State of Louisiana
Coastal Protection and Restoration Authority

2011 Operations, Maintenance, and Monitoring Report

for

Naomi Outfall Management (BA-03c) and Barataria Bay Waterway East Side Shoreline Protection (BA-26)

State Project Numbers BA-03c and BA-26
Priority Project Lists 5 and 6

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Jefferson & Plaquemines Parishes

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for
Naomi Outfall Management (BA-03c)
and
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Preface

The 2011 Operations, Maintenance, and Monitoring (OM&M) Report for Naomi Outfall Management (BA-03c) and Barataria Bay Waterway East Side Shoreline Protection (BA-26) includes monitoring data collected from November 1991–December 2010, and the most recent maintenance inspections, which were conducted for both projects on April 21, 2011. This is the fourth OM&M report in a series of reports for BA-03c and BA-26. For additional information on lessons learned, recommendations and project effectiveness, refer to past OM&M reports at http://www.lacoast.gov/new/projects/info.aspx?num=BA-03c.

I. Introduction

The State of Louisiana and Plaquemines Parish Government (PPG) jointly funded construction of the Naomi Siphon Diversion project (BA-03), a set of eight siphons that was built in 1992 to re-introduce freshwater from the Mississippi River into the adjacent marshes (Figure 1). The re-introduction was intended to restore some of the ecological functions supported by periodic over-bank flooding that occurred prior to the placement of the flood-control levees.

In order to better-manage the freshwater from the siphons and prevent saltwater intrusion, weirs were installed in two canals that connect the project area to the Barataria Bay Waterway. The weirs were constructed in 2002 as part of the Naomi Outfall Management project (BA-03c), which is funded through the federal Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) and sponsored by the National Resource Conservation Service (NRCS). The BA-03c project area encompasses the 13,130-acre BA-03 project area and includes an additional 13,000 + acres. In 2001, the CWPPRA-funded/NRCS-sponsored Barataria Bay Waterway East Side Shoreline Protection project (BA-26) was constructed to protect the area's marshes from shoreline erosion.

In 1999, a combined monitoring plan was written for the BA-03c and BA-26 projects. The decision was made to unify their monitoring plans because their project areas are adjacent to one another and the projects compliment and influence each other (LDNR 2003). For data analyses, all references to "project area" refer to this unified area of BA-03c and BA-26. The BA-03 project area is included within the BA-03c project area and all of the monitoring stations previously included in the BA-03 monitoring plan are now accounted for in the BA-03c/BA-26 monitoring plan.

Although the BA-03c and BA-26 projects are combined for monitoring purposes, their inspection reports and maintenance budgets remain separate and are included as separate items in this OM&M report. Operations, Maintenance & Monitoring reports are required for CWPPRA projects; however, BA-03 is a state project. Therefore, this report technically covers only BA-03c and BA-26, with the inclusion of siphon operations and related data as an understood necessary component of these projects.

Figure 1. Naomi Siphon Diversion (BA-03). Water is siphoned from the Mississippi River, discharged into a ponding area (not visible in this photograph), and distributed through a single channel into the surrounding marshes.

Naomi Outfall Management (BA-03c)

The BA-03c project area lies within the Barataria Basin in Jefferson and Plaquemines Parishes, Louisiana (Figure 2). The area is bordered by the Barataria Bay Waterway (BBW) and the town of Lafitte on the west and the Mississippi River (MR) back protection levee and the community of Naomi on the east. The area extends to the south of the Pen (a failed agricultural impoundment) and includes the Dupre Cut portion of the BBW. The project comprises ~ 26,956 ac (10,782 ha) of brackish and intermediate marsh.

The BA-03c project consists of two fixed-crest weirs with boat bays that were constructed in the Goose Bayou and Bayou Dupont Canals (see inspection photographs in Appendix A). These canals connect the open-water Pen with the BBW (Figure 2) and can serve as a conduit for freshwater from the Naomi siphons to exit the project area. Additionally, during high tide, higher saline water from the BBW can enter the project area through these canals. The weirs are designed to enhance the retention of freshwater within the project area and discourage saltwater intrusion.

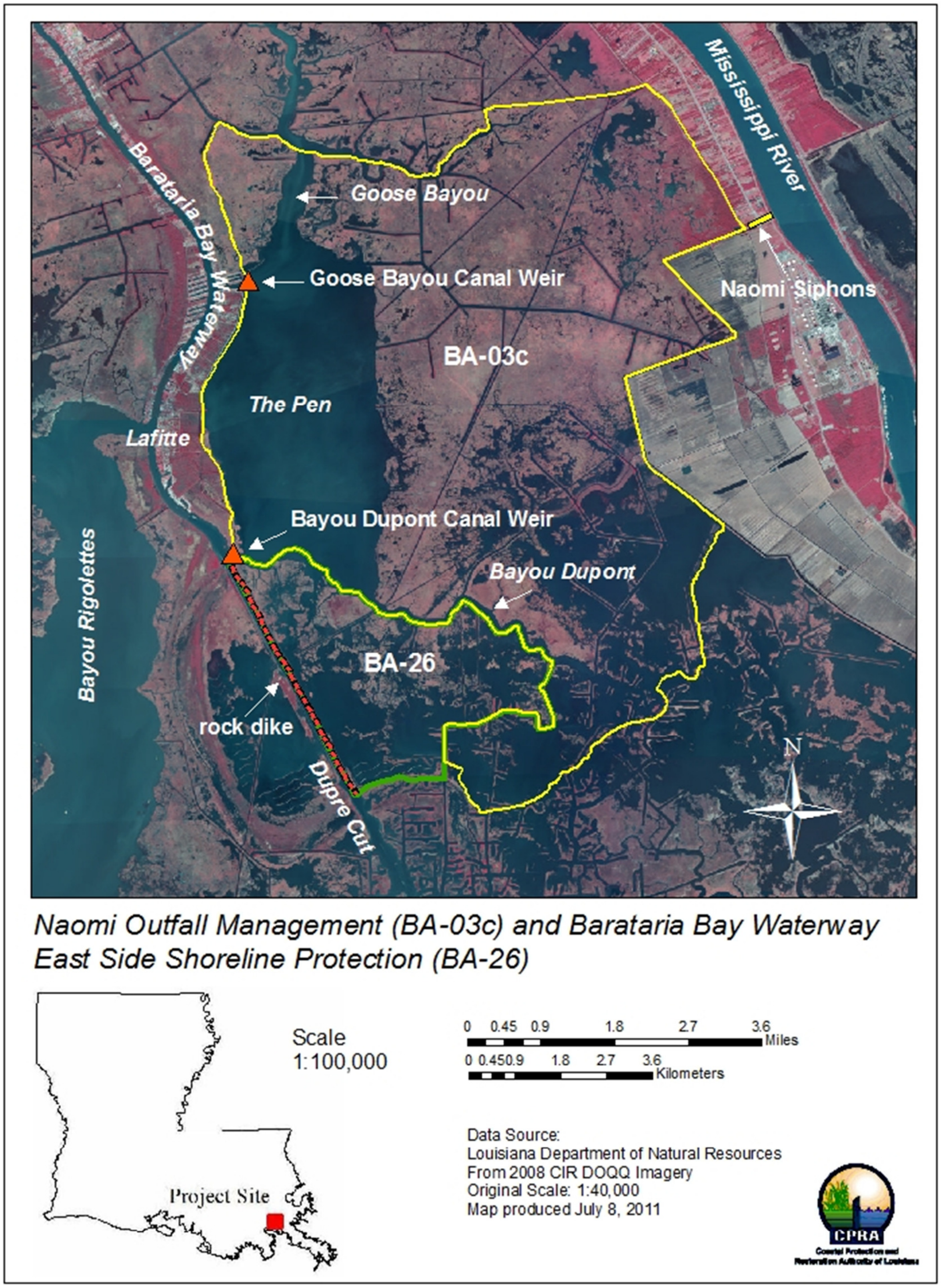

Figure 2. Naomi Outfall Management (BA-03c) and Barataria Bay Waterway East Side Shoreline Protection (BA-26) project boundaries and locations of siphons and weirs. The BA-03 project boundary is presented in Figures 24–26.

Barataria Bay Waterway East Side Shoreline Protection (BA-26)

The Barataria Bay Waterway East Side Shoreline Protection project (BA-26) encompasses 2,790 acres (880 ha) of intermediate to brackish marsh and open water habitat on the east bank of the BBW located in the Barataria Basin, Jefferson Parish, Louisiana. The project area is located approximately 1.5 miles south of Lafitte. The project is bounded by the BBW to the west, Bayou Barataria ridge to the south, unnamed canals to the east and Bayou Dupont to the north.

The BA-26 project includes approximately 17,100 linear feet (3.2 miles) of foreshore rock dike bank line protection and an earthen hydrologic barrier created from dredged material from the BBW placed to the east along the rock dike within the project area (Figure 3). The rock structure was constructed with an expanded clay core to reduce its overall weight. The clay material was encapsulated in geotextile bags and placed along the centerline of the dike. The dike is intended to re-establish the eastern bank of the BBW and to protect the adjacent marsh from unnatural water exchange and subsequent erosion that is exacerbated by wakes from vessel traffic.

Figure 3. Barataria Bay Waterway East Side Shoreline Protection project (BA-26).

II. Maintenance Activity: Naomi Outfall Management (BA-03c)

a. Project Features

Project construction began on June 1, 2002, and was completed on July 15, 2002. Project life is estimated to be 20 years. Project inspections occur annually.

On June 20, 2006, a contract was awarded to Double Aught Construction to place two warning buoys in places where warning signs were damaged and to replace five navigation lights. This project was completed on October 4, 2006.

The principal project features include:

1. One stone weir at Goose Bayou Canal
    a. Total length of weir = 458 ft.
    b. Bottom width of boat bay = 30 ft.
    c. Boat bay bottom elevation= -5 ft. (NAVD88)
    d. Weir crest = +1 ft. (NAVD88)
    e. Rock placed directly on geotextile
    f. Rock rip rap = 3,967 tons
    g. Geotextile = 2,851 yards
    h. Rock conforms to Rock Type 1 of Material Specification 523 with a gradation of:

Percent Lighter Than	Rock Unit Weight
100	700 lbs
50-100	300 lbs
15-50	150 lbs
0-15	45 lbs

    i. Four (4) - 4-piling clusters with navigation aid lights and warning signs
    j. Six (6) single pilings with warning signs
    k. Thirty-two buoys and associated stainless steel cable

2. One stone weir at Bayou Dupont Canal
    a. Total length of weir = 302 ft.
    b. Bottom width of boat bay = 30 ft.
    c. Boat bay bottom elevation = -5 ft. (NAVD88)
    d. Weir crest +1 ft. (NAVD88)
    e. Rock placed directly on geotextile
    f. Rock rip rap = 8,505 tons
    g. Geotextile = 3,374 yards

h. Rock conforms to Rock Type 1 of Material Specification 523 with a graduation of:

Percent Lighter Than	Rock Unit Weight
100	700 lbs
50 -100	300 lbs
15-50	150 lbs
0-15	45 lbs

i. Four (4) 4-pile clusters with day mark navigation signs and three (3) of the piling clusters have navigation aid lights.
j. Three (3) single pilings with warning signs (reduced from five (5) in 2006 repair project)
k. Twenty-two warning buoys with stainless steel cable
l. Two (2) marker buoys with warning markings and internal radar reflectors (added during 2006 repair project in place of two (2) single pilings with warning signs)

b. Project Feature Inspection Procedures

The purpose of the annual inspection of the BA-03c project is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing their condition and recommended corrective actions needed. If corrective actions are needed, 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 (LDNR 2002b). The annual inspection report also contains a summary of maintenance projects and an estimated projected budget for the upcoming three years for operation, maintenance and rehabilitation. The three-year projected operation and maintenance budget is shown in Appendix B.

An inspection of the BA-03c project was held on April 21, 2011, by Barry Richard of CPRA and Quin Kinler and Michael Trusclair of NRCS. Photographs of that inspection are included in Appendix A. Field inspection notes are in Appendix C.

c. Inspection Results

BAYOU DUPONT CANAL WEIR

Rock Riprap

The structure has been altered to facilitate construction of the South Shore of the Pen (BA-41) project. Rock has been temporarily removed from the weir and stored within the footprint of the structure (Appendix A, Photo #1). The structure will be replaced as designed at a later date.

Pilings

There is no noticeable damage to the existing pilings.

Warning Signs and Day Board Navigation Signs
All signs are in good condition.

Navigation Aid Lights
Two of the navigation aids have been removed to facilitate construction of the BA-41 project. These will be replaced at a later date. There is a contract in place to handle the maintenance and repair of all navigation lights.

Regulatory Marker Buoys
Both buoys are missing.

GOOSE BAYOU CANAL WEIR

Rock Riprap
Based on a survey conducted in December 2010 by Pyburn and Odom, Inc., the structure has settled an average of 2 feet since construction. This is evident because the structure is rarely above the water line (Appendix A, Photo #2).

Pilings
All pilings visually appeared to be damage-free and in good condition. Some of the reflective tape is missing or falling off.

Warning Signs and Day Board Navigation Signs
Some of the signs are losing their lettering due to weathering (Appendix A, Photo #2). The orange warning buoys on the north side came loose from the temporary repair and were repaired again before the inspection.

Navigation Aid Lights
There was no damage to any navigation lights. There is a contract in place to handle the maintenance and repair of all navigation lights.

d. Maintenance Recommendations
After receiving the survey data from the Goose Bayou Canal Weir, it was determined that there is no need to perform maintenance to the rock structure at this time. The marker buoys still need to be repaired and will be done by CPRA this year.

Immediate Repairs

- Bayou Dupont and Goose Bayou repair needs are listed under **c. Inspection Results**.

Programmed Maintenance

- A contract was awarded to Automatic Power for regular maintenance of the lights.

Overall, the BA-03c project is functioning properly and is in fair condition. Vandalism to the navigational aids continues to be a concern. The South Shore of the Pen Shoreline Protection project (BA-41) was under construction at the time of the inspection and the Bayou Dupont Canal weir was altered to facilitate construction access. It has been requested by CPRA that the structure remain as is through the construction of two more projects in the area, which are to be constructed in the near future.

III. Maintenance Activity: BBW East Side Shoreline Protection (BA-26)

a. Project Feature Inspection Procedures

Project construction began on February 19, 2001, and was completed on May 21, 2001. Project life is estimated to be 20 years. Project inspections occur on an annual basis.

In December 2005, a contract to elevate the rock wall was awarded to Luhr Bros., Inc. and resulted in the placement of 17,417 tons of rock riprap on the settled sections of the structure. The work was completed on January 24, 2006.

The purpose of the annual inspection of the BA-26 project is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing their condition and recommended corrective actions needed. If corrective actions are needed, 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 (LDNR 2002a). The annual inspection report also contains a summary of maintenance projects and an estimated projected budget for the upcoming three years for operation, maintenance and rehabilitation. The three year projected operation and maintenance budget is shown in Appendix B.

An inspection of the BA-26 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 of this report. Field inspection notes are in Appendix C.

b. Inspection Results

Rock Riprap

There are no noticeable damages to the rock structure since the previous inspection (Appendix A, Photo #3). More settlement has been observed in front of the marsh creation portion of the South Shore of the Pen Project (BA-41). A small gap in the rock structure was seen at approximate coordinates N29.61380°, W 090.07905°. This gap is probably the result of vandalism and should be monitored (Appendix A, Photo #4). Some accretion and vegetation was observed behind the rock structure at the north end of the project (Appendix A, Photo #5).

c. Maintenance Recommendations

Immediate Repairs

- No immediate repairs are necessary at this time.

Programmed Maintenance

- Continue to monitor the settlement of the rock structure.

The Barataria Bay Waterway East Side Protection Project (BA-26) is performing as intended. The rock dike is protecting the existing marsh as designed. Some settlement has been observed and will continue to be monitored; however, the structure should perform adequately through the next programmed maintenance lift.

IV. Operation Activity

a. Operation Plan

Siphon Operation

Plaquemines Parish Government (PPG) is responsible for operation of the Naomi siphons. An operation plan for managing siphon flow was originally developed by Brown and Root, Incorporated. A revised plan included recommendations by PPG and the Department of Natural Resources, Coastal Restoration Division. This plan called for eight pipes to be operated in January and February and May–December, and two pipes to be operating in March and April (LDNR 1996).

Estimated daily siphon discharge from 1993–1996 was calculated using the head differential between the river and the immediate outfall area, and the number of siphons in operation. Water elevation data were obtained from the USACE Mississippi River gauge at Alliance, LA, and the immediate outfall area staff gauge (BA03c-14). Since November 3, 2006, siphon discharge has been measured using a flow gauge (#07380238) installed and maintained by the United State Geological Survey (USGS) in the Naomi outfall canal http://waterdata.usgs.gov/la/nwis/.

b. Actual Operations

Siphon Discharge

The siphons can discharge 2,144 ft^3s^{-1} if all eight siphons are running and the river is at an optimum (high) river stage; however, since the start of operation in 1993, it is estimated that they ran >1000 ft^3s^{-1} only 18% of the time and above 2000 ft^3s^{-1} only 2% of the time. When flowing, the siphons have most commonly operated between 500–1000 ft^3s^{-1} (Figure 4). From February 1993–December 2010, the siphons were known to be in operation 48% of the time and 8% of the data were absent, often due to malfunctioning equipment. The reasons for limited siphon operation included low river stage and drought, which can reduce water height in the river to a level where the siphons lose prime and stop flowing. The following additional obstacles resulted in the siphons not operating for periods of time ranging from days to over a year: hurricanes and tropical storms, oil spills, maintenance issues (including difficulty in re-priming the siphons), management for fisheries, and staffing limitations within PPG. The siphons were inoperable from August 30, 2005, through December 30, 2006, as a result of damage due to Hurricane Katrina.

