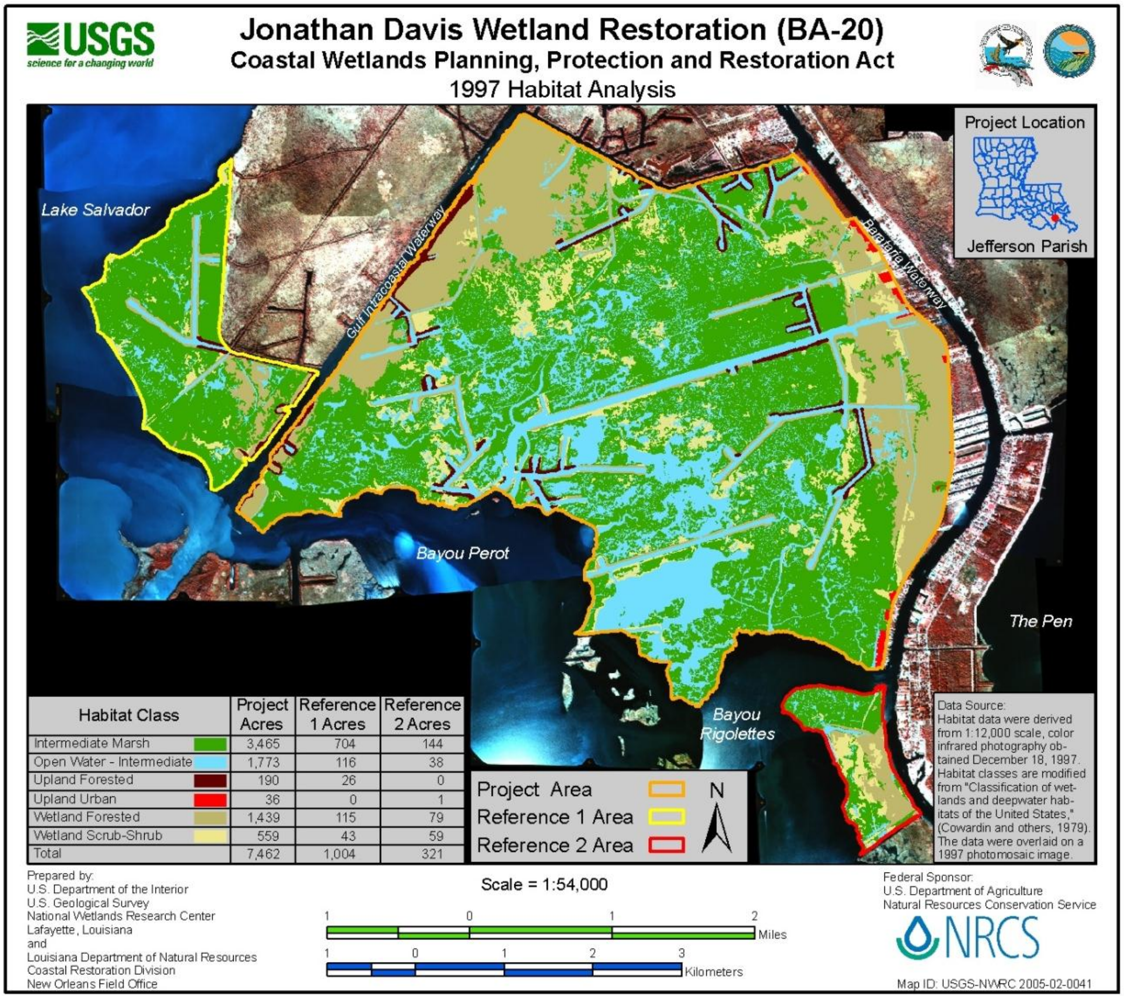
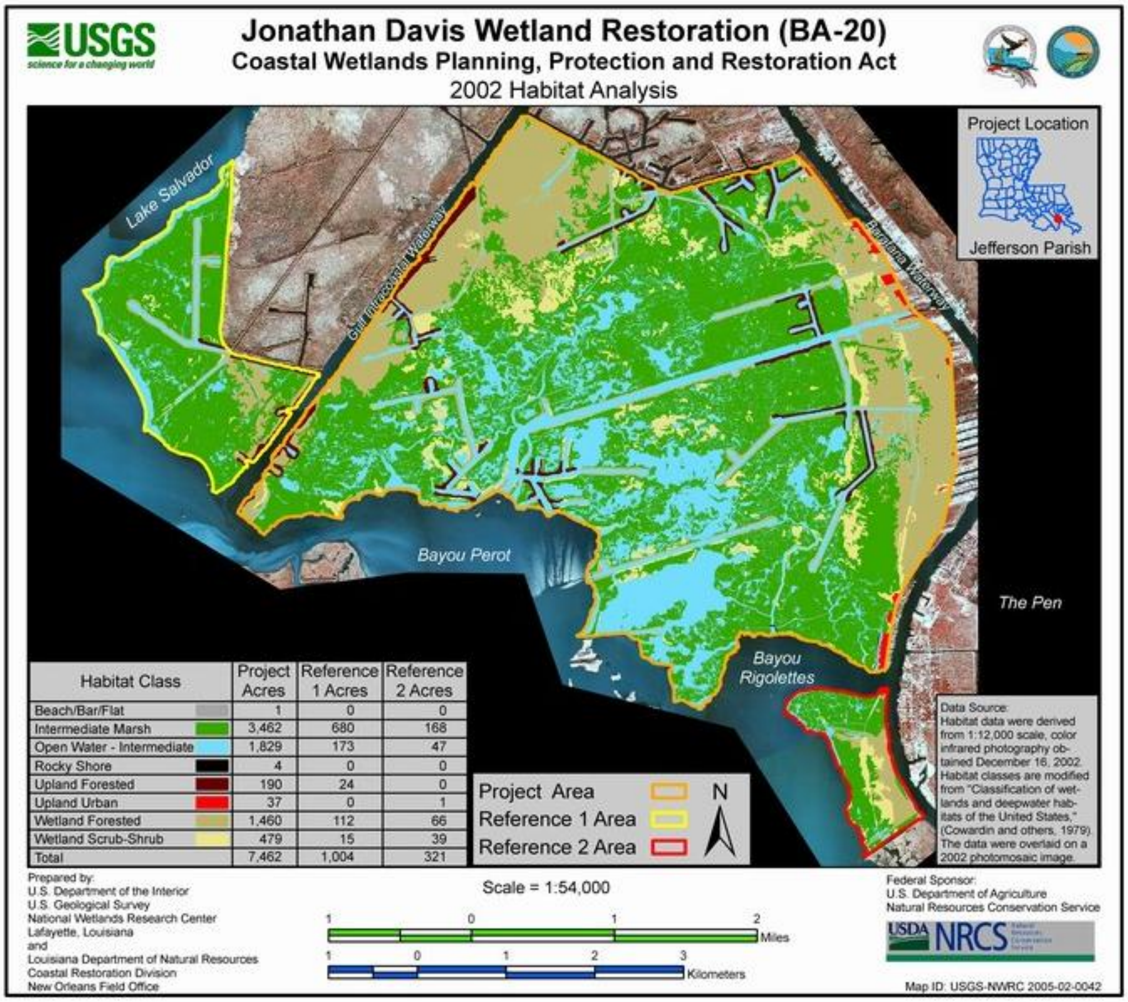


Figure 7. 1997 habitat analysis of the Jonathan Davis Wetland Restoration (BA-20) project and reference areas.



Habitat Class	Project Acres	Reference 1 Acres	Reference 2 Acres
Beach/Bar/Flat	1	0	0
Intermediate Marsh	3,462	680	168
Open Water - Intermediate	1,829	173	47
Rocky Shore	4	0	0
Upland Forested	190	24	0
Upland Urban	37	0	1
Wetland Forested	1,460	112	66
Wetland Scrub-Shrub	479	15	39
Total	7,462	1,004	321

Figure 8. 2002 habitat analysis of the Jonathan Davis Wetland Restoration (BA-20) project and reference areas.

Table 1. Acreage changes within major habitat class types of the Jonathan Davis Wetland Restoration (BA-20) project and reference areas.

Habitat Class	**(+/-) Change in Acreage (% of Total Acreage)**				
	Project Area			**Ref Area 1**	**Ref Area 2**
	1994-1997	1997-2002	Net	1997-2002	1997-2002
Intermediate Marsh	-199 (-2.7%)	-3 (<0.1%)	-202 (-2.7%)	-24 (-2.4%)	+24 (+7.5%)
Wetland Forested	+104	+21	+125	-2	-13
Wetland Scrub-Shrub	+243	-80	+163	-28	-20
Total Land	+151 (+2.0%)	-56 (-0.8%)	+95 (+1.3%)	-57 (-5.7%)	-9 (-2.8%)

areas. However, the possibility of misclassification of vegetation types, the existence of floating marsh in the project area, and the limited number of analysis years make it difficult to draw definitive conclusions. Overall, the project area appears to be relatively stable, showing relatively small changes from 1997 to 2002 and a net gain of 95 acres of land (1.3%) or 11.9 acres/yr from 1994 to 2002. A final land/water analysis will be conducted in 2014 and will provide a longer term analysis of land loss rates within the project area.

Salinity

Hourly salinity data was collected at the BA-20 continuous recorder stations (Figure 3) from December 1995 to January 2005, and has been collected at CRMS3985 and CRMS4245 from May 2008 to present (Figure 9). Monthly mean salinity at the different recorder stations displayed similar responses to seasonal influences and storm events. Salinity at BA20-90R was generally higher than salinity at the other project and reference stations. Salinity spikes resulted from several tropical events including Tropical Storm Frances/Hurricane George in 1998, and Hurricanes Gustave and Ike in 2008, but were generally not prolonged. A prolonged drought occurred from late 1999 through late 2000 with all stations experiencing elevated salinities during most of this period. Discrete salinity measurements revealed that mean salinities increased from the northern project area southward (down the estuary), as expected.

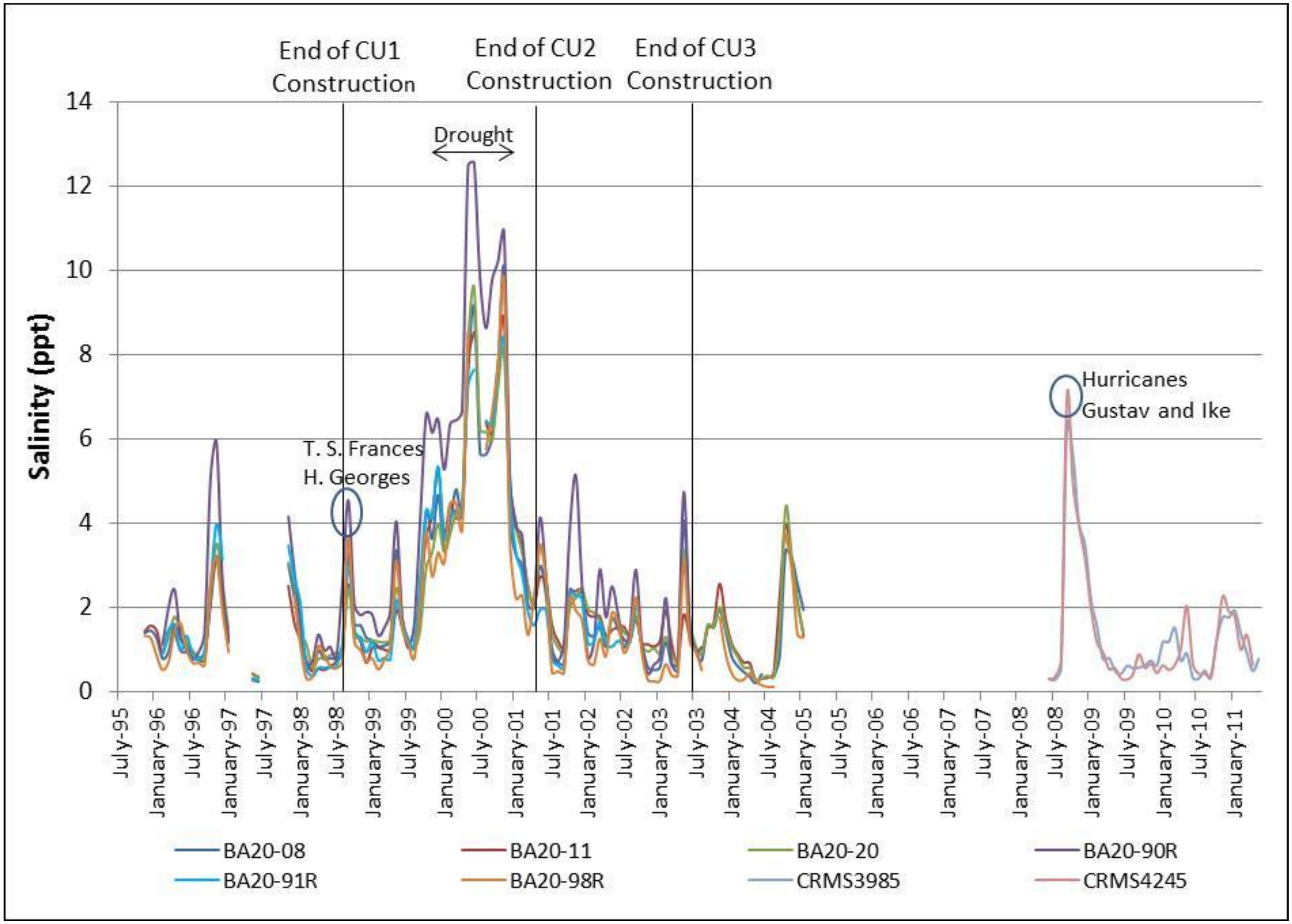


Figure 9. Monthly mean salinity data for all BA-20 and CRMS continuous recorder stations from 1995 to 2010.

Delayed and staggered construction of the project features led to complications in testing project impact on salinity levels. Construction of CU1, consisting of several rock weirs and plugs in the southwestern region of the project area (Figure 2), was finished in September 1998, while construction of CU2, consisting of a sheetpile weir and shoreline protection in the southeastern region of the project area, was not finished until May 2001. For this reason, separate tests were conducted on the eastern (BA20-20 vs BA20-90R) and western (BA20-08 vs BA20-98R) regions of the project area, each with separate, relative pre/post-construction units. CU3 was not completed until July 2003 and was not included in the salinity analysis.

The analysis of the western region (CU1: BA20-08 vs BA20-98R) had a pre-construction period from December 1995 to September 1998 and a post-construction period from October 1998 to January 2005. The analysis of the eastern region (CU2: BA20-20 vs BA20-90R) had a pre-construction period from December 1995 to May 2001 and a post-construction period from June 2001 to November 2003 (due to the loss of BA20-90R). A third analysis tested the southern project area as a whole by comparing three stages of construction: pre-construction (December 1995 – September 1998), during-construction (October 1998 – May 2001), and post-construction (June 2001 – January 2005). It should be noted that the drought period occurred during the 'during-construction' period and it would be expected that mean salinities would be highest during that time (Figure 10). However, one of the statistical assumptions would be that the drought is affecting all stations equally.

