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

2008 Operations, Maintenance, and Monitoring Report

for

Sabine Structure Replacement

State Project Number CS-23
Priority Project List 3

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Cameron Parish

Prepared by:

Mike Miller
and
Dewey Billodeau
CPRA/Office of Coastal Protection and Restoration
Lafayette Field Office
Abdalla Hall, Room 201
635 Cajundome Boulevard
Lafayette, LA 70506

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For
Sabine Structure Replacement (CS-23)

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I. Introduction

The Replace Hog Island Gully, West Cove and Headquarters Canal Structures (CS-23) project area is located within the Sabine National Wildlife Refuge, approximately 9 mi (14.5 km) south of the town of Hackberry in Cameron Parish, Louisiana (Figure 1). Established on December 6, 1937, the Sabine Refuge is bound on the east by Calcasieu Lake, on the west by Sabine Lake, on the north by broken marsh, and on the south by pasture land and coastal ridges.

O'Neil (1949) characterized the project area wetlands as fresh to intermediate marshes dominated by *Cladium mariscus* (Jamaica sawgrass). The Black Lake area, located north of the project, experienced an 81% reduction in the acreage of emergent wetlands between 1952 and 1974 (Adams et al. 1978). By 1972, the Black Lake area was characterized as brackish marsh (Chabreck and Linscombe 1978). A number of factors such as salinity stress, erosion, subsidence, burning and hydrologic modification influenced this habitat change.

Since there are primarily three avenues for water passage (Hog Island Gully, West Cove Canal, and Headquarters Canal) in the area, water management by weirs was initiated in the 1970's (Figure 2). By the 1990's, these structures had corroded with the continuous exposure to saline water to the extent that they were inoperable or almost inoperable.

Due to the detrimental impacts of excessive salinity on brackish and intermediate marshes, the ability to occasionally reduce or halt the inflow of saline water is critical. This level of control was not available with the original structures. The inability to manipulate gate structures jeopardized the integrity of thousands of acres of interior brackish and intermediate marshes which are lower in elevation and often occur in highly organic semi floating soils. The estimated subsidence rate in the project marshes ranges between 0.12 in/yr and 0.16 in/yr (0.32 and 0.42 cm/yr) (Penland et al. 1989).

Because of the restricted cross-sectional area of the pre-existing structures and culverts, the lower elevation interior marshes experienced longer periods of vegetative water logging stress than the marshes located east of Highway 27. The pre-existing structures afforded the primary avenues for drainage and were inadequate to provide sufficient discharge to evacuate excess water. Due to the project area not being fully enclosed, secondary drainage for the area could occur to the west through Sabine Lake via North, Central and South line canals.

In May 1999, the US Fish and Wildlife Service (USFWS) completed the environmental assessment (EA) plan addressing the Replacement of Water Control Structures at Hog Island Gully, West Cove Canal, and Headquarters Canal (CS-23).

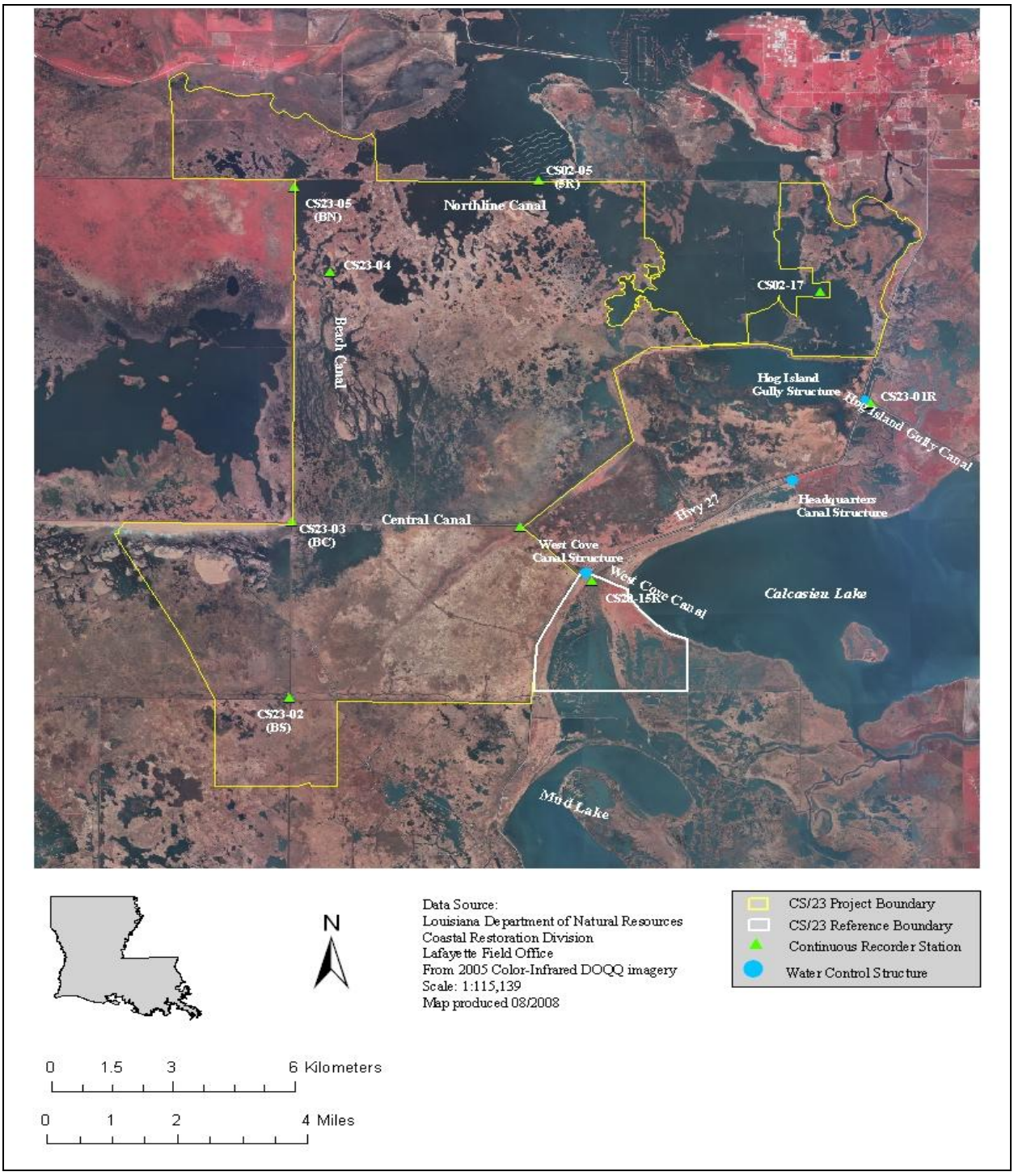


Figure 1. Replace Hog Island Gully, West Cove and Headquarters Canal Replacement Structures (CS-23) project features, project area boundaries and reference area boundaries.

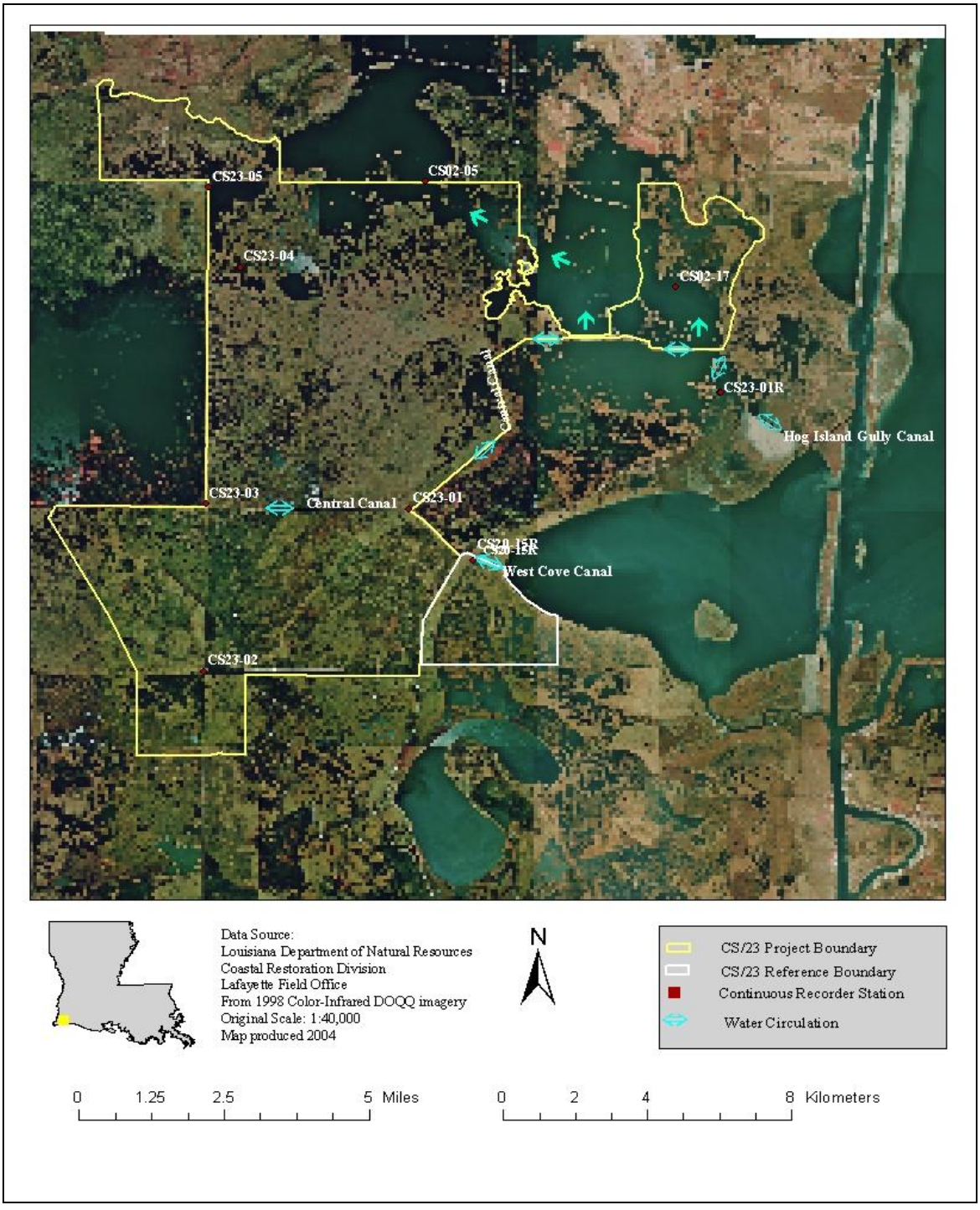


Figure 2. 1998 DOQQ imagery of continuous recorder monitoring stations and water circulation patterns in the Hog Island Gully, West Cove and Headquarters Canal Structure Replacement project and reference areas.

The plan called for the complete removal of the Hog Island Gully Structure, West Cove Canal Structure, and Headquarters Canal Structure and replacement with additional structures and culverts to provide larger cross sections for water removal and to minimize saltwater intrusion.

The replacement structures should be operated to more effectively discharge excess water, increase cross sectional area for ingress and egress of estuarine dependent species and more effectively curtail saltwater intrusion into the interior marshes. Since completion of the new structures, high saline waters could be precisely controlled, water discharge capacities increased, and vegetative stress through water logging has been minimized, thus enhancing emergent and submergent vegetative growth.

Construction began in November 1999 and was completed on the Hog Island Gully, West Cove, and Headquarters Canal structures in August 2000, June 2001, and February 2000, respectively. However, the Hog Island Gully and West Cove structures are not fully operational due to an electrical service problem, exacerbated by the damage to the structures from Hurricane Rita in 2005 and Hurricane Ike in 2008.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Sabine Refuge Structure Replacement Project (CS-23) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, LDNR 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 (O&M Plan, 2002). The annual inspection report also contains a summary of maintenance activities which were completed since project completion and an estimated projected budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix C.

An inspection of the Sabine Refuge Structure Replacement Project (CS-23) was held on March 18, 2008 under partly cloudy skies, windy conditions and mild temperatures. In attendance were Dewey Billodeau and Darrell Pontiff from LDNR. Jim Ashfield and Rueben LaBauve were representing USFWS. The inspection began at the Hog Island Gully Structure at approximately 10:00 am and ended at the West Cove Structure at 10:40 am.

The field inspection included an inspection of all three project sites. Staff gauge readings and existing temporary benchmarks where available were used to determine approximate elevations of water, rock embankments, concrete structures and other project features. Photographs were taken (see Appendix B) and Field Inspection notes were completed in the field to record measurements and deficiencies (see Appendix D).

b. Inspection Results

<u>Hog Island Gully Canal</u>

This structure is still not operable due to damage from Hurricane Rita in 2005. The security chain link fence has been replaced as described in the maintenance section above. The trash and debris on and around the structure has been cleaned up by others. The structure will require maintenance work to repair the gates with dual stem operation, repair the actuators, add reinforcement to flanges, update electrical system, install bird excluder devices, and install lighting (Photos: Appendix B, Photos 1-2)

<u>Headquarters' Canal</u>

This structure is still not operable due to damage from Hurricane Rita in 2005. The trash on and around the structure has been cleaned up by others. The structure will require maintenance work to replace the electrical controls and repair the actuator on one of the gates (Photos: Appendix B, Photos 5-6).