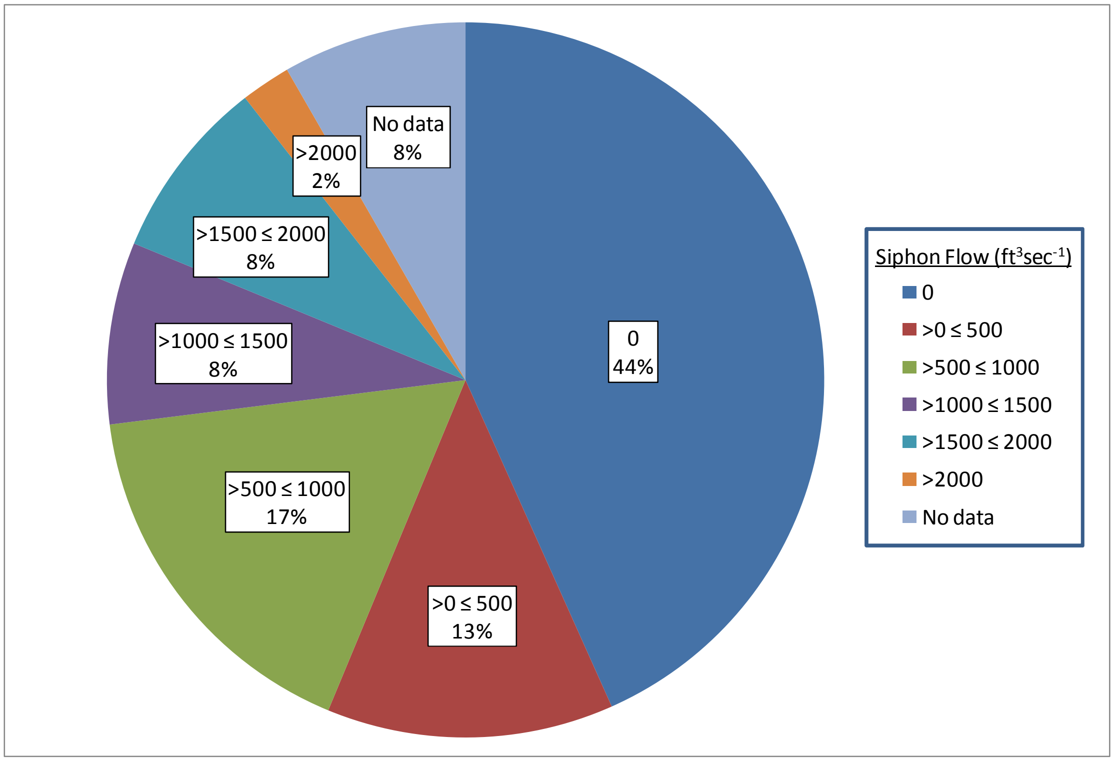

Figure 4. Siphon flow at the Naomi siphons between February 1993–December 2010, divided into mean daily flow rates. The percent values are the percent of time the siphons were operating within the stated flow range.

Siphon operations were examined in greater detail by calculating yearly mean siphon flow (Figure 5) and the number of days of major/minor/no flow and no data (Table 1). The maximum flow rate of the siphons is 2,144 ft^3s^{-1}; therefore, major flow was categorized as flow greater than or equal to half the maximum flow rate (1072 ft^3s^{-1}), with minor flow being categorized as less than half the maximum flow rate. The highest annual mean flow rate was 1116 ft^3s^{-1} in 1993; this year also had the highest percent of days the siphons were operating (93.7%).

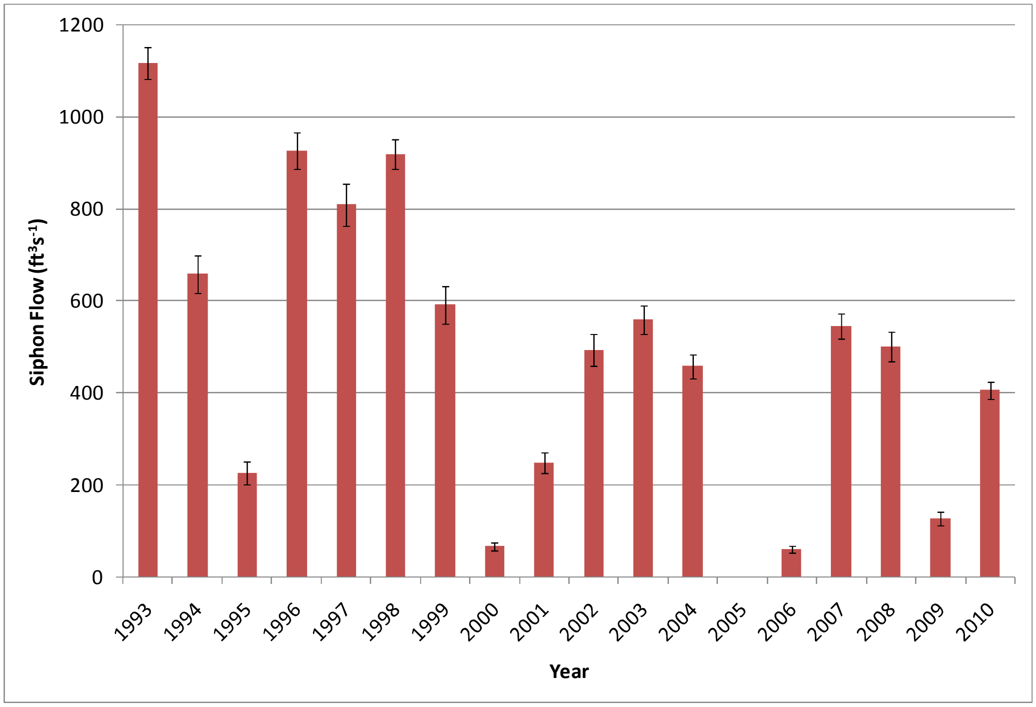

Figure 5. Yearly mean siphon flow (±SE) for the Naomi siphons from February 1993−December 2010. Siphons were limited in operation during 1995 (operations), 2000 (drought), 2005−2006 (Hurricane Katrina) and 2009 (maintenance issues).

Table 1. Annual siphon flow at the Naomi siphons from February 1993−December 2010. Flow is divided into number and percent of days with major flow, minor flow, no flow, and no data. Major/minor flow are differentiated by flow greater or lesser than half the siphons' capacity of 2,144 ft^3s^{-1}.

Year	# Days Major Flow ($\geq$1072 ft^3s^{-1})	%	# Days Minor Flow (<1072>0 ft^3s^{-1})	%	# Days No Flow (0 ft^3s^{-1})	%	# Days No Data	%
1993	186	56.0	125	37.7	12	3.6	9	2.7
1994	97	26.6	116	31.8	117	32.1	35	9.6
1995	32	8.8	46	12.6	286	78.4	1	0.3
1996	152	41.5	101	27.6	113	30.9	0	0.0
1997	151	41.4	49	13.4	140	38.4	25	6.9
1998	116	31.8	211	57.8	14	3.8	24	6.6
1999	110	30.1	49	13.4	206	56.4	0	0.0
2000	3	0.8	107	29.2	256	70.0	0	0.0
2001	14	3.8	138	37.8	194	53.2	19	5.2
2002	59	16.2	111	30.4	173	47.4	22	6.0
2003	63	17.3	193	52.9	89	24.4	20	5.5
2004	27	7.4	181	49.5	112	30.6	46	12.6
2005	0	0.0	0	0.0	124	34.0	241	66.0
2006	0	0.0	56	15.3	306	83.8	3	0.8
2007	27	7.4	152	41.6	90	24.7	96	26.3
2008	58	15.9	124	33.9	182	49.7	2	0.6
2009	6	1.6	65	17.8	294	80.6	0	0.0
2010	0	0.0	240	65.8	125	34.3	0	0.0
SUM	**1101**		**2064**		**2833**		**543**	

V. Monitoring Activity

Pursuant to a CWPPRA Task Force decision on August 14, 2003, to adopt the Coast-wide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, updates were made to the BA-03c/BA-26 Monitoring Plan to merge it with CRMS-*Wetlands*. This inclusion of CRMS data will 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-03c/BA-26 project area, CRMS0287 and CRMS4103. Hydrographic data collection for both stations began in 2008 and vegetation data collection began in 2007 for CRMS0287 and 2008 for CRMS4103.

Although a reference area or a reference station was not included in the original design for the BA-03, BA-03c and BA-26 projects, stations near the outer perimeter of the project area are utilized as reference stations to allow for comparisons. The stations chosen for reference include BA01-10, CRMS0248, CRMS0276, CRMS3985 and CRMS4245. All stations have continuous hydrographic recorders that log data hourly (Figure 6).

a. Monitoring Goals

The combined objectives of the Naomi Outfall Management (BA-03c) and Barataria Bay Waterway East (BA-26) projects are to manage the diverted freshwater from the Naomi siphon in the project area via the installation of two water control structures designed to reduce freshwater loss and saltwater intrusion, and to rebuild the east bank of the BBW to protect the adjacent marsh from erosion due to boat wakes and saltwater intrusion.

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

1. Reduce the mean salinity in the project area.
2. Improve the growing conditions and increase the relative abundance of fresh-to-intermediate marsh species.
3. Reduce the rate of conversion of marsh to open water in project area.

b. Monitoring Elements

Salinity

Salinity data were collected hourly at three project continuous recorder stations from June 1999–December 2010 and at two CRMS stations from February 2008–December 2010. Salinity was also monitored monthly at 16 discrete stations from November 1992–May 1999 and at 24 discrete stations from June 1999–December 2010 (Figure 6). Data were used to characterize the spatial and temporal variation of salinity in the project area. Salinity data from the project stations will continue to be collected through 2012.

Water elevation

Water elevation data (NAVD88) were collected hourly at three project continuous recorder stations from June 1999–December 2010 and at two CRMS stations from February 2008–December 2010 (Figure 6). Additional discrete water elevation measurements were recorded monthly at seven staff gauge stations from January 1993–March 2000 and at nine gauges from April 2000–December 2010. Data were used to characterize the spatial and temporal variation in water level throughout the project area. Water elevation data from the project stations will continue to be collected through 2012.

Vegetation

Species composition and relative abundance of emergent vegetation were quantified using modified Braun-Blanquet methods described in Steyer et al. (1995). Twenty-one stations were surveyed in 1992 (pre-siphon construction) and in 1995 (post-siphon construction). Forty plots ($4m^2$) were surveyed in years 1997, 2000, 2003 and 2006 and will be surveyed again in 2012. In 2009, only 39 stations were surveyed (BA03c-48 was excluded) due to the ongoing work associated with the Mississippi River Sediment Delivery Project-Bayou Dupont (BA-39). Emergent vegetation is surveyed annually at CRMS stations. Data collection began in 2007 for CRMS0287 and in 2008 for CRMS4103 (Figure 7).

Land-Water Analysis

In order to document changes in the ratio of land to open water, color-infrared aerial photography was obtained following procedures outlined in Steyer et al. (1995). Photography was taken in 1991 of the BA-03 project area (pre-siphon construction), in 2000 of the BA-03, BA-03c, and BA-26 project areas (post-siphon/pre-weir construction), and in 2009 of the BA-03c project area (post-weir construction). Aerial photography was flown in 2011 for the BA-26 project area and will be included in the 2014 OM&M report. A final set of aerial photographs for the BA-03c/BA-26 project area will be taken in 2017. Land-water analyses are conducted from the imagery to determine changes in acreage of land and water in the project area.

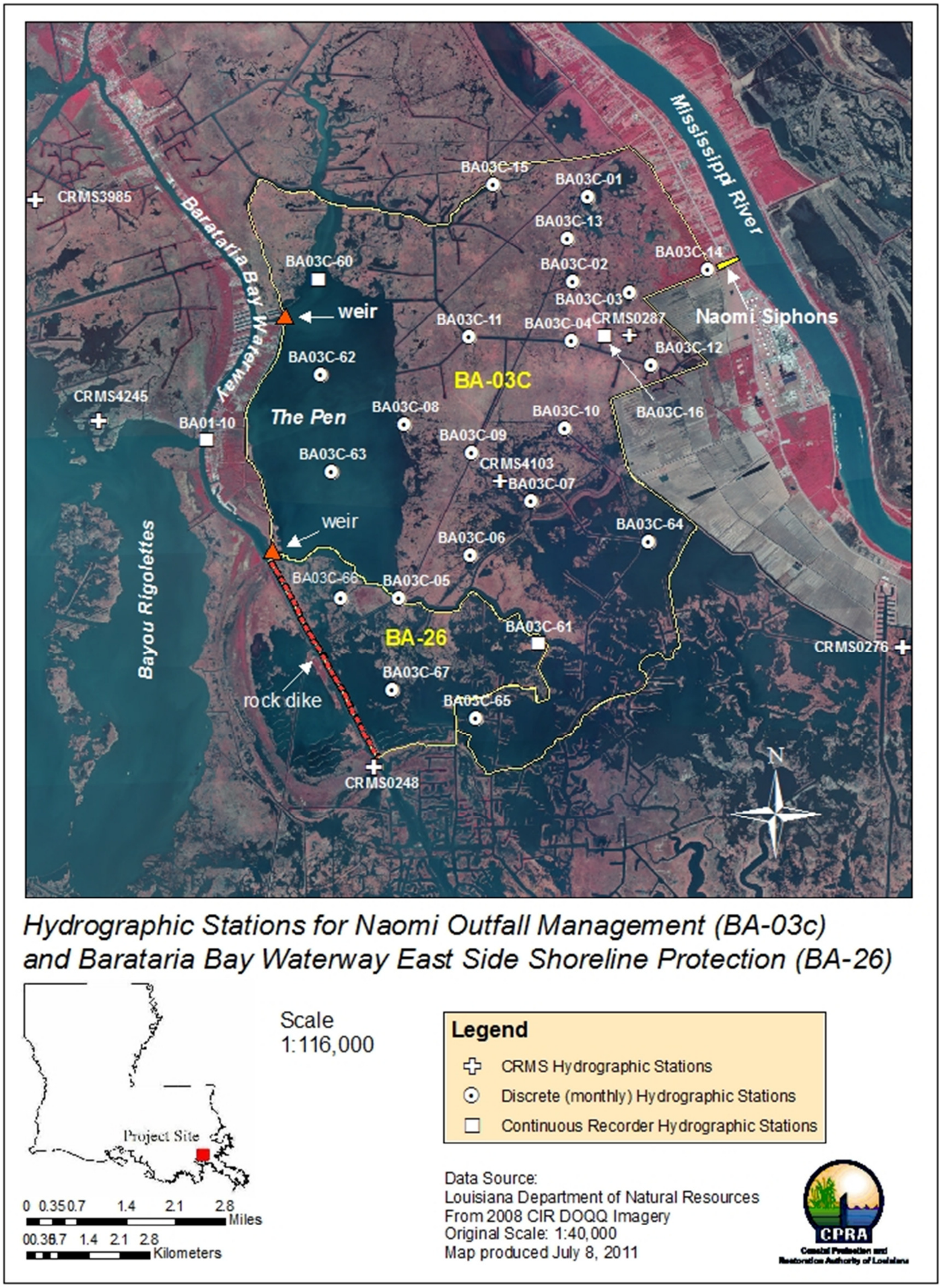

Figure 6. Naomi Outfall Management (BA-03c) and Barataria Bay Waterway East Side Shoreline Protection (BA-26) hydrographic stations. Staff gauges are located at stations BA03c-01, 03, 06, 10, 11, 14, 16, 60, and 61.

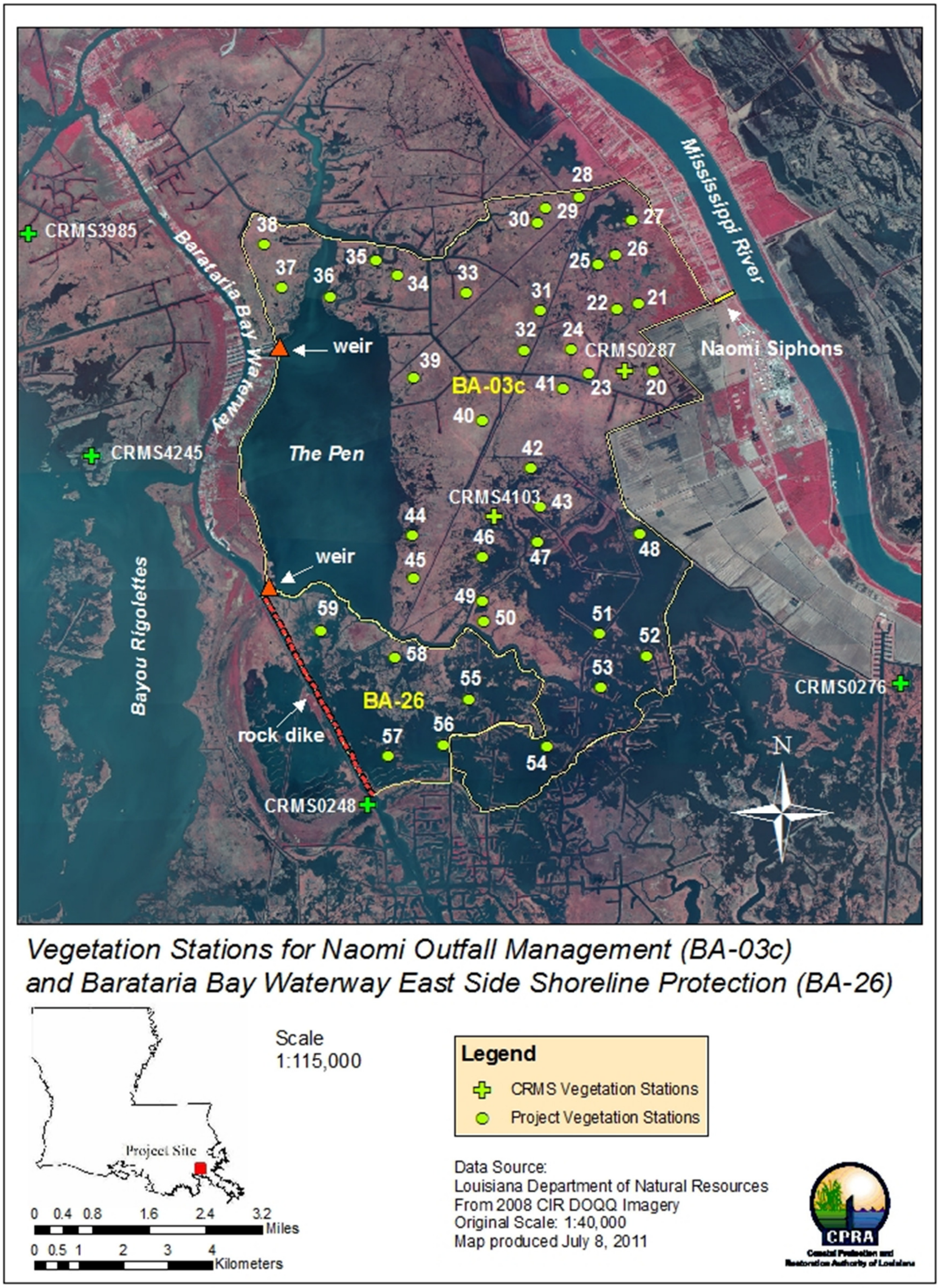

Figure 7. Naomi Outfall Management (BA-03c) and Barataria Bay Waterway East Side Shoreline Protection (BA-26) vegetation stations. Station names are abbreviated due to sizing constraints.

c. Preliminary Monitoring Results

Salinity

Salinity within the project area is influenced by normal seasonal variability within the Barataria Basin (Swenson and Swarzenski 1995; Wiseman et al. 1990). For example, salinity is generally lowest throughout the Basin during the spring, which corresponds to the period of highest flow for the Mississippi River. During periods of low river flow, such as during the drought from September 1999–December 2000, mean monthly salinity levels in the project area increased greatly, while siphon operation decreased due to low river stage (Figure 8). Since siphon operation is a function of river stage, the ability to control salinity during drought or normal low river stages (e.g. late summer and fall) is limited. Salinity increases in the project area also result from storms in the Gulf of Mexico, as was seen most recently with hurricanes Katrina (August 2005), Rita (September 2005), Gustav (August–September 2008), and Ike (September 2008).