A special note must be made about BA20-11 and BA20-91R, which were located in the northern portion of the project area (Figure 3). The original project specifications included plans for eight weir/breach armor structures in the northern area; however these structures were never built in order to allow sufficient ingress of water from the Davis Pond Diversion to the north. Because there are no structures between the project station (BA20-11) and the reference area station (BA20-91R), there is no reason to expect an environmental effect as a result of the project. Therefore, these stations were excluded from the salinity analyses.

The east and west analyses compared salinity between the pre- and post-construction periods using paired project and reference stations. The statistical model followed a 2X2 BACI factorial analysis of variance (ANOVA) in which a statistically significant interaction between the main effects (*period* and *location*) provides evidence for a project impact (Stewart-Oaten et al. (1986), Underwood (1994), and Smith (2002)). The third, overall analysis tested for impact using a 3X2 BACI ANOVA in which the variable *period* had three levels: pre-construction, during-construction, and post-construction. The statistical models depend on simultaneity of measurements among the various stations. For this

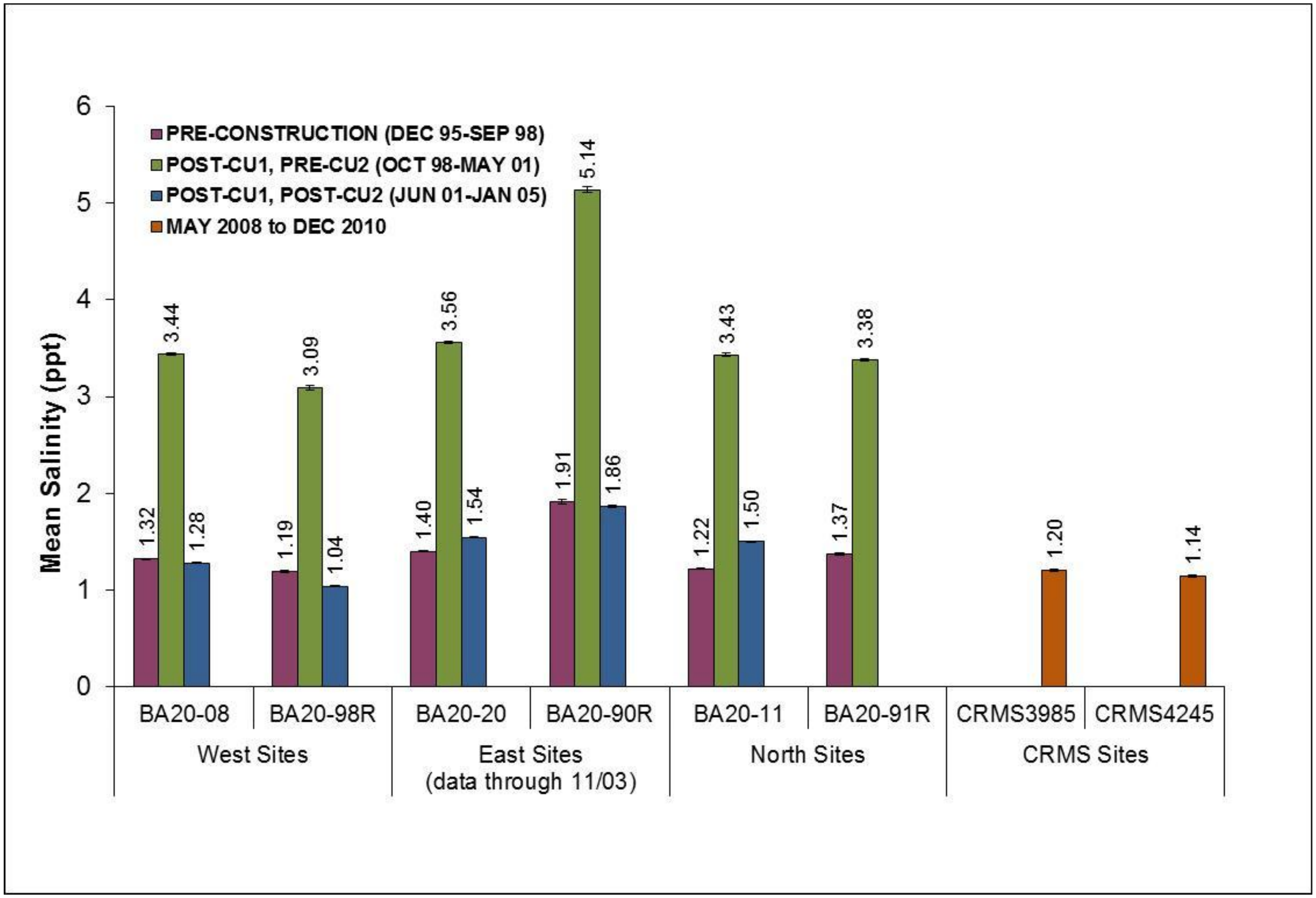


Figure 10. Mean salinity at each BA-20 continuous recorder station during different periods of construction and at each CRMS station from 2008 to 2010 calculated from hourly salinity readings.

reason, hourly salinity measurements were aggregated into weekly means, one week being enough time to average out temporal lags among the stations during tidal and meteorological events. Another advantage to using weekly means (versus hourly means) is that they exhibit less serial correlation, i.e., greater sample independence, which is an important underlying assumption of the statistical model. The hourly salinity measurements were first transformed into common logarithms in order to meet assumptions of normal distribution and uniform variance, and then aggregated into weekly means on which the statistics are based. The analyses were run using Proc GLM in SAS© Version 9 with *period* and *location* as fixed effects.

In the eastern project area, the '*period x location'* interaction showed a statistically significant impact (p=.0035) of the project on mean weekly salinity levels. This shows up graphically as lines out of parallel in Figure 11, which shows that salinity decreased slightly more at the reference station, BA20-90R, in the post-CU2 period than it did inside the project, a 51% and 42% reduction, respectively. The statistical significance reflects the size of the data set, not the size of the impact, which was modest, amounting to a difference of about one part per thousand from what would be expected if there were no impact. Although this was not the desired outcome, it should be noted that pre-construction salinity was already lower in the project area, and in order to see the same reduction as observed in the reference area, the salinity would have had to decrease to almost 0.5 ppt. In terms of percent reduction, the salinity would only have needed to decrease to 1.3 ppt in the project area to experience the same percent reduction as the reference area. The actual post-CU2 salinity in the project area was near that target at 1.5 ppt.

The western project area also experienced a slightly significant impact (p=.0355) of the project on mean weekly salinity levels at BA20-08. This shows up graphically as lines out of parallel in Figure 12, which shows that salinity increased slightly more in the project area in the post-CU1 period. Salinity increased by 71% and 60% in the project and reference areas, respectively. Again, the statistical significance corresponds to an impact with only modest biological significance, a departure of less than one part per thousand from what would be expected had there been no impact. It should be noted that the drought occurred during the pre-construction period for the eastern analysis and during the post-construction for the western analysis. The effects of the drought on salinity were extreme (Figure 10) and it may be possible that some stations could have been more adversely affected due to specific differences in geographic location. One of the assumptions of the analysis is that factors such as the drought would affect all stations equally.

The 3X2 BACI analysis of the complete southern project area (comprising sondes 08, 20, 90R, and 98R) also registered a statistically significant project impact ($p < .0001$) on mean weekly salinity levels. This shows up graphically in Figure 13 as

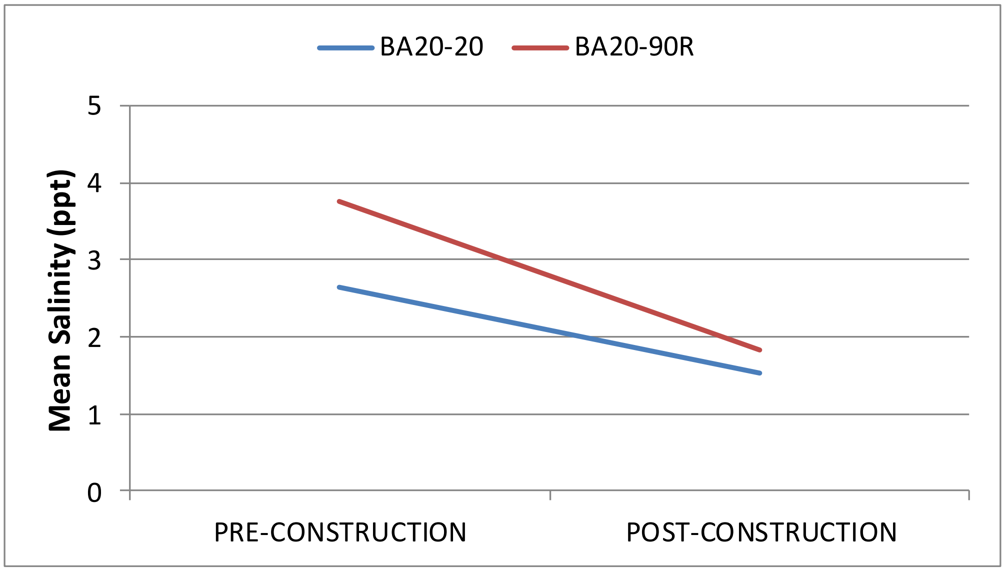


Figure 11. Comparison of mean weekly salinity of eastern sondes (BA20-20 and BA20-90R) during the pre- and post-CU2 periods.

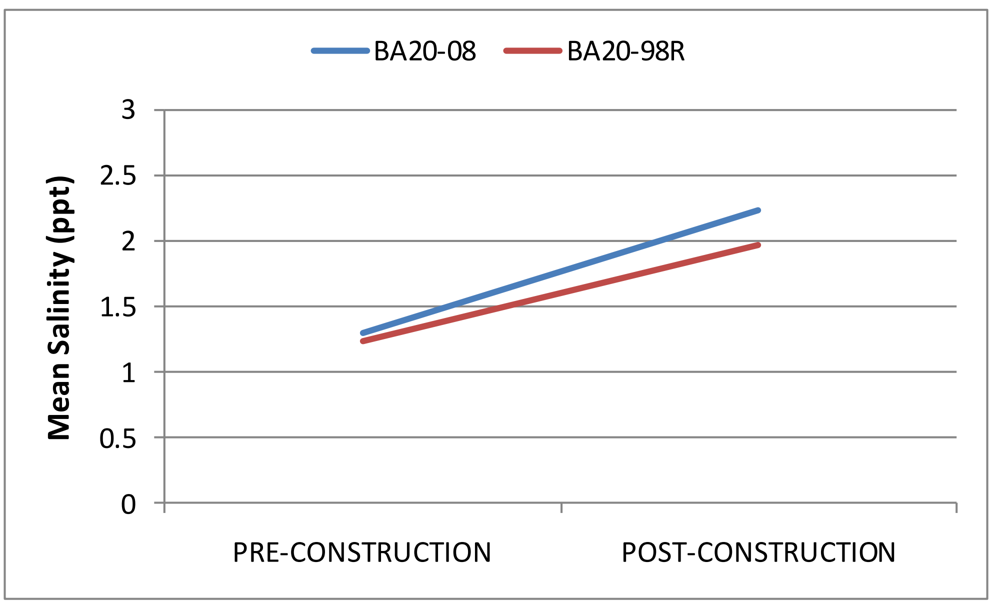


Figure 12. Comparison of mean weekly salinity of western sondes (BA20-08 and BA20-98R) during the pre- and post-CU1 periods.

lines out of parallel between the during-construction and post-construction periods. As in the other tests, the size of the impact was modest, representing a departure of less than one part per thousand from what would be expected had there been no impact. Project and reference mean salinity increased about equally between the pre- and during-construction time periods. There was a greater decrease in reference mean salinity (67% vs 61%) between the during- and post-construction time periods, with the resulting project and reference mean salinities being nearly identical in the post-construction period.

One of the project objectives was to reduce salinity fluctuations, with the specific goal of decreasing salinity variability within the project area. Salinity variability was expressed in terms of daily range for each station by subtracting the minimum from the maximum hourly salinity reading within each 24 hour period. While the overall salinity range during the entire sampling period was around 20 ppt, the mean daily salinity range was less than 1 ppt at all sites except for BA20-90R (Table 2). To test for the effects of CU1 and CU2 on salinity variability, mean daily salinity range at BA20-08 and BA20-98R was calculated for the pre- and post-CU1 periods and at BA20-20 and BA20-90R for the pre- and post-CU2 periods. An analysis of variance (ANOVA) was then conducted separately for the western (BA20-08 vs BA20-98R) and eastern (BA20-20 vs BA20-90R) areas using *period* (pre- vs post-construction) and *station* as the dependent variables. Tukey-Kramer's post-hoc test was used to examine various station/period comparisons. In the western project area, the mean daily salinity range at both project and reference sites was significantly higher in the post-CU1 period (F=38, $p<.0001$), although this was only equivalent to a 0.1 ppt increase (Figure 14). The increase at the project and reference sites was nearly identical, which was confirmed by an insignificant '*station x period*' interaction (F=0.24, $p=0.6261$). Therefore, the changes appear to be a reflection of widespread conditions, and CU1 did not significantly affect mean daily salinity range within the project area at BA20-08.

In the eastern project area, there was a significant difference in mean daily salinity range between the pre- and post-CU2 periods (F=33, $p<.0001$); however, post-hoc comparisons reveal that this is only true for the reference site, which showed a significant decrease of 0.35 ppt ($p<.0001$) (Figure 15). The difference between the pre- and post-CU2 periods at BA20-20 was not significant ($p=.7187$), although a small decrease was observed. A significant '*station x period*' interaction (F=26, $p<.0001$) is likely due to the difference in magnitude of salinity range between the two sites rather than to any negative project effect. It would have been impossible to see a similar decrease in the project area because the mean daily salinity range at the project site was already much lower than the reference site. Therefore, CU2 did not appear to have a positive or negative affect on the mean daily salinity range within the project area at BA20-20.