West Cove Canal

This structure is still not operable due to damage from Hurricane Rita in 2005. The security chain link fence has been replaced as described in the maintenance section above. The trash and debris on and around the structure has been cleaned up by others. The structure will require maintenance work to repair the gates with dual stem operation, repair the actuators, add reinforcement to flanges, update electrical system, install bird excluder devices, and install lighting (Photos: Appendix B, Photos 3-4).

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

ii. Programmatic/ Routine Repairs

The Hog Island Gully and West Cove structures will require maintenance work to repair the gates with dual stem operation, repair the actuators, add reinforcement to flanges, update electrical system, install bird excluder devices, and install lighting. The Headquarters' Canal structure will require maintenance work to replace the electrical controls and repair the actuator on one of the gates.

d. Maintenance History

General Maintenance: Below is a summary of completed maintenance projects and operation tasks performed since February 2000, the construction completion date of Sabine Refuge Structure Replacement Project (CS-23).

June 2005 – F. Miller & Sons, Inc. A maintenance event was performed to correct the following:

1. Install operating nut in gate 6A, Hog Island Gully.
2. Free gate 6b that is jammed, Hog Island Gully.
3. Replace operation nut in gate 3A, West Cove.
4. Replace batteries in all Rotork Actuators and re-calibrate.

Construction (Item Nos. 1, 2 & 3):	$ 7,800.00
Construction (Item No. 4):	$ 5,416.45

TOTAL CONSTRUCTION COST:	**$13,216.45**

June, 2006 – U.S. Fence & Gate, Inc. A maintenance event was performed to correct the following:

1. Remove existing fence and posts damaged by Hurricane RITA at both Hog Island Gully and West Cove Structures and replace with new chain link fence material and new posts.

Construction Cost:	$8,360.00
Engineering Design and Construction Oversight:	In-House
TOTAL CONSTRUCTION COST:	**$8,360.00**

III. Operation Activity

a. Operation Plan

Structure A-Hog Island Gully Canal
This structure has four 7.5 foot wide gates (HG1, HG2, HG5, and HG6) and two 3.0 foot wide gates (HG3 and HG 4) [306 ft^2 total area]. Each gate is 8 foot deep, assuming that water level is at marsh elevation (1.0' NGVD). Each gate is equipped with stop logs on slide gates that may be used to preclude all water flow. Of the four 7.5 foot wide gates, three have exterior flap gates, (HG1, HG2, and HG6).

Structure B- Headquarters Canal
This structure has three 5 foot wide diameter culverts (HQ1, HQ2, and HQ3) [59 ft total area]. The top of each culvert is at marsh level (1.0' NGVD). Each gate is equipped with an exterior flap gate that may be raised and locked closed to serve as an adjustable sluicegate.

Structure C – West Cove Canal
This structure has three 7.5 foot wide gates (WC1, WC3, and WC5) and two 3.0 foot wide gates (WC2 and WC4) [242 ft^2 total area]. Each gate is 8 foot deep, assuming that water level is at marsh elevation (1.0' NGVD). Each is equipped with stop logs in slide gates that may be used to preclude all water flow. Two of the four 7.5 foot gates have exterior flap gates (WC1 and WC5).

Normal Operation: Water exchange will be provided through open bays having approximately the same cross-sectional area as that provided by the old structures' fully open gates [182 ft^2 total area]. The slide/sluice fates of the flapgated bays may be adjusted by the refuge manager at his discretions, except for the middle Headquarters' Canal Structure culvert (HQ2) which will

remain 50 percent open. All flapgates will remain down in the operating position, except for HQ2 in which the flapgate will be locked closed to serve as the sluice gate.

Hog Island Gully Canal-Structure A: Normal management of this structure would provide a cross-sectional area of 112 ft^2 compared with 93.5 ft^2 of gated opening in the old structure.

HG1	HG1	HG2	HG2	HG3	HG3	HG4	HG4	HG5	HG5	HG6	HG6
Stop Logs	Flap Gate	Stop Logs	Flap Gate	Stop Logs	Flap Gate	Stop Logs	Flap Gate	Stop Logs	Flap Gate	Stop Logs	Flap Gate
MD	Down	MD	Down	-7’	None	-7’	None	-7’	None	MD	Down

MD=Manger’s discretion

Headquarters’ Canal – Structure B. Normal management provides a cross-sectional area of approximately 10 ft^2 compared with 0 to 12.6 ft^2 of gated opening maintained through operation of the old structure.

HQ1 Sluice	HQ2 Sluice	HQ3 Sluice
Sluice Open	Sluice ½ Open	Sluice Open

West Cove Canal - Structure C. Normal management would provide a cross-sectional area of 60 ft^2 compared to 59.5 ft^2 of gated opening in the old structure.

WC1 Stop Logs	WC1 Flap Gate	WC2 Stop Logs	WC2 Flap Gate	WC3 Stop Logs	WC3 Flap Gate	WC4 Stop Logs	WC4 Flap Gate	WC5 Stop Logs	WC5 Flap Gate
MD	Down	+2’	None	-7’	None	+2’	None	MD	Down

Deviations from normal operation will be short-term and conducted for the reason identified below.

Increased Exchange Operation:

Additional gates may be temporarily opened to the degree necessary as determined by the refuge manager for any of the following reasons.

1) To discharge excess water
2) To facilitate inflow of freshwater, or water of lower salinity
3) To enhance ingress and egress of estuarine-dependent fishes and shellfishes
4) To discharge anoxic waters

High Water Provisions: When water levels in interior marshes exceed four inches above average marsh level for four days or more, the discharge capacity of structures A, B, and or C will be increased with flap fates or by opening stop logs or sluice gates to permit outflows. Normal operation will be restored when the water conditions have receded.

Storm provisions: Prior to a storm's approach, flapgated bays may be readied in advance for later discharge of excess water by raising and thereby opening the sluice gates of those bays equipped with flapgates. Prior to a storm's approach, refuge personnel may restrict or close non-flapgated bays to reduce exposure or interior marshes to saltwater tidal surges. Following a storm, normal or restricted water exchange operations shall be resumed on non-flapgated bays in accordance with the established salinity and water level provisions and criteria. In an attempt to reduce the exposure of interior marshes to saltwater because of tropical depression tidal surges, the fates will be closed precluding any surges. Following the inundation of high tides and rainfall, the gates will be opened to alleviate interior marsh flooding.

Monitoring Activities: Baseline salinity and water level monitoring, using continuous recorders, began in April 1998 using the standard Coastal Wetlands, Planning, Protection, and Restoration Act monitoring protocol (Steyer et. al 1995). The Louisiana Department of Natural Resources Coastal Restoration Division has deployed six continuous monitoring recorders (sondes) within the project area. The U.S. Fish and Wildlife Service (USFWS) has been collecting salinity, water temperature, dissolved oxygen, pH, and specific conductivity parameters at area stations approximately every two weeks for over 15 years and will continue to do so after project completion. Due to the impending installation of Coastwide Reference Monitoring System (CRMS) stations (Figure 3), data collection at two of the continuous recorder monitoring stations (CS23-01 and CS23-02) was discontinued in May 2004. The remaining continuous recorder monitoring stations (CS23-02, CS23-03, CS23-05, CS23-01R, CS20-15R and CS02-05) will continue data collection and will be operated by the USFWS.

b. Actual Operations

USWFS is responsible for structure operations and small maintenance. Actual operation data may be obtained from the Sabine Refuge Headquarters Office.

However, the Hog Island Gully and West Cove structures were not fully operational prior to Hurricane Rita due to an electrical service problem as well as gate alignment problems.

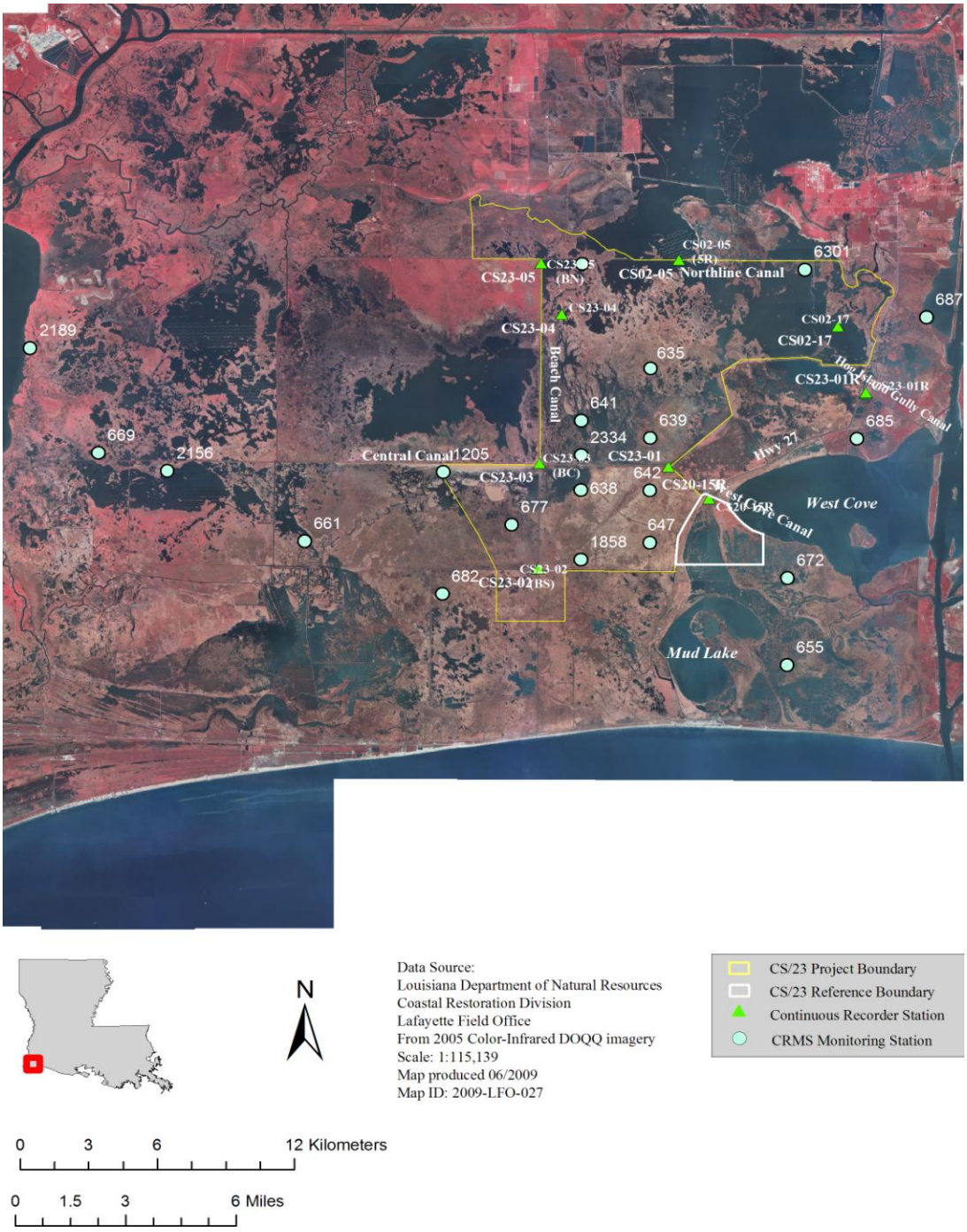


Figure 3. 2005 DOQQ imagery of continuous recorder and CRMS monitoring stations in the Hog Island Gully, West Cove and Headquarters Canal Structure Replacement project and reference areas.

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 CS-23 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.

a. Monitoring Goals:

The objective of the Hog Island Gully, West Cove & Headquarters Canal Structure Replacement Project is to increase the cross-sectional area of the project features to improve hydrologic conditions that control high saline waters, increase water discharge capacities, and maintain emergent vegetation.

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

1. Reduce the occurrence of salinities that exceed target levels during the growing and non-growing seasons at stations CS23-02, CS23-03, CS23-05 and CS02-05. Target levels range from 2 – 8 ppt during the growing season and 3 – 10 ppt during the non-growing season.

2. Minimize frequency and duration of marsh flooding events.

3. Maintain existing intermediate and brackish vegetation communities.

4. Increase occurrence of submerged aquatic vegetation (SAV).

b. Monitoring Elements

Aerial Photography

Near-vertical color-infrared aerial photography (1:24,000 scale) was used to measure land to water ratios for the project and reference areas. The photography was obtained in November 2000 prior to project construction and postconstruction in 2004. The original photography was checked for flight accuracy, color correctness, and clarity and was subsequently archived. Aerial photography was scanned, mosaicked, and georectified by USGS/NWRC personnel according to standard operating procedures (Steyer et al. 1995, revised 2000). The photography will be obtained after construction in 2009, and 2018.

