State of Louisiana
Coastal Protection and Restoration Authority of Louisiana (CPRA)

2019 Operations, Maintenance, and Monitoring Report

for

Humble Canal Hydrologic Restoration (ME-11)

State Project Number ME-11
Priority Project List 8

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Cameron Parish

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Preface

This report includes monitoring data collected through December 2018, and the annual maintenance inspection from August 2019. The Humble Canal Hydrologic Restoration project (ME-11) is a 20-year Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III, Priority List 8) project administered by the Natural Resources Conservation Service (NRCS) and the Coastal Protection and Restoration Authority of Louisiana (CPRA).

The 2019 report is the 5th report in a series of reports. For additional information on lessons learned, recommendations and project effectiveness please refer to the 2003, 2010, 2013 and 2016 Operations, Maintenance, and Monitoring Reports on the CPRA web site at http://coastal.Louisiana.gov/. These reports will be made available for download at the following website: http://cims.coastal.la.gov.

I. Introduction

The Humble Canal Hydrologic Restoration project (ME-11) was part of CWPPRA PPL 8 and is sponsored by the Natural Resources Conservation Service (NRCS). The project encompasses 4,030 acres (1,228 ha) of intermediate marsh in Cameron Parish, Louisiana (figure 1). The project area is bounded by Little Chenier Ridge to the south, the Mermentau River to the east, and oilfield canals to the north and west. Project construction was completed in March 2003. The area has experienced Hurricanes Rita (2005) and Ike (2008), a severe drought (2011) and most recently several years of above average rainfall, including the flood of 2016.

Historically the marshes within the ME-11 project area were intermediate and contiguous with the large fresh to intermediate interior marshes of the Mermentau Lakes sub basin (O'Neil 1949). During the intervening decades the project area transitioned between fresh and intermediate vegetation as the overall quantity of marsh acreage was drastically reduced by Hurricane Audrey's storm surge of over 12 ft in 1957 (NOAA SLOSH Model), oilfield exploration and production, and multiple saline pulses due to changes in the hydrologic landscape (Chabreck et al. 1968) (Chabreck and Linscombe 1978, 1988, 1997, and 2001, and Sasser and Visser 2008). Land loss data indicate that from 1932 to 1990, approximately 826 acres (334 ha) of land were converted to open water in the Humble Canal project area, which represents approximately one fifth of the project area. Hydrologic alterations were both local for oil and gas exploration and regional for greater shipping transportation and flood control, which increased flooding and saltwater intrusion into the project area (Good et al. 1995, Mouledous et al. 2016). This simultaneously subdivided the landscape into smaller often impounded hydrologic units and created deep water conduits to the saline waters of the Gulf of Mexico. This ecological change increased flooding and salinity in fresh and intermediate marshes leading to their transformation to more flooding and saline tolerant marsh vegetation or shallow open water habitat (CRMS spatial viewer land/water 2019, Barras et al. 2008, Couvillion et al 2017). These landscape alterations included the construction of Humble Canal in the 1950's and the repeated dredging of the Mermentau River which led to saltwater intrusion from the south and east and construction of the Catfish Point Locks resulting in excessive water levels in some areas.

To aid in the removal of excess water without permitting saline water into the project area, a water control structure as well as all associated access channels, embankments and timber bulkheads were constructed in an oilfield access canal north of Marseillais Bayou (figure 1). Construction began in September 2002 and ended with implementation in March 2003.
The principle constructed project features of the Humble Canal Hydrologic Restoration Project include the following:

A. **Water Control Structure:**
   - Five - 48" x 50' corrugated aluminum pipe with weir type drop inlets and flap gated outlets.
   - One - 18" x 50' corrugated aluminum pipe with screw gate
   - Embankments and timber bulkhead