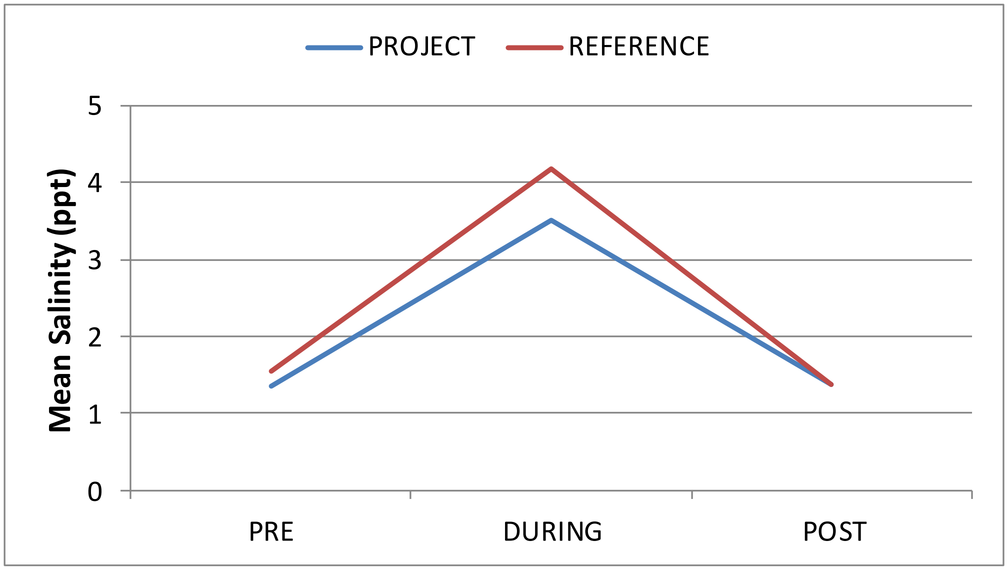


Figure 13. Comparison of mean weekly salinity of project stations (BA20-08 and BA20-20) vs reference stations (BA20-90R and BA20-98R) during three stages of project construction.

Table 2. Mean, minimum, and maximum salinity (ppt) over the entire sampling period, as well as the mean daily range in salinity, for all BA-20 project and reference sites.

	Time Period	Mean Salinity (ppt)	Minimum Salinity (ppt)	Maximum Salinity (ppt)	Mean Daily Salinity Range (ppt)
BA20-08	12/95-1/05	1.98	0.10	19.58*	0.30
BA20-20	12/95-11/03	2.27	0.13	17.83*	0.46
BA20-90R	12/95-11/03	3.08	0.20	24.61*	1.20
BA20-98R	12/95-1/05	1.74	0.10	22.7*	0.38
CRMS3985	5/08-12/10	1.20	0.14	14.58**	0.30
CRMS4245	5/08-12/10	1.15	0.15	8.42	0.26

*occurred during drought in November 2000
**occurred in September 2008 during Hurricane Ike; CRMS4245 was not recording due to malfunction

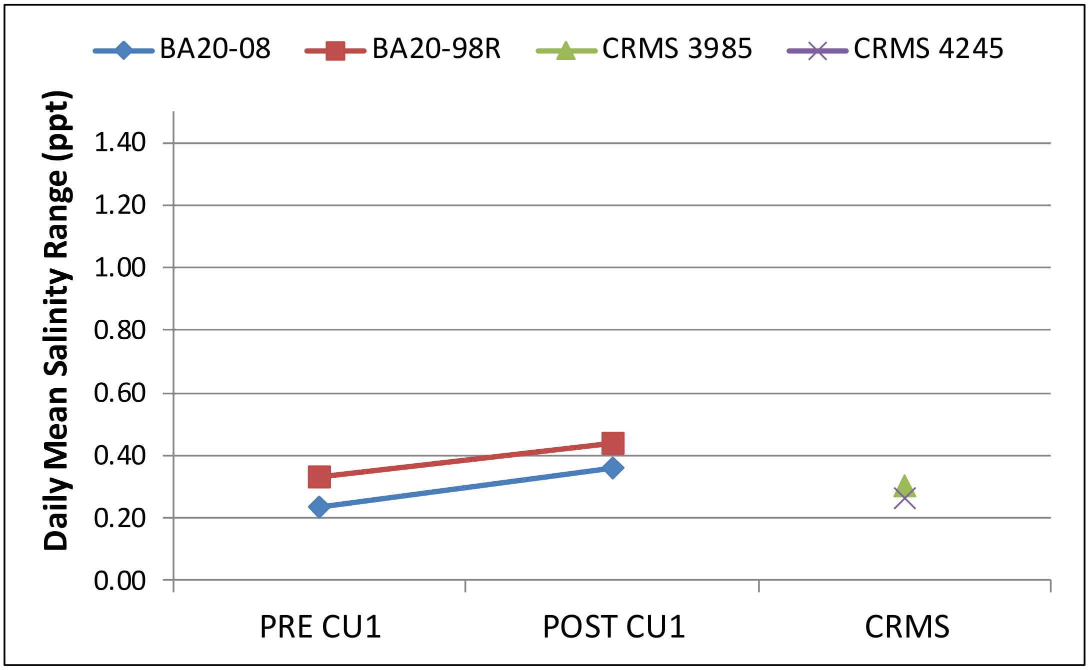


Figure 14. Daily mean salinity range (ppt) at the western project and reference sites (BA20-08, BA20-98R) before and after construction of CU1 and at the CRMS sites (3985, 4245) from 2008 to 2010.

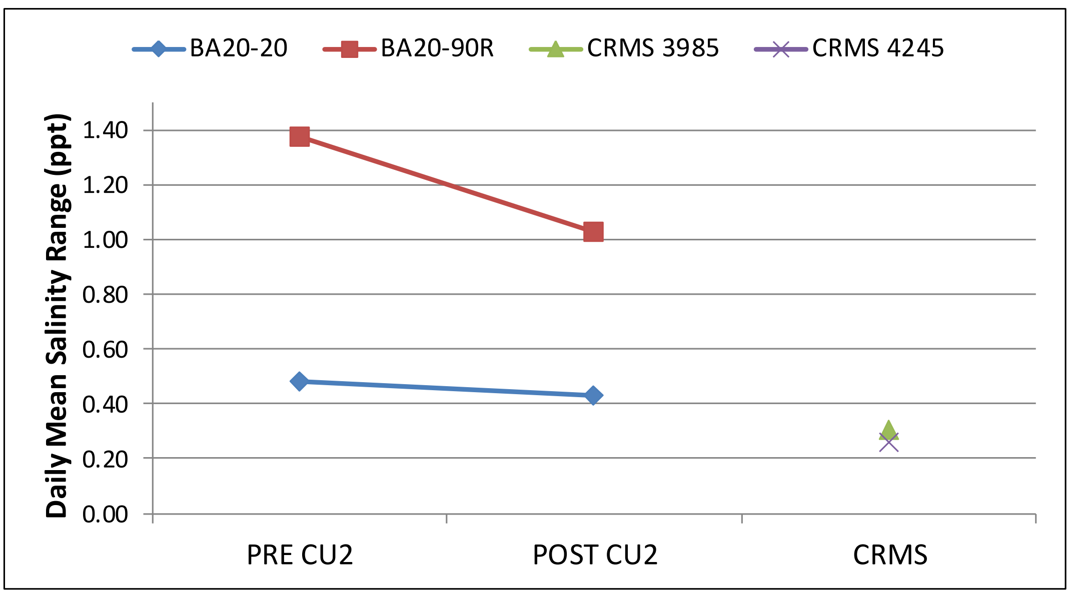


Figure 15. Daily mean salinity range (ppt) at the eastern project and reference sites (BA20-20, BA20-90R) before and after construction of CU2 and at the CRMS sites (3985, 4245) from 2008 to 2010.

Mean daily salinity range from 2008 to 2010 was also calculated for the two CRMS sites within the project area and is shown in Figures 14 and 15 for comparison. Mean daily salinity range at the CRMS sites during this period was very similar to the mean daily range at BA20-08, BA20-20, and BA20-98R during the earlier sampling period. There was no difference in mean daily salinity range between the two CRMS sites ($F=3.89$, $p=.0488$).

Water Level

Hourly water level data (ft NAVD88) was collected at the BA-20 continuous recorder stations (Figure 3) from November 1997 to January 2005, and has been collected at CRMS3985 and CRMS4245 from May 2008 to present (Figure 16). Water level at the different recorder stations displayed similar responses to seasonal influences and storm events. Water elevations were higher in spring, early summer, and fall, while lower levels occurred in late summer and winter. Two tropical storm events in September 1998 produced different effects on water levels in the project and reference areas. Tropical Storm Frances, which made landfall to the west of the project area, caused a sharp increase in water levels, while Hurricane Georges, which made landfall to the east, caused a decrease in water levels. Water level increases were also observed during Hurricanes Isidore and Lili in 2002 and during Hurricanes Gustav and Ike in 2008.

Mean water levels were lowest at all stations except BA20-98R in the period between construction of CU1 and CU2, which was most likely a result of the drought that occurred during this period (Figure 17). This was probably also the case for BA20-98R, however high water data during the 1998 storm season was lost at this site due to sonde malfunction. Water levels were the highest at all BA-20 project and reference sites during the post-CU2 period compared to the pre-CU1/CU2 periods. Mean water levels at the two CRMS sites since 2008 are also higher than mean water levels at the BA-20 stations for all construction periods. However, possible differences in elevation surveys between the BA-20 sites and CRMS sites, such as the reference benchmark used, may cause some error when comparing the NAVD water level between these two groups of stations.

One of the stated goals of the project was to reduce water level variability within the project area. In order to test for the effects of the project on water level variability, a tidal analysis was conducted. A program was written which identified the maximum (high tide) and minimum (low tide) water elevations for each tidal period. Figures 18 and 19 show the tidal periods at BA20-08 and BA20-20 from November 25, 1997 to January 6, 1998. High tide (red) and low tide (blue) for each period were identified and any tidal period longer than15 hours in length was excluded. Abnormally long tidal periods were excluded because these were presumably influenced by weather events. Tidal range was calculated by subtracting each minimum elevation from the preceding maximum

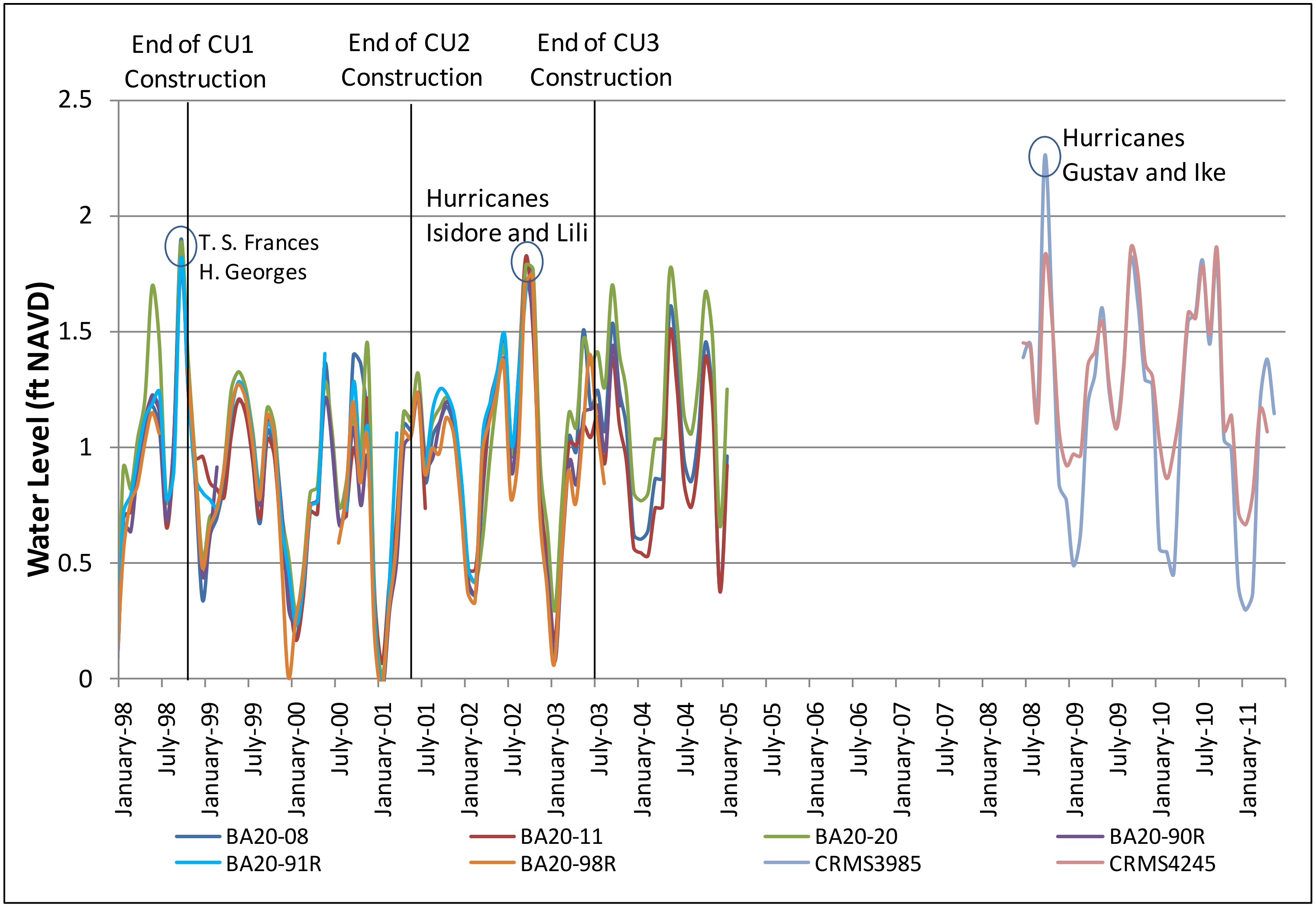


Figure 16. Monthly mean water level data (ft NAVD88) for all BA-20 and CRMS continuous recorder stations from 1995 to 2010.