Salinity

Salinities were monitored hourly utilizing eight continuous recorders (Figure 3). Six are located in the project area, one in the reference area and one outside of the project area within Hog Island Gully Canal. Five recorders are associated with this project (CS23-01, CS23-02, CS23-03, CS23-04, CS23-01R), two associated with Rycade Canal (CS02-05, CS02-17) and one from East Mud

Lake (CS20-15R). Continuous data will be calculating average annual salinities throughout the project and reference area. Salinity data will also be used to identify occurrences of salinities that exceed target levels within the project area at stations CS23-03, CS23-05 and CS02-05 and CS02-17. Salinity was monitored in 1998-1999 (pre-construction) and from 1/1/04 -12/31/07 (post-construction) at stations CS23-03, CS23-05, CS02-05, CS23-01R and CS20-15R. Due to the devastating effects of Hurricane Rita salinity data was not collected from 08/01/05 – 04/05/06. Based on the monitoring plan review, two project stations were removed in May of 2004.

Water Level

Water levels are monitored hourly utilizing eight continuous recorders (Figure 3) and are located at the salinity stations outlined in the previous section. To document annual duration and frequency of flooding, water levels were analyzed at 4 of the continuous recorder stations which were referenced to marsh elevations. A staff gauge has been surveyed adjacent to each continuous recorder to correlate water levels to a known datum. Marsh elevations have been established at stations (CS23-03, CS23-05, CS02-05, CS02-17), and will be used to analyze duration and frequency of flooding events.

Vegetation

Species composition, richness and relative abundance will be evaluated in the project and reference areas using the Braun-Blanquet method as described in Steyer et al. (1995). Fifty 4 m^2 sample areas (replicate 2 m x 2 m plots) are used to monitor percent cover, species composition, and height of dominant plants. Forty plots are located in the project area and ten existing plots are located in the CS-20 reference area. The plots were established along a North/South transect line and are marked by GPS points and PVC poles to allow revisiting over time. Vegetation was monitored in 1999 (pre-construction) and 2004 (post-construction). Data collection at project vegetation stations was discontinued after 2004 and future vegetation data will be collected at the 10 CRMS-*Wetland*s stations that fall within the project and surrounding reference stations.

Submerged Aquatic Vegetation

To determine the occurrence of SAV within the project and reference area, eight ponds are randomly sampled for presence or absence of SAV using the modified rake method (Nyman and Chabreck 1996). Five ponds are located in the project area and three in the reference area. Transect lines are set up within each pond and a minimum of 25 samples are taken along each transect line, not to exceed 100 samples per line. Depending on pond configuration and wind direction, the number of transect lines within each pond varies. SAV was monitored in 1999 (pre-construction) and in July 2004 post-construction. SAV data will continue to be collected in 2009, 2014 and 2018.

CRMS Supplemental

In addition to the project specific monitoring elements listed above, a variety of other data is collected at CRMS-*Wetlands* stations which can be used as supporting or contextual information. Data types collected at CRMS sites include hydrologic from continuous recorder (mentioned above), vegetative, physical soil characteristics, discrete porewater, surface elevation, and land:water analysis of 1 km^2 area encompassing the station. For this report, data from four sites

within the project area is compared to data from four sites outside the project area in a traditional project versus reference manner. In the future, data collected from the CRMS network over a sufficient amount of time to develop valid trends will be used to develop integrated data indices at different spatial scales (local, basin, coastal) to which we can compare project performance.

Soil cores were collected one time (within a year of site establishment) to describe soil properties (bulk density and percent organic matter). Three, 4" (10.16-cm) diameter cores were collected to a depth of 24 cm and divided into 6, 4-cm sections at the site. The soil was processed by the Department of Agronomy and Environmental Management at Louisiana State University.

Soil surface elevation change utilizing a combination of sediment elevation tables (RSET) and vertical accretion from feldspar horizon markers are being measured twice per year at each site. This data will be used to describe general components of elevation change and establish accretion/subsidence rates. The RSET will be surveyed to a known elevation datum (ft, NAVD88) so it can be directly compared to other elevation variables such as water level. CRMS sites inside (0651, 635, 641, 638, 639, 2334, 677, 1858, 647, 642) and outside (0685, 0655, 0669, 2156, 2189) were used for this report.

Vegetation Index - FQI

Floristic Quality Indices (FQIs) have been developed for several regions to determine the quality of a wetland based on its species composition (Cohen et al., 2004; Bourbaghs et al., 2006). This FQI was developed by Jenneke Visser and an expert panel on Louisiana coastal vegetation as part of CRMS analytical working group in 2007. The panel provided an agreed upon score (Coefficient of Conservatism or CC Score) from 0 to 10 for each species in a list of ~500 plant species occurring in Louisiana's coastal wetlands. CC scores are weighted by percent vegetative cover and summed to determine the FQI for the CRMS site.

c. Preliminary Monitoring Results and Discussion

Aerial Photography

Land/water analysis was acquired in November 2000 (Figure 4). Results indicate that the project area had a ratio of 67.5% land to 32.5% water while the reference area was comprised of 57.9% land to 42.1% water. A photo-mosaic of the aerial photography was produced (Figure 5). Post-construction photography was collected in 2004 and is currently being processed.

Salinity

Salinity data was collected hourly at eight stations (Figure 1, Table 1) associated within the CS-23 project and reference areas.

Table 1. Continuous recorder stations and data collection periods.

Station	Data collection period
CS23-01	02/25/98 – 05/19/04
CS23-02	03/18/98 – 05/19/04
CS23-03	03/18/98 – 12/31/07
CS23-04*	03/18/98 – 08/25/99
CS23-05	03/18/98 – 12/31/07
CS23-01R	03/17/98 – 12/31/07
CS02-05**	01/01/96 – 12/31/07
CS02-17**	01/01/96 – 07/29/04
CS20-15R	01/01/95 – 12/31/07

Weekly mean salinity was calculated from daily means of hourly data (Figures 6a and 6b). Statistical tests were performed on pairs of stations pre- and post-construction to determine if the project had the desired effect on specific sonde pairs. Median tests on the difference in salinity for each week were conducted pre- and post-construction. Of the station pairs tested, all but CS23-01R relative to CS23-05 were significantly different at the α=0.05 level (Table 3).

Table 2. Sonde comparison test for salinity difference between stations for the pre and post construction period within the CS-23 project and reference areas.

Paired sonde comparison results				Salinity Difference (Site A - Site B) (ppt)	
Site A	Site B	measure	p-value	Pre-Construction	Post-Construction
CS23-05	CS23-03	Salinity	<.0001	-1.71	-1.10
CS20-15R	CS23-01R	Salinity	<.0001	-6.99	-0.21
CS02-05	CS23-05	Salinity	0.0006	1.20	6.39
CS23-01R	CS23-05	Salinity	0.4508	10.62	9.30
CS23-01R	CS02-05	Salinity	<.0001	16.14	10.24
CS20-15R	CS23-03	Salinity	0.0224	3.21	7.66

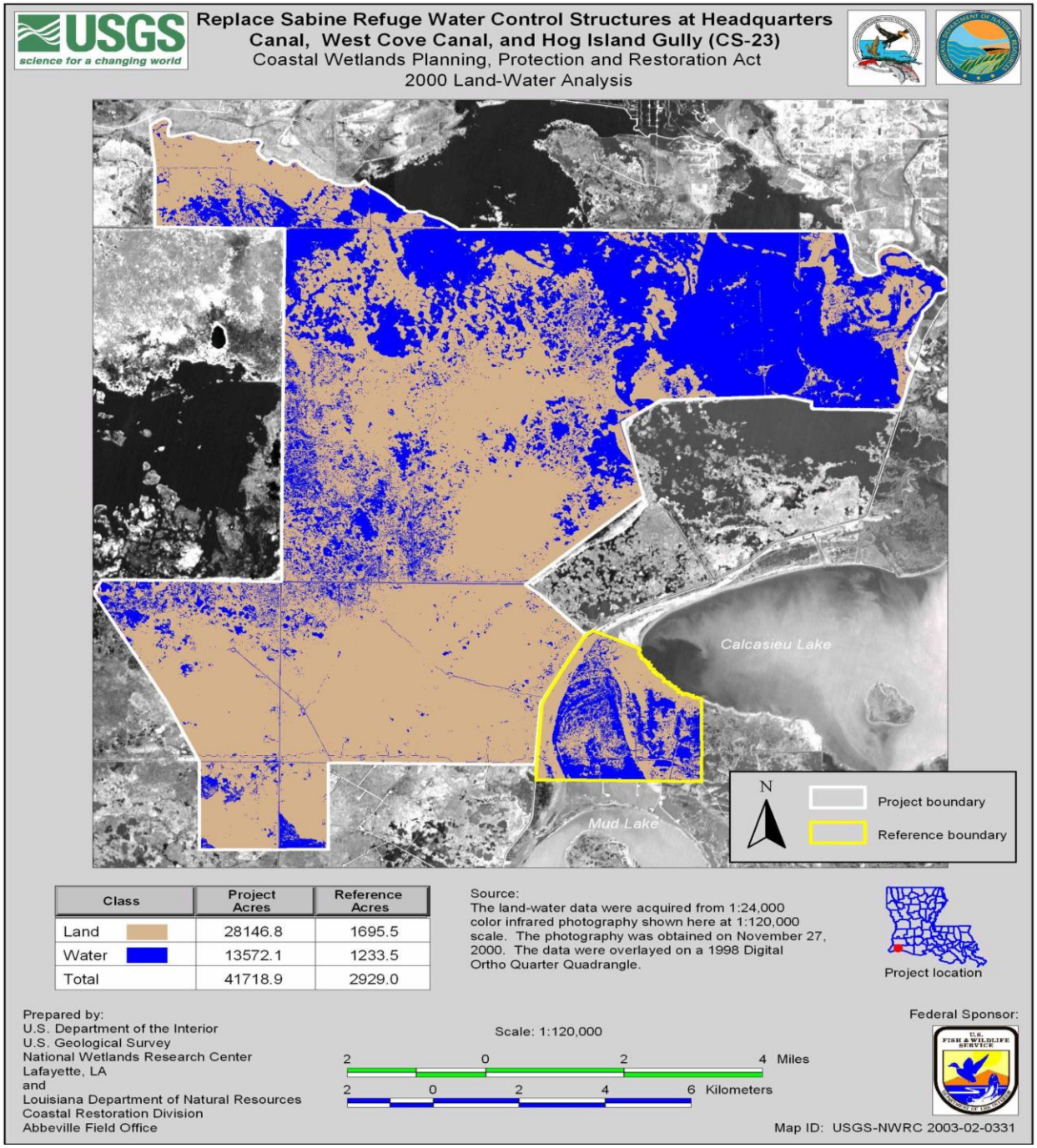


Figure 4. Land/water analysis of the Sabine Structure Replacement (CS-23) for the project and reference areas from photography obtained November 27, 2000.