B. **Water Hyacinth Fence:** Approximately 88 linear feet of hyacinth fence.

C. **Marine Barrier Fence:** Approximately 100 linear feet of marine vessel barrier fence.

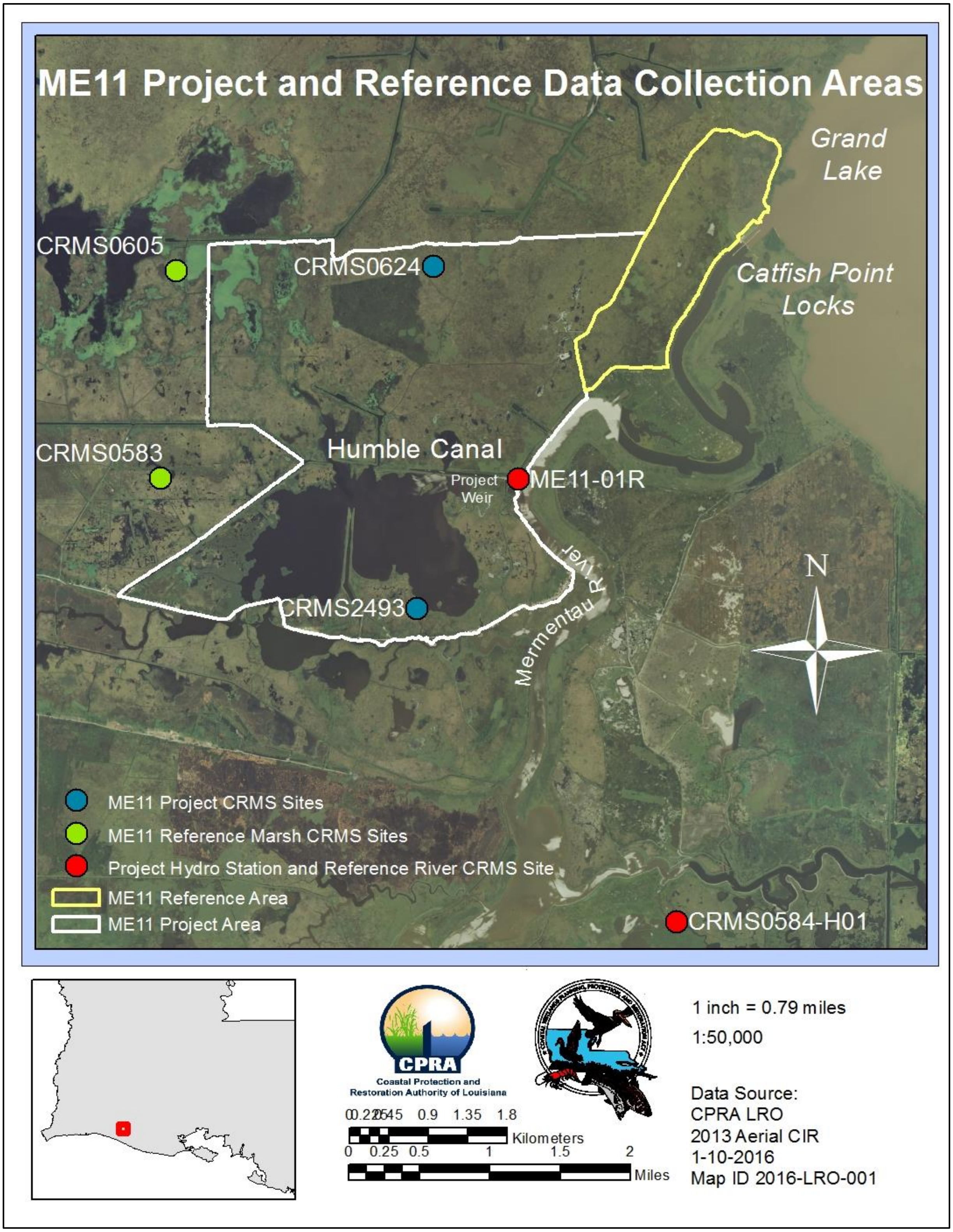

Figure 1. Humble Canal Hydrologic Restoration Project (ME11); project and reference areas, CRMS sites, and project specific hydrologic station and weir.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Humble Canal Hydrologic Restoration Project (ME-11) is to evaluate the constructed project features, 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, 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 (O&M Plan, 2003). The annual inspection report also contains a summary of maintenance projects, if any, which were completed since completion of constructed project features 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 B.

An inspection of the Humble Canal Hydrologic Restoration Project (ME-11) was held on August 14, 2019 under partly cloudy skies and warm temperatures. In attendance were Mel Guidry and Chris Wheat with Lonnie Harper & Associates. The boat was launched off of Little Chenier Road at the Mermentau River and traveled north to the Humble Canal Project Site.

The field inspection included a complete visual inspection of all project features. Staff gauge readings where available were used to determine approximate elevations of water, earthen embankments, water control structure and other project features. Photographs were taken at each project feature (see Appendix A) and Field Inspection notes were completed in the field to record measurements and any notable deficiencies (see Appendix C).

b. Inspection Results

<u>Marine barrier fence</u>

The structure is in excellent condition and the warning signs were intact. (Photos: Appendix A, Photo 1)

<u>Hyacinth guard</u>

This feature is in good condition, but needs some minor repairs. A portion of the wire fence material has degraded and broken off just above the water line. The wooden pilings and bracing are intact. (Photos: Appendix A, Photo 2 & 3)

Water control structure

The structure is in good condition. The stoplogs and screw gate appear to be functioning as intended. One flapgate appears to be missing. Some grating on the outlet side needs to be replaced. The wingwall rock armor on the inlet and outlet side of the structure and the crushed stone aggregate on the top of the structure are intact. (Photos: Appendix A, Photos 2 & 4)

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

There are no repairs required at this time.

ii. Programmatic/ Routine Repairs

Before the end of life, the grating, hyacinth fence, and one flapgate is in need of repair. Landrights agreement have expired and will need to be extended to perform this work.

d. Maintenance History

General Maintenance: Below is a summary of completed maintenance projects and operation tasks performed since March 2003, the construction completion date of the Humble Canal Hydrologic Restoration Project (ME-11).

2009 M & M Electric – Repairs were made to the structure to repair storm damage as well as routine maintenance repairs. Forty five (45) tons of rock rip rap were placed around the wingwalls. Sixty tons (60) tons of crushed stone aggregate were placed on top of the structure along with five-hundred (500) square yards of geotextile fabric. Repairs were made to the hyacinth guard, flap gates, locking arms and stop logs. Two warning signs were replaced at the marine vessel barrier. The costs associated with this maintenance event were as follows:

E & D, Construction Oversight, As Builts	$15,314.00
Construction Contract (Incl. C.O. # 1)	$59,300.00
TOTAL	**$74,614.00**

III. Operation Activity

a. Operation Plan

CWPPRA funding for this project includes dedicated monies to operation and maintenance. CPRA is responsible for the operations, maintenance, monitoring, and replacement of project elements through the 20-year life of the project.

Operations of the structures are performed in accordance with the salinity and water levels noted below.

Excerpt from the Operation, Maintenance, and Monitoring Plan

Structure Operational Scheme

18" diameter marine ingress structure with screwgate	< 6 ppt at structure	Screw gate open
	≥ 6 ppt at structure	Screw gate closed
Five 48" diameter water control structures with stoplogs and flap gates	1.2' NA VD88 (marsh elevation)	Flaps operating stoplogs adjusted to achieve water level at marsh elevation

Safety Factors:

1) If interior *Panicum hemitomon* marsh has salinity reading exceeding 2 ppt, the 6 ppt structure closing criteria will be adjusted downward accordingly to insure protection of the marsh resource.
2) If excessive water levels occur as a result of rainfall or other event, the stoplogs will be lowered as necessary to allow excess water to be removed until water level reaches 1.2' NA VD88 (marsh level).

b. Actual Operations

CPRA manages an Operations Contract for collecting recorded data from a continuous monitoring station, maintenance of the monitoring equipment, and manipulation of the structure in accordance with the OM&M plan. An Operations and Maintenance Contract was awarded to Simon and Delany, LLC; however, the contract ended in August 2018.

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 ME-11 Monitoring Plan to merge it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There are two CRMS sites located in the project area (CRMS0624 and CRMS2493), two located in similar marsh habitat outside the project area (CRMS0605 and CRMS0583), and one CRMS site (CRMS0584) located near the Mermentau River in a similar habitat to the project specific SONDE (ME11-01R).

a. Monitoring Goals

The objective of the Humble Canal Hydrologic Restoration Project is to improve removal of excess water without permitting saline water into the project area.

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

1. Increase present (yr 2000) land to water ratio.

2. Maintain mean water levels in the project area between 6 in below and 2 in above marsh level.

3. Maintain mean monthly salinity (0–3 ppt) in the project area after construction and prevent salinities from exceeding 7 ppt.

4. Increase or maintain the occurrence and cover of fresh marsh vegetation species in the project area.

5. Increase frequency of occurrence of submerged aquatic vegetation (SAV) in the project area.

b. Monitoring Elements

Aerial Photography:
Near-vertical color-infrared aerial photography (1:12,000 scale) was used to measure land to open water ratios and land change rates for the project and reference areas. The photography was obtained in 2000 prior to project construction and post construction in 2005. Aerial photography was checked for flight accuracy, color correctness, and clarity, and was scanned, mosaicked, and geo-rectified by USGS/NWRC personnel according to standard operating procedures (Steyer et al. 1995, revised 2000). The CRMS spatial viewer provided historic data for land water quantification in the project area starting in 1932. The years analyzed for land water quantities through the CRMS viewer were 1932-2010 at irregular intervals as data became available. The data provided by this tool is at a large spatial scale and is designed to show trends in land change, not exact acreages.