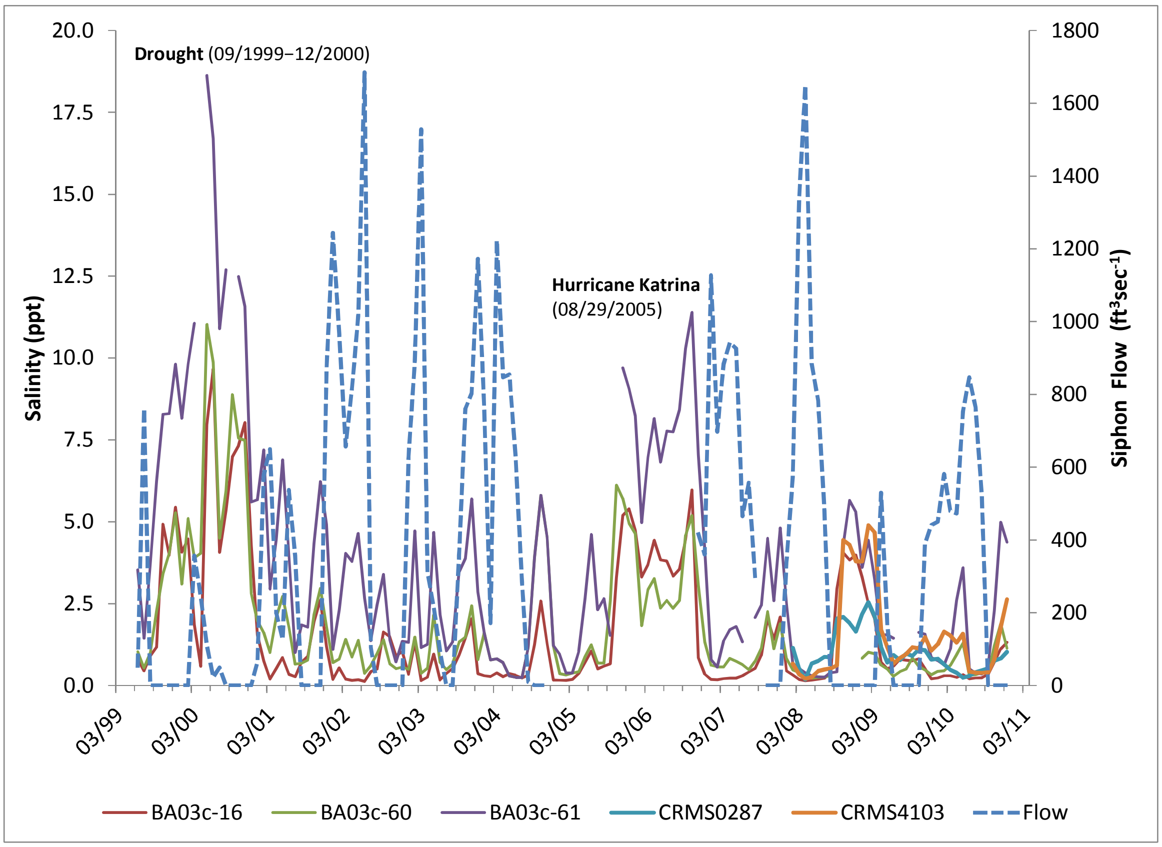

Figure 8. Mean monthly salinity and siphon flow in the BA-03c/BA-26 project area from June 1999–December 2010. CRMS data start February 2008.

When the siphons were flowing, salinity was lower at the project stations, (Table 2A, Figure 9) CRMS stations (Table 2B, Figure 10), and reference stations. Because the same salinity trend was seen both within the project area and at reference stations, the decrease in salinity is likely a partial factor of naturally lower salinities in the region during times of siphon flow. This is explained by the co-occurrence of the siphons running during times of high river discharge, when natural freshening of the basin typically occurs. Neighboring restoration projects, such as the Davis Pond Diversion, may also influence salinity in the surrounding project area and at reference sites.

While natural environmental factors and nearby diversions can complicate the ability to isolate the freshening influence of the Naomi siphons, some effects can clearly be noted. Mean daily salinity was compared between project continuous recorder stations and reference stations when the siphons were not flowing to identify stations where salinity was similar under non-modified environmental conditions. Salinity for these stations was then compared when the siphons were running to see if significant differences could be detected. Analyses were conducted on data from June 1999–December 2010. Salinity data were analyzed using ANOVA in Proc GLM with a post-hoc Tukey's test ($\alpha=0.05$) (SAS Institute Inc., Cary, NC, version 9.1).

When the siphons were not running, the mean daily salinity at project stations BA03c-16, 60 and 61, and reference station BA01-10 differed between all locations ($p<0.05$), except between station BA03c-16 near the outfall canal and BA03c-60 in the northwest project area ($p>0.05$) (Table 2A, Figure 9). Therefore, these two stations were used for comparison of salinity during siphon flow. When the siphons were running, the mean daily salinity at BA03c-16 was significantly lower than the salinity at BA03c-60, indicating greater freshening at the station nearest the outfall canal ($p<0.05$).

Mean daily salinity was also compared during flow and no flow time periods using CRMS stations 0287 and 4103, project stations, and reference stations. Analyses were conducted on data from May 2008 (start of data collection for the two CRMS stations) through December 2010. When the siphons were not flowing, salinity at project station BA03c-16 was similar to CRMS0287 and to reference stations BA01-10, CRMS3985 and CRMS4245 ($p>0.05$), but during flow, these comparisons were all significantly different due to the greater freshening effect at BA03c-16 ($p<0.05$) (Table 2B, Figure 10). Additionally, salinity at CRMS4103, located centrally within the project area, was similar to reference station BA01-10 during no flow but was significantly lower during siphon operation ($p<0.05$). These results indicate a likely freshening effect from the siphons that is detectable a further distance from the outfall canal.

The percent difference in mean daily salinity during siphon operation and non-operation was calculated for each project, CRMS, and reference station to provide a comparison of siphon effects in and surrounding the project area. As mentioned previously, all stations, including reference stations, experienced lower salinities during times when the siphons were running. However, in the long-term data set for the project stations and reference station, the percent difference in salinity is considerably greater at BA03c-16 (120%), than at BA03c-60 (64%), BA03c-61 (69%), and BA01-10 (58%) (Table 2A). These results point to a greater freshening influence of the siphons near the outfall canal. The greater reduction in salinity for BA03c-16 is also evident for the short-term data set that incorporates the CRMS data (149.7%) (Table 2B). Reference station BA01-10, which lies to the west of the project area on the opposite side of the weirs, exhibited the second highest percent difference (113.4%), possibly due to the Davis Pond Diversion operation during this time.

Table 2. Comparison of mean daily salinity between flow and no flow periods at project, CRMS, and reference stations in the BA-03c/BA-26 project area. **A**: analysis for project stations; **B**: analysis that incorporated the CRMS stations.

Time Period	Station		Flow			No Flow			Percent
			N	Salinity (ppt)	SE	N	Salinity (ppt)	SE	Difference
(A) 06/1999–12/2010	BA-03c Project	BA03c-16	1592	0.66	0.04	2006	2.63	0.05	119.8
		BA03c-60	1656	1.30	0.05	1899	2.51	0.06	63.7
		BA03c-61	1522	2.57	0.08	1828	5.26	0.09	68.7
	BA-03c Reference	BA01-10	1541	1.76	0.06	2054	3.20	0.06	58.3
(B) 05/2008–12/2010	BA-03c Project	BA03c-16	386	0.24	0.01	581	1.67	0.06	149.7
		BA03c-60	386	0.51	0.02	420	0.76	0.03	40.2
		BA03c-61	380	1.04	0.06	392	2.98	0.10	96.4
	BA-03c Reference	BA01-10	385	0.49	0.03	581	1.76	0.08	113.4
	CRMS Project	CRMS0287	338	0.62	0.02	527	1.30	0.03	71.4
		CRMS4103	348	0.93	0.03	497	2.08	0.07	76.3
	CRMS Reference	CRMS0248	362	1.47	0.09	471	3.45	0.14	80.3
		CRMS0276	346	3.10	0.10	551	5.84	0.16	61.3
		CRMS3985	386	0.70	0.03	546	1.58	0.08	77.5
		CRMS4245	355	0.67	0.03	469	1.49	0.08	76.6

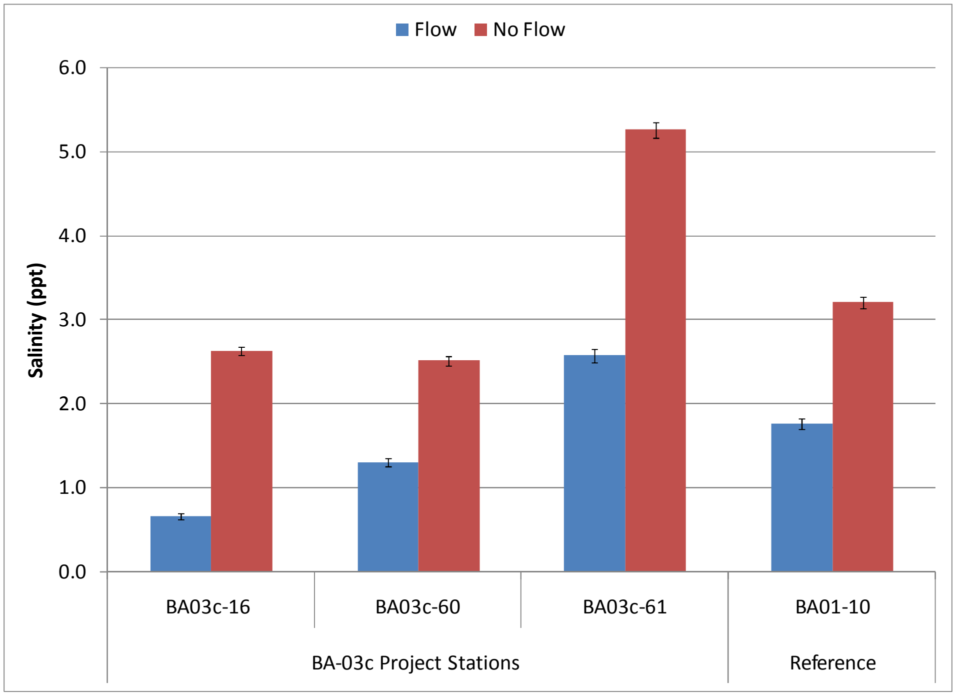

Figure 9. Mean daily salinity (±SE) at project and reference continuous recorder stations during flow and no flow time periods between June 1999–December 2010.

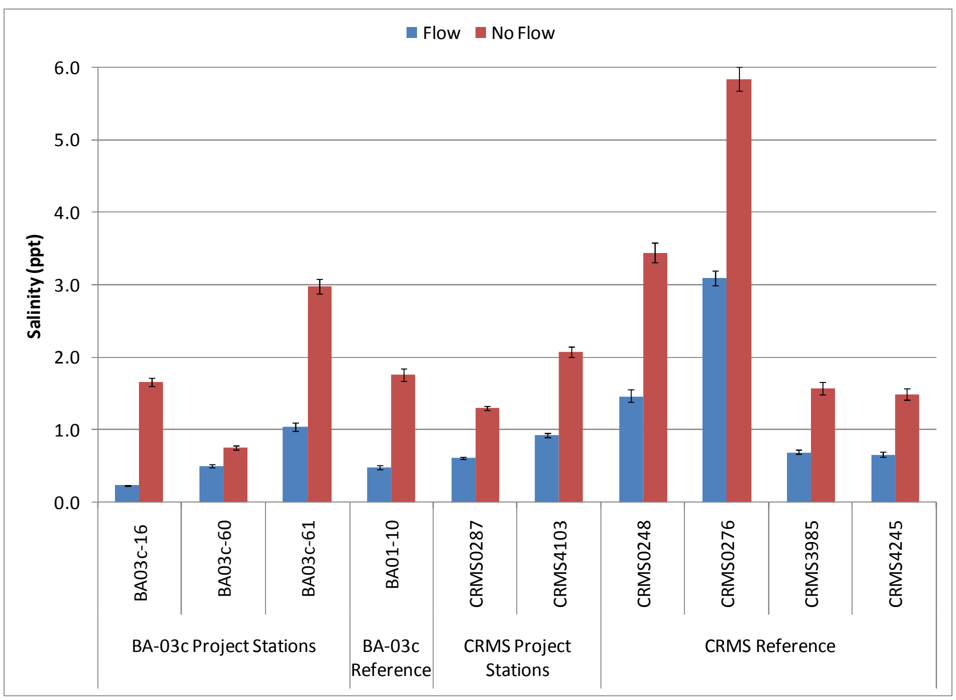

Figure 10. Mean daily salinity (±SE) at project, CRMS, and reference continuous recorder stations during flow and no flow time periods between May 2008–December 2010.

Salinities in the project area were also measured monthly at 16 discrete hydrographic stations between November 1992–May 1999. In June 1999, eight discrete stations were added, for a total of 24 stations that have been operational since this date. Comparisons of salinity at each station during periods of siphon flow and no flow demonstrate that the stations in the northeastern region of the project area, closest to the outfall canal, experienced the greatest reduction in salinity during siphon flow (Table 3). Not surprisingly, BA03c-14, located in the outfall canal, experienced the greatest decrease in salinity during flow (82%), followed by BA03c-16 (81%) and BA03c-03 (80%). In general, the freshening influence of the siphons decreased with increasing distance from the outfall canal. Figure 11 shows annual mean salinity in northern and southern regions of the project area in comparison to siphon flow. The northern stations include 01–04, 11–16, 60 and 62. The southern stations include 5–10, 61, and 63–67 (Figure 7).

Table 3. Percent difference in average monthly salinity during flow and no flow conditions at discrete hydrographic stations in the BA-03c/BA-26 project area. Bolded stations are in the northern project area, unbolded stations are in the southern project area, and stations BA03c-60, BA03c-62 and BA03c-63 are in the far western region in the Pen.

Station	No Flow		Flow		% Difference
	N	Salinity (ppt)	N	Salinity (ppt)	
BA03c-14	73	1.7	108	0.3	82
BA03c-16	89	2.2	122	0.4	81
BA03c-03	82	1.9	115	0.4	80
BA03c-04	92	2.2	122	0.4	80
BA03c-13	89	2.1	118	0.4	80
BA03c-02	91	2.2	120	0.4	79
BA03c-01	87	1.8	115	0.4	78
BA03c-11	92	2.4	123	0.6	76
BA03c-12	92	2.1	123	0.6	72
BA03c-15	92	1.8	122	0.6	69
BA03c-09	89	2.7	115	0.8	68
BA03c-08	91	3.0	118	1.2	60
BA03c-05	91	4.2	116	1.7	59
BA03c-07	87	3.8	112	1.8	53
BA03c-06	86	3.9	116	1.8	53
BA03c-63	62	4.1	53	2.1	49
BA03c-62	62	3.2	52	1.7	48
BA03c-60	60	2.4	55	1.2	48
BA03c-10	83	3.7	110	2.0	45
BA03c-66	54	4.3	53	2.5	42
BA03c-61	61	5.1	55	3.0	42
BA03c-67	55	5.2	52	3.2	39
BA03c-65	60	6.2	54	3.9	37
BA03c-64	58	5.3	46	3.7	30

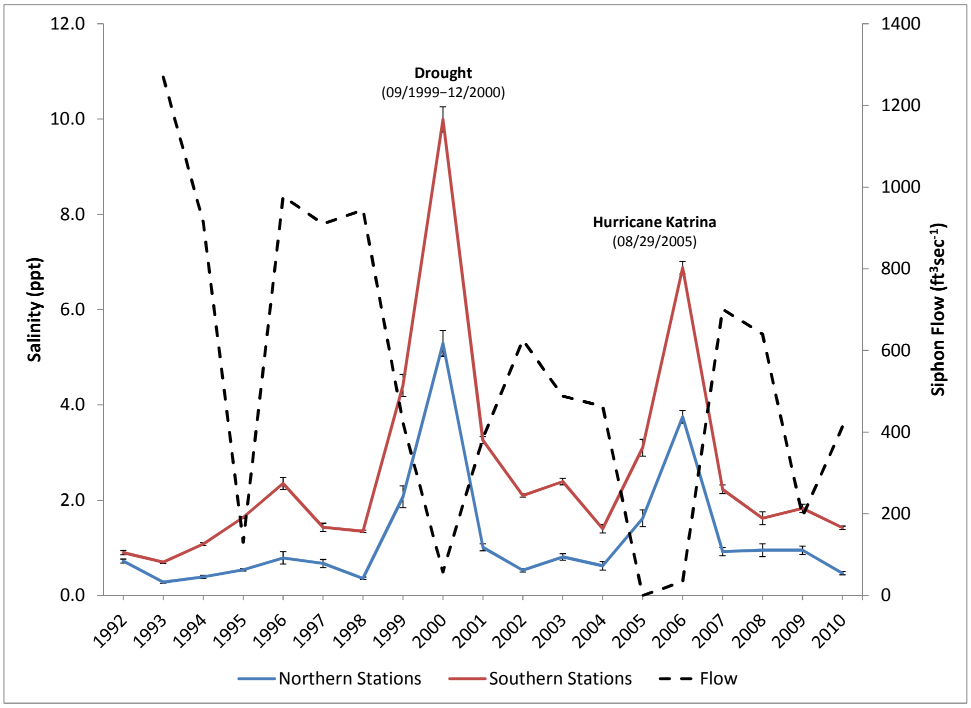

Figure 11. Mean annual salinity and siphon flow at monthly discrete hydrographic stations in the northern and southern regions of the BA-03c/BA-26 project area.