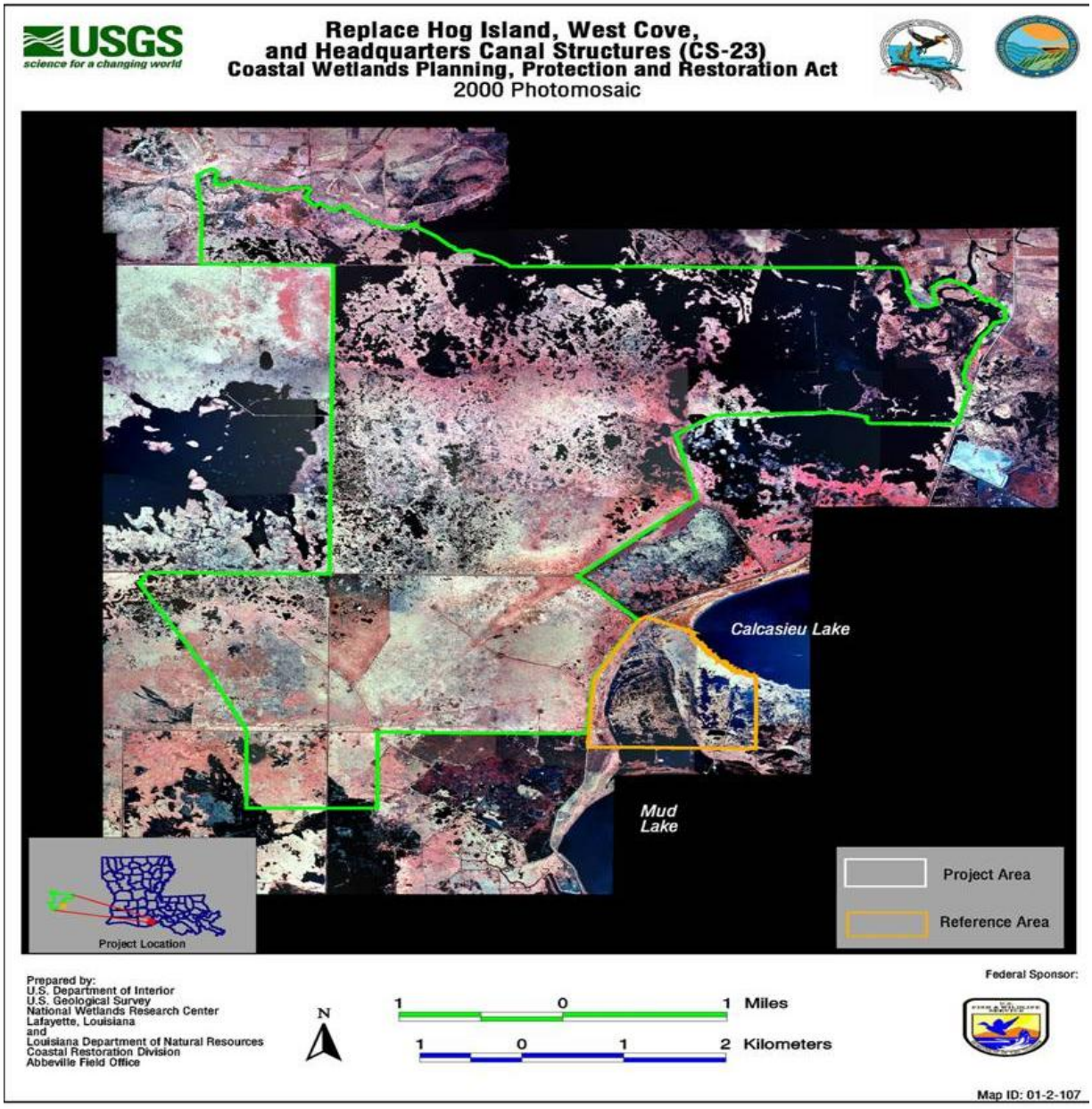


Figure 5. Photo-mosaic of the Hog Island Gully, West Cove and Headquarters Canal Structure Replacement project area from photography obtained November 27, 2000**.**

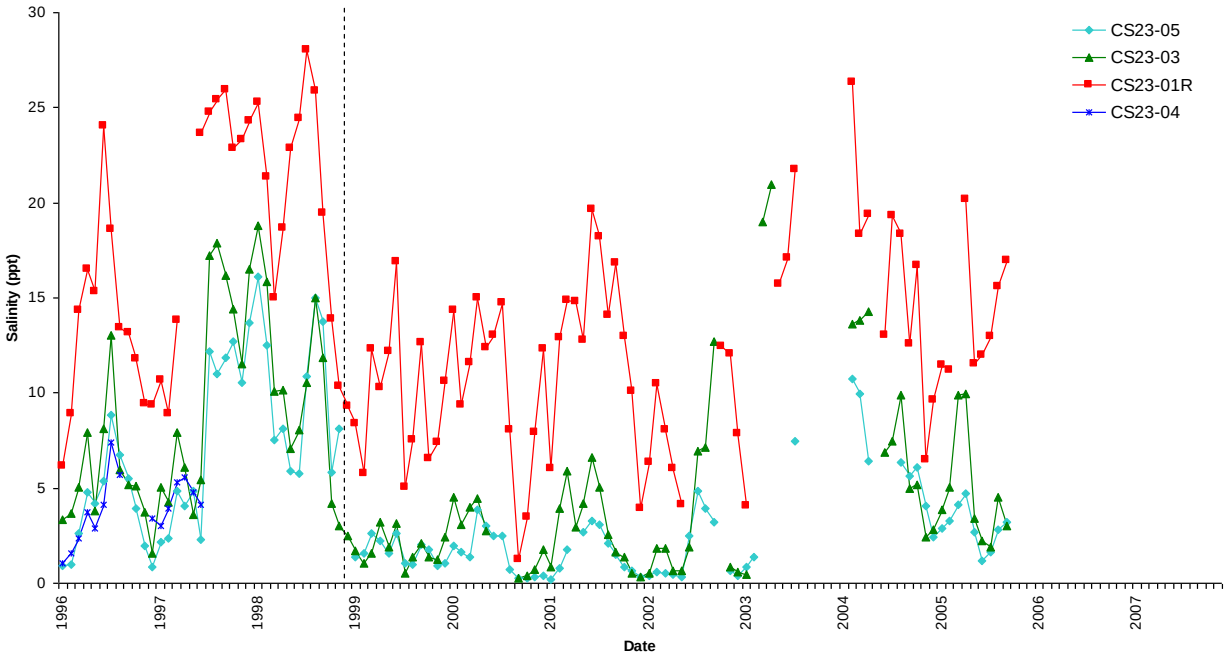


Figure 6a. Monthly mean salinity in the northern portion of CS-23. Vertical line represents project construction.

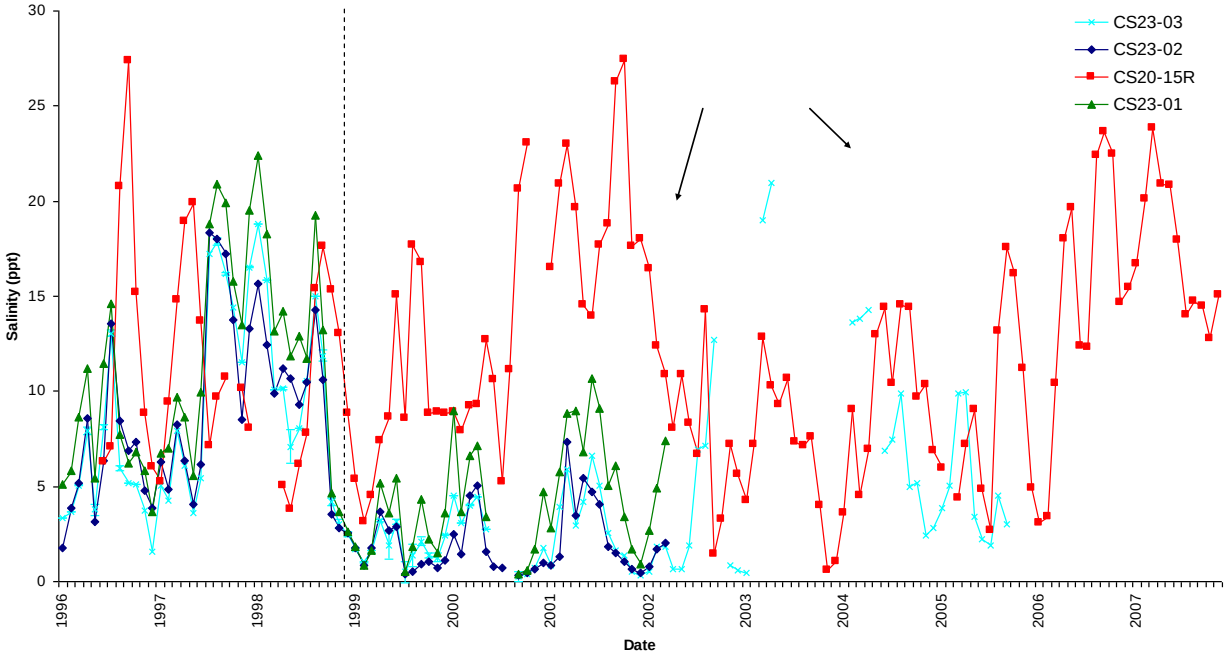


Figure 6b. Monthly mean salinity in the southern portion of CS-23. Vertical line represents project construction.

There were significant differences in salinity between pairs at most stations pre- and post-construction. CS23-03 had higher salinity than CS23-05 both pre- and post-construction but the magnitude of that difference was lower post-construction. CS02-05 salinities increased relative to CS23-05 salinities post-construction which suggests that an additional salt source affected CS02-05 post-construction. It is interesting to note that the difference in salinity at CS23-01R and CS23-05 were insignificant pre- and post-construction, indicating that CS23-01R was always 9 to 10 ppt higher than CS23-05, but the difference did not increase post-construction. The difference between CS23-01R and CS02-05 decreased significantly pre- and post-construction. The difference between the relationship between CS23-05 and CS23-01R, and CS02-05 and CS23-01R is likely due to the fact that CS02-05 was much lower than CS23-05 pre-construction. Finally, salinities at CS23-03 and CS20-15R increased post-construction suggesting that CS23-03 became fresher post-construction, possibly indicating a project effect.

Salinity relative to target levels which were set forth in the Environmental Assessment (EA) for the Replacement of Water Control Structures at the Hog Island Gully, West Cove and Headquarters Canal Project (XCS/CS-23; 1999). The percent of the time stations were in the salinity range were calculated using pre- and post-construction hourly salinity (ppt) data from 03/18/98 – 12/31/07. Stations CS02-05, CS23-02, CS23-03 and CS23-05 which had salinity target levels for the growing (March – August) and non-growing (September – February) seasons were calculated (Figure 7). The percentage of total time target levels were maintained during the post-construction growing season at stations CS02-05, CS23-02, CS23-03 and CS23-05 were 65.78, 48.60, 57.43 and 61.35 percent, respectively. The percentage of total time target levels were maintained during the post-construction non-growing season was 52.15, 27.12, 43.56 and 44.90 percent respectively (Figure 9). The percent of time stations were within the target range during the growing season increased for CS02-05 and C02-17 but decreased for CS23-02, CS23-03, and CS23-05. The percent of time stations were within the target range during the non-growing season decreased for all stations. In this regard, the project has not had the desired effect indicating a need for operational control at the structures.

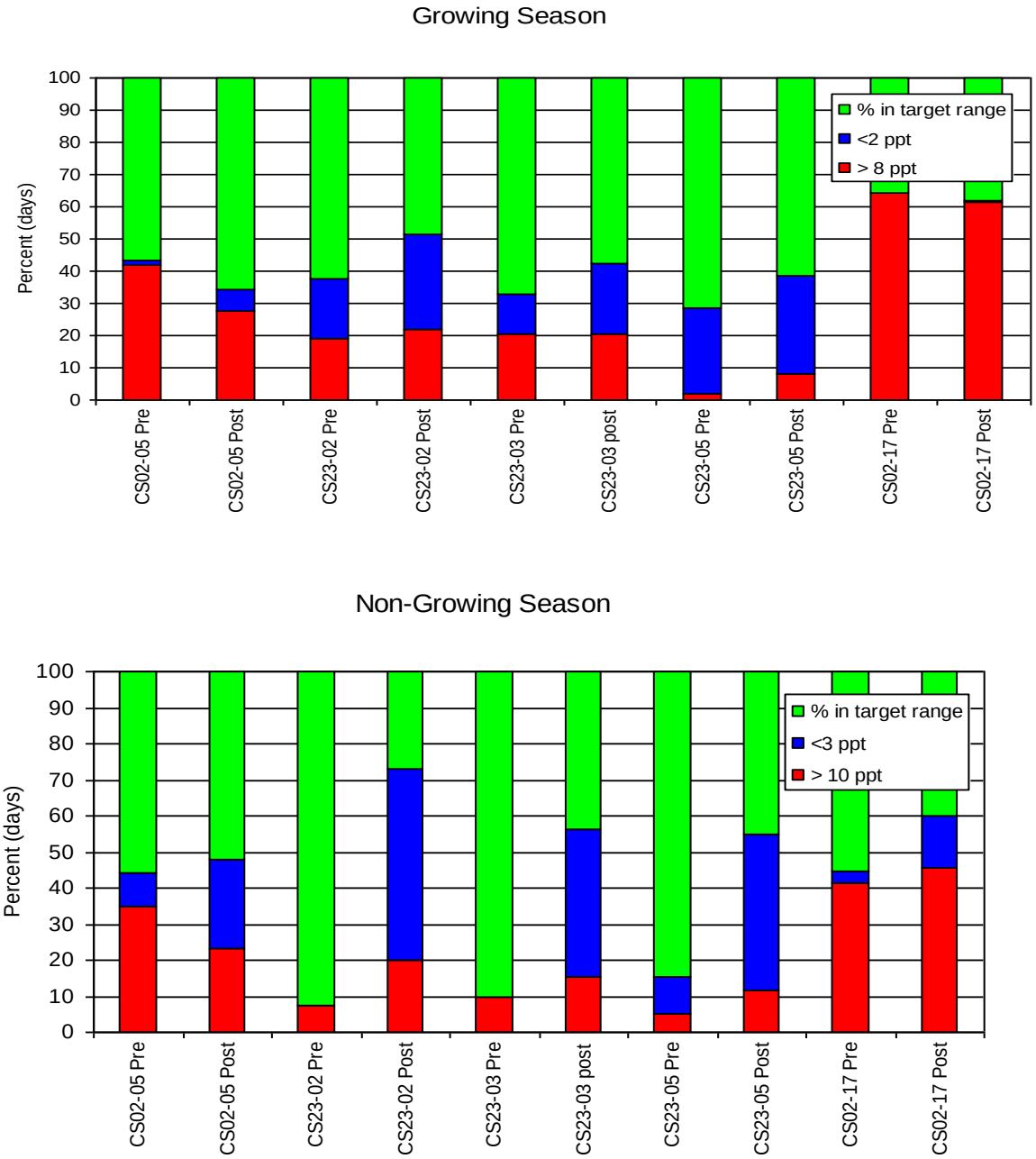


Figure 7. Frequency distribution of salinities that fall within the target ranges during the growing and non growing seasons in the project area from 1996 to 2007.