Water level:

To monitor water levels prior to CRMS implementation in 2006, two continuous data recorder and staff gauge stations were deployed; one in the project area and one in the Mermentau River (figure 2). Water level data was used to determine if the project area water level was being maintained within the target range (Sharp and Guidry 2011). Project specific monitoring ceased in April, 2004 except for the continuous recorder ME11-01R, located at the confluence of Humble Canal and the Mermentau River, which has been active from 2000 through 2018. CRMS monitoring in the project area began in November, 2006 and five CRMS sites were used to monitor project, reference and Mermentau River water level along with ME11-01R. All water level and marsh elevation data in this report are reported in GEOID 12A to compare between locations based on a 2014 coastwide CRMS survey effort.

Salinity:

Salinity was monitored monthly at permanent discrete sampling stations within the project area until 2003 and with continuous data recorders in the project and reference areas as well as at CRMS sites. Discrete salinity data was used to characterize the spatial variation in salinity throughout the project area, and to determine if project area salinity was being maintained within the target range. The continuous recorder ME11-01R has been actively collecting data from 2000-2018 and is located at the confluence of Humble Canal and the Mermentau River. This project specific recorder and five CRMS sites were used to monitor project, reference and Mermentau River salinity after November, 2006.

Emergent Vegetation:

To assess the impact of the project on vegetation, vegetation monitoring stations were established systematically along transects throughout the project and reference area (figure 2). Stations were monitored using a modified Braun-Blanquet sampling method as outlined in (Steyer et al. 1995). Percent cover, height of dominant species, and species richness was documented in 4 m^2 sampling plots. Vegetation was evaluated at the sampling sites in the fall of 2000 (pre-construction) and in the fall of 2003 (post-construction). A subset of the vegetation stations were sampled after Hurricane Rita in 2005, 2006, 2007 and 2008. Beginning in 2006 vegetation was monitored at five CRMS sites inside and outside of the project boundaries. Individual species' cover data from project specific monitoring and CRMS stations were summarized according to the Floristic Quality Index (FQI) method utilized by CRMS (Cretini et al. 2011) where cover is qualified by scoring species according to whether they are generally associated with disturbance or stability. Vegetation data was also assigned a salinity category based on what marsh type the individual species were most commonly found, e.g. fresh, intermediate, brackish, and saline, along with transitional classes such as fresh-intermediate, intermediate-brackish, and brackish-saline using the Visser classifications (Visser et al. 2002). This approach examines marsh type transitions and trends as the process of changing classifications takes place. The CRMS percent cover and layer height vegetation data was transformed into a three dimensional vegetation volume and then indexed by marsh type to generate a 0-100 score for the vegetation volume present (Wood et al. 2015). This metric focuses on the quantity of vegetation present irrespective of species and can aid in the separation of similar marsh types with different growth potential.

Submerged Aquatic Vegetation (SAV):

The effect of the project on SAV abundance was determined by comparing SAV abundance before and after project construction. Three ponds were sampled in the project area and three in the reference with two transects sampled in each pond (figure 2). Frequency of SAV occurrence was determined by methods described in Chabreck and Hoffpauir (1962) and Nyman and Chabreck (1995). SAV was evaluated in the fall of 2000 (pre-construction) and in the fall of 2003 (post construction) (Sharp and Guidry 2011).

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 (figure 1). Data types collected at CRMS sites include hydrologic from continuous recorders, vegetative, physical soil characteristics, discrete porewater salinity, surface elevation change, vertical accretion and land-water analysis of a 1 km^2 area encompassing the station (Folse et al. 2018). For this report, hydrologic and vegetation data were used to assess project goals and physical soil characteristics, discrete porewater salinity, surface elevation change, and land-water analysis were used to provide contextual information for the project. Data was utilized from two sites within the project area (CRMS0624 – northern project area and CRMS2493 – southern project area) and from two CRMS reference sites adjacent to the project area (CRMS0583 and CRMS0605) and a CRMS reference site in an area under similar hydrologic conditions to the project specific recorder ME11-01R which is still active (CRMS0584).