Effect of Weirs on Salinity

In order to assess the effect of the two weirs on salinity in the BA-03c/BA-26 project area, mean daily salinity was compared before and after weir installation at the three continuous recorder project stations and at reference station BA01-10, located on the opposite side of the weirs. Salinity was lower post-weir at the project stations and at the reference station during both no flow and flow time periods ($p<0.05$) (Table 4, Figure 12). Because this decrease in salinity also occurred at the reference station, it is likely that the freshening in the basin post-weir is due to naturally lower salinities during this time period. Salinity at the reference station could also be influenced by the Davis Pond Freshwater Diversion (BA-01). Reference station BA01-10 lies just within the outer perimeter of the BA-01 project area. The diversion began operation on July 18, 2002, just three days after construction of the weirs was completed.

Since the purpose of the weirs is to retain fresh water from the siphons in the project area and prevent salt water intrusion, it could be expected that stations within the project area would exhibit a greater decrease in salinity during siphon flow post-weir installation. The percent change in salinity pre/post weir installation at the three project stations during siphon flow was 73.5% (BA03c-16), 70.6% (BA03c-60), and 65.8% (BA03c-61), while the percent change in salinity at reference site BA01-10 was 69.8%. The percent change for the reference site falls within the range for the project sites, making it difficult to discern any effect from the weirs on salinity within the project area.

Table 4. Mean daily salinity pre/post weir construction during periods of flow, no flow, and combined flow/no flow at project stations within the BA-03c/BA-26 project area and at reference station BA01-10 located on the opposite side of the weirs.

Flow Regimes	Station	Pre-weir Construction			Post-weir Construction			
		06/01/1999–08/14/2002			08/15/2002–12/31/2010			Percent
		N	Salinity (ppt)	SE	N	Salinity (ppt)	SE	Change
No Flow	BA03c-16	598	3.65	0.11	1408	2.20	0.04	39.8
	BA03c-60	633	3.64	0.12	1266	1.95	0.05	46.4
	BA03c-61	613	7.04	0.17	1215	4.36	0.09	38.0
	BA01-10 R	654	4.82	0.14	1400	2.45	0.06	49.1
Flow	BA03c-16	449	1.40	0.14	1143	0.37	0.01	73.5
	BA03c-60	464	2.64	0.15	1192	0.78	0.02	70.6
	BA03c-61	404	4.97	0.23	1118	1.70	0.06	65.8
	BA01-10 R	552	3.18	0.13	989	0.96	0.04	69.8
Combined Flow/No Flow	BA03c-16	1047	2.68	0.09	2551	1.38	0.03	48.7
	BA03c-60	1097	3.21	0.09	2458	1.38	0.03	57.1
	BA03c-61	1017	6.22	0.14	2333	3.09	0.06	50.3
	BA01-10 R	1206	4.07	0.10	2389	1.83	0.04	54.9

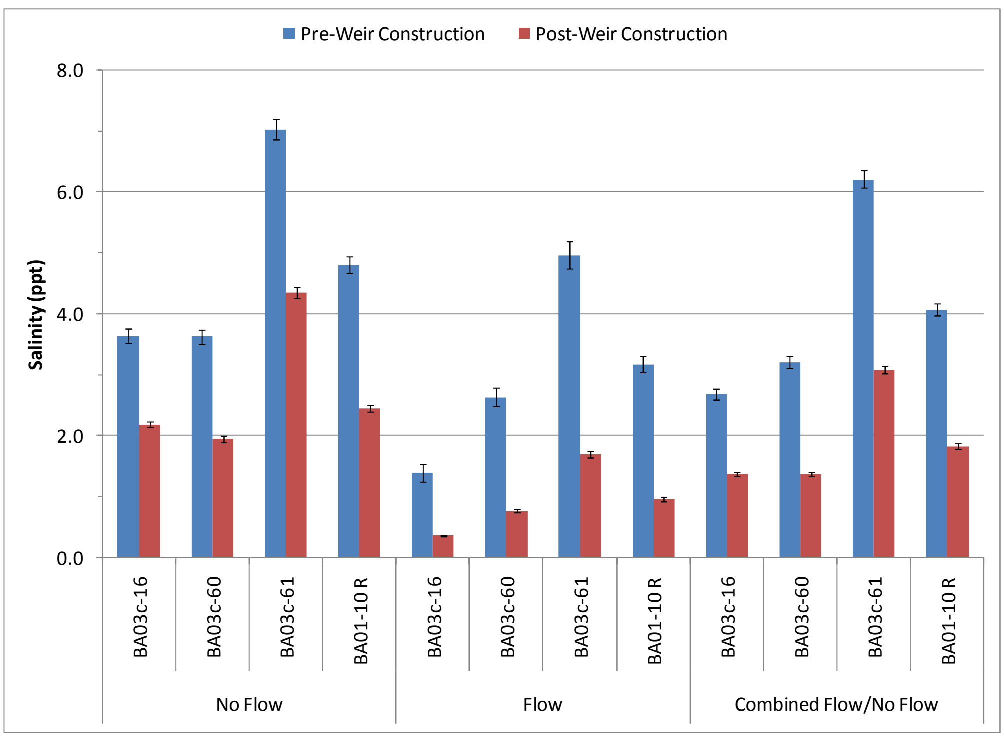

Figure 12. Mean daily salinity (±SE) compared pre/post weir construction during periods of flow, no flow, and combined flow/no flow, at project stations within the BA-03c/BA-26 project area and at reference station BA01-10, located on the opposite side of the weirs.

Water Elevation

Comparisons of mean daily water elevation (NAVD88) between flow and no flow time periods at the project continuous recorder sites and the reference site showed that water elevation did not change significantly at these locations when the siphons were running ($p>0.05$) (Figure 13). Mean daily water elevation at CRMS stations located both within and surrounding the project area also did not change significantly between periods of flow and no flow ($p>0.05$) (Figure 14). Water elevation data were analyzed using ANOVA in Proc GLM with a post-hoc Tukey's test ($\alpha=0.05$) (SAS Institute Inc., Cary, NC, version 9.1).

Water elevation (NAVD88) from discrete monthly staff gauge readings in the project area was similar among all stations ($p>0.05$) when the siphons were not running (Table 5). However, during siphon operation, the elevation at station BA03c-14, located in the outfall canal, was significantly higher than at any of the other stations ($p<0.05$). BA03c-14 and BA03c-03 were the only two stations where elevation was significantly higher during flow than during no flow ($p<0.05$). In general, the percent difference in water elevation between flow and no flow time periods decreased with increasing distance from the outfall canal (Table 5).

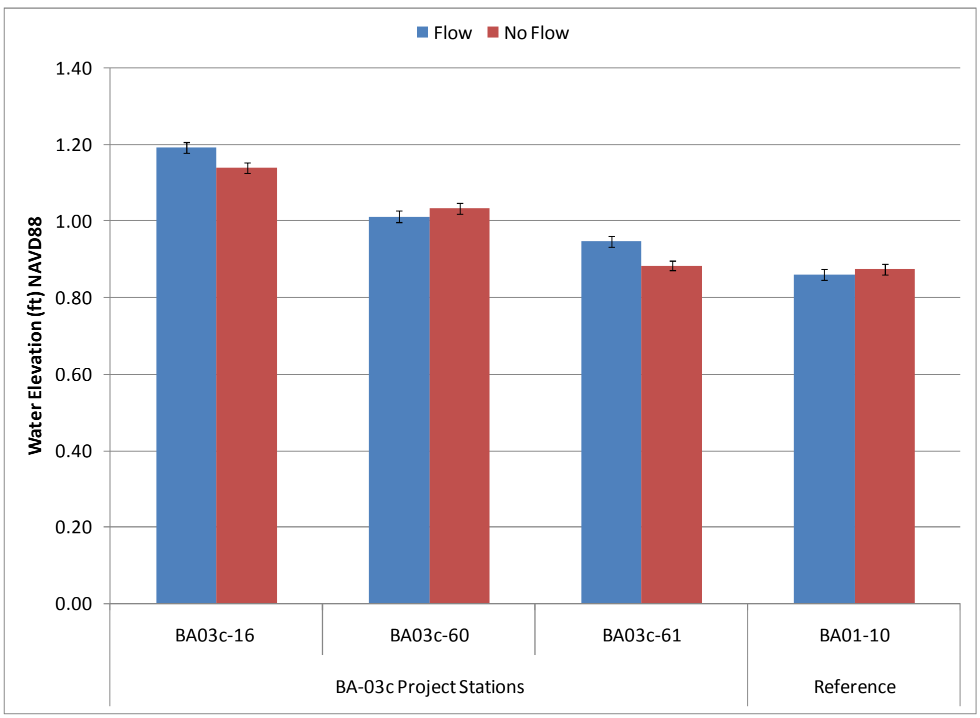

Figure 13. Comparison of mean daily water elevation (NAVD88) (±SE) at the project stations and at reference station BA01-10 between periods of siphon flow and no flow between June 1999–December 2010.

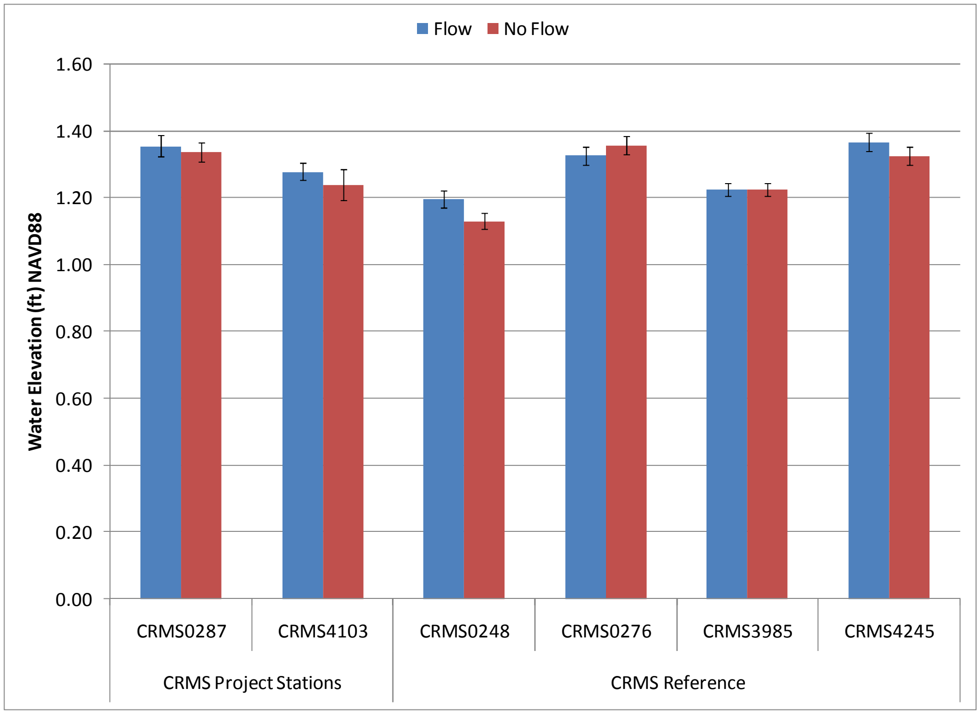

Figure 14. Comparison of mean daily water elevation (NAVD88) (±SE) between periods of siphon flow and no flow at CRMS stations located within and outside (reference) the project area (May 2008–December 2010).

Table 5. Percent difference for mean monthly water elevation (NAVD88) between periods of siphon flow and no flow at staff gauge locations within the BA-03c/BA-26 project area. Data are for January 1993–December 2010, except for stations BA03c-60 and BA03c-61, which were added in April 2000.

Station	Flow			No Flow			% Difference
	N	Water Elev. NAVD88 (ft)	SE	N	Water Elev. NAVD88 (ft)	SE	
BA03c-14	86	2.51	0.09	63	1.00	0.07	86.1
BA03c-03	106	1.57	0.06	65	1.07	0.08	38.3
BA03c-16	112	1.27	0.05	74	1.14	0.07	10.8
BA03c-01	99	1.20	0.05	61	0.91	0.08	27.2
BA03c-11	119	1.13	0.06	86	1.02	0.07	10.3
BA03c-10	102	1.11	0.07	73	1.01	0.08	9.9
BA03c-06	104	1.06	0.05	70	1.09	0.07	-3.0
BA03c-60	40	0.87	0.07	41	0.89	0.09	-3.1
BA03c-61	51	0.77	0.07	51	0.82	0.07	-5.3

Effect of Weirs on Water Elevation

Mean daily water elevation was compared pre- and post-weir installation to detect any effects from the weirs on water elevation within the project area (Figure 15). None of the stations in the project area showed significant increases in water elevation during siphon operation after the weirs were installed ($p>0.05$). The only station that exhibited a significant increase in water elevation post-weir installation was reference site BA01-10, located on the opposite side of the weir ($p<0.05$). As stated previously, reference station BA01-10 lies just within the outer perimeter of the Davis Pond Freshwater Diversion (BA-01) project area. The diversion began operation on July 18, 2002, just three days after construction of the weirs was completed. The increase in water elevation post-weir construction at BA01-10 may partly be due to the effects of the newly introduced diversion waters.

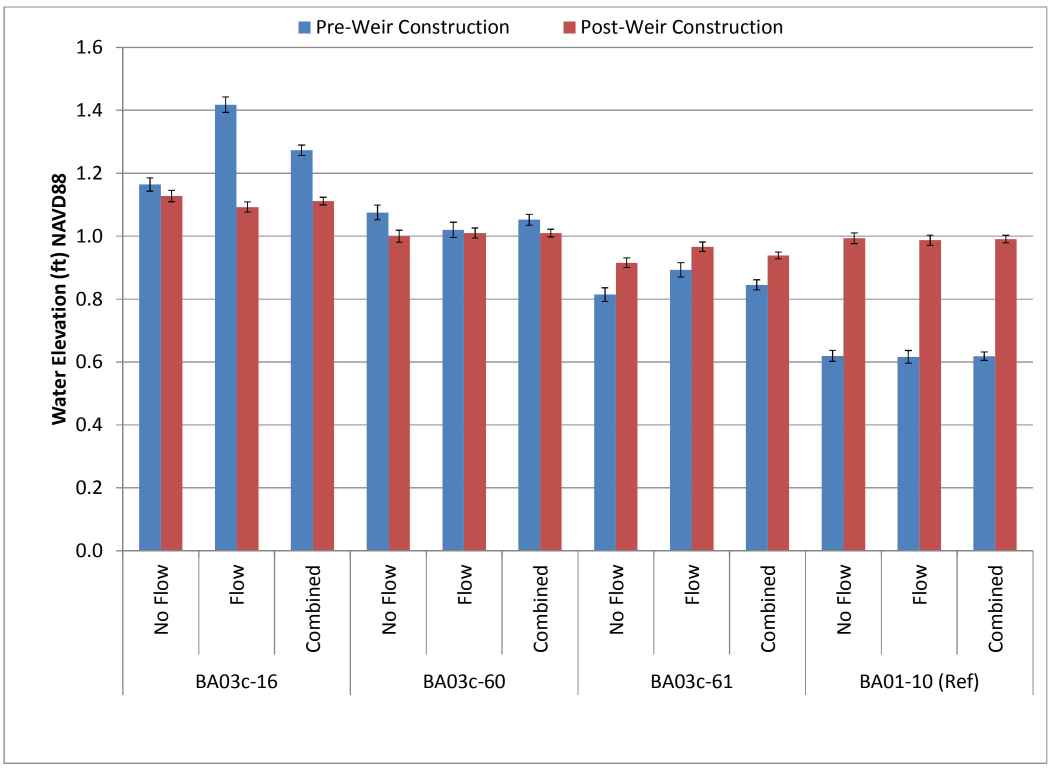

Figure 15. Mean daily water elevation (NAVD88) (±SE) compared pre/post weir construction during periods of flow, no flow, and combined flow/no flow within the BA-03c/BA-26 project area and at reference station BA01-10. Pre-weir time period: June 1, 1999–August 14, 2002; post-weir time period: August 15, 2002–December 31, 2010.

Vegetation

Percent Cover

Vegetation surveys conducted in 1992 and 1995 indicated that the northeast portion of the project area was comprised of fresh to intermediate marsh with *Sagittaria lancifolia* (bulltongue; fresh-intermediate sp.) as the dominant species. The southern portion of the project area was comprised of brackish marsh with *Spartina patens* (marshay cordgrass; intermediate-brackish sp.) as the dominant species. Vegetation surveys conducted since 1997 cannot be directly compared with earlier surveys due to different methodologies, times of year, and sampling sites.

Since 1997, *S. patens* has consistently had the highest percent cover in the total project area (Figure 16) and in the southern plots. However, in the northern plots, *S. lancifolia* was dominant except during years when salinity was elevated in the project area. In these years, *S. patens* became the dominant species. This transition to *S. patens* dominance occurred in 2000, when the region experienced elevated salinities due to a drought, and in 2006, the year after Hurricane Katrina. At CRMS0287, located in the northeastern project area, *S. lancifolia* had the highest percent cover each year, except in 2007, when *Symphyotrichum tenuifolium* (perennial saltmarsh aster; intermediate-brackish sp.) had the highest percent cover (Figure 17). At CRMS4103, located in the central project area, *S. patens* had the highest percent cover in 2008 and 2009, but in 2010, *Polygonum punctatum* (dotted smartweed; fresh-intermediate sp.) was most abundant (Figure 18).

Floristic Quality Index

This report is the first for the BA-03c/BA-26 project that includes the Floristic Quality Index (FQI) to describe the vegetative community. The calculation of FQI was originally developed by Swink and Wilhelm (1979), but has been modified by Cretini et al. (2009) to more effectively describe the coastal community in Louisiana. The FQI is calculated using the percent cover for each species and a value that is assigned to each species based on how indicative it is of a stable community. This value is called the coefficient of conservatism (CC) and ranges from 0 to 10, with 0 being a species of low value and 10 being a species that is characteristic of a vigorous coastal wetland. For example, invasive species are assigned a 0 value, while *Spartina alterniflora* (smooth cordgrass) is assigned a 10. By this method of categorization, the higher the FQI score for a project area, the more robust its vegetative community.