Water level

Weekly mean water level relative to the marsh surface was calculated from daily means of hourly data (Figures 8a and 8b). Statistical tests were performed on pairs of sondes pre- and post-construction to determine if the project had the desired effect on specific sonde pairs. Median tests on the difference in flooding for each week were conducted pre- and post-construction. Of the sonde pairs tested, the differences between CS20-15R and CS23-01R as well as CS23-01R and CS23-05 were significant at the α=0.05 level (Table 3).

Flooding at sites CS23-05 and CS23-03 pre- and post-construction was not significantly different. The flooding difference between CS20-15R and CS23-01R was greater pre-construction than post-construction suggesting some non-project related effect on water level near West Cove. The difference in water level changed significantly between CS23-01R and CS23-05 where CS23-01R had higher flooding pre-construction and CS23-05 had higher flooding post-construction, which suggests a negative project effect. Flooding between CS20-15R and CS23-03 was not significantly different pre- or post-construction.

Table 3. Sonde comparison test for flooding difference between stations for the pre- and post-construction period within the CS-23 project and reference areas.

Paired sonde comparison results				Flooding Difference (Site A - Site B) (ft)	
Site A	Site B	measure	p-value	Pre-Construction	Post-Construction
CS23-05	CS23-03	WL	0.6936	-0.25	0.04
CS20-15R	CS23-01R	WL	0.0135	0.35	0.09
CS23-01R	CS23-05	WL	<.0001	0.16	-0.32
CS20-15R	CS23-03	WL	0.0680	0.09	-0.18

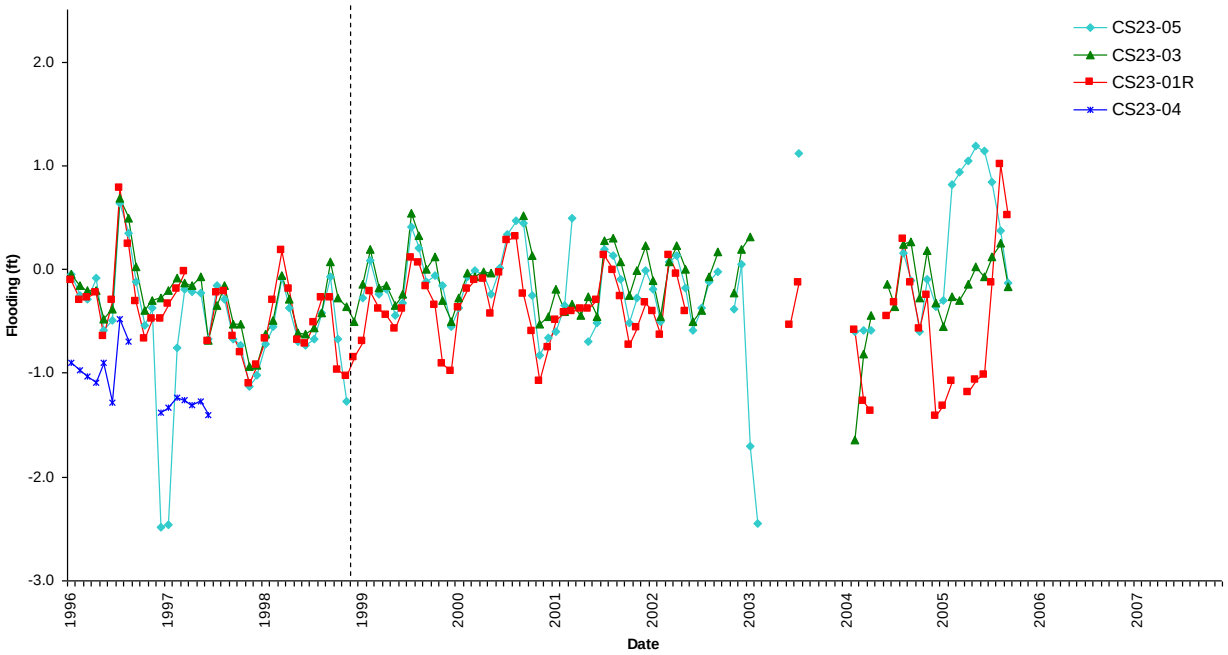


Figure 8a. Monthly mean flooding (water level relative to the marsh surface) in the northern portion of CS-23. Vertical line represents project construction.

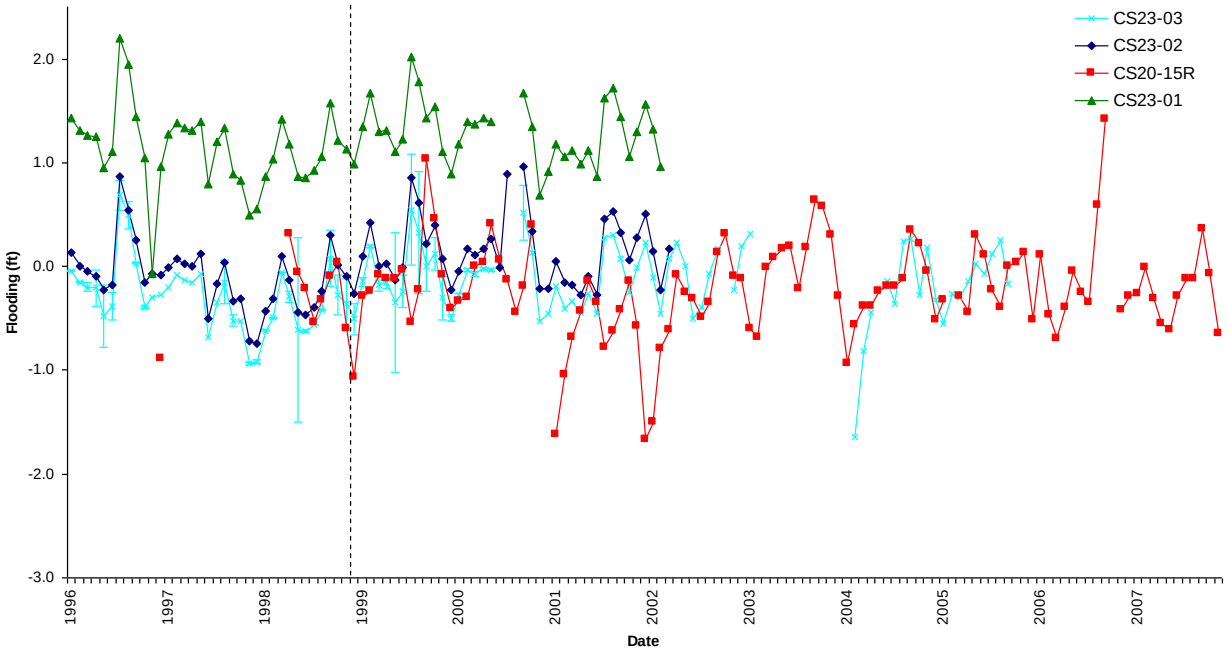


Figure 8b. Monthly mean flooding (water level relative to the marsh surface) in the southern portion of CS-23. Vertical line represents project construction.

Vegetation FQI

Vegetation surveys were conducted in June 1999 and June 2004 (n=49 plots) during the post-construction period within the CS-23 project area and in 1997, 1999, 2003, 2005, 2006 and 2007 post-construction within the CS-20 reference area. To determine plant species, percent cover and the quality of the species, a species cover and floristic quality index was utilized which qualifies cover values combined with quality classifications so that invasive species and those indicative of disturbance or destabilization get lower scores than those that indicate stable marshes (Figures 9 and 10). The CS-23 project area was dominated by *Spartina patens* and *Schoenoplectus americanus* both pre- and post-construction. Species cover (%) decreased from over 100% to around 80% and *Distichlis spicata* was replaced with *Paspalum vaginatum* which is indicative of drought stress (Figure 9). Accordingly, floristic quality decreased in the project area from 0.77 to 0.66. The CS-20 Reference area which serves as a reference for CS-23 saw little change from 1999 to 2003. The dominant species, *Spartina patens* and *Distichlis spicata* did not change and floristic quality increased slightly from 0.73 to 0.81. The reference area was sampled after Hurricane Rita (CS-23 was not sampled because it was inaccessible after the storms due to bridge failure on Hwy 27) and the area saw an initial decrease in all cover and then a steady increase in both cover and quality from 2005 to 2007 with a shift from *Spartina patens* dominance to *Distichlis spicata* dominance with the presence of *Spartina alterniflora* (Figure 10).

Submerged Aquatic Vegetation

SAV was collected in 1999 pre-construction and 2004 post-construction. Percent cover was calculated on all SAV by transect in the project and reference areas. An analysis of variance was conducted on the data to test whether area (project/reference), year (1999, 2004), or the interaction of area*year had an effect on % Cover. Results indicated that there was no significant difference between all terms and there was virtually the same amount of SAV in the project and reference areas each year. However, the Reference area had only *Ruppia maritima* and the project area was much more diverse in 2004 (Figure 11). The next data collection is scheduled for July 2009.

CRMS Supplemental: Water Level and Salinity

Salinity and flooding (water level relative to the marsh) were plotted for each site utilized with enough data (two project and four reference sites). Most of the sondes in the project area are in water wells because there is not enough open water to set up open water sondes. Well data was not utilized for this analysis. Salinities were highest near Calcasieu lake at CRMS0685 and lowest near Sabine Lake at CRMS0669 (Figure 12). Flooding was lowest near the lake at CRMS0685 and highest in the project are at CRMS2334 (Figure 13).

Soil Porewater

Soil interstitial (porewater) salinity data were collected from 10 and 30 cm (Figure 14). Mean porewater salinities were up around 15 to 20 ppt among the reference sites and 10 to 15 ppt in the project area in 2006 due to the storm surge of Hurricane Rita. Porewater salinities steadily fell and were around 5 to 10 ppt into 2008 at all sites surveyed. Reference sites were generally higher than project sites during the entire period.

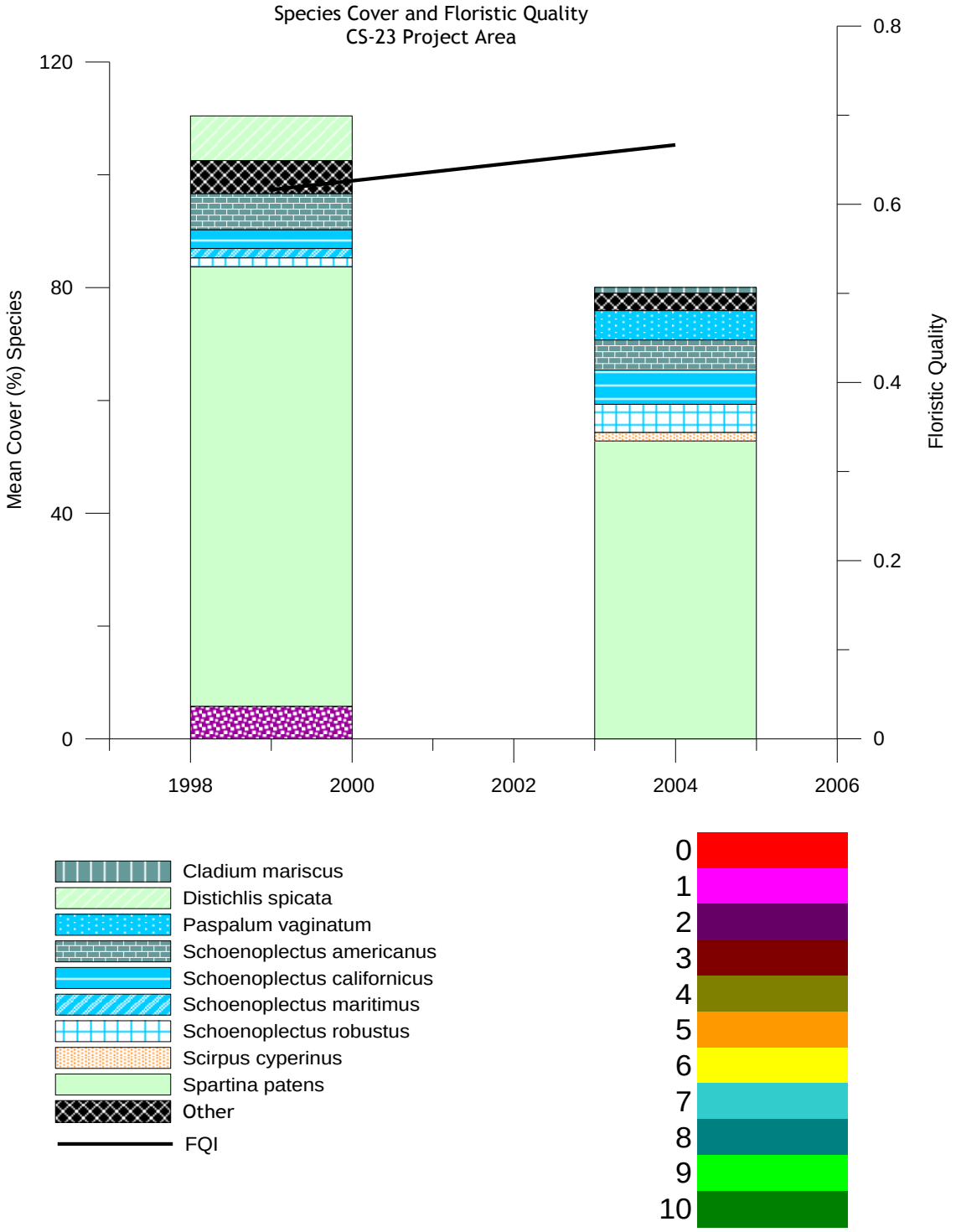


Figure 9. Percent coverage of species and floristic quality index of vegetation data collected from CS-23 Project Area. Values are means of 10 stations within the site; therefore, the sum of % coverage of individual species can be greater than 100 %.