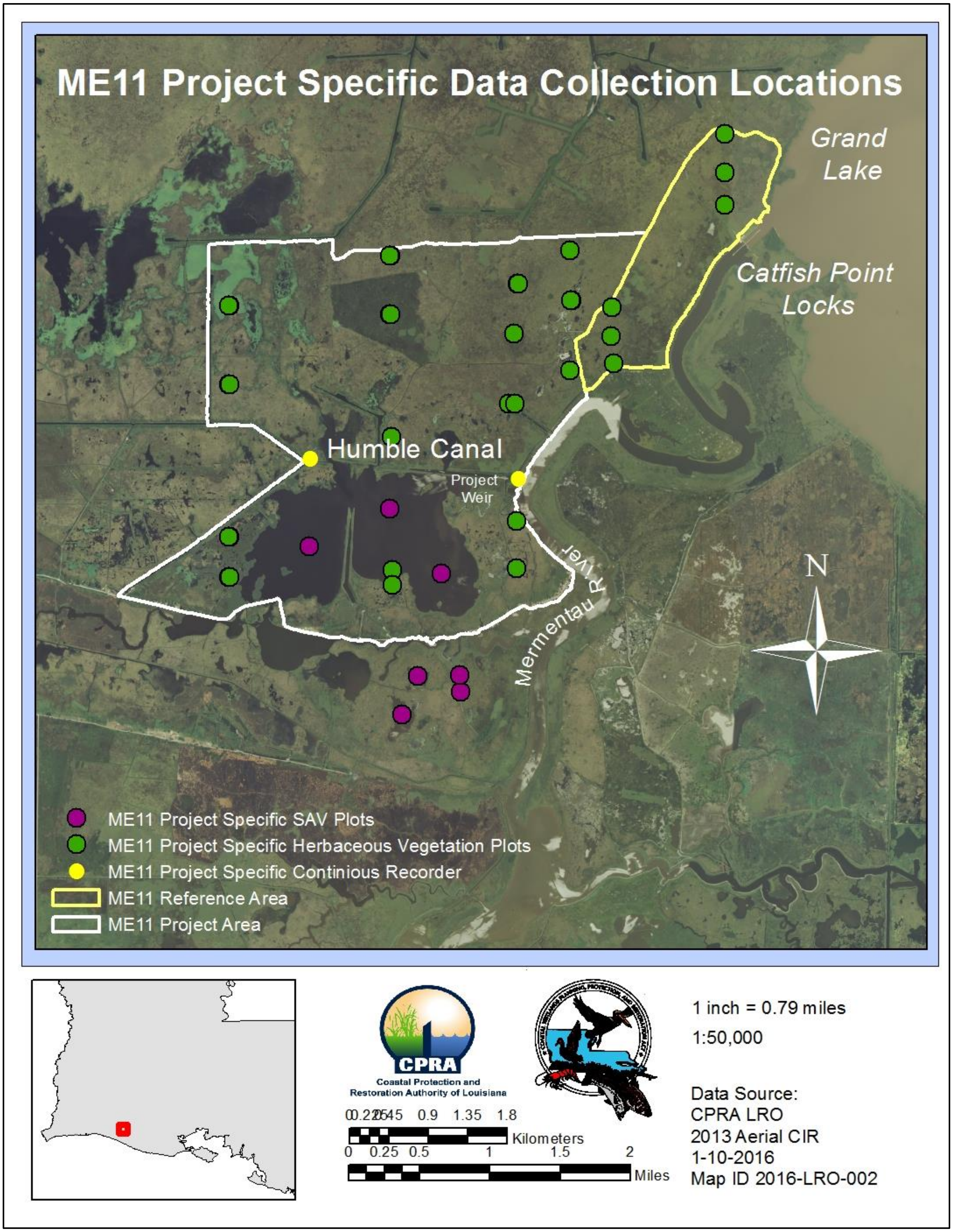

Figure 2. ME-11 project and reference areas with locations of project specific continuous data recorders, vegetation, and SAV stations.

IV. Monitoring Activity (continued)

c. Monitoring Results and Discussion

Aerial photography:

The Land:Water analysis of project and reference areas was conducted on November 20, 2000 (figure 3) and October 25, 2005 (figure 4). The project goal was to increase the Land:Water ratio from 2000 to 2005 but the project area lost 7 acres of land and the reference area lost 2 acres (table 1). Both values represent less than 1% of the respective areas. Note that the post construction photography was taken right after Hurricane Rita which negatively affected the values. The land to water ratio in the project area was almost unchanged from 2000 to 2005 as the majority of the land loss in the northern part of the project was offset by land gain in the southern project area (figure 5). The more widespread land loss impacts of Hurricane Rita were seen to the west and north of the project area causing extensive damage to area marshes that failed to revegetate (Couvillion et al 2011, 2017).

Analysis of moderate scale multi-temporal photography at CRMS sites was used to view a longer temporal scale of land change in and around the ME-11 project area (1932-2016). The historic large scale land to water conversion at the project CRMS site 2493 and reference CRMS site 0605 took place during the time period from 1932 to 1987 with both locations' land mass shrinking 39.6% and 51.1% respectively (figure 6). The Mermentau River reference CRMS site 0584 lost land over this period also but at a much lower pace of 15.2%. The most variable site was the reference CRMS site 0605 which dramatically lost land during the 1932 to 1977 time frame, losing over 50% of the marsh. Reference CRMS site 0605 rebounded, gaining back nearly all of the surrendered land by 1995; just to again lose much of that land through 2009. The project and reference CRMS sites 0624 and 0583 varied only marginally throughout the entire course of record from 1932 to 2016. The Mermentau River reference CRMS site 0584 did undergo a slow methodical land loss of 11.0%, until 2005 after which it has remained stable. CRMS site 0605 gained land in 2010, likely due to the extensive drought in the area. Overall the project area has remained stable from 1985 through 2016 based on the absences of a slope in the percent land change analysis (figure 7).

Table 1. Land:Water acreages of the project and reference areas from 2000 (pre-construction) and 2005 (post-construction) in the project and reference areas.

		Project			Reference		
Year		Acres	Hectares	%	Acres	Hectares	%
2000	Land	2993	1211	68	683	276	99
2000	Water	1401	567	32	9	4	1
2005	Land	2986	1208	68	681	276	98
2005	Water	1408	570	32	11	4	2