The ideal range for the Floristic Quality Index (FQI) for brackish and intermediate marshes in Louisiana is >80 (Cretini et al. 2009). This is considerably higher than the range for the annual FQI calculated for the BA-03c/BA26 project area (FQI 51−61; Figure 16), CRMS0287 (FQI 48−58; Figure 17) and CRMS4103 (FQI 47−67; Figure 18). The ideal ranges for marshes in Louisiana may be adjusted in the future as more field data are collected. For an in-depth description of the scoring and FQI calculation, refer to Cretini et al. (2009).

The FQI for the BA-03c/BA-26 project area dropped in 2000 and 2009, with the decrease in 2000 likely being a result of the drought (Figure 16). This year had the lowest number of species recorded in the project area (32 species) and the lowest total percent cover (75%). The vegetation community rebounded in 2003, with an increase in species richness, percent cover, and FQI. Species richness and FQI remained high in 2006, but the total percent cover declined. A decrease in percent cover does not necessitate a corresponding drop in the FQI if the primary species in decline have low CC scores and can be balanced by increases in species with considerably higher CC scores. This relationship is demonstrated to some extent between 2003 and 2006, when *Sagittaria lancifolia* experienced the sharpest decline among species (12%, CC score: 6), and *S. patens,* a species with a higher CC score, exhibited the greatest increase (5%, CC score: 9).

The FQI decline in 2009 was largely due to a decrease in the percent cover of *S. patens* (12%, CC score: 9), bringing the FQI back to near 2000 levels. However the total percent cover increased for that year, with the recovery of the population of *S. lancifolia* (13%, CC score: 6) and an expansion in the population of *Polygonum hydropiperoides* (swamp smartweed; fresh sp.) (10%, CC score: 4), two species with relatively low/moderate CC scores.

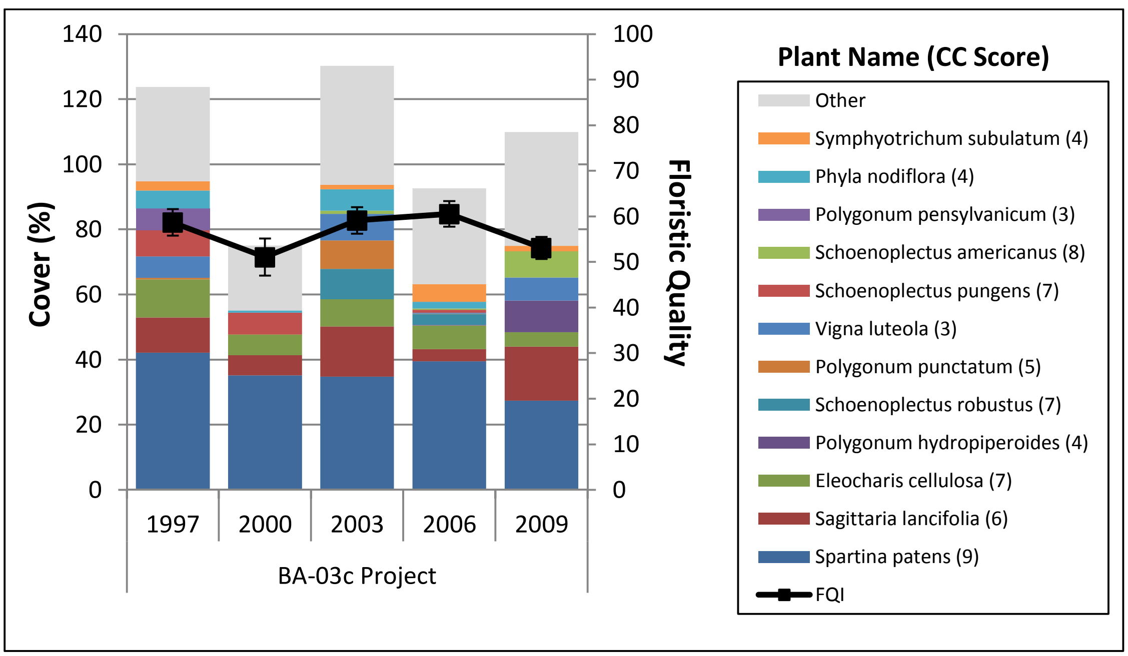

Figure 16. Vegetation percent cover and floristic quality index (FQI) for the BA-03c/BA-26 project area.

Vegetation at CRMS0287 increased in percent cover and FQI from 2007–2009, with the FQI leveling out in 2009 (Figure 17). A drop in percent cover occurred from 2009–2010, but the FQI remained relatively stable during this time. *Symphyotrichum tenuifolium* exhibited the greatest decline in percent cover between these years (23%, CC score: 5). CRMS4103 changed little in total percent cover and FQI between 2009–2010, but there was a pronounced drop in both values between 2008–2009. This is largely due to a decline in *S. patens* (50%, CC score: 9) (Figure 18).

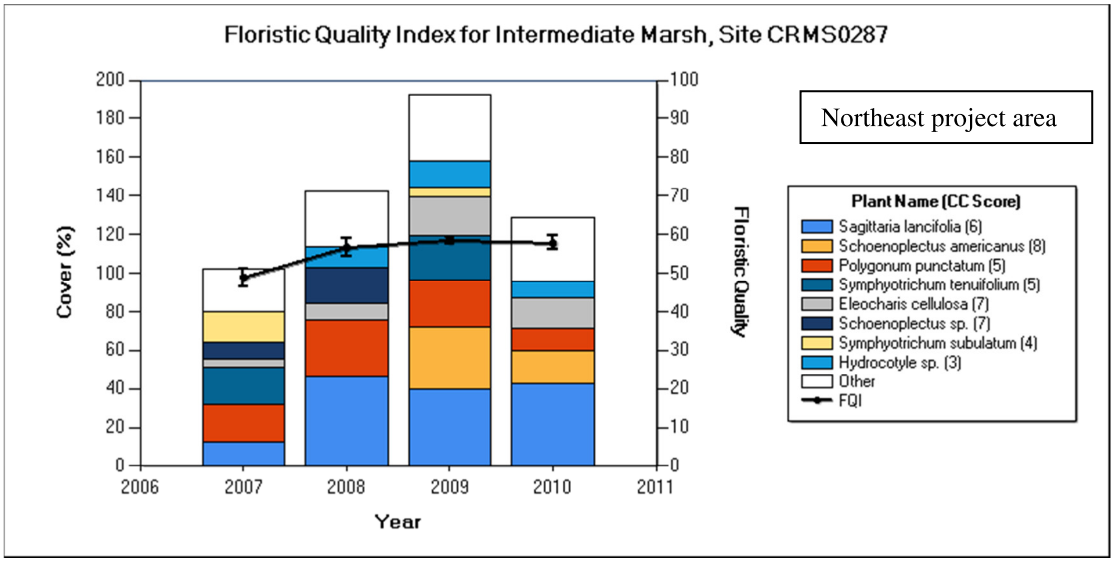

Figure 17. Vegetation percent cover and floristic quality index (FQI) for CRMS0287.

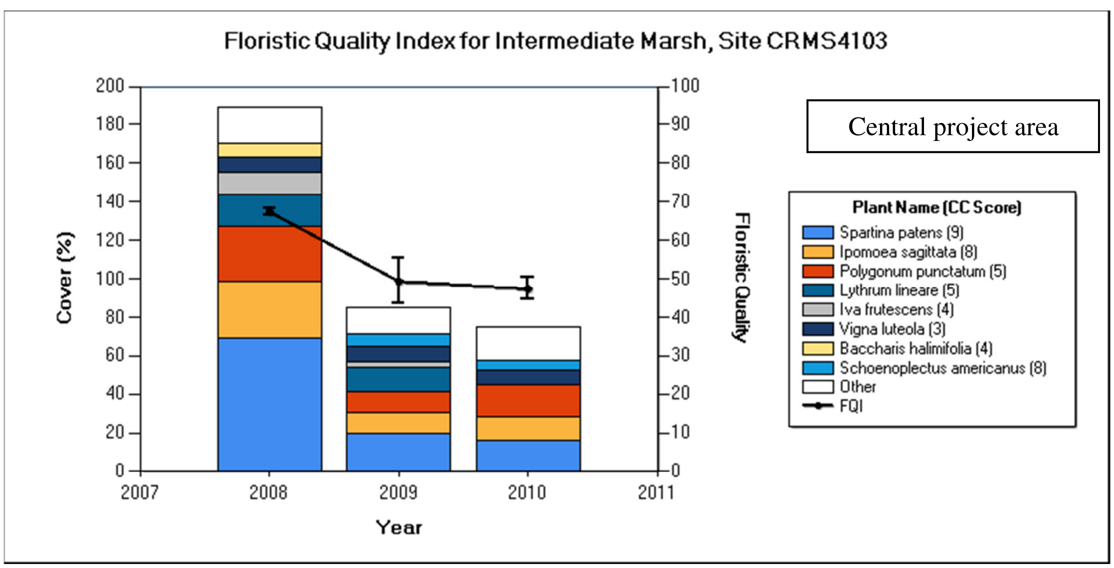

Figure 18. Vegetation percent cover and floristic quality index (FQI) for CRMS4103.

Percent Occurrence
Spartina patens occurred at more plots in the total project area than any other plant, except in 2009, when it occurred equally with *P. hydropoperoides* (Table 6A, Appendix D). In the northern project area, *S. lancifolia* had the highest average frequency of occurrence at plots (85%), while in the southern project area, *S. patens* occurred most frequently (96%). *Polygonum punctatum* (dotted smartweed) was the most frequently occurring species at CRMS0287, being found at 100% of stations each year except in 2010, when it occurred at 80% of sites (Table 6B). *Ipomoea sagittata* (saltmarsh morning glory) had the greatest percent occurrence at CRMS4103, being found in 100% of plots each year (Table 6C).

Vegetation Communities
Since one of the project goals is to increase the relative abundance of fresh-to-intermediate marsh species, a comparison was made to see how the percent cover of these species changed between years. Each species surveyed was assigned a salinity value based on the environment where it typically occurs. The salinity values were assigned following the format by Cretini et al. (2009). Species were categorized into two groups: a “fresh” group containing species found in fresh (F), fresh/intermediate (F/I), and intermediate (I) wetlands; and a “salty” group, containing species found in intermediate-brackish (I/B), brackish (B), brackish/salt (B/S), and salt (S) wetlands. The percent cover for species in each salinity category in the BA-03c/BA-26 project area is plotted in Figure 19, while Figure 20 shows the comparison between the broader fresh/salty groups. Data were analyzed with ANOVA in Proc GLM using a post-hoc Tukey’s test ($\alpha=0.05$) (SAS Institute Inc., Cary, NC, version 9.1).

Within the BA-03c/BA-26 project area, the percent cover of saltier species showed no change ($p>0.05$) between 1997–2009. However, there were significant differences in the percent cover of fresher species between each consecutive year surveyed ($p<0.05$) (Figure 20). The greatest change occurred between the 1997–2000 surveys, with the percent cover of fresh species dropping from 86% to 30%, likely due to the drought and the high salinity in the basin. The percent cover of fresh species increased again in 2003, only to drop back down to near 2000 levels in 2006. This may be due to the storm surge and habitat destruction that occurred following Hurricane Katrina. Between 2006 and 2009, the percent cover of fresh species increased to a level that is similar to the percent cover in 2003.

The percent cover of each salinity category for plant species surveyed at CRMS0287, CRMS4103 and at comparison stations is plotted in Figure 21. Analysis of the broader fresh/salty species at CRMS0287 shows that the percent cover of fresher species was lowest in 2007, peaked in 2009, and then declined in 2010 to its lowest level since 2007 (Figure 22). The percent cover of saltier species increased in 2009 ($p<0.05$); however, it declined again in 2010 to a value similar to those in previous years. CRMS4103 experienced a decrease in percent cover for both fresh and salty species between 2008–2009 ($p<0.05$), but experienced little change in percent cover for either salinity category between 2009–2010 (Figure 23).

Table 6. The percent of vegetation sampling sites where each species occurred in the BA-03c/BA-26 project area (A), at CRMS0287 (B), and at CRMS4103 (C). Tables contain the top 10 species by frequency of occurrence. Abbreviations for marsh habitat where species typically occur: F: freshwater, I: intermediate, B: brackish, S: salt, *: habitat not defined.

** Totals for *number of species* refer to the complete species list in Appendix D.

A Scientific Name	Common Name	% Occurrence-Project Stations					Habitat
		1997	2000	2003	2006	2009	
Spartina patens	Saltmeadow cordgrass	65	75	70	75	62	I/B
Sagittaria lancifolia	Bulltongue arrowhead	45	48	50	45	57	F/I
Ipomoea sagittata	Saltmarsh morning-glory	30	38	43	40	36	F/I
Eleocharis cellulosa	Gulf Coast spikerush	40	28	45	43	29	F/I
Vigna luteola	Hairypod cowpea	45		40	13	36	I
Phyla nodiflora	Turkey tangle fogfruit	45	25	40	20		F
Hydrocotyle sp.	Hydrocotyle	35	10	33	8	29	F
Symphyotrichum tenuifolium	Perennial saltmarsh aster	35	40		18		I/B
Symphyotrichum subulatum	Eastern annual saltmarsh aster	28		20	15	26	I
Bacopa monnieri	Herb of grace	10	18	23	23	13	F/I
Number of species*		**47**	**32**	**39**	**41**	**39**	

B Scientific Name	Common Name	% Occurrence-CRMS0287				Habitat
		2007	2008	2009	2010	
Polygonum punctatum	Dotted smartweed	100	100	100	80	F/I
Hydrocotyle sp.	Hydrocotyle	90	90	90	90	F
Sagittaria lancifolia	Bulltongue arrowhead	90	90	90	90	F/I
Lythrum lineare	Wand lythrum	50	50	60	80	I/B
Phyla sp.	Fogfruit	60	70	60	50	F
Eleocharis cellulosa	Gulf Coast spikerush	30	30	60	80	F/I
Symphyotrichum tenuifolium	Perennial saltmarsh aster	50	40	90		I/B
Schoenoplectus sp.	Bulrush	70	70			*
Schoenoplectus americanus	Chairmaker's bulrush			70	60	I/B
Eleocharis sp.	Spikerush	40	40			I
Number of species**		**19**	**18**	**21**	**15**	

C Scientific Name	Common Name	% Occurrence-CRMS4103			Habitat
		2008	2009	2010	
Ipomoea sagittata	Saltmarsh morning-glory	100	100	100	F/I
Polygonum punctatum	Dotted smartweed	100	90	89	F/I
Spartina patens	Saltmeadow cordgrass	100	100	67	I/B
Vigna luteola	Hairypod cowpea	40	90	89	I
Lythrum lineare	Wand lythrum	70	70	78	I/B
Solidago sempervirens	Seaside goldenrod	40	70	67	F/I
Iva frutescens	Jesuit's bark	60	50	33	I
Cuscuta indecora	Bigseed alfalfa dodder		60	67	I
Hydrocotyle sp.	Hydrocotyle	10	70	44	F
Sagittaria lancifolia	Bulltongue arrowhead	30	40	44	F/I
Number of species**		**19**	**27**	**20**	

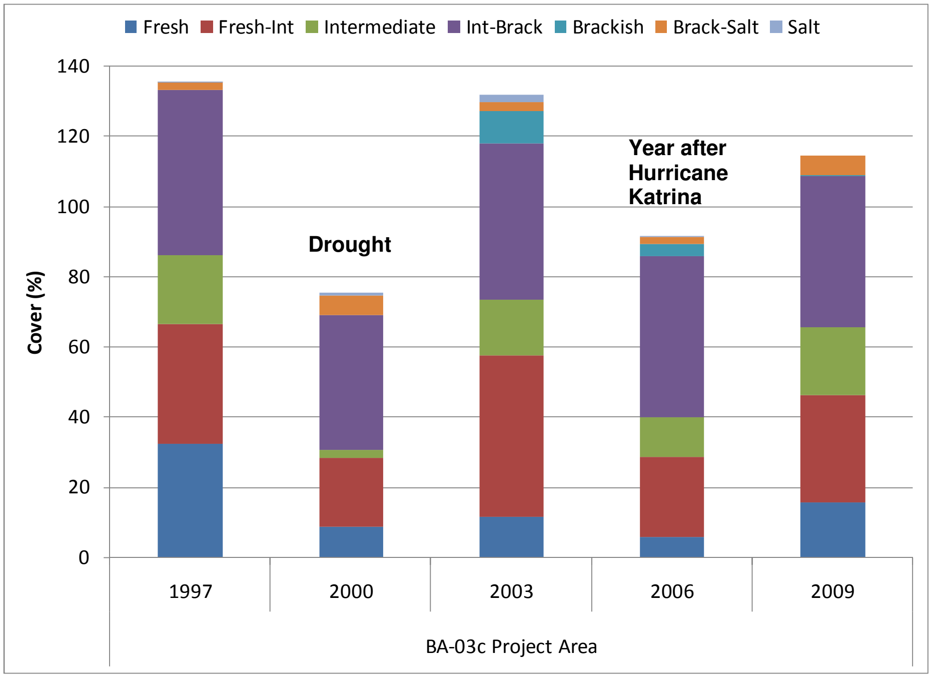

Figure 19. Percent cover of vegetation within each salinity category surveyed in the BA-03c project area.