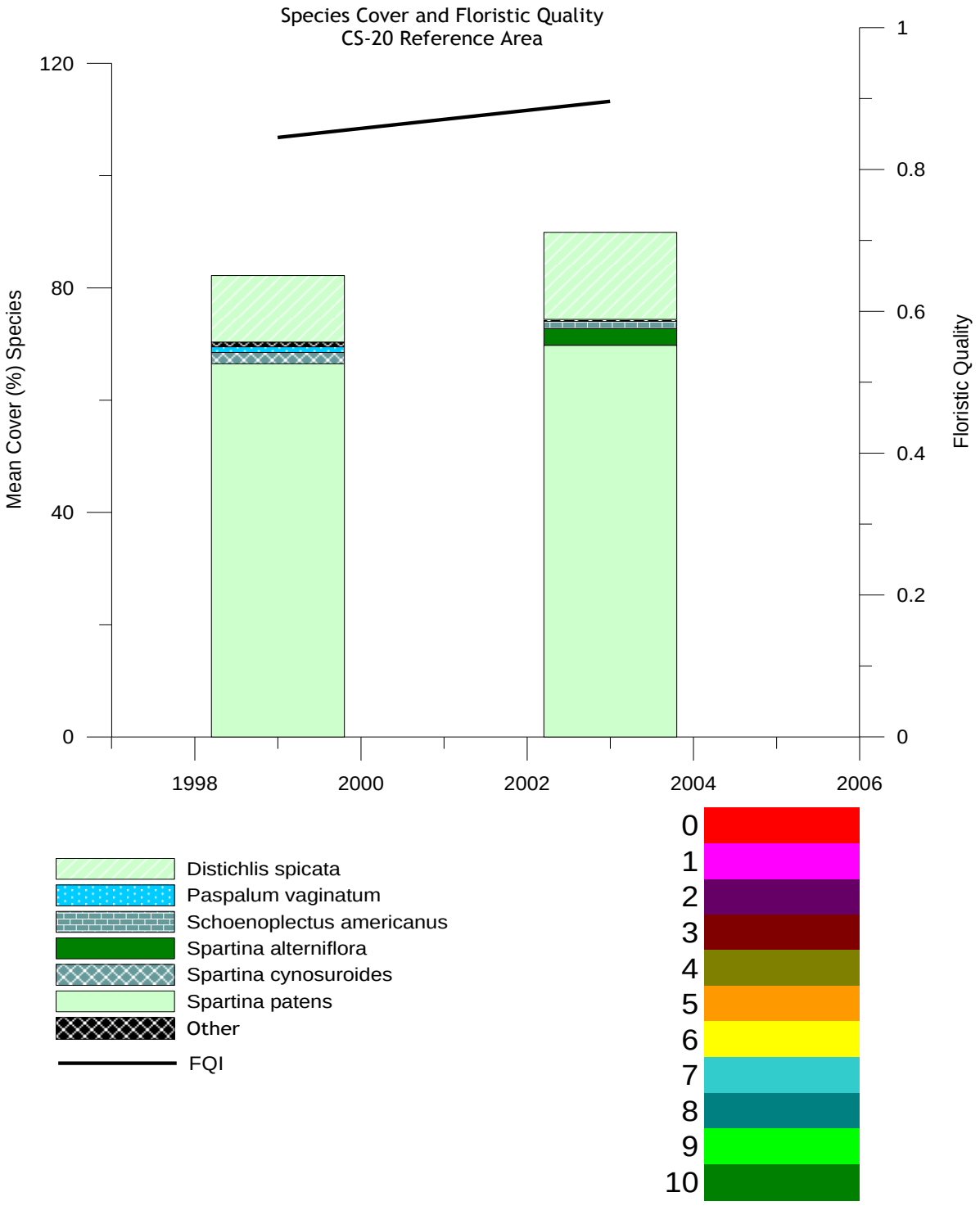


Figure 10. Percent coverage of species and floristic quality index of vegetation data collected from CS-23 Reference Area, CS-20. Values are means of 10 stations within the site; therefore, the sum of % coverage of individual species can be greater than 100 %.

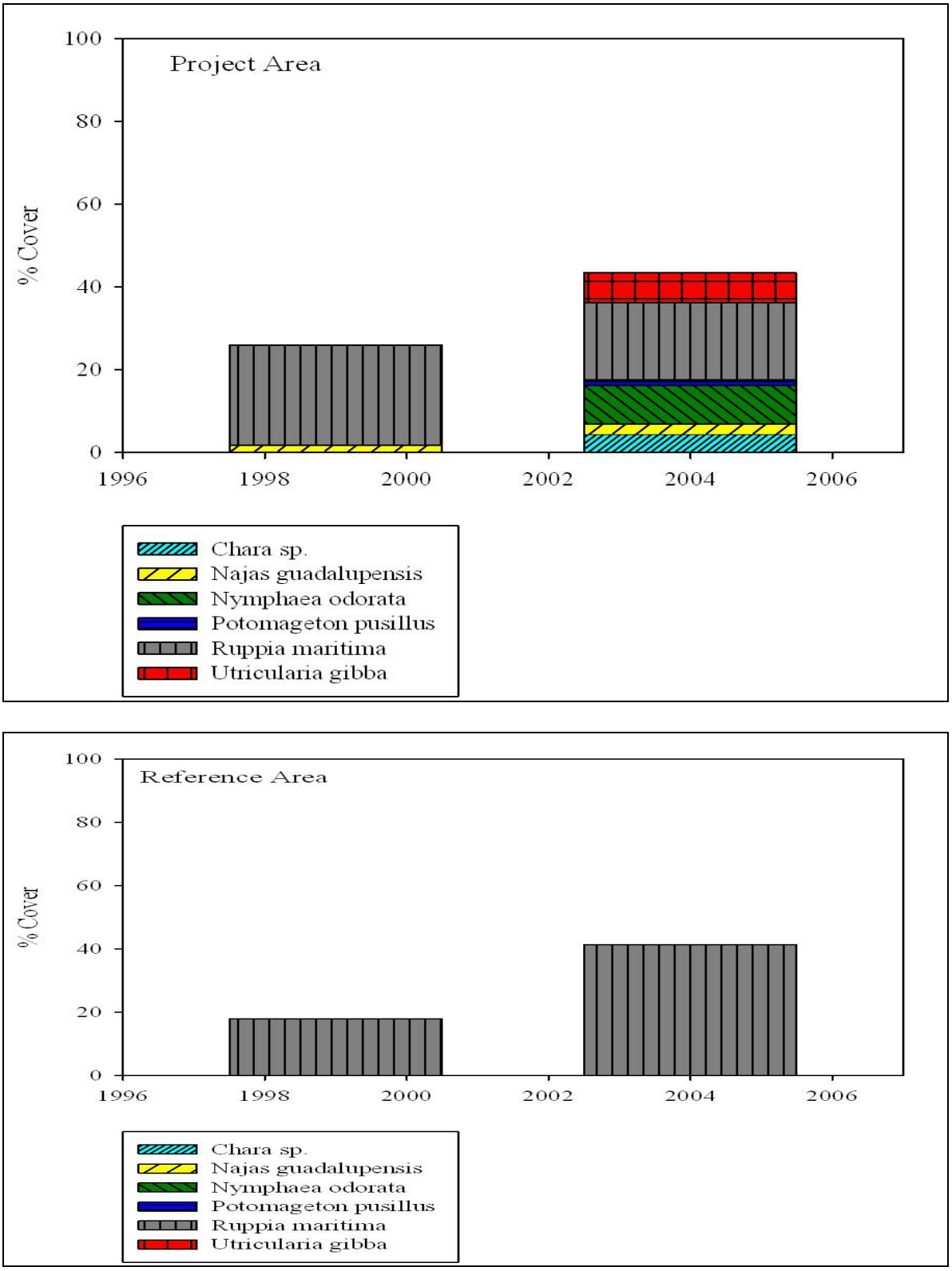


Figure 11. Percent Cover of SAV within project and reference areas for 1999 pre-construction and 2004 post-construction years.

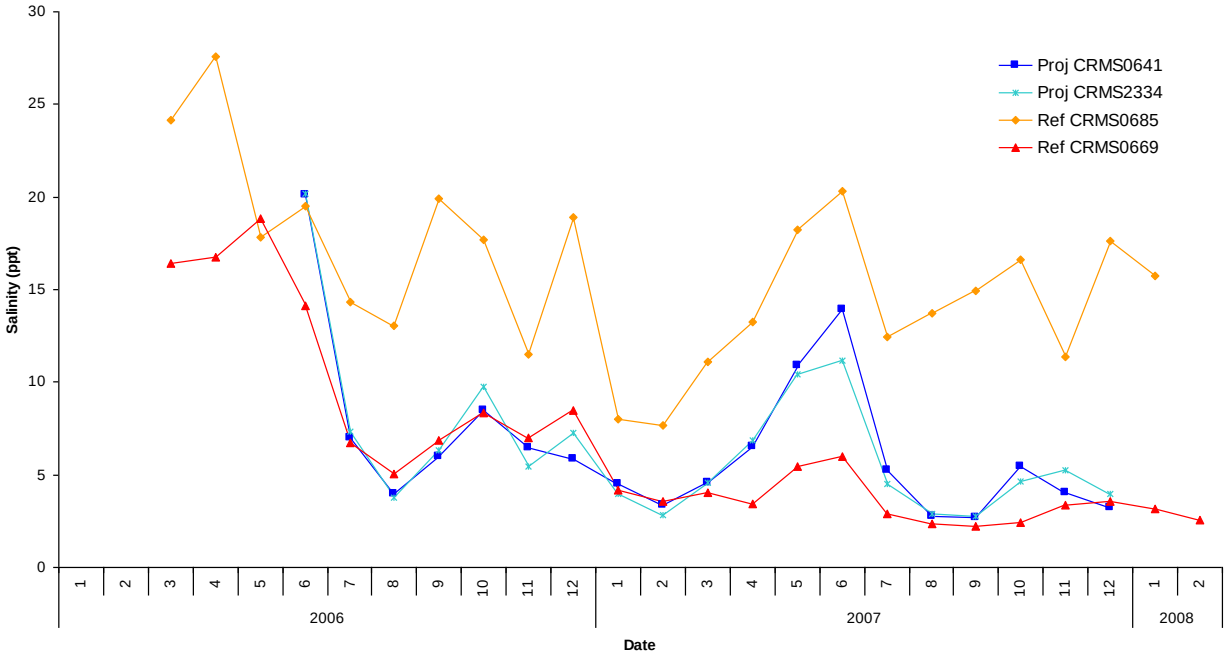


Figure 12. Mean monthly salinity taken at CRMS sites in the project and reference areas.