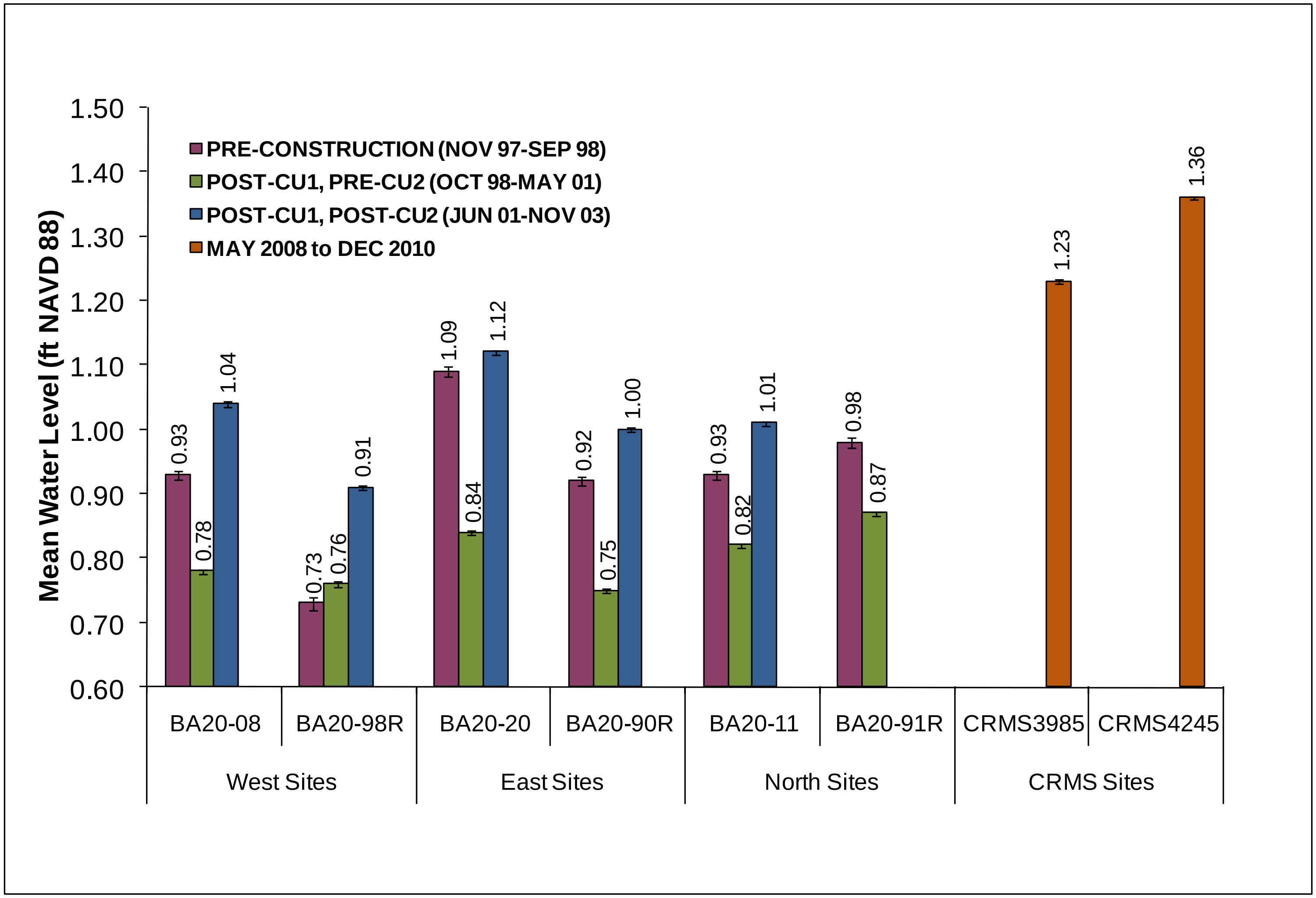


Figure 17. Mean water level at each BA-20 continuous recorder station during three different periods of construction and at each CRMS station from 2008 to 2010 based on hourly water level readings.

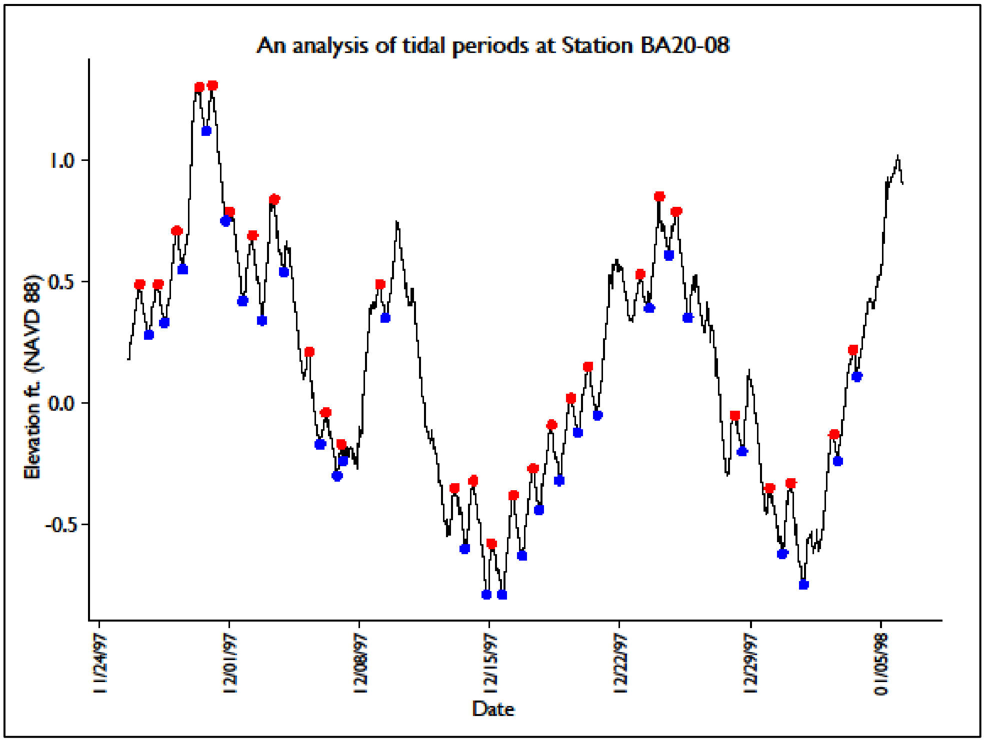


Figure 18. Tidal periods at BA20-08 from November 25, 1997 to January 6, 1998.

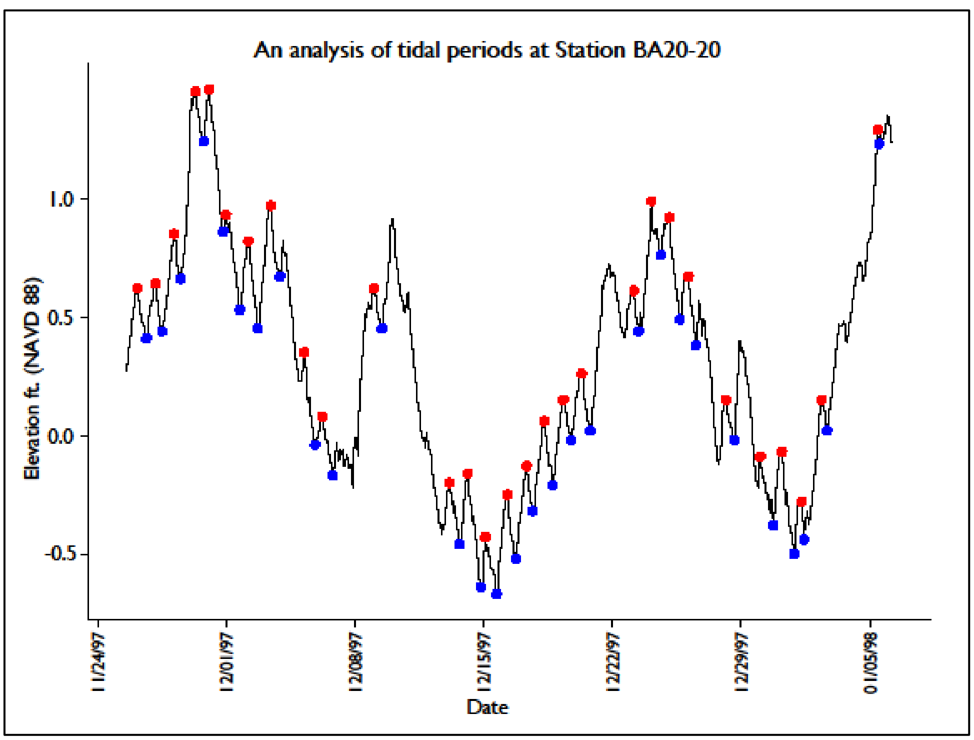


Figure 19. Tidal periods at BA20-20 from November 25, 1997 to January 6, 1998.

elevation for each tidal period. Mean tidal range was then subjected to an analysis of variance (ANOVA) with construction period (pre- vs post-construction) and station as the dependent variables.

To test for the impacts of CU1 on water level variability, BA20-08 and BA20-98R (western project area) were compared using a pre-construction period from November 1997 to September 1998 and a post-construction period from October 1998 to November 2003. Mean tidal range in the western project area was significantly lower in the post-construction (CU1) period ($F=38$, $p<8.16\times10^{-10}$), and the reduction of tidal range at reference station BA20-98R was significantly greater than the reduction in the project area ('*period x station*': $F=9.5$, $p<0.002$) (Figure 20). The reduction in tidal range appears to be a regional occurrence, and not a result of CU1 construction. The smaller reduction of tidal range in the project area is likely due to the fact that the pre-construction tidal range was comparatively lower in the project area, allowing more 'room' for reduction at the reference station. In order to experience the same reduction in tidal range as the reference area, post-CU1 mean tidal range in the project area would have needed to approach 0.18 ft, which may be an unrealistic expectation for the natural tidal range in the project area. Therefore, the smaller reduction in the project area is not due to any negative project affect.

To test for the impacts of CU2 on water variability, BA20-20 and BA20-90R (eastern project area) were compared using a pre-construction period from November 1997 to May 2001 and a post-construction period from June 2001 to November 2003. Mean tidal range in the eastern project area was significantly higher in the post-construction (CU2) period ($F=45$, $p<2.58\times10^{-11}$) (Figure 21). In this case, the '*period x station*' interaction was not significant ($F=1.9$, $p<0.17$) which suggests that the tidal range increased by a similar magnitude at the project and reference sites. Based on the tidal analysis, we would reject the hypothesis that CU1 and CU2 significantly reduced water level variability in the project area.

Mean tidal range from 2008 to 2010 was also calculated using water elevation data from CRMS3985 and CRMS4245 within the project area. These data were not used in the analysis due to the difference in time periods, but the results are shown in Figures 20 and 21 for comparison. Mean tidal range at CRMS4245, which is located in an area of highly fragmented marsh at the southern end of the project area, was higher than all of the other sites, including the reference stations (Figures 22 and 23). Tidal range at this site was most similar to reference site, BA20-90R, which it is closest to geographically. This site will benefit from the completion of CU4 in late 2011, which will provide nearly continuous shoreline protection along the southern boundary of the project area. In the northern project area, CRMS3985 displayed a more moderate tidal range, which was between the tidal ranges measured at BA20-08 and BA20-20 in the earlier time period. Future tidal analyses will be conducted on the CRMS data to determine if CU4 has an

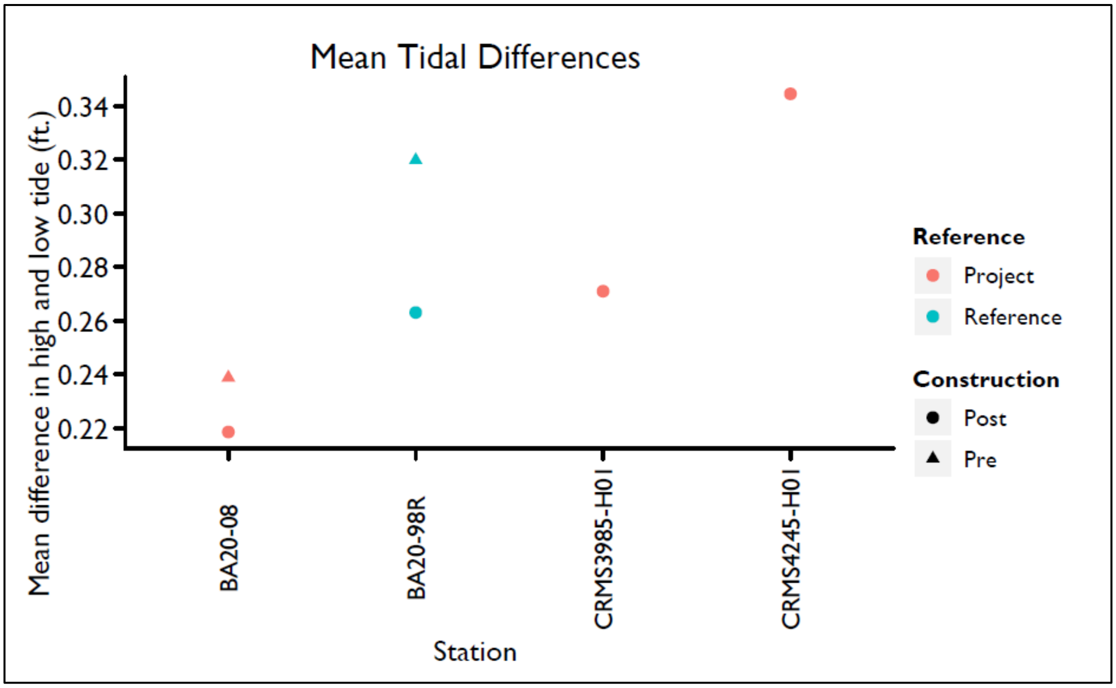


Figure 20. Mean tidal differences at the western project (BA20-08) and reference (BA20-98R) sites before and after construction of CU1 and at the CRMS sites (3985, 4245) from 2008 to 2010.

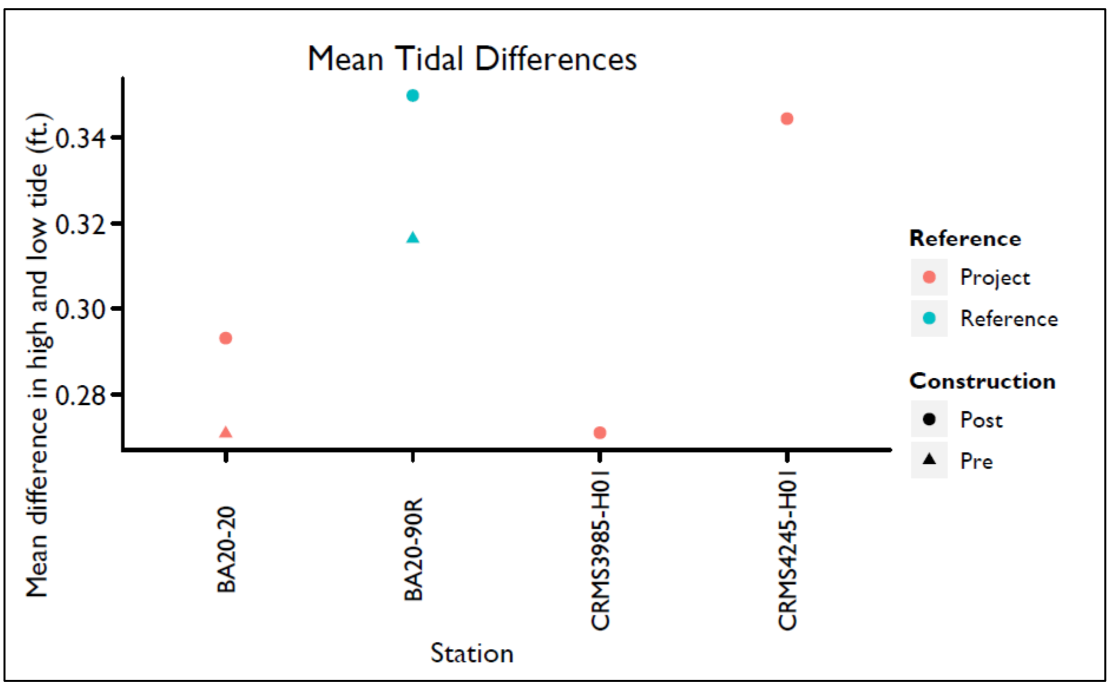


Figure 21. Mean tidal differences at the eastern project (BA20-20) and reference (BA20-90R) sites before and after construction of CU2 and at the CRMS sites (3985, 4245) from 2008 to 2010.