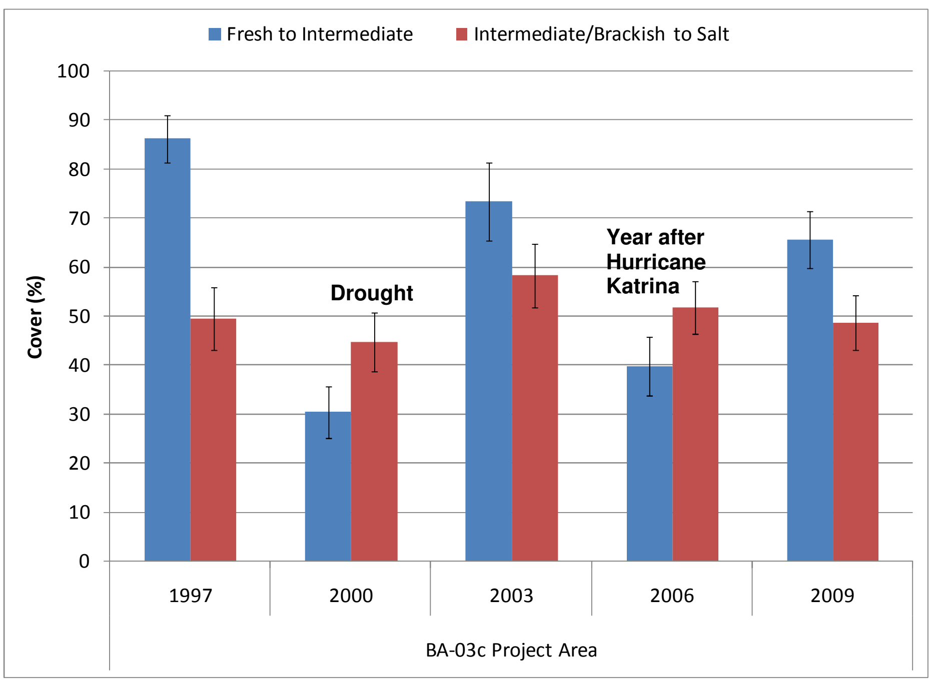

Figure 20. Percent cover (±SE) for vegetation in the BA-03c project area divided into two salinity categories: fresh–intermediate and intermediate/brackish–salt.

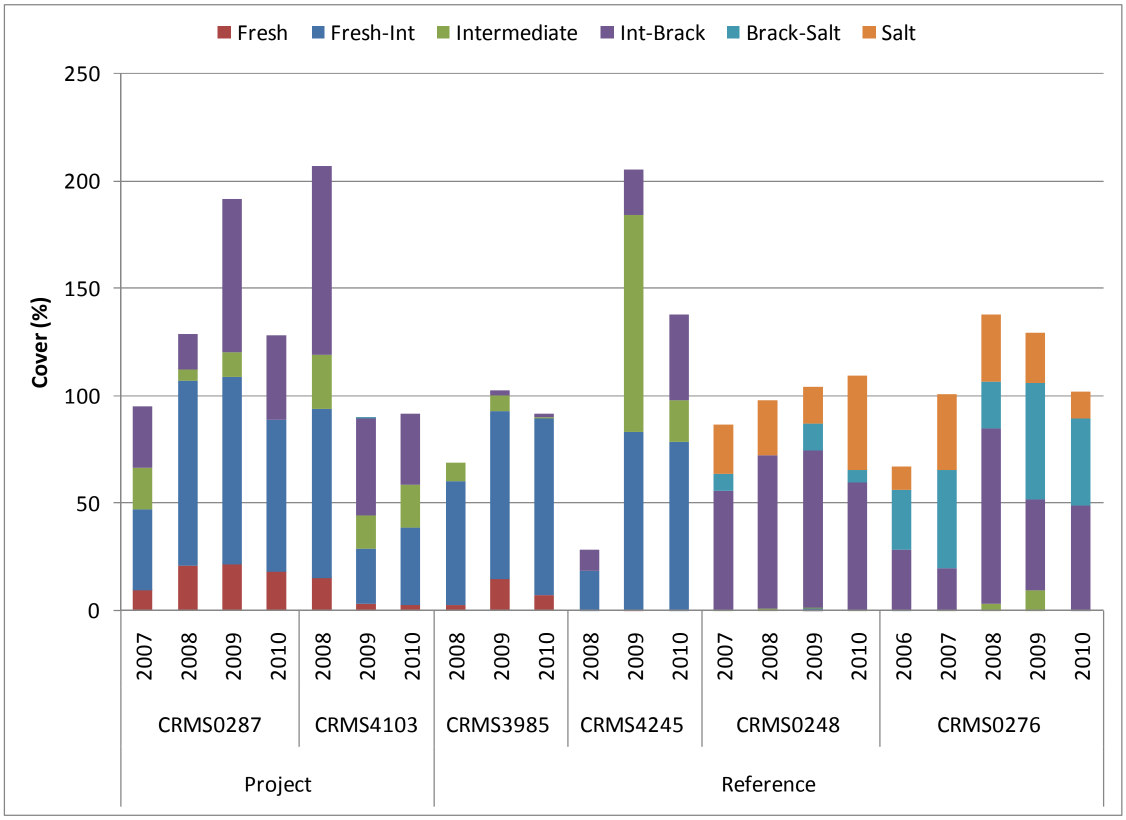

Figure 21. Percent cover of vegetation within each salinity category surveyed at CRMS stations located within and surrounding the BA-03c project area. CRMS3985, CRMS4245, CRMS0248, and CRMS0276 are located northwest, west, south, and southeast of the project area, respectively (Figure 7).

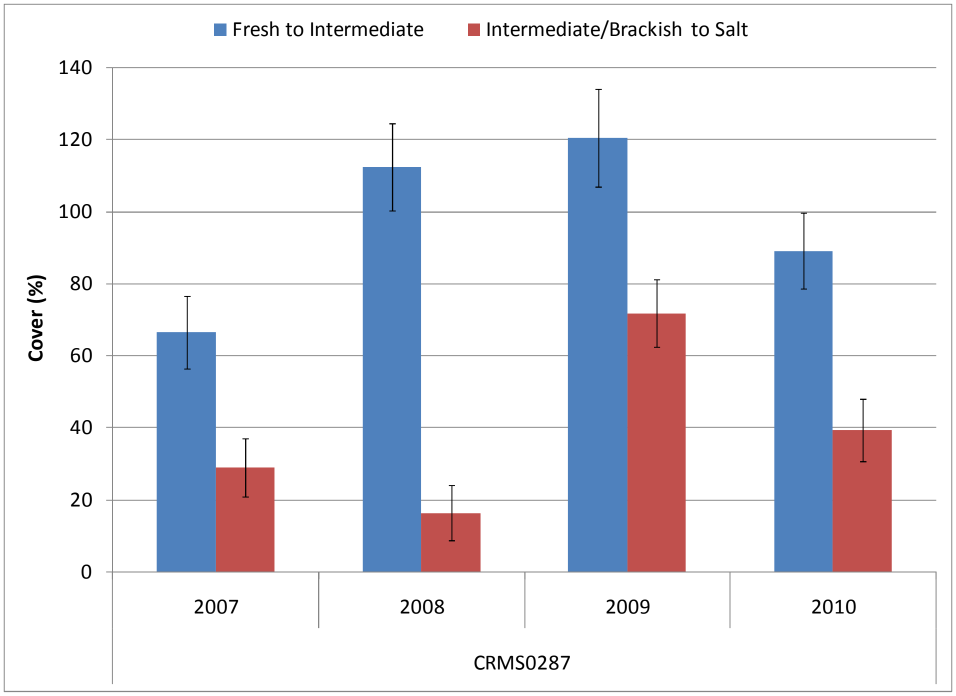

Figure 22. Percent cover (±SE) for vegetation at CRMS0287 divided into two salinity categories: fresh–intermediate, and intermediate/brackish–salt.

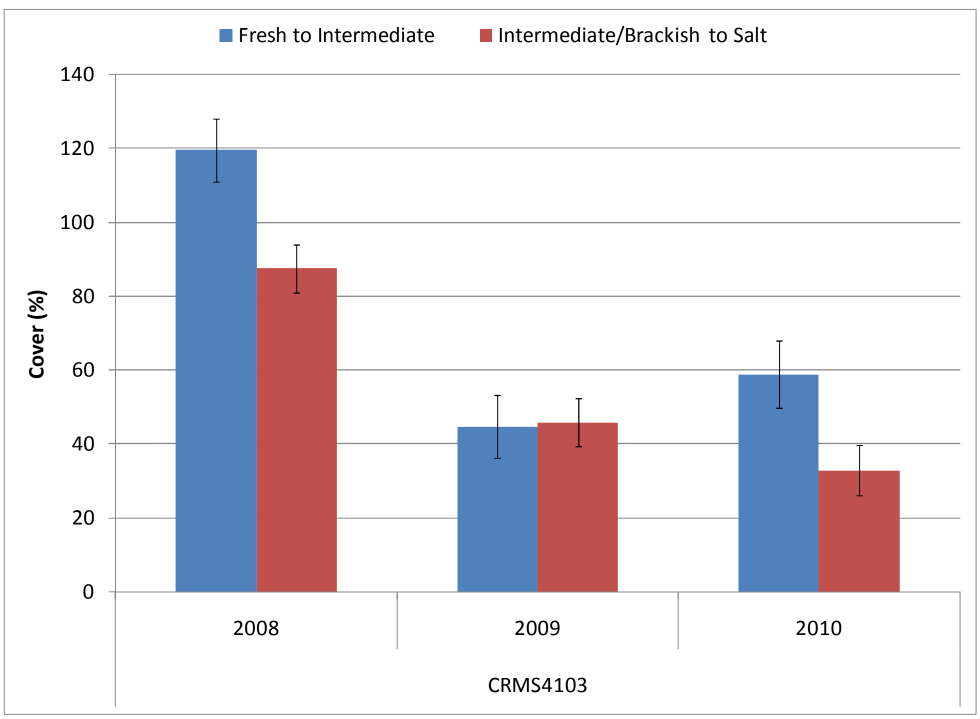

Figure 23. Percent cover (±SE) for vegetation at CRMS4103 divided into two salinity groups: fresh–intermediate, and intermediate/brackish–salt.

Land-Water Analysis

Pre-construction aerial photography was flown on November 05, 1991, for the Naomi Siphon Diversion (BA-03) project area (Figure 24). The post-construction aerial photography was flown on November 23, 2000, and includes the BA-03 project area, as well as the BA-03c and BA-26 project areas (Figure 25). The pre- and post-construction land-water analyses cannot be directly compared due to the difference in scale between the two years (1:12,000 in 1991 and 1:24,000 in 2000). The aerial photography for BA-03c was flown on December 19, 2009, at 1:12,000 (Figure 26). The project area for BA-03 was extracted from this imagery to allow for comparison to the 1991 photography. The acres of land increased from 8,175 acres in 1991, to 8,289 acres in 2009, while the acres of water decreased from 4,956 in 1999, to 4,842 in 2009. Aerial photography for BA-26 was flown in 2011 and will be included in the 2014 OM&M report.

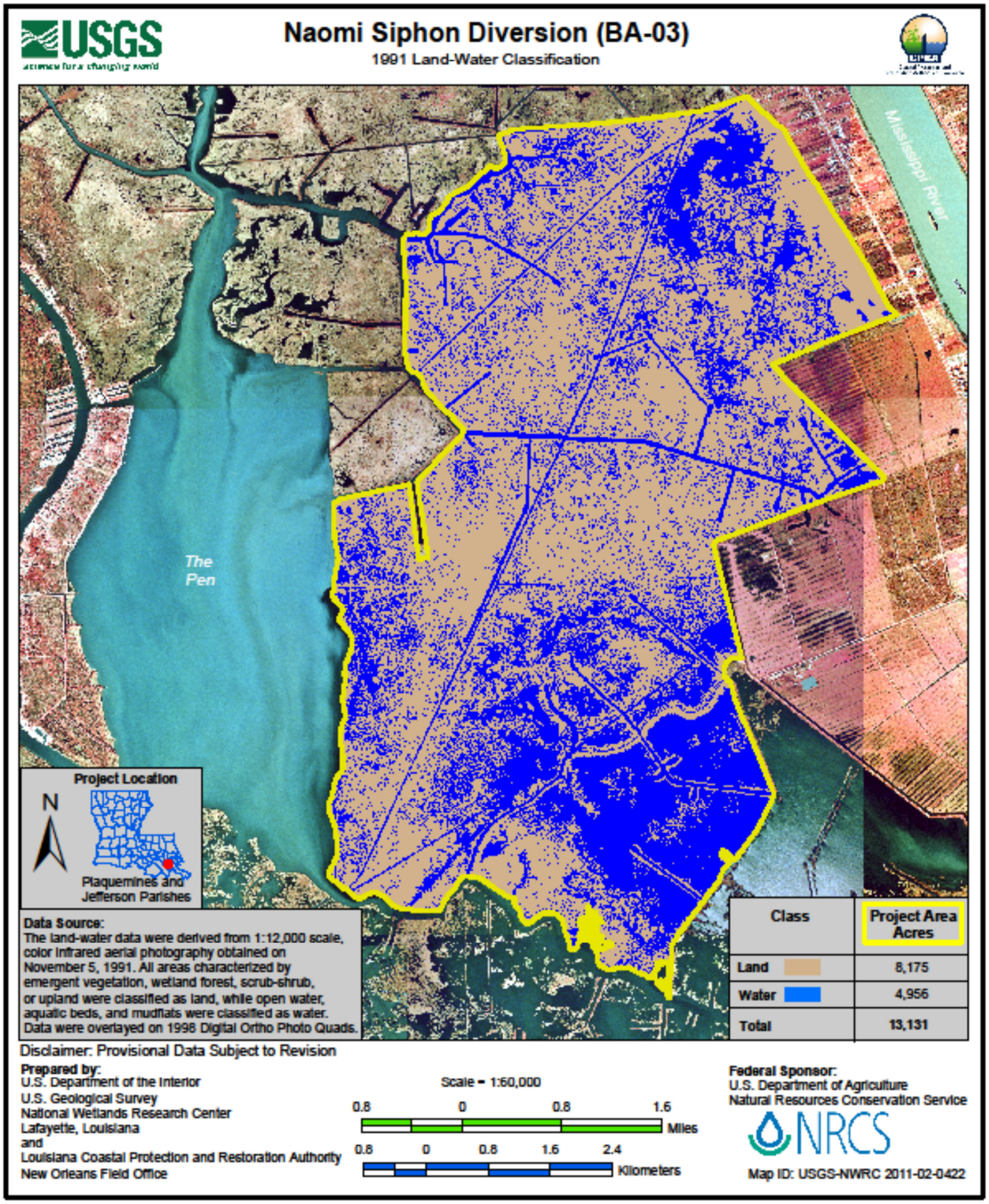

Figure 24. Pre-siphon construction aerial photography (1991) and land-water analysis of the Naomi Siphon Diversion (BA-03) project area.

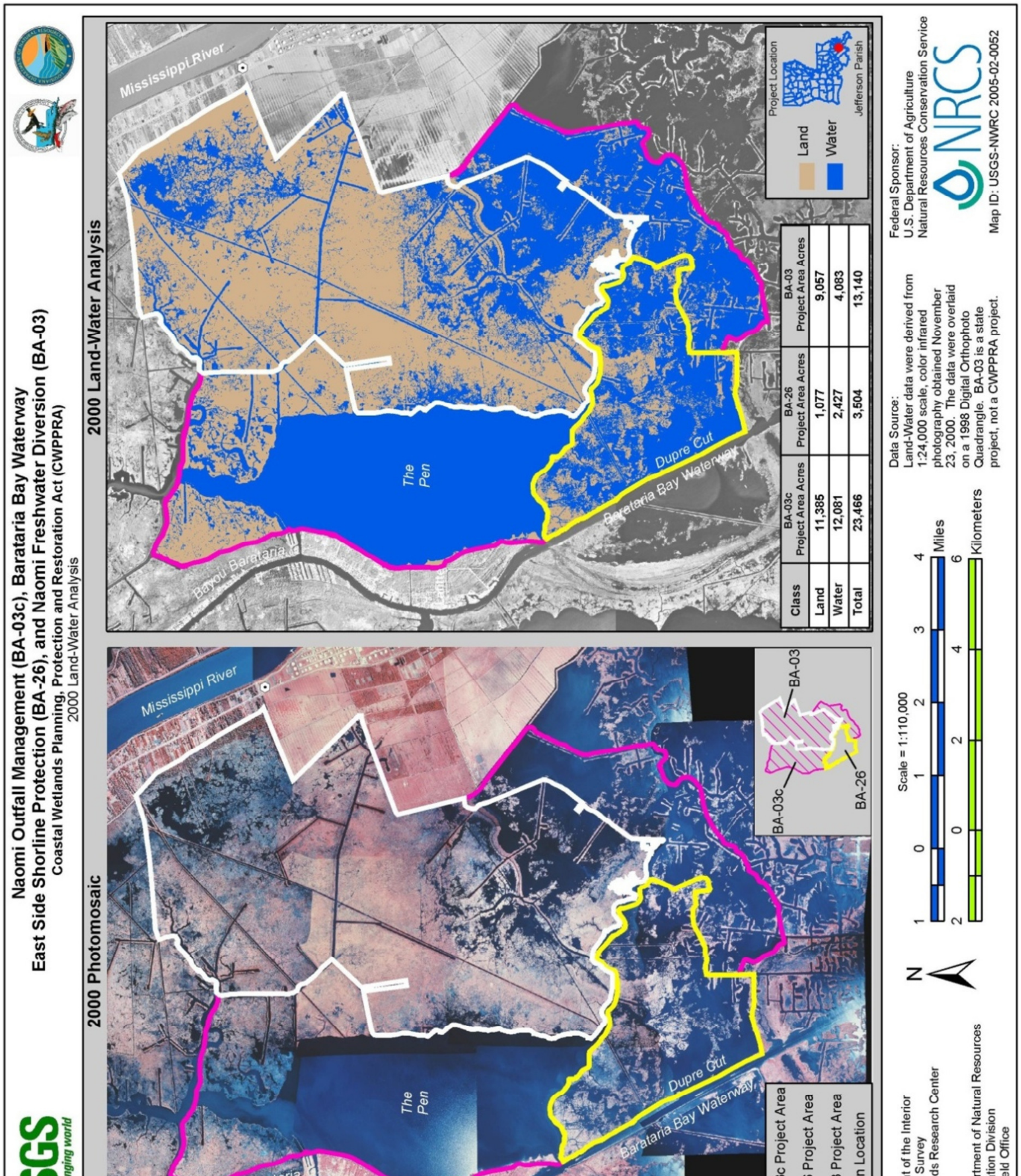

Figure 25 . Post-siphon construction aerial photography (2000) and land-water analysis of the BA-03, BA-03c, and BA-26 project areas.