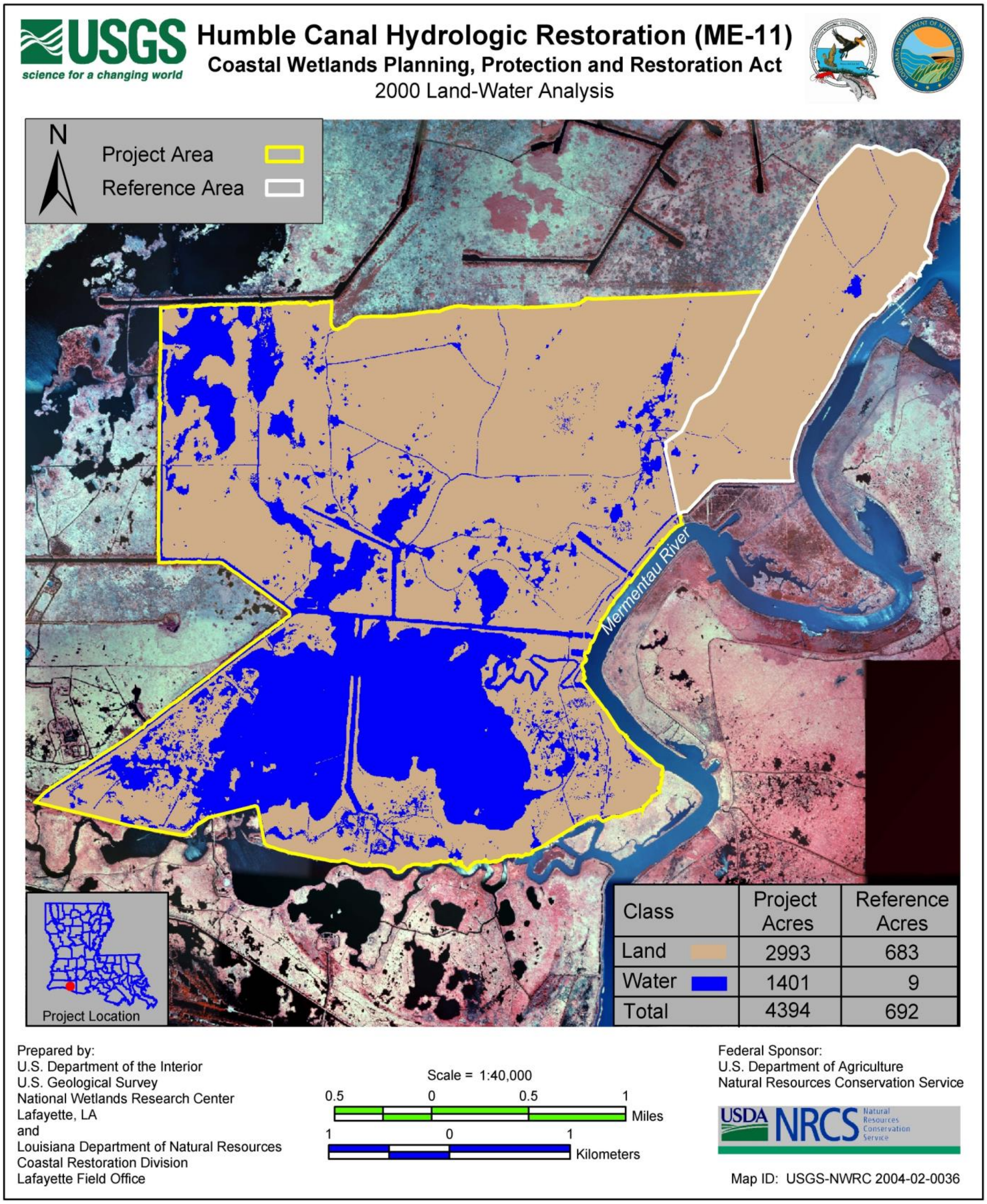

Figure 3. Land:Water analysis of aerial photography collected November 20, 2000.

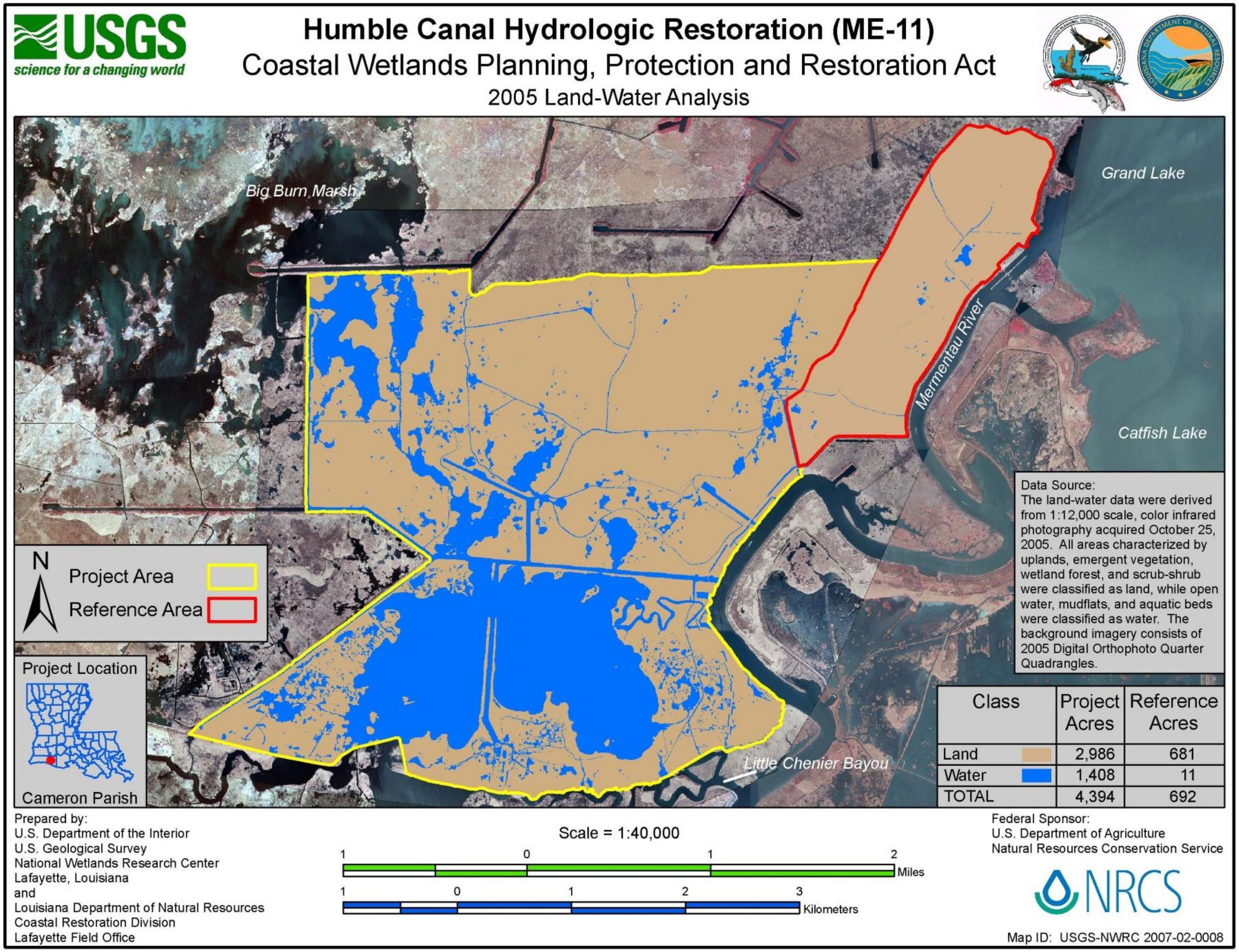

Figure 4. Land:Water analysis of aerial photography collected October 25, 2005.