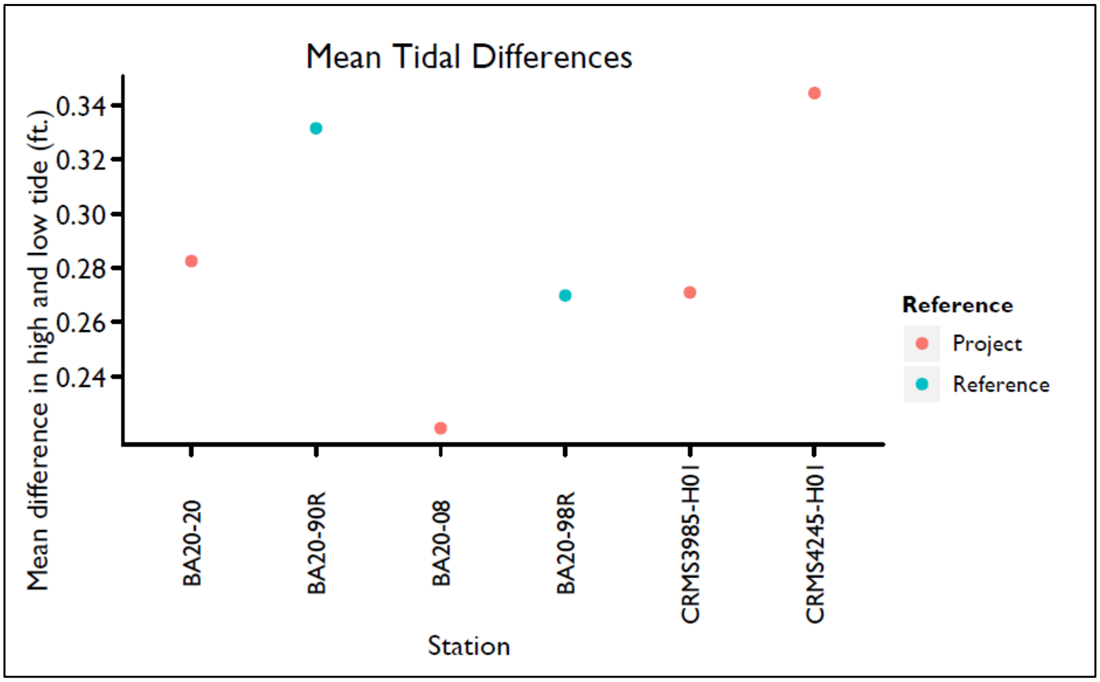


Figure 22. Mean tidal differences at BA-20 project and reference stations from November 1997 to November 2005, and at CRMS sites within the project area from 2008 to 2010.

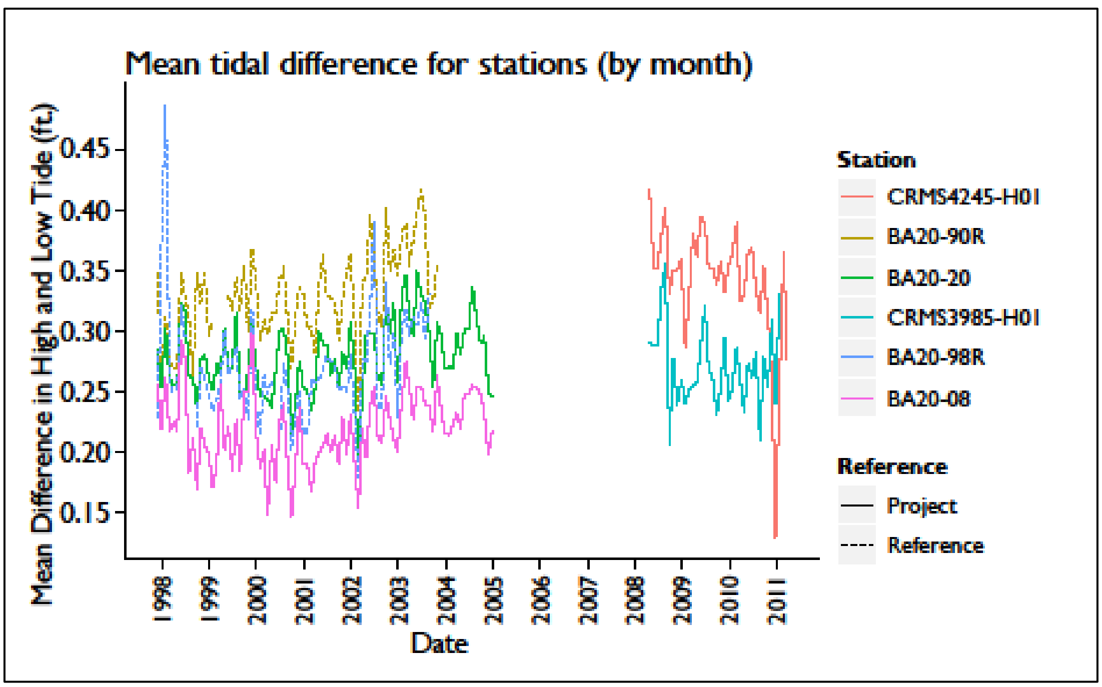


Figure 23. Mean monthly tidal differences at BA-20 project and reference stations from November 1997 to November 2005, and at CRMS sites within the project area from 2008 to 2010.

effect on reducing water level variability within the project area, however the immediate goal of CU4 is to reduce shoreline loss.

Shoreline Change

Shoreline analysis of the CU2, Bayou Rigolettes Bank Stabilization, from 2001 to 2004 showed an increase in land of 1.7 acres in the project area, and a loss of 3.6 acres in the adjacent reference area (Figure 24). The land gain in the project area is due to the infilling of access dredged material between the rock wall and the original shoreline during construction. During the as-built survey of the shoreline (2001), the infilled area was not included because it was unvegetated, but by 2004 this area had become mostly vegetated. Unfortunately, the reference area has not been resurveyed since 2001 because it is now part of the Barataria Landbridge Shoreline Protection Project, Phase 4 (BA-27d) and has been protected with rock revetment since 2006. However, it appears that the Bayou Rigolettes Bank Stabilization (CU2) was successful not only in reducing shoreline loss, but even increasing land acreage, when compared to the reference area from 2001 to 2004.

The shoreline analysis of CU2 and the eastern portion of CU3 (Bayou Rigolettes Bank Stabilization) from 2004 to 2010 showed a net gain of 1.9 acres with negligible loss occurring (Figure 25). This increase in land occurred mostly in the CU3 area which had been constructed not long before the 2004 survey. As observed in the 2001-2004 analysis, the area between the rock wall and the original shoreline became vegetated, thereby causing an increase in shoreline acreage.

The shoreline analysis of the western portion of CU3 (Bayou Perot Bank Stabilization) exhibited a net land loss of 4.6 acres (+3.8 acres, -8.4 acres) (Figure 26). However, the major extent of the land loss appears to be occurring along a large section of interior marsh located within the central portion of the project area. Therefore, separate land area calculations were made to determine the land changes to the 'shoreline' and 'interior marsh' independently. The 'shoreline' component exhibited a net gain of 3.34 acres (+3.51 acres, -0.17 acres), and the 'interior marsh' exhibited a net loss of 8 acres (+0.29 acres, -8.25 acres). The gain of land along the 'shoreline' component was again due to the vegetating of areas between the rock wall and the original shoreline between the first and second surveys. However, it appears that significant land loss continues to occur along the shoreline of the large interior pond, despite the fact that the rock structure now reduces some wave action in this area. It is possible that the 'interior marsh' loss may have been even greater if the structure had not been in place.

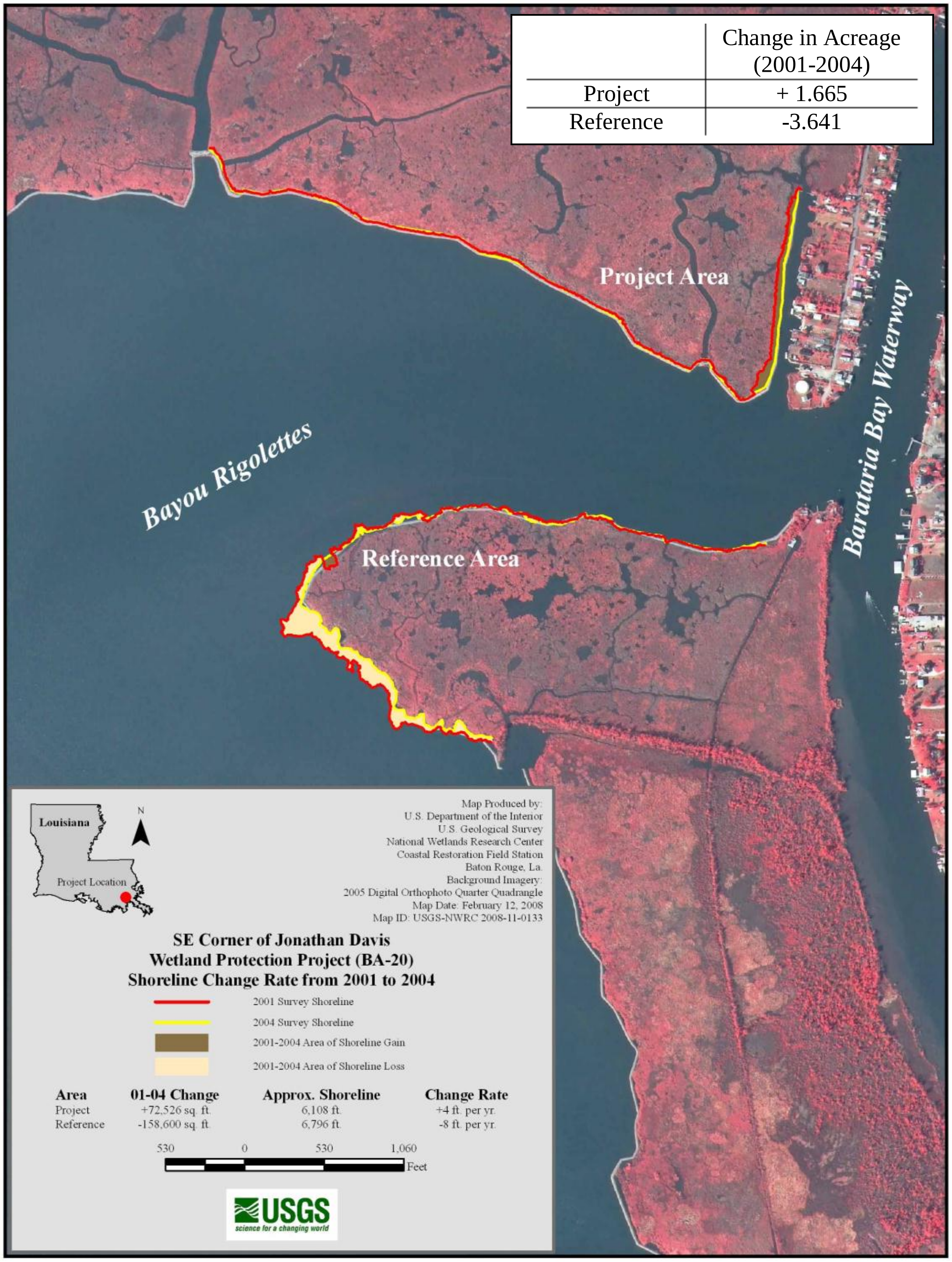


Figure 24. Shoreline change within Construction Unit 2 and the eastern reference area of the Jonathan Davis Wetland Restoration (BA-20) project from 2001 to 2004.

Figure 25. Shoreline change within Construction Unit 2 and the eastern portion of Construction Unit 3 of the Jonathan Davis Wetland Restoration (BA-20) project from 2004 to 2010.

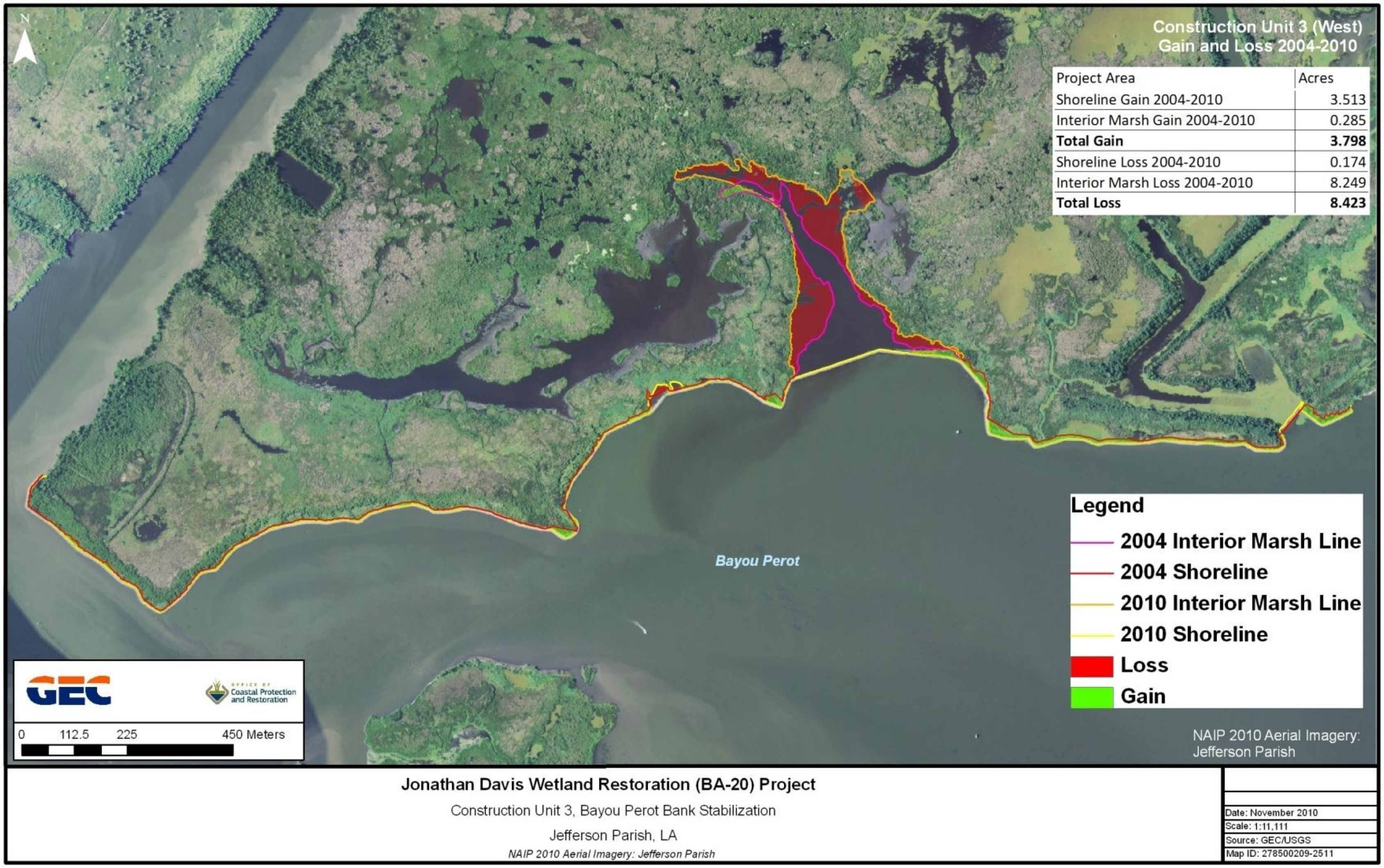


Figure 26. Shoreline change within the western portion of Construction Unit 3 of the Jonathan Davis Wetland Restoration (BA-20) project from 2004 to 2010.