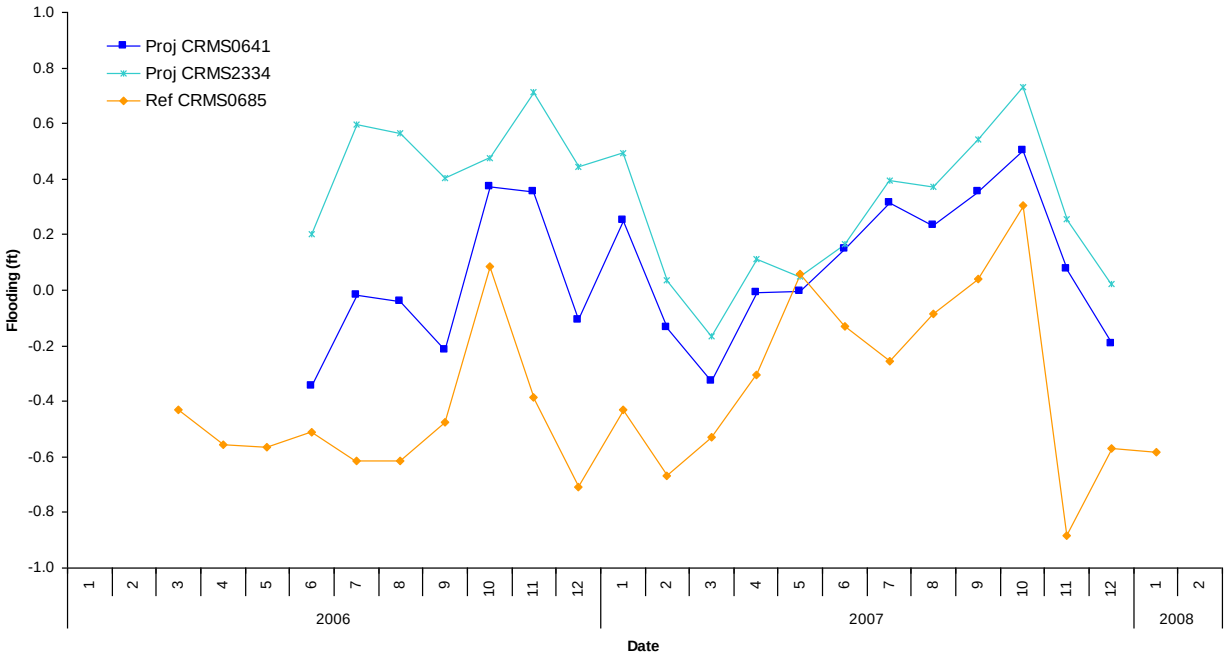


Figure 13. Mean monthly water level taken CRMS sites in the project and reference areas.

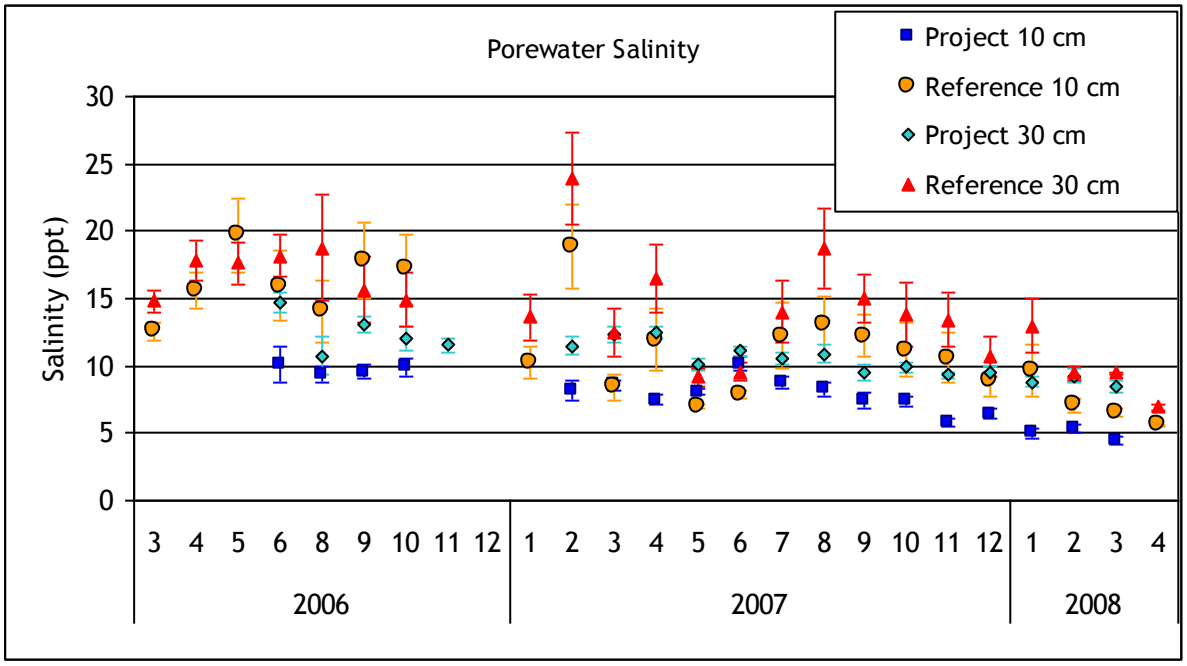


Figure 14. CRMS porewater salinity data from 10 and 30 cm (mean ± 1 standard error).

Soil Surface Elevation Change

There were insufficient data to estimate elevation change and accretion using the sites selected for this analysis. In the future, we will be able to estimate the rate of elevation change, accretion and shallow subsidence among the project and reference sites. If the project is affecting marsh formation factors, it should become apparent over time.

Vegetation – FQI

The project and reference CRMS sites were summarized for floristic quality analysis. Generally, the project sites were more diverse, had higher cover by species, and had lower FQI scores than the reference sites in 2006 and 2007 (Figures 16 and 17). Most of the species present in the project area were lower quality species except for the sedges (*Schoenoplectus* species) and *Spartina patens*. Many may be disturbance species that emerged after Hurricane Rita. Among the reference sites, cover remained around 100% and FQI remained around 0.75 from 2006 to 2007. Cover of *Spartina alterniflora* decreased while *Bacopa monnieri* and *Schoenoplectus robustus* increased.

Soil Bulk Properties

Bulk density and percent organic matter were summarized among project sites and reference sites. Reference sites had slightly higher bulk density in the top 8 cm than project soils (figure 18a). Project sites had slightly higher organic matter percent than reference sites throughout the depth of the core (Figure 18b).

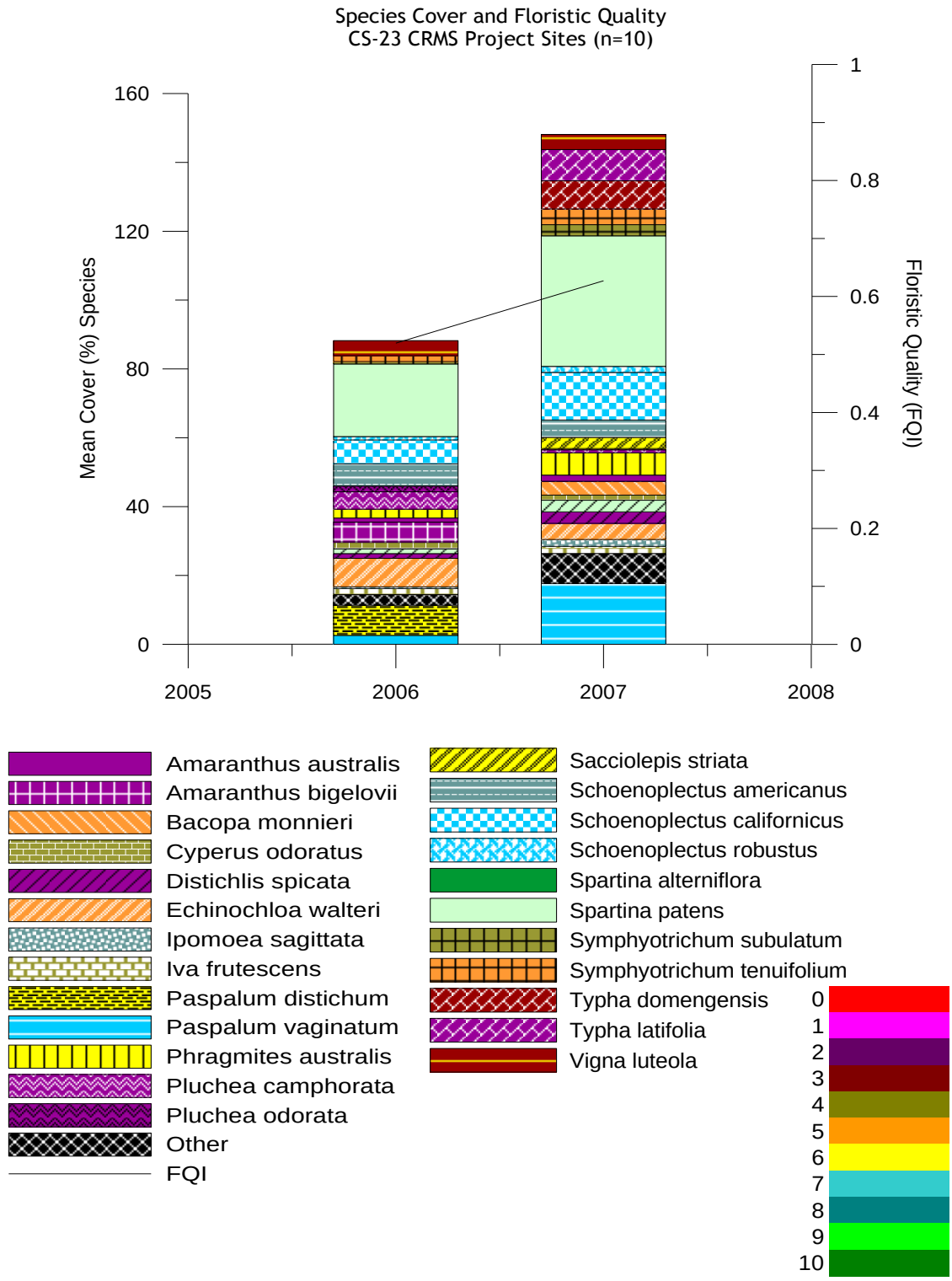


Figure 15. Percent coverage of species and floristic quality index of vegetation data collected from CRMS Project sites. Values are means of 10 stations within the site; therefore, the sum of % coverage of individual species can be greater than 100 %.