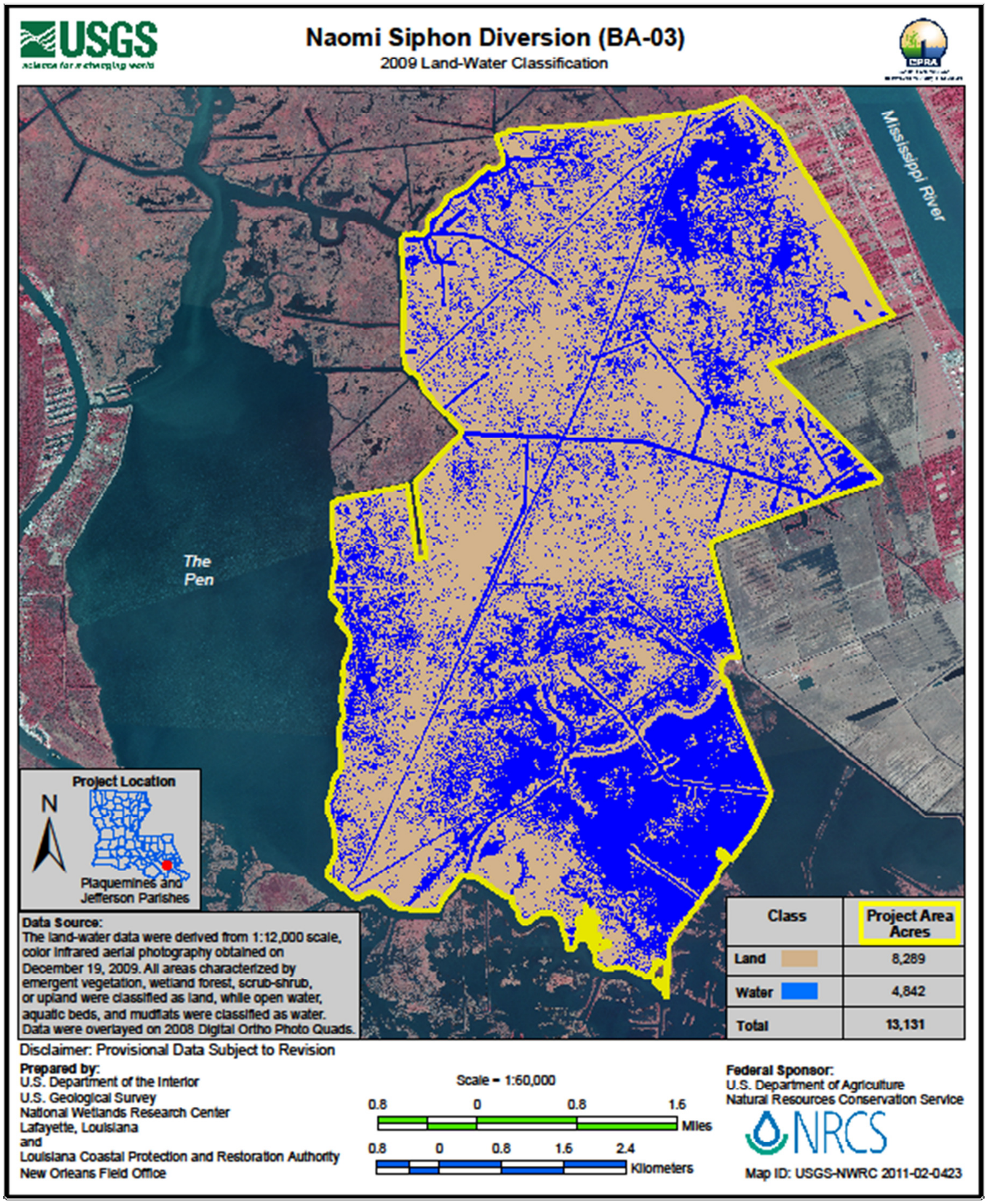

Figure 26. Aerial photography (2009) and land-water analysis of Naomi Siphon Diversion (BA-03) project area.

CRMS Supplemental

Three sediment cores were collected from CRMS0287 and CRMS4103 on June 17, 2008, and will be collected from these sites again in 2018. Average bulk density and percent organic content were analyzed from the three cores in 4 cm increments down to 24 cm depth. Bulk density increased with depth at CRMS0287 (Figure 27); however, there was more fluctuation at CRMS4103, with the 0–4 cm increment and 12–16 cm increment having the greatest density (Figure 28). The sediment at CRMS4103 was denser than the sediment at CRMS0287, which is northeast of CRMS4103 and closer to the outfall canal. Mean percent organic content at CRMS0287 was highest between 8–12 cm and was lowest at the surface (Figure 29). The mean percent organic content for CRMS4103 was also lowest at the surface, but was highest between 12–16 cm (Figure 30). The organic content of the soil was higher at CRMS0287 than at CRMS4103.

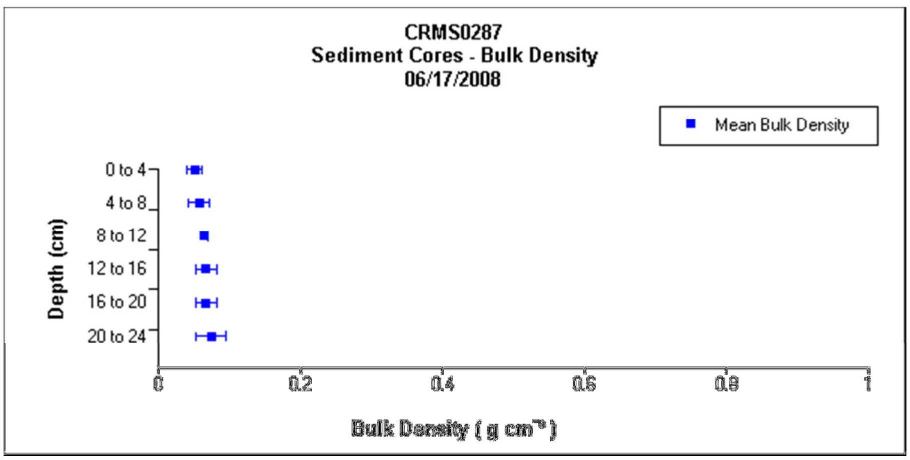

Figure 27. Mean bulk density of sediment cores collected at CRMS0287.

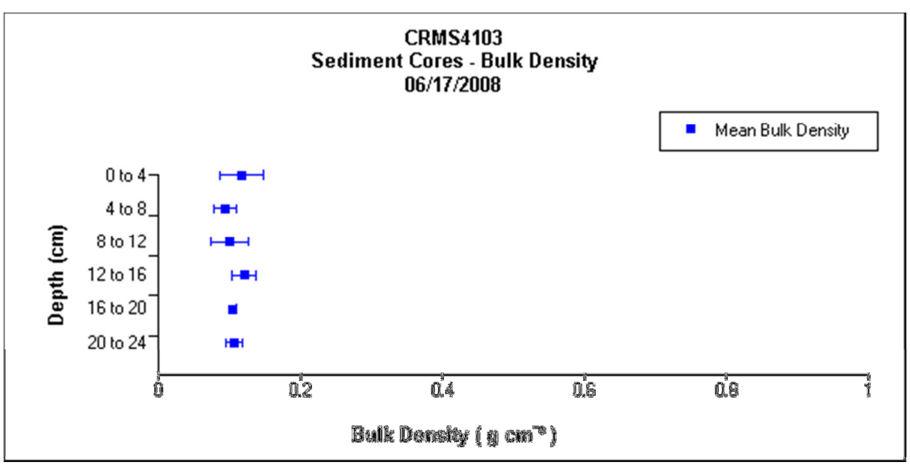

Figure 28. Mean bulk density of sediment cores collected at CRMS4103.

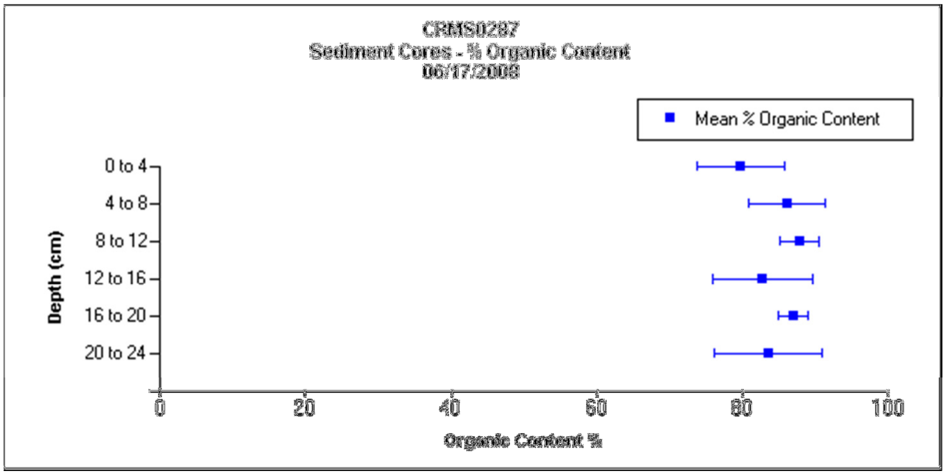

Figure 29. Mean percent organic content of sediment cores collected at CRMS0287.

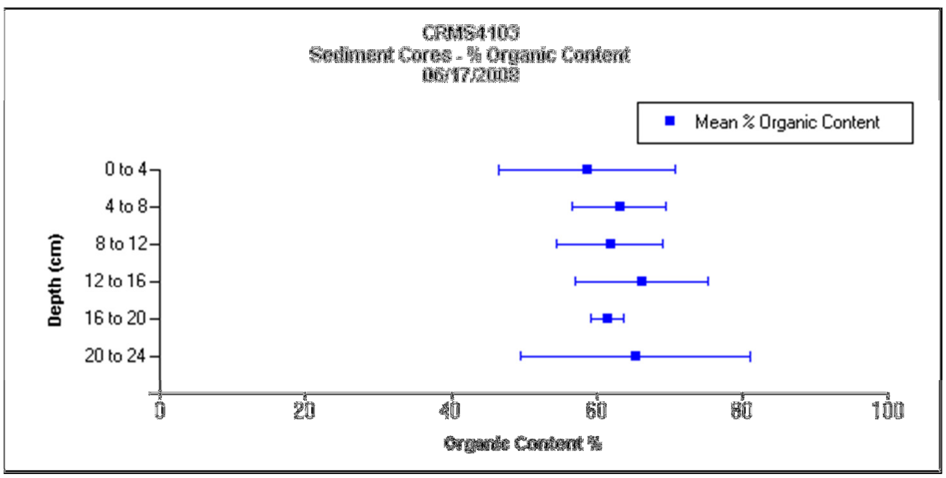

Figure 30. Mean percent organic content of sediment cores collected at CRMS4103.

d. Discussion

The Naomi siphons were proposed to operate with eight pipes running at just over 1,000 ft^3s^{-1} for all months except March and April, when only two pipes were to be in operation (LDNR 1996). Since 1993, the siphons have operated at over 1000 ft^3sec^{-1} only 18% of the time due to multiple challenges, including low river level, oil spills, hurricanes, maintenance issues and fishery interests. The operation schedule has been approached by Plaquemines Parish Government with great flexibility; however, this flexibility renders it difficult to determine the capability of the siphons to fully meet the project goals.

It has been difficult to assess any effects from the weirs on project monitoring goals. Under current flow operations, it is unclear if significant freshwater from the siphons is even flowing far enough west to reach the weirs. The evaluation of weir effectiveness has been further complicated by their continued settlement. The Goose Bayou weir has settled an average of two feet since construction and is now rarely visible above the water line. However, it should be noted that the majority of the weir is constructed beneath the water line, and therefore this structure should continue in part to operate as designed. The Bayou Dupont weir was significantly altered some time between inspection of the structure on May 18, 2010, and the end of September 2010. Rocks were removed from the weir to allow construction access for the CWPPRA-funded South Shore of the Pen Shoreline Protection Project (BA-41). It has been requested that the weir remain as is through the construction of two additional projects in the area. While this modification to the weir likely had little influence on monitoring for this report, its potential impact will need to be addressed in the 2014 OM&M report, depending on how long it takes to complete the construction of the three projects and to repair the weir.

Additionally, assessing the effects of the siphons and weirs is challenging because no project reference site was designated prior to project construction. However, since the implementation of the *CRMS-Wetlands* program, CRMS stations surrounding the project area have been utilized as reference sites and are providing valuable data to help gauge the effectiveness of this restoration project.

VI. Conclusions

a. Project Effectiveness

The first goal of the Naomi Outfall Management and Barataria Bay Waterway East Side Shoreline Protection projects is to reduce the mean salinity in the project area. Salinity is clearly being reduced as a result of the siphons at stations inside and near the mouth of the outfall canal. Salinity between May 2008–December 2010 was also reduced during siphon flow at CRMS4103, located in the central project area. With further distance from the outfall canal it becomes more difficult to credit salinity reductions solely to the siphons. Salinity reductions in the project area are often occurring when the river stage is high and the salinity in the project area may be lower due to increased discharge from the mouth of the river and perhaps freshwater from the Davis Pond Diversion. It can be expected that increasing the flow through the siphons would expand the range of freshening in the project area.

The construction of the boat-bay weirs was intended to 1) retain freshwater from the diversion and direct it south and 2) reduce inflow of saltwater from the Barataria Bay Waterway. Since the percent change in salinity pre/post weir construction for the reference site falls within the range of salinity change for the project sites, it is difficult to discern any effect from the weirs on salinity in the project area. Settling of the weirs, in particular the Goose Bayou Canal weir (Appendix A), may have diminished the water control potential from these structures.

The second goal of this project is to improve the growing conditions and increase the relative abundance of fresh-to-intermediate marsh species in the project area. Between the 2000 (pre-weir) and 2003 (post-weir) vegetation surveys, there was a significant increase in the percent cover of fresh-to-intermediate species (30% to 73%). However, 2000 was a drought year and the vegetation community reflected higher salinities in the basin by transitioning to a more salt-dominated community. The abundance of fresh−intermediate and intermediate/brackish−salt species has varied between years, with 1997 having the highest percent cover of fresher species and 2000 having the lowest. Significant events such as drought and hurricanes, especially Hurricane Katrina in 2005, affect the plant community composition and percent cover and demonstrate the response of wetlands to their environmental conditions. From these data, shifts between fresher and saltier plant communities appear to be influenced more by basin-wide environmental factors than by siphon operation or the installation of the weirs. However, if the siphons were run more frequently and at an increased flow rate, the project area could see a transition to a community with a greater abundance of fresh-intermediate species.

Water elevation was monitored as part of this project to ensure that there would not be a negative impact on vegetation from increased flooding due to siphon flow. Water elevation data from continuous recorders in the project area demonstrated that there was no significant increase in water elevation when the siphons were flowing. Two discrete water elevation stations did show an increase in water elevation during flow. These stations are located in and at the mouth of the outfall canal and represent a highly localized response in elevation to siphon flow. The construction of the weirs may have prompted additional concerns about an increase in water elevation within the project area during siphon flow; however, no significant increase occurred at any of the continuous recorder stations in the project area post-construction.

The third goal—to reduce the rate of conversion of marsh to open water in the project area—was met for the Naomi Siphon Diversion (BA-03) project area. This goal could not be assessed for the BA-03c/BA-26 project area. Land-water analyses for the BA-03 project area show that there has been no loss of land between 1991 and 2009; in fact, there has been an increase from 8,175 acres to 8,289 acres. The 2000 aerial photography included the BA-03, BA-03c, and BA-26 project areas. However, it could not be used for comparison of land-water analyses because it was flown at a different scale than the 1991 and 2009 imagery. Aerial photography for the BA-26 project area was flown in 2011 and its land-water analysis will be included in the 2014 OM&M report.

b. Recommended Improvements

If salinities are to be further lowered in the project area, the siphons need to be run more frequently and at a greater flow rate. This report demonstrates that when the siphons flow, salinity is being lowered inside of and near the outfall canal and also within the central project area, but the influence of the siphons rapidly decreases with distance. A redesign of the siphons to allow them to flow during low river stages would allow for fresh water to enter the project area when it is most needed—when the discharge from the river is the lowest.

It is recommended that CPRA has greater input and control over siphon operations. While CPRA employees need not be the ones responsible for starting and stopping the siphons, final decisions on siphon flow should be made by CPRA, taking into account concerns from interested parties. The contract for operations of the siphons should include a list of required documentation and a schedule for providing the appropriate documents to CPRA.

The importance of elevating the weirs back to their designed elevation is uncertain. There is no strong evidence demonstrating that the weirs as designed are contributing to meeting the project goals. For freshwater to be retained in the project area, it appears as if more efficient water retention structures are needed.

c. Lessons Learned

The freshening potential of the siphons is not being fully-realized due to limited siphon flow. Although an operation plan was originally drafted for the siphons, a multitude of conflicting interests has resulted in significant deviation from this plan.

Prior to construction of the siphons, more input should have been solicited from individuals and groups that have vested interests in the area that was projected to be influenced by the Naomi siphons.

Providing an outside party, rather than CPRA, with control over siphon operation may not be the most efficient way to utilize this type of restoration strategy.

It would have been beneficial to include in an operator contract a schedule for providing specified deliverables. For example, CPRA could have designed a log sheet for daily documentation of siphon flow and required a completed log sheet to be provided to the monitoring manager at the end of each month.

Neighboring restoration projects, such as the Davis Pond Freshwater Diversion, can complicate the ability to isolate the effects from the restoration project being assessed.

Reference stations/project areas should be designated in the initial monitoring plan, taking into account the potential influence of neighboring restoration projects.

Monitoring responsibilities need to be clearly outlined and communicated to contractors.

Combining two monitoring projects into one monitoring plan and OM&M report can lead to confusion. The goals for BA-03c and BA-26 are shared; however, assessment of these goals does not include a mechanism for determining how the rock dike has contributed to meeting project goals. The handling of multiple projects in one report needs to be done with great care and a focus on how the reader will comprehend the inter-relatedness of the projects.

VII. References

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Appendix A

Inspection Photographs for Naomi Outfall Management (BA-03c) and Barataria Bay Waterway East Side Shoreline Protection (BA-26)

Naomi Outfall Management (BA-03c)

Photo 1. Naomi Outfall Management (BA-03c). Bayou Dupont Canal weir, looking out from the Pen.

Photo 2. Naomi Outfall Management (BA-03c). Goose Bayou Canal weir, looking west. The weir has settled below the waterline.

Barataria Bay Waterway East Side Shoreline Protection (BA-26)

Photo 3. Barataria Bay Waterway East Side Shoreline Protection (BA-26).

Photo 4. A gap in the rock dike for the BA-26 project.

Barataria Bay Waterway East Side Shoreline Protection (BA-26) con't.