Vegetation

Emergent vegetation data was collected in 1996 (pre-construction), in 1999 (1 year post-CU1 construction), and in 2002 (4 years post-CU1 construction and 1 year post-CU2 construction). It is unlikely that a significant response in species composition or cover would be observed in 1999, only one year after the construction of the CU1 weirs. Likewise, in 2002 CU2 had only been constructed for just over a year at the time of the vegetation survey. Therefore, the CU1 project features on the vegetation in 2002 would likely produce the only measureable effect over the three data collection events. Annual CRMS vegetation surveys began at CRMS3985 and CRMS4245 in 2008, which will provide a long term picture of the vegetation in the project area. However, it should be noted that the BA-20 sites provided broader coverage of the project area, and direct comparison to the CRMS sites may be confounded by localized differences in vegetation at those sites.

Mean percent cover calculations showed that *Sagittaria lancifolia* and *Spartina patens* were the dominant species in the project and reference areas (Figure 27). The project and reference areas exhibited similar trends over the three sampling years, with *Sagittaria lancifolia* decreasing and *Spartina patens* increasing from 1996 to 2002. One of the measureable goals of the project was to stabilize or increase the abundance of intermediate-to-fresh marsh plant species. Species were classified as fresh, fresh-intermediate, intermediate, etc. based on classifications provided by Jenneke Visser. Percent coverage data from the BA-20 and CRMS sites was then used to summarize changes in marsh classifications over time (Figure 28). The fresh, fresh/intermediate, and intermediate classifications were then grouped together for comparison to the intermediate/brackish and brackish classifications. Brackish/salt and salt classifications were also included, but percent coverages in these categories were very low. Results showed a decrease in percent cover of fresh/intermediate species and an increase in percent cover of intermediate/brackish species in both the project and reference areas from 1996 to 2002 (Figure 29). The decrease in cover of fresh/intermediate species was more pronounced between 1999 and 2002, which was most likely an effect of the drought that occurred from August 1999 to November 2000. The decrease was greater in the reference area than in the project area, however, which could indicate that the CU1 project features may have had a protective effect. By 2002, the percent coverage of fresh/intermediate species in the project area was greater than the coverage of intermediate/brackish species, while the percent coverage of intermediate/brackish species was greater in the reference area.

At CRMS3985 and CRMS4245, the total percent cover of all species was very low in 2008 (Figure 28). This may be due to the fact that sampling occurred in October, only one month after Hurricanes Gustav and Ike. Coverage of fresh/intermediate species was comparable to the coverage of fresh/intermediate species within the reference area in 2002, although it was much higher than the coverage of intermediate/brackish species. The coverage of fresh/intermediate species rebounded in 2009 to levels similar to those observed at the BA-20 sites in 1999 (pre-drought), but then decreased

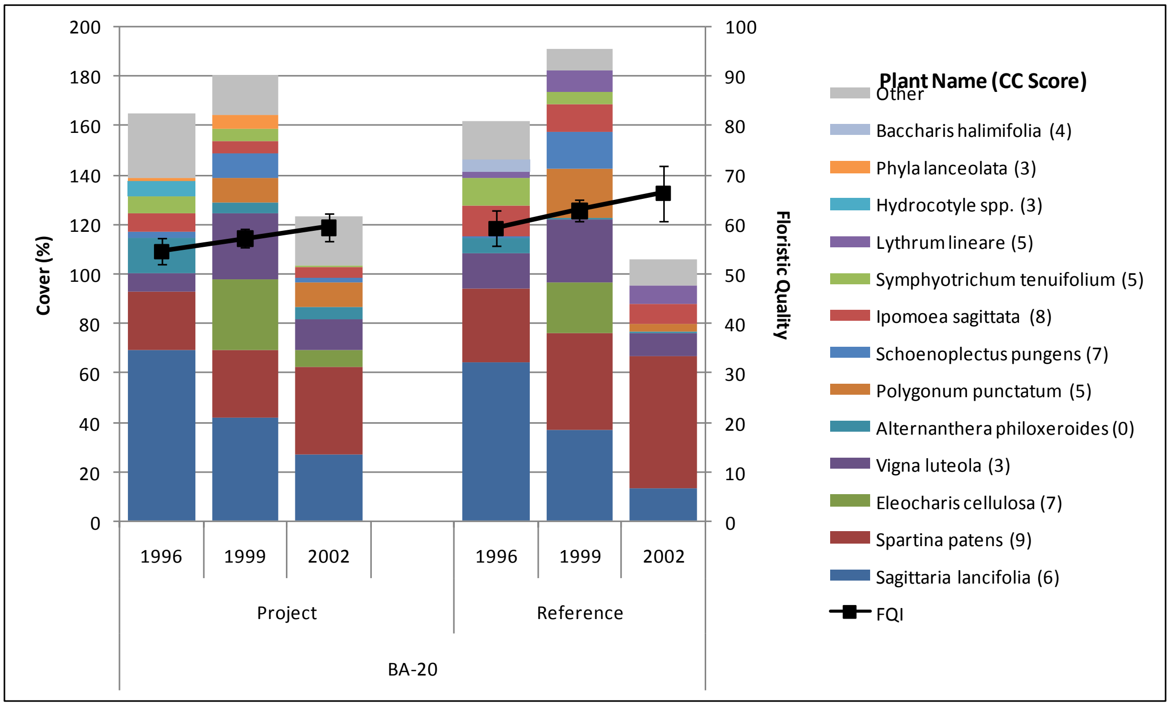


Figure 27. Mean percent cover of species within the BA-20 project and reference areas and the Floristic Quality Index (FQI) score for each year. The CC Score represents the quality of the individual species on a scale from 1 to 10 where 1 represents disturbance species and 10 indicates stability.

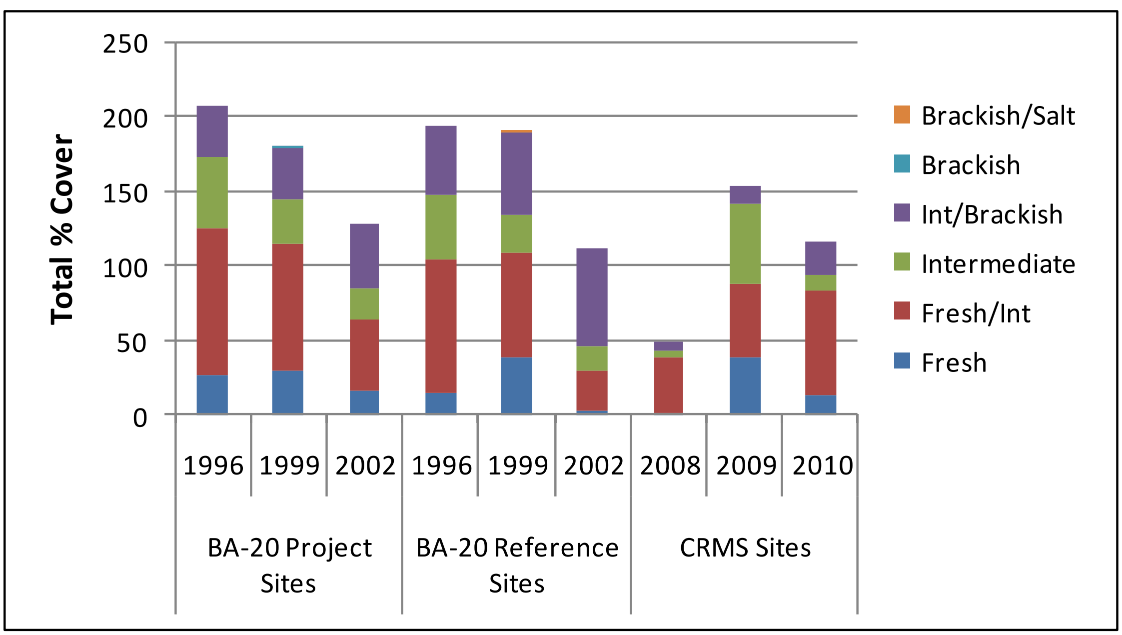


Figure 28. Total of mean % covers of all habitat classes at BA-20 project and reference sites in 1996, 1999, 2002 and at two CRMS sites (3985 and 4245) within the BA-20 project area in 2008, 2009, and 2010.

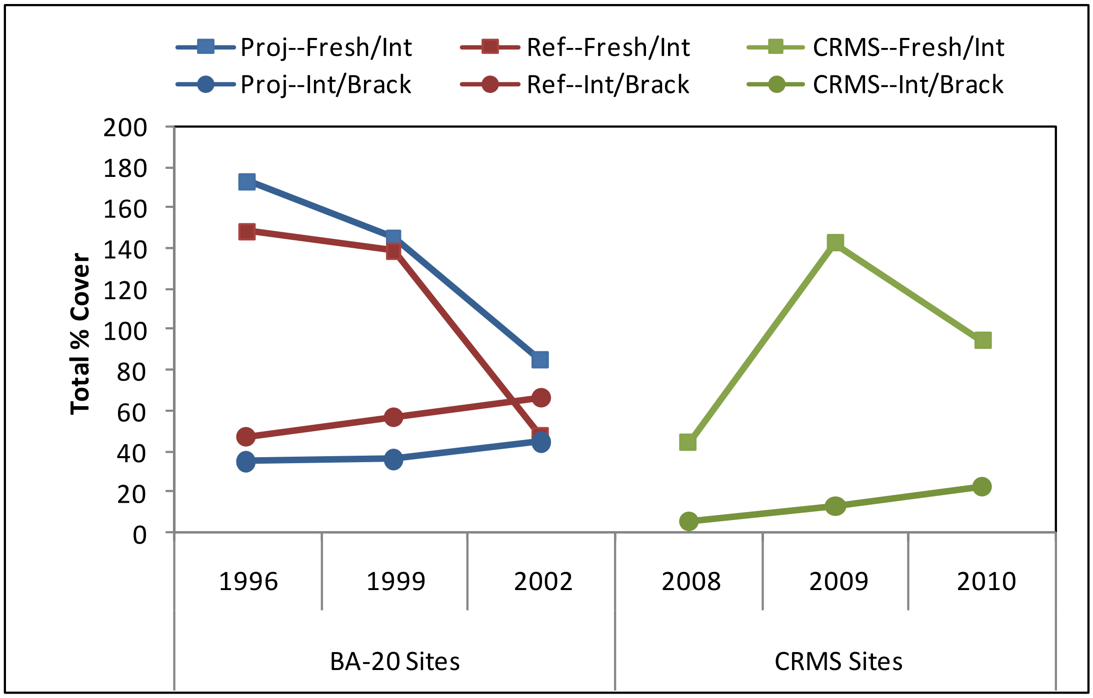


Figure 29. Total of mean % covers for fresh/intermediate species vs. intermediate/brackish species at BA-20 project and reference sites in 1996, 1999, 2002 and at two CRMS sites (3985 and 4245) within the BA-20 project area in 2008, 2009, and 2010.

again in 2010. Coverage of intermediate/brackish species was low compared to coverage of fresh/intermediate species from 2008 to 2010.

One tool that has been used to assess the quality of the vegetation community at the CRMS sites is the Floristic Quality Index (FQI) (Cretini et al. 2011). The FQI is calculated by assigning each species a CC score, or coefficient of conservatism, which is scaled from 1 to 10 and reflects a species' tolerance to disturbance and habitat specificity. A modified FQI was developed by the CRMS Vegetation Analytical Team, which assembled a team of experts to assign CC scores to Louisiana's wetland plant species. The modified FQI equation takes into account not only the CC scores, but also the percent covers of species at a site, and the resulting score is scaled from 0 to 100.

Mean FQI scores were calculated for the BA-20 project and reference areas for each of the three sampling years (Figure 27). FQI scores were relatively stable but showed a slight increase each sampling year in the project and reference areas from 1996 to 2002. FQI was also slightly higher in the reference area than in the project area. These results are likely due to the drought-induced decrease in fresh/intermediate species, which are often associated with disturbance and therefore have low CC scores, and also to the concurrent increase of *Spartina patens*, which has a high CC score of 9. Although the abundance of fresh/intermediate species did not increase in the project area due to the drought, the FQI scores indicate that the habitat condition in the project and reference areas remained relatively stable throughout the sampling period. FQI scores, however, were still below the ideal range of 80-100 for intermediate marsh, as estimated by the CRMS Vegetation Analytical Team (Cretini et al. 2011). FQI scores at the two CRMS sites were lowest in 2008, probably as a result of Hurricanes Gustav and Ike (Figures 30 and 31). Scores were similar between the two CRMS sites in 2008 and 2009, but then decreased at CRMS3985 in 2010. CRMS FQI scores from 2008-2010 were generally lower than those observed for the BA-20 sampling years, except for the score calculated for CRMS4245 in 2010. As mentioned previously, however, the CRMS sites provide a snapshot within a 200 x 200-m sampling area and may not reflect the project area as a whole.

CRMS Supplemental

Three soil cores were extracted from each CRMS site on June 6, 2008 and were analyzed for bulk density and % organic content in 4-cm increments down to 24 cm. Low mean bulk densities below 0.2 g cm^{-3} were observed at both sites and were slightly lower at CRMS3985 than at CRMS4245, which is located in an area of floating marsh (Figures 32 and 33). CRMS 3985 exhibited a higher and more variable % organic content (mean=56%) than CRMS4245 (mean=38%) (Figures 34 and 35). Marsh elevation change and vertical accretion data are being collected at CRMS3985, but the current estimates are preliminary and will not be presented at this time. Marsh

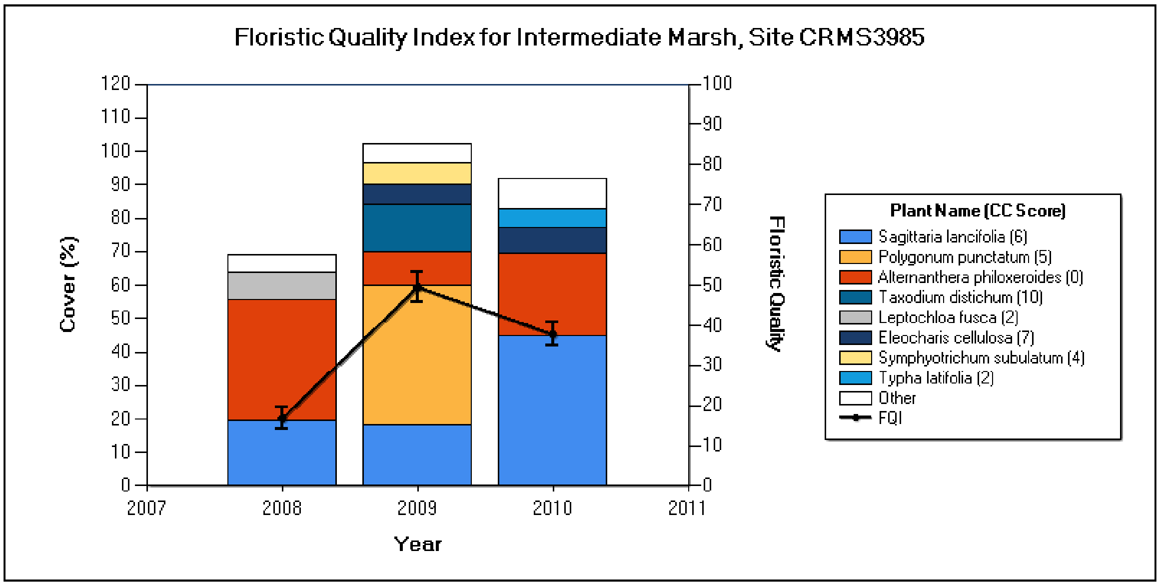


Figure 30. Mean % cover of major species and FQI score at CRMS 3985 in 2008, 2009, and 2010.