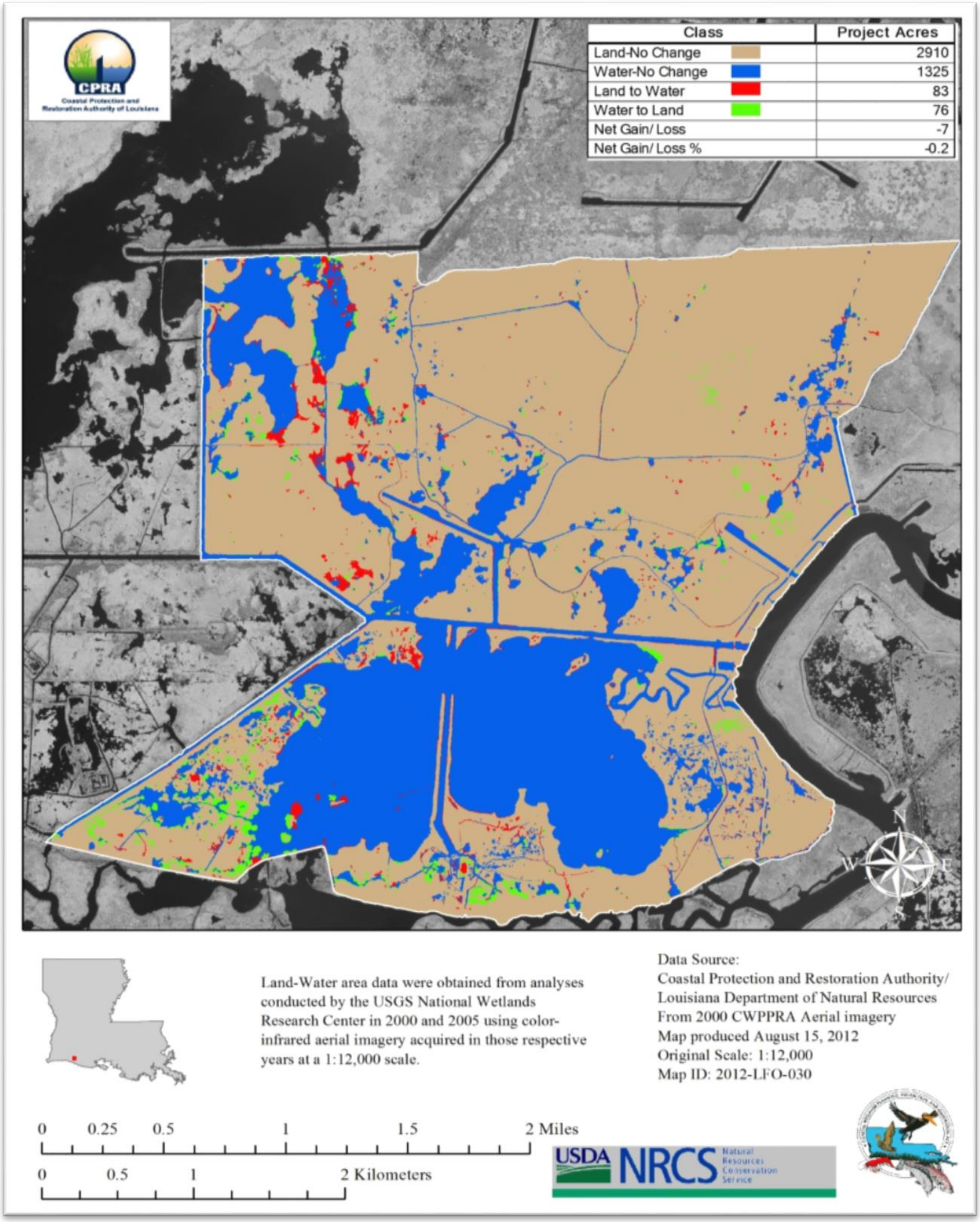

Figure 5. Land:Water analysis change between 2000 and 2005 in the ME-11 project area, there was very little total change between these two sample dates. The northern project area lost land while the southern project area gained land.

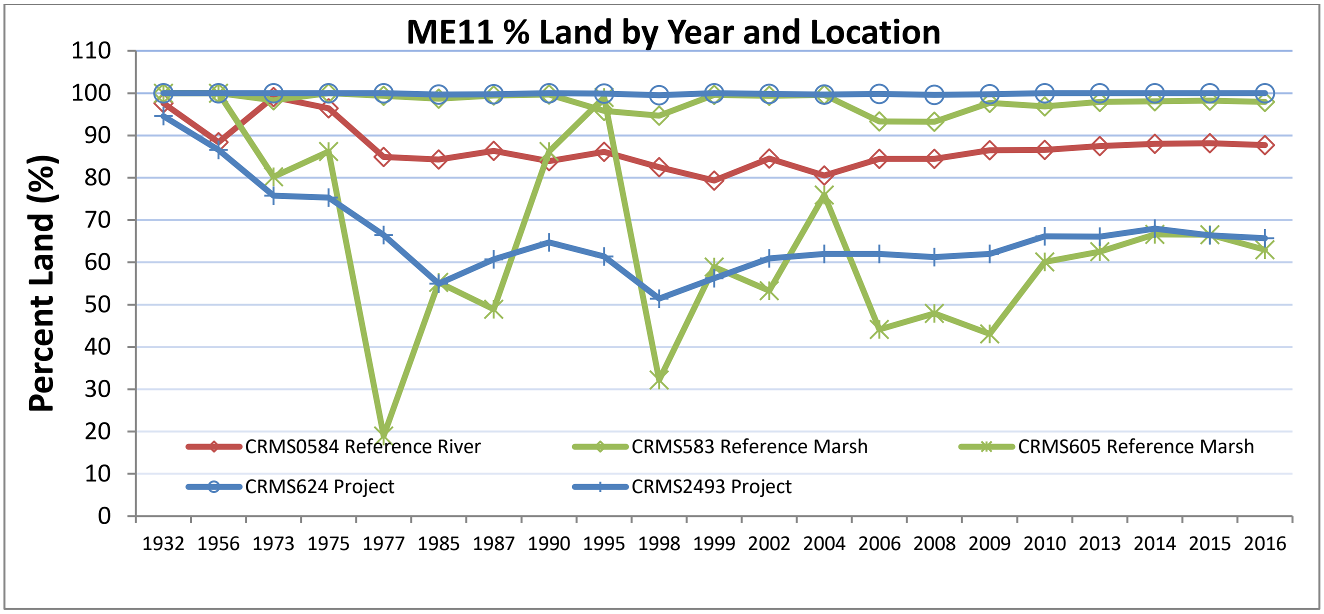

Figure 6. Percent land by year in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583), and Mermentau River reference CRMS site (CRMS0584). Note that the data displayed above is on a different spatial scale than the data in the above three figures and is for trend examination (CRMS spatial viewer land/water).