Photo 5. Evidence of accretion behind the rock wall for the BA-26 project.

Appendix B

Three Year Budget Projection

Naomi Outfall Management Project (BA-03c)

Federal Sponsor: NRCS

Construction Completed : 8/2002

PPL 5

Current Approved O&M Budget	Year 0	Year - 1	Year - 2	Year - 3	Year - 4	Year - 5	Year - 6	Year - 7	Year - 8	Year - 9	Year - 10	Year - 11	Year - 12	Year - 13	Year - 14	Year - 15	Year - 16	Year - 17	Year - 18	Year - 19	Project Life	Currently
June 2009	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	Budget	Funded
State O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$488,980	$488,980
Corps Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal S&A	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total																					$488,980	$488,980
																					Remaining	Current 3 year
Projected O&M Expenditures																					Project Life	Request
Maintenance Inspection										$3,429	$3,518	$3,610	$3,703	$3,800	$3,899	$4,000	$4,104	$4,211	$4,320	$4,432	$43,026	$43,026
General Maintenance																					$0	$0
Surveys																					$0	$0
Sign Replacement										$7,000							$7,000				$14,000	$14,000
Federal S&A													$1,749								$1,749	$1,749
Maintenance/Rehabilitation																					$0	$0
E&D													$7,454								$7,454	$7,454
Construction													$186,341								$186,341	$186,341
Construction Oversight													$37,268								$37,268	$37,268
Total										$10,429	$3,518	$3,610	$236,515	$3,800	$3,899	$4,000	$11,104	$4,211	$4,320	$4,432	$289,837	$289,837

O&M Expenditures from COE Report	$196,058	Current O&M Budget less COE Admin	$488,980	Current Project Life Budget less COE Admin		$488,980
State O&M Expenditures not submitted for in-kind credit	$0	Remaining Available O&M Budget	$258,693	Total Projected Project Life Budget		$520,125
Federal Sponsor MIPRs (if applicable)	$34,229	**Add'l Funding amount needed thru FY12-FY14**	**$31,145**	**Project Life Budget Request Amount**		**$31,145**
Total Estimated O&M Expenditures (as of April 2010)	$230,287					Not needed at this time

Barataria Bay Waterway East Bank Protection (BA-26)																						
Federal Sponsor: NRCS																						
Construction Completed : 5/2001																						
PPL 6																						
Current Approved O&M Budget	Year 0	Year - 1	Year - 2	Year - 3	Year - 4	Year - 5	Year - 6	Year - 7	Year - 8	Year - 9	Year - 10	Year - 11	Year - 12	Year - 13	Year - 14	Year - 15	Year - 16	Year - 17	Year - 18	Year - 19	Project Life	Currently
	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	Budget	Funded
State O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,228,500	$455,687
Corps Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal S&A	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total																					$1,228,500	$455,687
																					Remaining	Current 3 year
Projected O&M Expenditures																					Project Life	Request
Maintenance Inspection										$3,658	$3,753	$3,851	$3,951	$4,054	$4,159	$4,267	$4,378	$4,492	$4,609	$4,728	$45,899	$0
General Maintenance																					$0	$0
Surveys													$60,000								$60,000	$0
Sign Replacement																					$0	$0
Federal S&A																					$0	$0
Maintenance/Rehabilitation																					$0	$0
E&D														$12,000							$12,000	$0
Construction														$300,000							$300,000	$0
Construction Oversight														$75,000							$75,000	$0
Total										$3,658	$3,753	$3,851	$63,951	$391,054	$4,159	$4,267	$4,378	$4,492	$4,609	$4,728	$492,899	$0
O&M Expenditures from COE Report				$772,813				Current O&M Budget less COE Admin					$1,228,500				Current Project Life Budget less COE Admin					$1,228,500
State O&M Expenditures not submitted for in-kind credit				$0				Remaining Available O&M Budget					$455,687				Total Projected Project Life Budget					$1,265,712
Federal Sponsor MIPRs (if applicable)				$0				**Incremental Funding Request Amount FY12-FY1**					**$37,212**				**Project Life Budget Request Amount**					**$37,212**
Total Estimated O&M Expenditures (as of April 2010)				$772,813																		

Appendix C

Field Inspection Notes

FIELD INSPECTION CHECK SHEET

Project No. / Name:	Naomi Outfall Management	Date of Inspection:	4/21/2011 Time: 9:30
Structure No.	**Bayou Dupont Canal**	Inspector(s):	Richard, Kinler, Trusclair
Structure Description:	Stone Weir	Water Level:	Inside: N/A Outside: 0.80'
Type of Inspection:	Annual	Weather Conditions:	Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Rock Riprap	Good	None	N/A	#1	Structure altered for construction of BA-41
Creosote Piling	Fair	None	None	#1	
Warning Signs and Day Board Navigation Signs	Fair	None	None	#1	
Navigation Aid Lights	Fair	None	None	#1	Structure altered for construction of BA-41
Warning Buoys	Poor	See observations	None	#1	
Vandalism	N/A	N/A	N/A		

FIELD INSPECTION CHECK SHEET

Project No. / Name:	Naomi Outfall Management	Date of Inspection:	4/21/2011 Time: 9:30
Structure No.	**Goose Bayou Canal**	Inspector(s):	Richard, Kinler, Trusclair
Structure Description:	Stone Weir	Water Level:	Inside: N/A Outside: 0.80'
Type of Inspection:	Annual	Weather Conditions:	Partly Cloudy, Moderate Wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Rock Riprap	Good	None	N/A		Possible settlement, survey needed.
Creosote Piling	Good	None	None	#2	
Warning Signs and Day Board Navigation Signs	Good	None	None	#2	Weathering of lettering, some reflective tape missing. Continue to observe.
Navigation Aid Lights	Good	None	None	#2	
Warning Buoys	Good	None	None	#2	New temporary repair holding for now. Permanent repair needed.
Vandalism	N/A	N/A	N/A		

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-26 Barataria Waterway (East) Shoreline Protection**

Date of Inspection: 4/21/2011 Time: 9:30 am

Structure No. no number assigned

Inspector(s): Richard, Kinler, Trusclair

Structure Description: Foreshore Rock Dike

Water Level Inside: N/A Outside: 0.80'

Type of Inspection: Annual

Weater Conditions: Partly Cloudy, Moderate Wind

Item	Condition	Pysical Damage	Corrosion	Photo #	Observations and Remarks
Foreshore Rock Dike	Good	small gap	None	1, 2, 3	small gap at approx. coordinates N29.61380, W090.07904 some settlement, no action, continue observing
Settlement Plates	Good	None	None		
Signage /Supports	Good	None	None		

Appendix D

Vegetation Tables: Percent Occurrence

Table 1. The percent of project-specific vegetation sampling sites (N=40 for 1997–2006, N=39 for 2009) where each species occurred in the Naomi Outfall Management Project (BA-03c). Abbreviations for marsh habitat where species typically occur: F: freshwater, F/I: freshwater-intermediate, I: intermediate, I/B: intermediate-brackish, B: brackish, B/S: brackish-salt, S: salt.

Scientific Name	Common Name	% Occurrence-Project Stations					Habitat
		1997	2000	2003	2006	2009	
Spartina patens	Saltmeadow cordgrass	65	75	70	75	62	I/B
Sagittaria lancifolia	Bulltongue arrowhead	45	48	50	45	57	F/I
Ipomoea sagittata	Saltmarsh morning-glory	30	38	43	40	36	F/I
Eleocharis cellulosa	Gulf Coast spikerush	40	28	45	43	29	F/I
Vigna luteola	Hairypod cowpea	45		40	13	36	I
Phyla nodiflora	Turkey tangle fogfruit	45	25	40	20		F
Hydrocotyle sp.	Hydrocotyle	35	10	33	8	29	F
Symphyotrichum tenuifolium	Perennial saltmarsh aster	35	40		18		I/B
Symphyotrichum subulatum	Eastern annual saltmarsh aster	28		20	15	26	I
Bacopa monnieri	Herb of grace	10	18	23	23	13	F/I
Lythrum lineare	Wand lythrum			38	25	21	I/B
Polygonum punctatum	Dotted smartweed	3	5	60	3		F/I
Cyperus odoratus	Fragrant flatsedge	13	10	20	8	18	I
Polygonum hydropiperoides	Swamp smartweed				3	62	F
Schoenoplectus pungens	Common threesquare	35	25		3		F
Alternanthera philoxeroides	Alligatorweed	10	15	10	13	11	F/I
Eleocharis sp.	Spikerush	28		5		29	I
Distichlis spicata	Seashore saltgrass	3	25	10	5	16	B/S
Pluchea camphorata	Camphor pluchea	18	5	20	15		I/B
Solidago sempervirens	Seaside goldenrod	18	15	5	10	8	F/I
Schoenoplectus americanus	Chairmaker's bulrush			5	5	41	I/B
Schoenoplectus robustus	Sturdy bulrush			38	13		B
Ammannia sp.	Redstem	3	3	10	5	24	F/I
Iva frutescens	Jesuit's bark	3	10	5	15	11	I
Echinochloa walteri	Coast cockspur grass		3	10	10	18	I
Ludwigia sp.	Primrose-willow	20				18	F
Cyperus sp.	Flatsedge	13	15		10		F/I
Polygonum pensylvanicum	Pennsylvania smartweed	38					F
Eleocharis parvula	Dwarf spikerush	3	3	20	5	6	I/B
Kosteletzkya virginica	Virginia saltmarsh mallow		3	3	20	11	F/I
Baccharis halimifolia	Eastern baccharis	15	10	5	5		F/I
Pluchea odorata	Sweetscent					31	I/B
Andropogon glomeratus	Bushy bluestem	18	8			6	F
Thelypteris palustris	Eastern marsh fern	10	3	8	10		F
Cyperus strigosus	Strawcolored nutgrass					29	F
Sacciolepis striata	American cupscale	5	18			3	F
Spartina alterniflora	Smooth cordgrass	3	10	8	5		S
Panicum repens	Torpedo grass		3	8		13	I
Amaranthus australis	Southern amaranth	3		15	3		I/B
Polygonum sp.	Knotweed	20					F
Mikania scandens	Climbing hempvine	8			10		F

Table 1 con't. The percent of project-specific vegetation sampling sites (N=40 for 1997–2006, N=39 for 2009) where each species occurred in the Naomi Outfall Management Project (BA-03c) area. Abbreviations for marsh habitat where species typically occur: F: freshwater, F/I: freshwater-intermediate, I: intermediate, I/B: intermediate-brackish, B: brackish, B/S: brackish-salt, S: salt.

Scientific Name	Common Name	% Occurrence-Project Stations					Habitat
		1997	2000	2003	2006	2009	
Setaria sp.	Bristlegrass	18					*
Amaranthus cannabinus	Tidalmarsh amaranth					16	I/B
Cyperus compressus	Poorland flatsedge			15			F
Cuscuta sp.	Dodder				5	8	F/I
Cynanchum angustifolium	Gulf Coast swallow-wort					13	B/S
Juncus roemerianus	Needlegrass rush	3	3	3	3	3	B/S
Phyla sp.	Fogfruit					13	F
Hibiscus sp.	Rosemallow	13					F/I
Panicum hemitomon	Maidencane				13		F
Setaria parviflora	Marsh bristlegrass	5	3	5			F
Galium tinctorium	Stiff marsh bedstraw			8		3	F
Setaria pumila	Yellow foxtail				3	8	I/B
Thelypteris sp.	Maiden fern					11	F
Typha latifolia	Broadleaf cattail		3			8	F
Setaria magna	Giant bristlegrass	3		3	5		I
Spartina cynosuroides	Big cordgrass					8	B
Amaranthus sp.	Pigweed				8		*
Schoenoplectus sp.	Bulrush				8		*
Sporobolus sp.	Dropseed	8					B/S
Typha sp.	Cattail			3	5		F/I
Cyperus haspan	Haspan flatsedge					6	F
Hibiscus moscheutos	Crimsoneyed rosemallow	5					F/I
Juncus effusus	Common rush	5					F
Lemna minor	Common duckweed		5				F
Sagittaria platyphylla	Delta arrowhead	5					F
Salvinia minima	Water spangles	3	3				F
Rhynchospora colorata	Starrush whitetop					3	F
Baccharis sp.	Baccharis	3					*
Cuscuta indecora	Bigseed alfalfa dodder			3			I
Echinochloa crus-galli	Barnyardgrass	3					F/I
Eichhornia crassipes	Common water hyacinth	3					F/I
Fuirena sp.	Umbrella-sedge			3			*
Panicum dichotomiflorum	Fall panicgrass				3		F/I
Paspalum distichum	Knotgrass			3			F
Pluchea foetida	Stinking camphorweed	3					F
Sphenoclea zeylanica	Chickenspike	3					F
Zizaniopsis miliacea	Giant cutgrass			3			F
Number of species		**47**	**32**	**39**	**41**	**39**	

* Habitat not defined

Table 2. The percent of vegetation sampling sites (N=10) at which each species occurred in the Naomi Outfall Management Project (BA-03c) at CRMS0287 during the 2007–2010 annual surveys. Species are sorted by mean percent occurrence through the years. CRMS0287 is located in the northern region of the project area. Abbreviations for marsh habitat where species typically occur: F: freshwater, F/I: freshwater-intermediate, I: intermediate, I/B: intermediate-brackish, B: brackish, B/S: brackish-salt, S: salt.

Scientific Name	Common Name	% Occurrence-CRMS0287				Habitat
		2007	2008	2009	2010	
Polygonum punctatum	Dotted smartweed	100	100	100	80	F/I
Hydrocotyle sp.	Hydrocotyle	90	90	90	90	F
Sagittaria lancifolia	Bulltongue arrowhead	90	90	90	90	F/I
Lythrum lineare	Wand lythrum	50	50	60	80	I/B
Phyla sp.	Fogfruit	60	70	60	50	F
Eleocharis cellulosa	Gulf Coast spikerush	30	30	60	80	F/I
Symphyotrichum tenuifolium	Perennial saltmarsh aster	50	40	90		I/B
Schoenoplectus sp.	Bulrush	70	70			*
Schoenoplectus americanus	Chairmaker's bulrush			70	60	I/B
Eleocharis sp.	Spikerush	40	40			I
Symphyotrichum subulatum	Eastern annual saltmarsh aster	40		40		I
Eleocharis macrostachya	Pale spikerush			60		I
Bacopa monnieri	Herb of grace	10	10	20	10	F/I
Cyperus haspan	Haspan flatsedge		10	20	20	F
Pluchea odorata	Sweetscent	10		40		I/B
Eleocharis flavescens	Yellow spikerush			20	20	I/B
Eleocharis parvula	Dwarf spikerush	10	20		10	I/B
Galium tinctorium	Stiff marsh bedstraw	30	10			F
Spartina patens	Saltmeadow cordgrass	10	10	10	10	I/B
Sacciolepis striata	American cupscale	20		10		F
Amaranthus australis	Pigweed			10	10	I/B
Cyperus filicinus	Fern flatsedge			20		F/I
Cyperus odoratus	Fragrant flatsedge	10		10		I
Ludwigia leptocarpa	Angelstem primrose-willow	20				F/I
Ludwigia octovalvis	Mexican primrose-willow		10		10	F
Rhynchospora colorata	Starrush whitetop		10	10		F
Ammannia sp.	Redstem			10		F/I
Andropogon glomeratus	Bushy bluestem	10				F
Baccharis halimifolia	Eastern baccharis		10			F/I
Dichanthelium commutatum	Variable panicgrass		10			F
Kosteletzkya virginica	Virginia saltmarsh mallow				10	F/I
Number of species		**19**	**18**	**21**	**15**	

* Habitat not defined

Table 3. The percent of vegetation sampling sites where each species occurred at CRMS4103 during the 2008–2010 surveys. N=10 for 2008 and 2009, N=9 for 2010. Species are sorted by mean percent occurrence through the years. CRMS4103 is located in the central region of the project area. Abbreviations for marsh habitat where species typically occur: F: freshwater, F/I: freshwater-intermediate, I: intermediate, I/B: intermediate-brackish, B: brackish, B/S: brackish-salt, S: salt.

Scientific Name	Common Name	% Occurrence-CRMS4103			Habitat
		2008	2009	2010	
Ipomoea sagittata	Saltmarsh morning-glory	100	100	100	F/I
Polygonum punctatum	Dotted smartweed	100	90	89	F/I
Spartina patens	Saltmeadow cordgrass	100	100	67	I/B
Vigna luteola	Hairypod cowpea	40	90	89	I
Lythrum lineare	Wand lythrum	70	70	78	I/B
Solidago sempervirens	Seaside goldenrod	40	70	67	F/I
Iva frutescens	Jesuit's bark	60	50	33	I
Cuscuta indecora	Bigseed alfalfa dodder		60	67	I
Hydrocotyle sp.	Hydrocotyle	10	70	44	F
Sagittaria lancifolia	Bulltongue arrowhead	30	40	44	F/I
Symphyotrichum tenuifolium	Perennial saltmarsh aster		40	67	I/B
Schoenoplectus americanus	Chairmaker's bulrush	20	30	33	I/B
Cuscuta pentagona	Fiveangled dodder	80			F/I
Baccharis halimifolia	Eastern baccharis	30		33	F/I
Amaranthus australis	Pigweed		50	11	I/B
Bacopa monnieri	Herb of grace	10	30	11	F/I
Eleocharis sp.	Spikerush	30	10	11	I
Pluchea odorata	Sweetscent		50		I/B
Setaria parviflora	Marsh bristlegrass	20		11	F
Kosteletzkya virginica	Virginia saltmarsh mallow	10	10	11	F/I
Rotala ramosior	Lowland rotala		30		F
Eleocharis albida	White spikerush	10	20		I/B
Juncus effusus	Common rush			22	F
Eleocharis erythropoda	Bald spikerush		10	11	I/B
Eleocharis parvula	Dwarf spikerush		10	11	I/B
Cyperus sp.	Flatsedge		20		F/I
Galium tinctorium	Stiff marsh bedstraw	10	10		F
Cynanchum angustifolium	Gulf Coast swallow-wort		10		B/S
Echinochloa muricata	Rough barnyardgrass		10		F
Eleocharis cellulosa	Gulf Coast spikerush		10		F/I
Ludwigia octovalvis	Mexican primrose-willow	10			F
Sabatia sp.	Rose gentian		10		*
Schoenoplectus robustus	Sturdy bulrush		10		B
Number of species		**19**	**28**	**21**	

* Habitat not defined