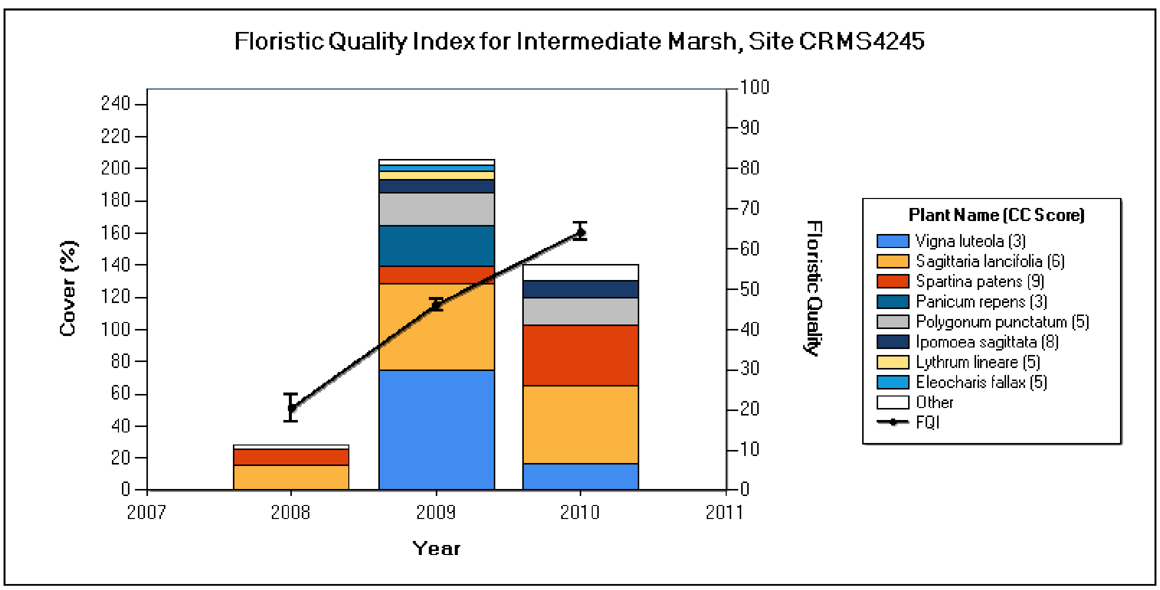


Figure 31. Mean % cover of major species and FQI score at CRMS 4245 in 2008, 2009, and 2010.

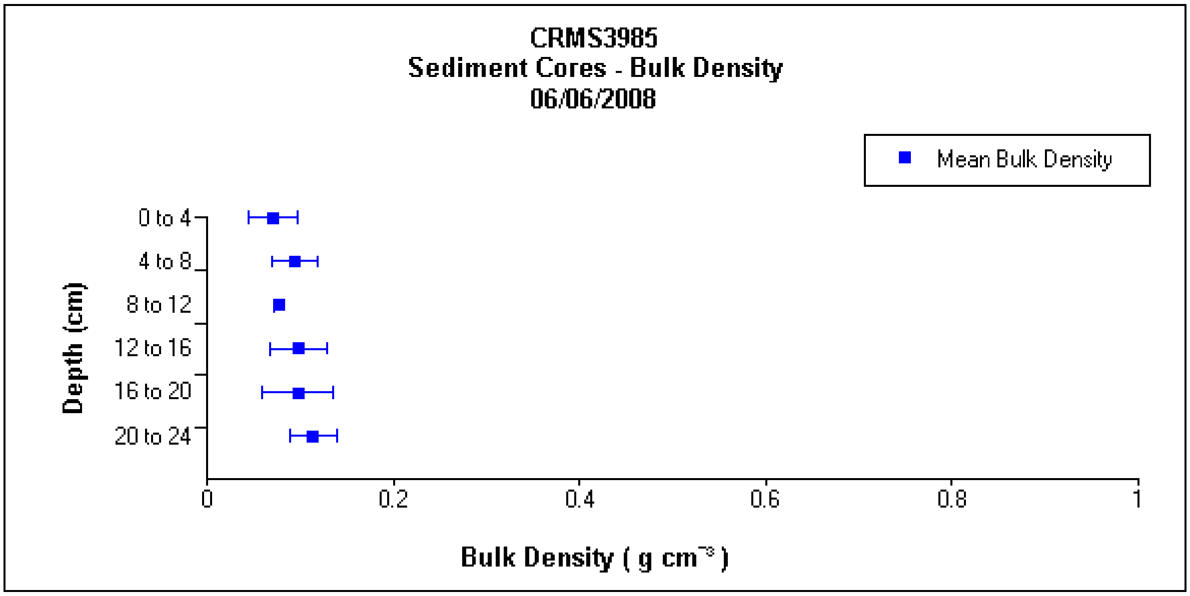


Figure 32. Mean bulk density of three sediment cores taken at CRMS3985 in June 2008.

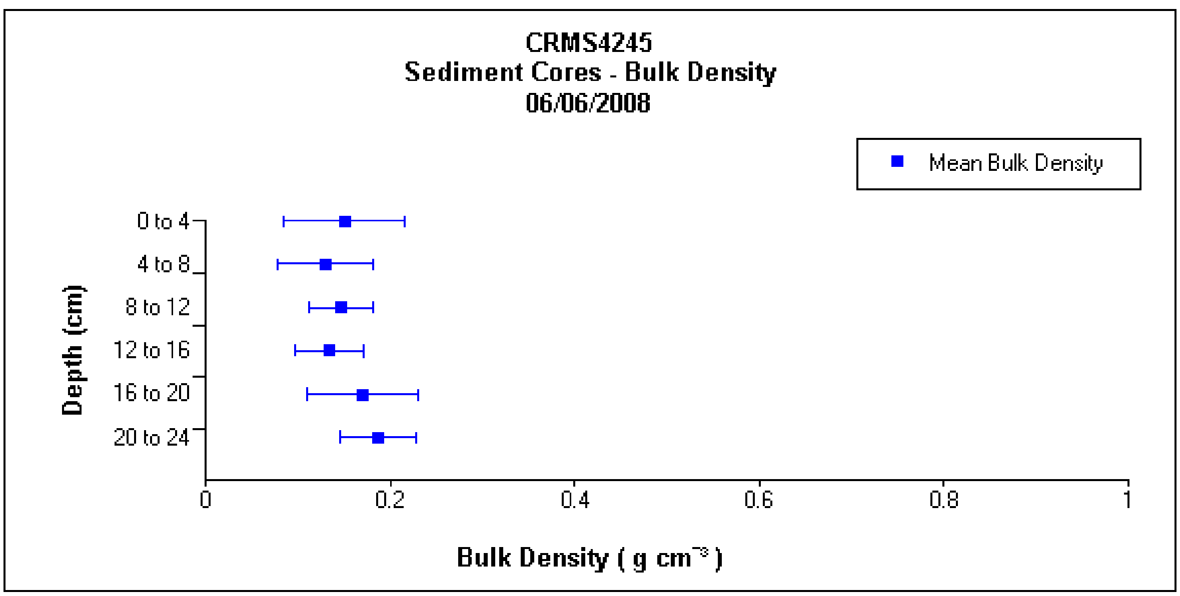


Figure 33. Mean bulk density of three sediment cores taken at CRMS4245 in June 2008.

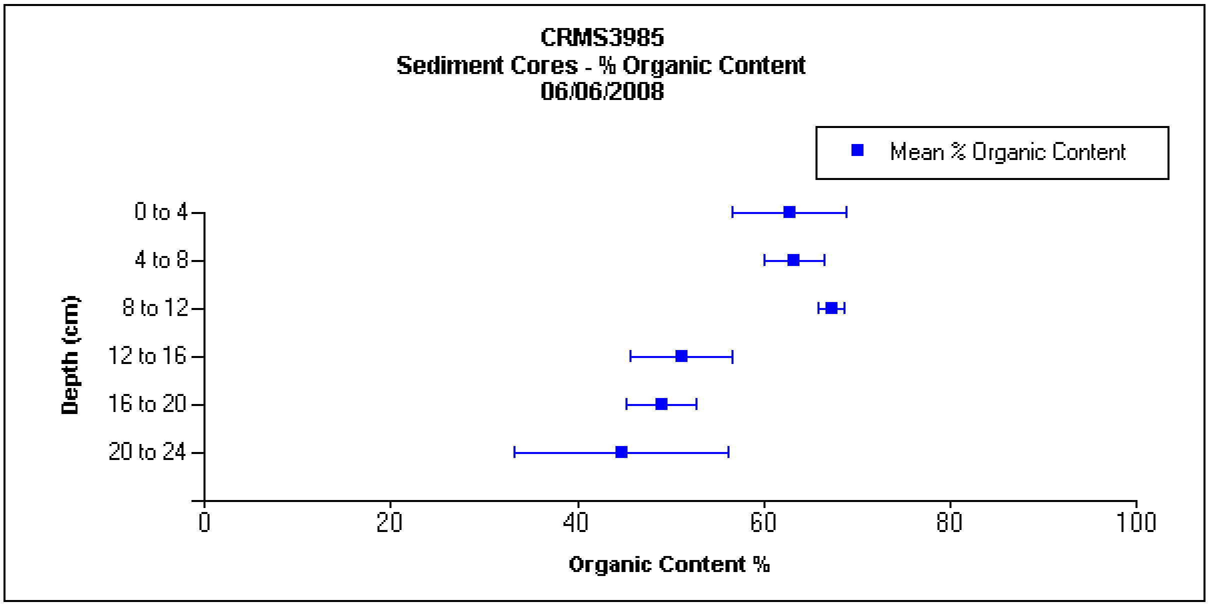


Figure 34. Mean % organic content of three sediment cores taken at CRMS3985 in June 2008.

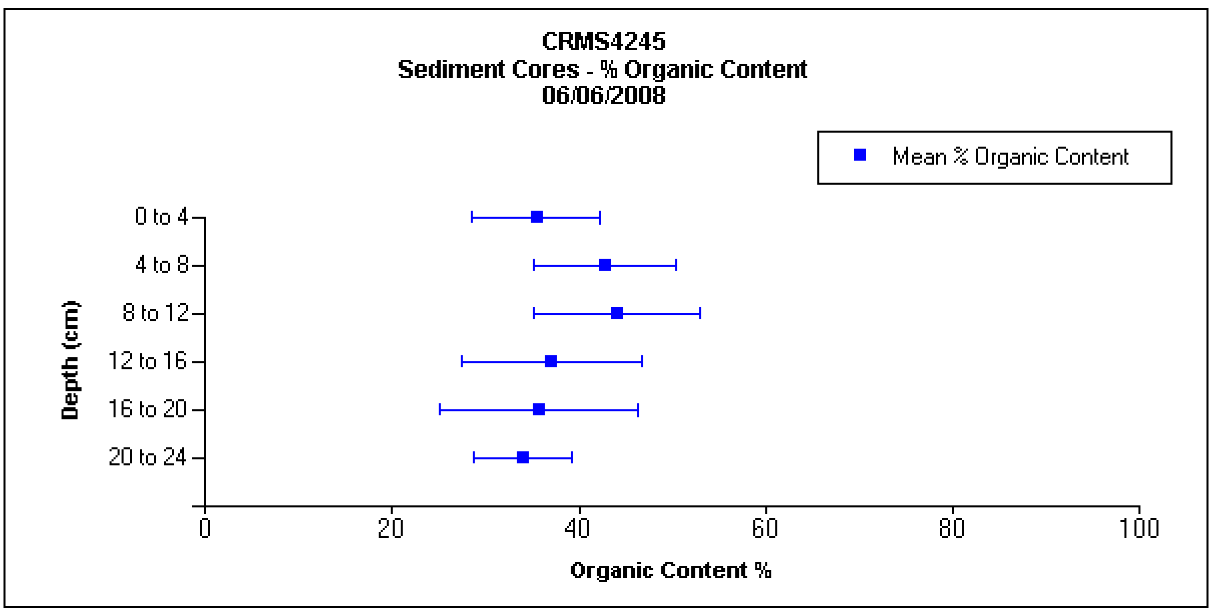


Figure 35. Mean % organic content of three sediment cores taken at CRMS4245 in June 2008.

elevation change is not being evaluated at CRMS4245 because this is a floating marsh site.

d. Discussion

The delayed and staggered construction regime combined with a strong environmental stress (the drought) led to difficulties in testing for project effects. The most recent habitat analysis was conducted in 2002, which would only have reflected changes due to CU1 construction. The percentage of land lost in the project area (0.8%) was comparatively smaller than the land lost within the reference areas in the post-CU1 period (5.7% and 2.8%). However, it is not possible to attribute this to the project with any certainty due to possible error in processing and to the presence of floating marsh in the project. Therefore, the first monitoring goal, to reduce the rate of emergent marsh loss, is inconclusive. The land/water analysis to be conducted in 2014 will provide further information to evaluate this goal.

Salinity levels in the project area were generally in the intermediate marsh range, which was consistent with the results of the habitat analysis. The drought, however, caused a prolonged period of elevated salinity which may have confounded the analysis if all stations were not equally affected. Possible effects of the project on salinity were found, but the changes in salinity between the project area and the reference area are so minute that no definite conclusions can be made. The second and third monitoring goals, to decrease variability in salinity and water level within the project area, were evaluated for impacts from CU1 and CU2. Unfortunately, the CU1 and CU2 project features did not appear to have a measurable effect on salinity or water level variability, as indicated by daily salinity range or mean tidal range.