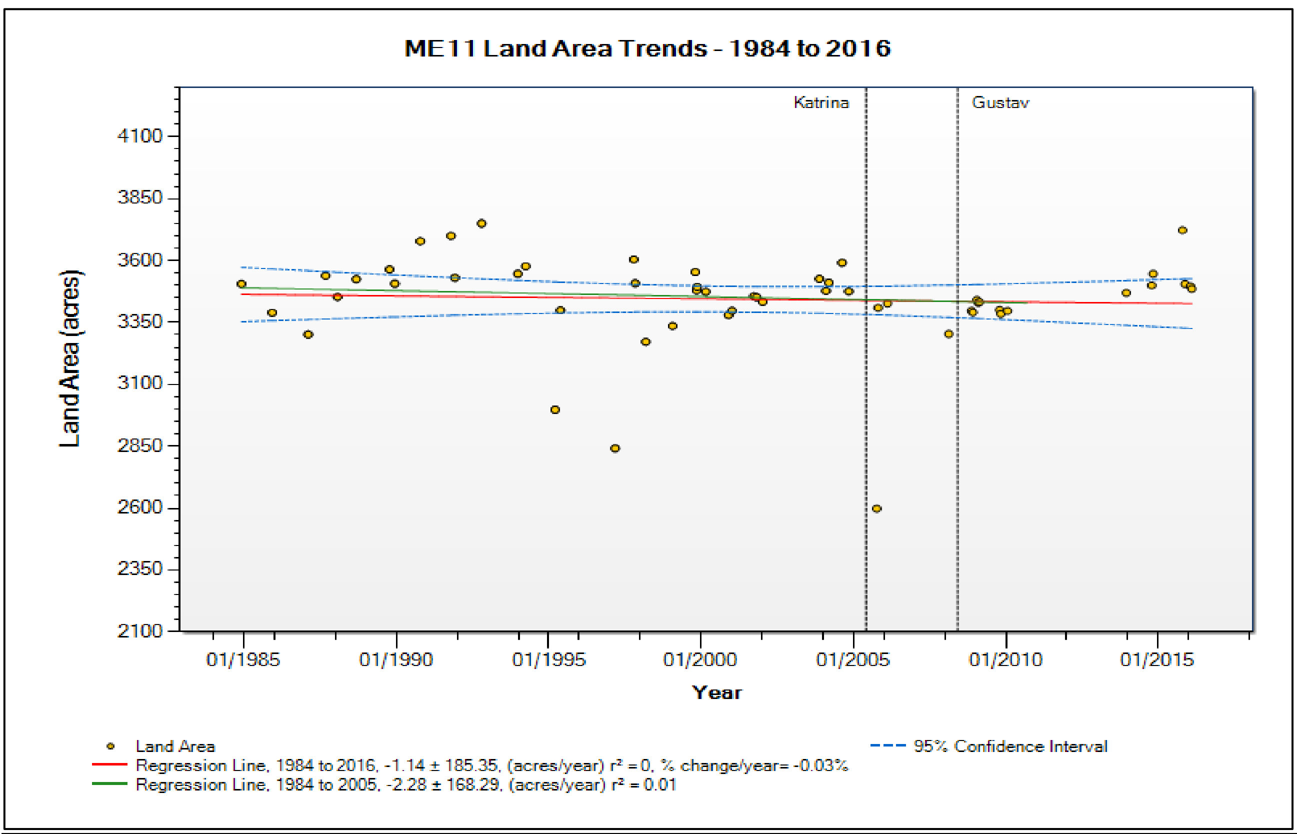

Figure 7. Percent land at the ME-11 project scale showing general stability through time.

Water Level:

The project hydrologic control structure on Humble Canal separated the wetlands west of the Mermentau River from the frequently saline waters of the Mermentau River. A consequence of this separation is reduced hydrologic capacity for drainage under heavy upland rainfall conditions and the loss of input from the river during low precipitation periods, though this water would typically be saline. The goal for water level was to maintain flooding between six inches below and two inches above marsh elevation. The overall water level trends from 2000 through 2018 show that in general the three locations respond similar on a monthly time scale (figure 8). However large environmental stimuli effect these locations differently. Hurricane Ike in late 2008 pushed large amounts of water into the upper Mermentau basin but the project CRMS sites (1.15 ft) received less peak flooding than the reference CRMS sites (2.35 ft) by more than a foot. This trend continued during the extreme drought of 2010-2011 when on three separate occasions the project and reference CRMS sites dropped well below the Mermentau River reference recorder ME11-01R average for several months reaching an extreme in July of over one foot difference. In general the reference CRMS sites' water elevation is higher than that of the ME11-01R location which is in turn higher that the CRMS project locations. The CRMS project sites generally have a lower water level compared to these two references locations likely due to the project water control structure.

The project and reference CRMS sites tracked similarly on a yearly basis, maintaining in target water levels approximately equal percentages of the year, though after 2012 the reference sites were in target slightly more than the project sites due to a higher marsh elevation. The Mermentau River reference recorder was generally more variable than these two locations with the exception of 2007, 2009, and 2018 (figure 9). During the drought conditions of 2010-2011 the ME11-01R site was in target much more often than the CRMS project or reference sites as their water levels were extremely low. Conversely the heavier rainfall years of 2012-2015 showed that the project and reference CRMS sites were within target significantly more than the Mermentau River. For the first time in several years the project and reference marshes were below target in 2018; this was due to lower spring rainfall and the completion of a new flood control structure. The monitoring plan called for BACI analysis of whether the proportion of time water levels were within the target range varied pre and post construction in the project and reference area. The proportion of each week within the target range was calculated from project and reference recorders from 2000 to 2004. Concurrent data were used in non-parametric one-way ANOVA tests which revealed that there was no significant difference between the areas pre and post construction ($\chi^2 = 0.3205$, $p<0.5713$) (Sharp and Guidry 2011). Water level was beyond the target range around 70% of the time in the project area and 60% of the time in the reference area both pre and post construction. A similar analysis between the project CRMS sites, reference CRMS sites, and the Mermentau River reference recorder ME11-01R was conducted on weekly average water level during 2008 to 2018. Water level was within the target range approximately 44% of the time in the reference CRMS sites, while the project CRMS sites were within target 42% of the time; these differences were not significantly different based on a non-parametric Median test ($\chi^2 = 0.294$, $p<0.588$). This model was conducted on weekly averages across the years 2008-2018 to use only concurrent data. The Mermentau River reference recorder ME11-01R at 33% in target was less than that of the project CRMS sites. Concurrent data was used in a non-parametric Median test which showed a distinct difference between these locations ($\chi^2 = 12.884$, $p<0.0003$).

In the project CRMS sites, water levels were consistently at or below the target in the dry years (2010, 2011, and 2018) and were generally above target in wetter years (2012, 2013, 2015, and 2016). This suggests that the project structure cannot efficiently remove large volumes of water from the project area under heavy rainfall conditions. In the project CRMS sites during 2008, water levels were in target 73.5% of the time but the project levee was also breached post Hurricane Ike to expedite upland drainage. The reference CRMS sites were in the target more often during the years 2006, 2008, and 2014; which correlate with two intentional levee breaches and a brief spring and summer drought in 2014. The reference CRMS sites were similar to the project CRMS sites in pattern but the reference sites were in target consistently more often than the project sites albeit not by a wide margin. As previously stated, a plug in an oilfield canal just north of the weir in the project area was cut by the gravity drainage district at least four times: once for Hurricane Rita, for Hurricane Ike, and for at least two other large rain events. This was the impetus for the gravity drainage district (CDD) flood control structure built just to the north of the project structure which was finished in spring 2017. The Mermentau River reference recorder was generally in the target range of water level more often during dry years due to the tidal connectivity and cross sectional volume of the water bodies associated with this site; this however comes at the expense of saline waters regularly penetrating the contiguous marshes. This trend was radically reversed during the wet years of 2012-2015 when the river recorder was over target water level between 75% and 95% of the time (figure 10). Overall the trend in the project CRMS sites was very similar to the reference CRMS sites, with water levels at or above marsh elevation dominating the flooding regime. The Mermentau River reference recorder ME11-01R was substantially different indicating that the project and reference CRMS sites are hydrologically isolated from the river. This coincides with several instances of intentional levee breaching during this period which indicates that during intense rainfall events the cross sectional area of the drainage features is not sufficient to remove excess runoff. If these breaches had not occurred there would have been larger differences between the project CRMS sites and the Mermentau River, as will likely be the case in the future now that the new non project flood control features are complete.