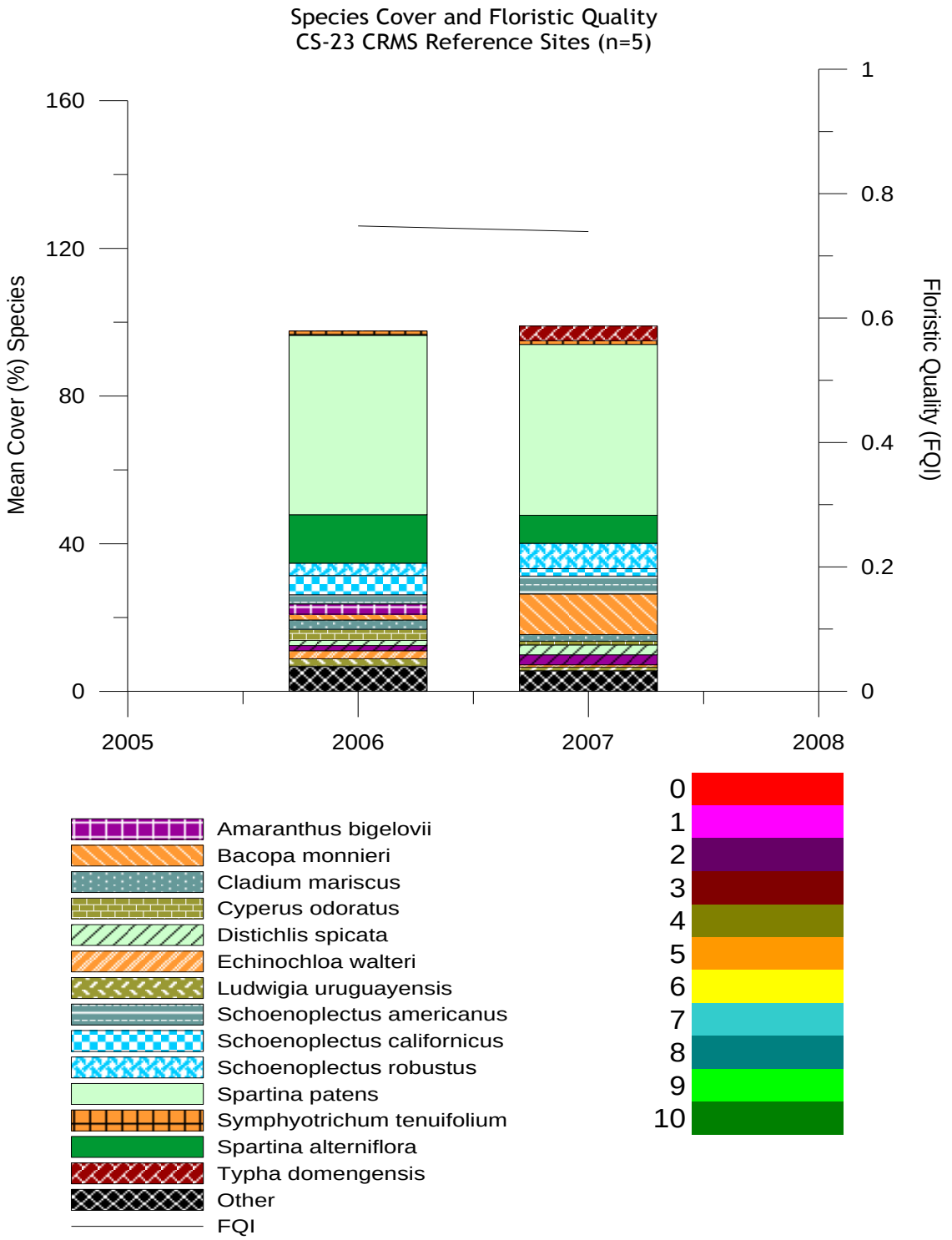
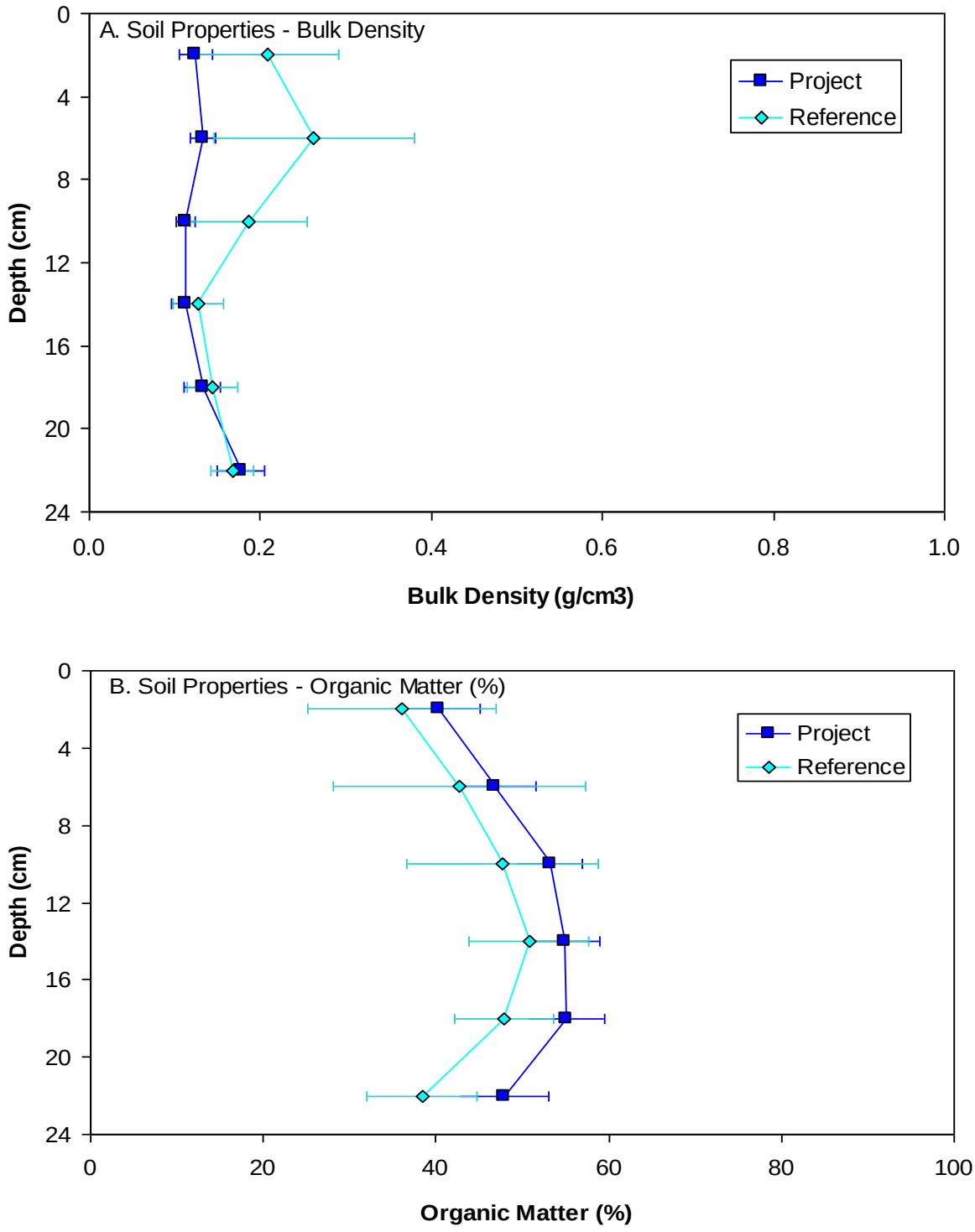


Figure 16. Percent coverage of species and floristic quality index of vegetation data collected from CRMS Reference sites. Values are means of 10 stations within the site; therefore, the sum of % coverage of individual species can be greater than 100 %.



Figures 17a and 17b. Bulk density and % organic matter of CRMS sites with available data for soil bulk properties among project and reference sites (mean ± 1 standard error).

V. Conclusions

a. Project Effectiveness

Overall, the Sabine Refuge Structure Replacement Project is in poor condition with all of the structures sustaining damage from Hurricane Rita and is non-operable at this time. Due to the inability to operate the structures correctly, salinity and water level spikes have occurred, although less frequently post-construction than pre-construction.

Once the Hog Island Gully and West Cove Canal structures become fully operational, their ability to halt saltwater inflows and reduce water level fluctuations within the project area and surrounding areas will become evident.

b. Recommended Improvements

Several field trips have been conducted with FEMA representatives to acquire federal approval on necessary repairs/replacement of equipment as noted above. FEMA approved only $144,185.24 for structure repairs while the estimated repair cost is $756,500. USFWS will use separate Federal funding to repair the structures through a third party, Tennessee Valley Authority (TVA). Engineering Consultant for LDNR, Lonnie Harper, has prepared plans and specifications for repair of these structures and has delivered to TVA in February, 2008 with an anticipated bid date late spring of 2008. Jeff Davis Electrical restored service to the area with true three phase power. This eliminates the need for the rotary converters which should eliminate the electrical problems.

c. Lessons Learned

Installation instructions should be written for the installation of the pedestal, stem, and actuator, which state the tolerances to be used.

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APPENDIX A
(Inspection Photographs)

Photo No.1, Inside view of Hog Island Gully Structure.

Photo No. 2, Lake side view of Hog Island Gully Structure.

Photo No. 3, Inside view of West Cove Structure.

Photo No. 4, Lake side view of West Cove Structure.

Photo No. 5, Inlet side of Headquarters Structure.

Photo No. 6, Outlet side of Headquarters Structure.

APPENDIX B
(Three Year Budget Projection)

SNWR STRUCTURES/ CS-23 / PPL 3

Three-Year Operations & Maintenance Budgets 07/01/2008 - 06/30/2011

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Pat Landry	*Dewey Billodeau*	*USFWS*	*Dewey Billodeau*

	2008/2009	2009/2010	2010/2011
Maintenance Inspection	$ 5,570.00	$ 5,737.00	$ 5,909.00
Structure Operation	$ 10,000.00	$ 10,000.00	$ 10,000.00
Administration			$ -
Maintenance/Rehabilitation			

08/09 Description:

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

09/10 Description: USFWS will request additional O&M funds to complete the project, double stems, actuators, etc.

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

10/11 Description:

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

	2008/2009	2009/2010	2010/2011
Total O&M Budgets	**$ 15,570.00**	**$ 15,737.00**	**$ 15,909.00**

O &M Budget (3 yr Total)	**$ 47,216.00**
Unexpended O & M Budget	**$ 427,421.54**
Remaining O & M Budget (Projected)	**$ 380,205.54**

OPERATION AND MAINTENANCE BUDGET 07/01/2008-06/30/2009

SNWR STRUCTURES/CS-23/PPL3

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$5,570.00	**$5,570.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$0.00	**$0.00**
Operations Contract	LUMP	1	$0.00	**$0.00**
Construction Oversight	LUMP	1	$0.00	**$0.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:					
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navagation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	1	$0.00	$0.00
Materials		LUMP	1	$0.00	$0.00
Mob / Demob		LUMP	1	$0.00	$0.00
Contingency		LUMP	1	$0.00	$0.00
General Structure Maintenance		LUMP	1	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$5,570.00**

OPERATION AND MAINTENANCE BUDGET 07/01/2009-06/30/2010

SNWR STRUCTURES/CS-23/PPL3

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$5,737.00	**$5,737.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$0.00	**$0.00**
Operations Contract	LUMP	1	$0.00	**$0.00**
Construction Oversight	LUMP	1	$0.00	**$0.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:					
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navagation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	1	$0.00	$0.00
Materials		LUMP	1	$0.00	$0.00
Mob / Demob		LUMP	1	$0.00	$0.00
Contingency		LUMP	1	$0.00	$0.00
General Structure Maintenance		LUMP	1	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$5,737.00**

OPERATION AND MAINTENANCE BUDGET 07/01/2010-06/30/2011

SNWR STRUCTURES/CS-23/PPL3

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$5,909.00	**$5,909.00**
General Structure Maintenance	LUMP	1	$0.00	**$0.00**
Engineering and Design	LUMP	1	$0.00	**$0.00**
Operations Contract	LUMP	1	$0.00	**$0.00**
Construction Oversight	LUMP	1	$0.00	**$0.00**

ADMINISTRATION

LDNR / CRD Admin.	LUMP	1	$0.00	$0.00
FEDERAL SPONSER Admin.	LUMP	1	$0.00	$0.00
SURVEY Admin.	LUMP	1	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:				
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:					
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navagation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	1	$0.00	$0.00
Materials		LUMP	1	$0.00	$0.00
Mob / Demob		LUMP	1	$0.00	$0.00
Contingency		LUMP	1	$0.00	$0.00
General Structure Maintenance		LUMP	1	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$5,909.00**

APPENDIX C
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:CS-23 Sabine Refuge Structure Replacement

Date of Inspection: March 18, 2008 Time: 10:40 a.m.

Structure No. West Cove Canal

Inspector(s):Dewey Billodeau, Darrell Pontiff (LDNR)
Jim Ashfield, Rueben LaBauve (USFWS)

Structure Description: Control Structure

Water Level Inside:N/A Outside: N/A

Type of Inspection: Annual

Weather Conditions: Partly Cloudy, Windy and Mild

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Gates	Fair	Yes		3 & 4	Alignment problems.
Electrical	Poor	Yes			All electrical components demolished.
Hardware/Stairs	Good				
Fencing	Good				Chain link fence and posts replaced in June 2006.
Timber Piles	Good				
Timber Wales	N/A				
Actuators	Fair				All actuators will have to be taken apart and serviced.
Cables	Good				
Signage /Supports	Good				
Rip Rap Rock Dike W.W. Reinf.	Good				
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:CS-23 Sabine Refuge Structure Replacement

Date of Inspection: March 18, 2008 Time: 10:22 a.m.

Structure No. Headquarters' Canal

Inspector(s):Dewey Billodeau, Darrell Pontiff (LDNR)
Jim Ashfield, Rueben LaBauve (USFWS)

Structure Description: Control Structure

Water Level Inside:N/A Outside: N/A

Type of Inspection: Annual

Weather Conditions: Partly Cloudy, Windy and Mild

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Gates Electrical	Fair Poor	Probable Yes		5 & 6	Possible alignment problems with gates and/or stems. All electrical components demolished.
Hardware	Good				
Timber Piles	Good				
Timber Wales	Good				
Actuators	Fair	Yes			The actuator will have to be taken apart and serviced.
Cables	N/A				
Signage /Supports	N/A				
Rip Rap Rock Dike W.W. Reinf.	Good				
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:CS-23 Sabine Refuge Structure Replacement

Date of Inspection: March 18, 2008 Time: 10:00 a.m.

Structure No. Hog Island Gully Canal

Inspector(s):Dewey Billodeau, Darrell Pontiff (LDNR)
Jim Ashfield, Rueben LaBauve (USFWS)

Structure Description: Control Structure

Water Level Inside:N/A Outside: N/A

Type of Inspection: Annual

Weather Conditions: Partly Cloudy, Windy and Mild

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good				
Gates	Fair	Yes		1 & 2	Alignment problems.
Electrical	Poor	Yes			All electrical components demolished.
Hardware					
Fencing	Good				Chain link fence and posts replaced in June 2006.
Timber Piles	Good				
Timber Wales	N/A				
Actuators	Fair				All actuators will have to be taken apart and serviced.
Cables	Good				
Signage /Supports	Good				
Rip Rap Rock Dike W.W. Reinf.	Good				
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?