Because the vegetative monitoring period ended in 2002, we could only test for impacts of CU1 in the available data. Unfortunately, the drought which occurred in the post-CU1 period caused a decrease in freshwater-intermediate species coverage and an increase in intermediate-brackish species coverage in both the project and reference areas between 1996 and 2002. The fourth monitoring goal, to stabilize or increase relative abundance of intermediate-to-fresh marsh plant species, was not met during the post-CU1 sampling period because of the drought; however, the decrease in coverage of freshwater-intermediate species was less pronounced in the project area versus the reference area. This may indicate that the structures acted as a buffer for the vegetative community in the project area. CRMS vegetation sampling did not begin until 2008, and the first sampling year was affected by Hurricanes Gustav and Ike. The percent coverage of fresh/intermediate species in 2009 and 2010 was not as high as the pre-drought fresh/intermediate coverage observed in the project area in 1996. It is recommended that another vegetation survey be conducted on the original BA-20 vegetation plots to provide long-term results which can be directly compared to the previous surveys.

The fifth monitoring goal was to reduce the marsh edge erosion rate along the southern project boundary. The shoreline protection structures appeared to have a positive effect on the project area and this goal appears to have been met. Dredged materials added to the project area during construction played a major role in the amount of land gained. Significant shoreline loss in the reference area between 2001 and 2004 also supports project effectiveness.

V. Conclusions

a. Project Effectiveness

Bank stabilization features along Bayou Rigolettes and Bayou Perot have been effective not only in reducing erosion of the marsh edge, but also in increasing shoreline acreage in an area with historically high shoreline erosion rates. The effect of the weir and plug features on salinity is inconclusive, although project features do not appear to be reducing variation of salinity and water levels in the project area as stated in the project goals. The vegetation community displayed a trend towards a more saline environment in the post-construction period due to the drought, and fresh/intermediate vegetation coverage at the CRMS sites is not as high as pre-drought coverage at the project sites. Hydrologic and vegetation data will continue to be collected at the CRMS stations, allowing for long-term evaluation of the project area.

b. Recommended Improvements

Additional monitoring of the BA-20 vegetation plots is recommended since the last survey occurred in 2002. The 2002 survey occurred not long after an extreme drought and before the construction of some of the BA-20 project features. Although vegetation is available from the CRMS sites within the project area, data from these stations may reflect localized differences in vegetation and are not as spatially distributed across the project area. For example, CRMS4245 is located in an area of floating marsh, and percent coverage estimates may differ greatly depending on marsh conditions at the time of sampling.

c. Lessons Learned

The most important lesson learned, in regards to biological monitoring, was that a staggered, long-term construction regime can have an adverse effect on data interpretation as seen in Jonathan Davis (BA-20). In the future, monitoring of a project should be scheduled from 1-3 years pre-construction and 3-5 years post-construction, as determined by the final date of construction, not the start of construction. It is unrealistic to assume construction will always be completed at a single point in time.

Based on multiple O & M inspections, the rock dike has proven to be very effective in reducing shoreline erosion, while experiencing no deterioration and requiring no recommended maintenance. The foreshore rock dike on parts of the west reach of CU3 was constructed with zero crown width and 3:1 side slopes. This type typical section with zero crown width is impractical to construct due to the size of the stone. Future rock dike construction should specify a minimum crown top width. Parts of CU1 used a zero crown width. All subsequent project designs since that time used a specified minimum crown top width. Please refer to the as-built drawings in subsequent units and the adaptive management comments for this project, where this was a case example cited for changing current methods of design.

VI. References

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Appendix A
(Inspection Photographs)

Photo #1 – Structure #14

Photo #2 – Structure #15

Photo #3 – New Rock to Structure #16 (under vegetation)

Photo #4 – Low spot near Structure #20

Appendix B
(Three Year Budget Projection)

Jonathan Davis Wetland Restoration Project (BA-20)

Federal Sponsor: NRCS

Construction Completed : 5/29/2001

PPL 2

Current Approved O&M Budget June 2009	Year 0 FY02	Year - 1 FY03	Year -2 FY04	Year -3 FY05	Year -4 FY06	Year -5 FY07	Year -6 FY08	Year -7 FY09	Year -8 FY10	Year -9 FY11	Year -10 FY12	Year -11 FY13	Year -12 FY14	Year -13 FY15	Year -14 FY16	Year -15 FY17	Year -16 FY18	Year - 17 FY19	Year -18 FY20	Year -19 FY21	Project Life Budget	Currently Funded
State O&M	$4,200	$4,309	$4,421	$4,536	$84,433	$504,924	$4,899	$5,027	$5,157	$111,609	$2,668,178	$5,570	$5,715	$218,766	$170,377	$3,462,144	$11,333	$11,498	$11,667	$11,840	$7,310,604	$7,310,604
Corps Admin																					$0	$0
Federal S&A																					$0	$0
Total																					$7,310,604	$7,310,604

Projected O&M Expenditures																					Remaining Project Life	Current 3 year Request
Maintenance Inspection	$4,200	$4,309	$4,421	$4,536	$4,654	$4,775	$4,899	$5,027	$5,157	$5,291	$5,429	$5,570	$5,715	$5,864	$6,016	$6,172	$6,333	$6,498	$6,667	$6,840	$61,103	$16,714
General Maintenance																					$0	$0
Surveys					$75,000					$100,000					$150,000						$150,000	$0
Sign Replacement														$200,000							$200,000	$0
Federal S&A					$4,779	$19,420				$6,317	$102,622			$12,352	$9,361	$132,967					$257,302	$102,622
Maintenance/Rehabilitation																					$0	$0
E&D						$32,688					$155,327					$198,005					$353,332	$155,327
Construction						$430,809					$2,312,307					$3,000,000					$5,312,307	$2,312,307
Construction Oversight						$17,232					$92,492					$120,000					$212,492	$92,492
Total	$4,200	$4,309	$4,421	$4,536	$84,433	$504,924	$4,899	$5,027	$5,157	$111,609	$2,668,178	$5,570	$5,715	$218,215	$165,377	$3,457,144	$6,333	$6,498	$6,667	$6,840	$6,546,537	$2,679,463

O&M Expenditures from COE Report	$88,001	Current O&M Budget less COE Admin	$7,310,604	Current Project Life Budget less COE Admin	$7,310,604
State O&M Expenditures not submitted for in-kind credit	$0	Remaining Available O&M Budget	$7,222,604	Total Projected Project Life Budget	$6,634,538
Federal Sponsor MIPRs (if applicable)	$0	**Incremental Funding Request Amount FY12-FY14**	**-$4,543,140**	**Project Life Budget Request Amount**	**-$676,067**
Total Estimated O&M Expenditures (as of April 2010)	$88,001				

Appendix C
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.1 -Site No. 12__ __ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored plug Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good				**Observations:**
Armored Plug	Good				There have been no changes since the last inspection. NRCS and OCPR agree that no maintenance required at this time.
Earthen Embankment	Good				

Construction Unit No.1

Structure Description: 294 linear ft. rock rip-rap armored rock-filled plug located in a pipeline channel north of Bayou Perot, west of Bayou Barataria, and east of the GIWW The crest of the weir was set at an elevation of +3.9 ft. NGVD. The rock-filled plug contains 2,689 tons of rock filled with 2,518 tons of rip-rap armor. Aluminum warning signs are also located through the rock embankment.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.1 -Site No. 13__ __ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored weir Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good				**Observations:** It is apparent this structure has settled. However, it is agreed that there is no need for maintenance at this time.
Armored Plug	Fair				
Earthen Embankment	Good				

Construction Unit No.1
Structure Description: 300 linear ft. rock rip-rap armored rock filled weir with a 50 ft. wide boat bay located north of Bayou Perot and Site 12, west of Bayou Barataria, and east of the GIWW. The crest of the weir is set at an elevation of +1.0 ft. NGVD. The invert of the boat bay is set at an elevation of -5.0 ft. NGVD. Rock wingwalls were constructed to an elevation of +3.6 ft. NGVD. On the west side and +4.0 ft. NGVD on the east side of the weir. The rock filled weir contains 1,093 tons of rock fill and 772 tons of rip-rap armor. Aluminum warning signs are located adjacent to the structure.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.1 -Site No. 14___ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored plug Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good			1	**Observations:** 80% of the repairs have been completed at this time. Looks good.
Armored Plug	Good			1	
Earthen Embankment	Fair			1	

Construction Unit No.1
Structure Description: 138 linear ft. of rock rip-rap armored rock filled channel plug located in a pipeline channel north of Bayou Perot, west of Bayou Barataria and east of GIWW and Site 13. The crest of the plug was constructed to an elevation of +3.2 ft. NGVD. The rock filled plug contains 2,580 tons of rock fill and 1,346 tons of rock rip-rap armor. Aluminum warning signs are located through the rock embankment.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.1 -Site No. 15__ __ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored weir w/ boat bay Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good			2	**Observations:** The maintenance work is completed and this is now a channel plug structure.
Armored Plug	Good			2	
Earthen Embankment	Good			2	**Remarks:**

Construction Unit No.1
Structure Description: Rock Riprap Channel Plug

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.1 -Site No. 16__ __ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored plug Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good			3	
Armored Plug	Fair			3	**Observation:** There have been no changes since the last inspection. Maintenance not needed at this time.
Earthen Embankment	Good			3	
					Remarks:

Construction Unit No.1
303 linear ft. of rock rip-rap armored rock filled plug located in a pipeline channel north of Bayou Perot, west of Bayou Barataria, east of the GIWW and Site 15. The crest of the plug was constructed to an elevation of +4.0 ft. NGVD. The rock filled plug contains 6,483 tons of rock fill and 1,766 tons of rock rip-rap armor. Two (2) aluminum warning signs are located through the rock plug embankment.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.1 -Site No. 17__ __ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored plug Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good				
Armored Plug	Good				**Observation:** Repairs completed, structure is in good condition.
Earthen Embankment	Good				**Remarks:**

Construction Unit No.1
Structure Description: 197 linear ft. of rock rip-rap armored rock filled plug located in a pipeline channel north of Bayou Perot, west of Bayou Barataria, and east of the GIWW. The crest of the plug was constructed to an elevation of 3.8' NAVD. The rock filled plug contains2,253 tons of rock fill and 1,201 tons of rock rip-rap armor. Aluminum warning signs supported by galvanized pipe are located through the rock embankment.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.1 -Site No. 19____ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored weir Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good				**Observation:**
Armored Plug	Good				There have been no changes since the last inspection. NRCS and OCPR agree that this structure does not need maintenance at this time.
Earthen Embankment	Good				

Construction Unit No.1
Structure Description: 239 linear ft. of rock rip-rap armored rock filled fixed crest weir with a 60 ft. wide boat bay located in a pipeline channel east of the GIWW, north of Bayou Perot, and west of Bayou Barataria. The crest of the weir was constructed to an elevation of +1.9 ft. NGVD on the north side and +2.0 ft. NGVD on the south. The boat bay invert was constructed to an elevation of -2.5 ft. NGVD. The rock filled plug contains 1,014 tons of rock fill with 572 tons of rock rip-rap armor. Aluminum waring signs are located on each side of the barge bay through the rock embankment.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.2 -Site No. 20_ __ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored plug Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good				
Armored Plug	Good				**Observation:** There have been no changes since the last inspection. No maintenance required at this time. Will monitor this structure on future site visits.
Earthen Embankment	Good				This structure has become heavily vegetated and a closer inspection should be made to determine if any sedimentation has occurred.

Construction Unit No.1
Structure Description: 170 linear ft. of rock rip-rap armored rock filled plug located north of Bayou Rigolettes, west of Bayou Barataria, and east of Bayou Perot. The plug crest was constructed to an elevation of +4.0 ft. NGVD. The rock filled plug contains 1,829 tons of rock fill with 795 tons of rock rip-rap armor. Two (2) aluminum warning signs are located on each end of the structure through the armored rock plug embankment.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.2 -Site No. 21__ __ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock rip-rap armored plug Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good				
Armored Plug	Good				**Observation:** There have been no changes since the last inspection. No maintenance will be required at this time.
Earthen Embankment	Good				

Construction Unit No.1
Structure Description: 83 linear ft. of rock rip-rap armored rock filled plug located north of Bayou Rigolettes, west of Bayou Barataria, and east of Bayou Perot. The plug crest was constructed to an elevation of +4.0 ft. NGVD. The rock filled plug contains 285 tons of rock fill and 220 tons of rock rip-rap armor. Two (2) aluminum warning signs supported by galvanized pipe are located on each end of the structure through the rock embankment.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.2 -Site No. 22A____ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Canal Bank Stabilization Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good				**Observation:**
Rock Armored Bank	Good				There have been no changes since the last inspection. No maintenance is required at this time.
Earthen Embankment	Good				

Construction Unit No.2
Structure Description: Canal bank stabilization consisting of 1,385 linear ft. of rock rip-rap protection on the west bank of the access channel at the Baltazaar Point Subdivision. The rip-rap was constructed to an elevation of +3.0 ft.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. ____Construction Unit No.2 -Site No. 22____ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Steel sheet pile structure w/ boat bay Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	Good				
Handrails Hardware, etc.	Good				**Observation:** There have been no changes since the last inspection. No maintenance required at this time.
Signage and supports	Good				
Rock weir	Good				
Earthen Wingwalls	Good				
Rock Armored Earthen Embankment	Good				

Construction Unit No.2
Structure Description: 58 linear ft. of steel sheet pile bulkhead with a crest elevation of +1.95 ft. and a 24' - 8-1/2" wide boat bay with a crest elevation of -0.93 ft. located off of Bayou Regolettes, west of Bayou Barataria and east of GIWW. The structure consists of a steel sheet pile weir with 1,426 square feet of sheet piling set at +1.95 ft. At the bottom the boat bay, is a 1.5 ft. thick rock rip-rap scour pad seciton with an invert of -0.93 ft. This structure ties into structure 22A on the west side. Aluminum warning signs supported by 12" diameter timber piles are located at the entrance of the boat bay.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland**

Date of Inspection: 4/21/2011

Time: 9:30 am

Structure No. _Construction Unit No.2____

Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock dike along Bayou Rigolettes

Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual

Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good			4	
Armored Plug	Good			4	**Observation:** Some more spots of settlement have been noticed.
Rock Dike	Good			4	Repairs will be made during a future maintenance event.
Earthen Embankment	Good			4	

Construction Unit No.2
Structure Description: The rock dike consist of 3,967 linear ft. of rock dike with a 6 ft. top width and a crest elevation of +3.5 ft. The shoreline stabilization extends from Site 22A west to Structure No.20.

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-20 Jonathan Davis Wetland** Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No.__Construction Unit No.3____ Inspector(s): Richard, Kinler, Trusclair

Structure Description: Rock dike along Bayou Perot Water Level Inside: N/A Outside: 0.8'

Type of Inspection: Annual, Post Storm, other Annual Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Signage and supports	Good				
Armored Plug	Good				**Observation:**
Rock Dike	Good				There have been no changes since the last inspection. Repairs will be made during a future maintenance event.
Earthen Embankment	Good				

Construction Unit No.3
Structure Description: The rock dike consist of 13,088 linear ft. of rock dike with a 6 ft. top width and a crest elevation of +3.5 ft. The shoreline stabilization extends from Site 12 west to the Gulf Intracoastal Waterway