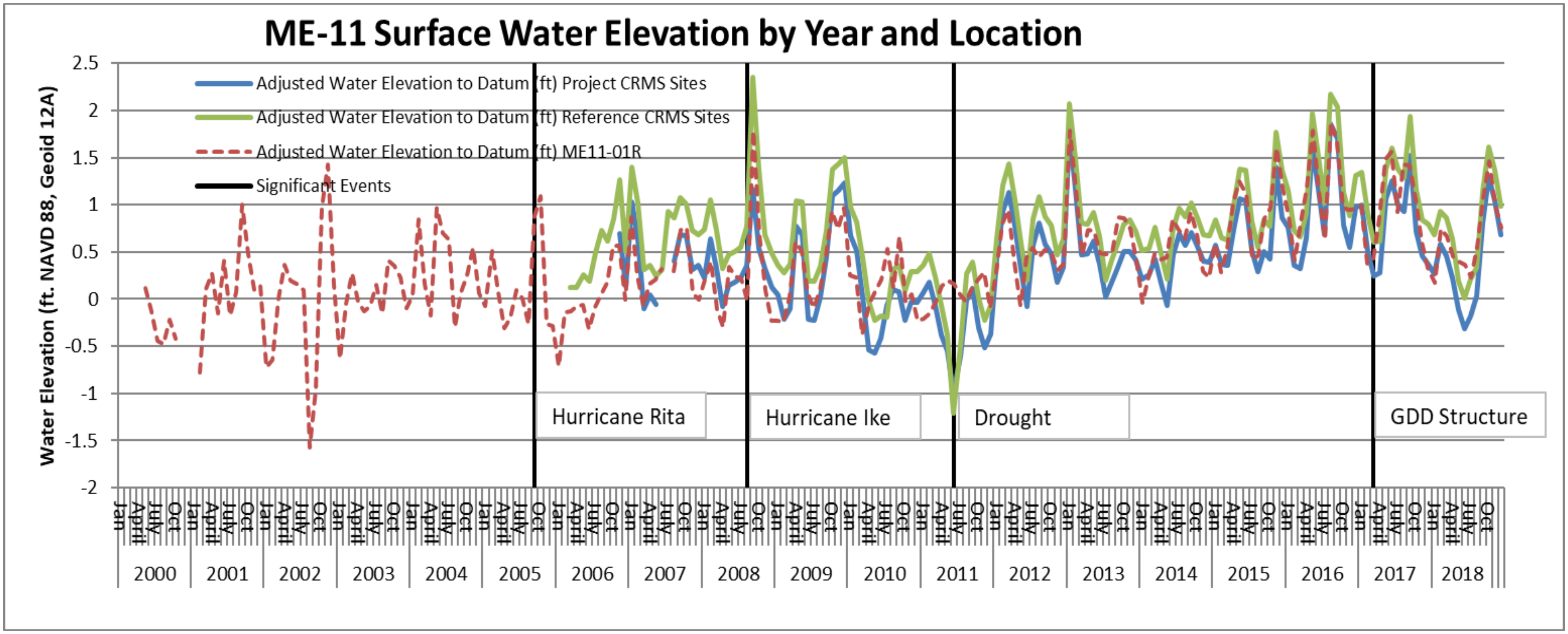

Figure 8. Monthly mean water levels in the project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and the Mermentau River reference recorder (ME11-01R). The three locations generally track similarly to one another except during extreme events. The 2011 drought shows the hydraulic separation of the project and reference marsh from the Mermentau River as water levels in the project marsh dropped below -1.0 ft. while the river remained above zero.

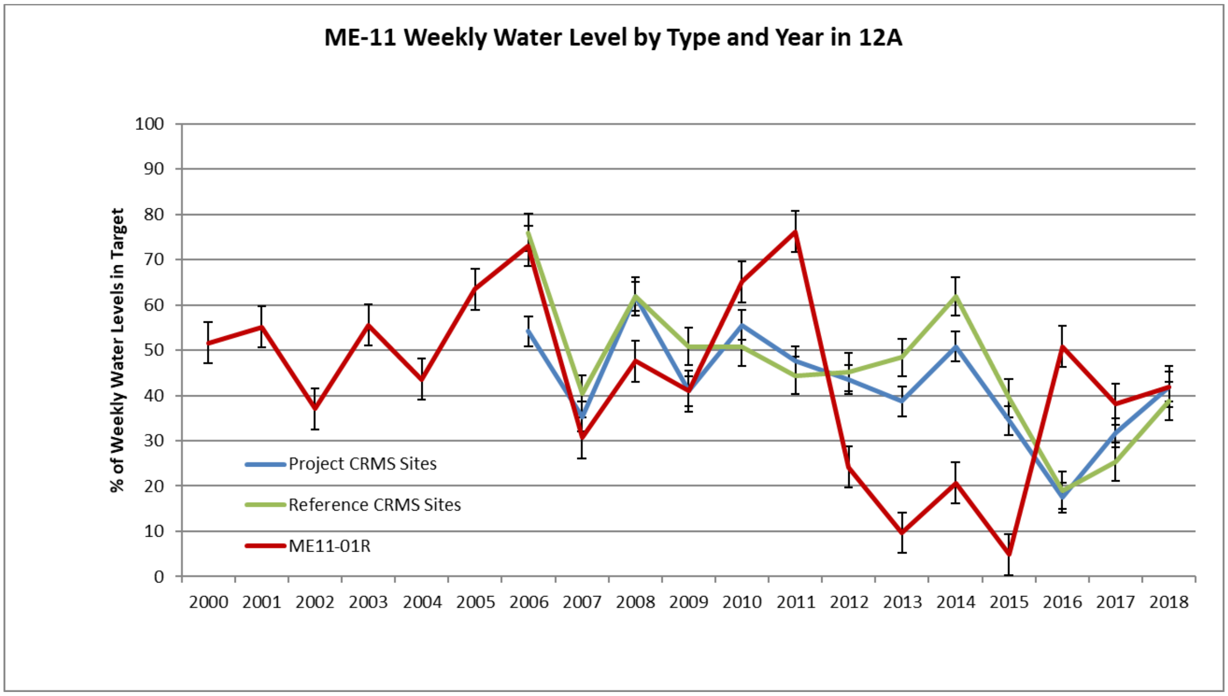

Figure 9. Percent of the year the project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and the Mermentau River reference recorder (ME11-01R) were within six inches below marsh and two inches above marsh elevation.

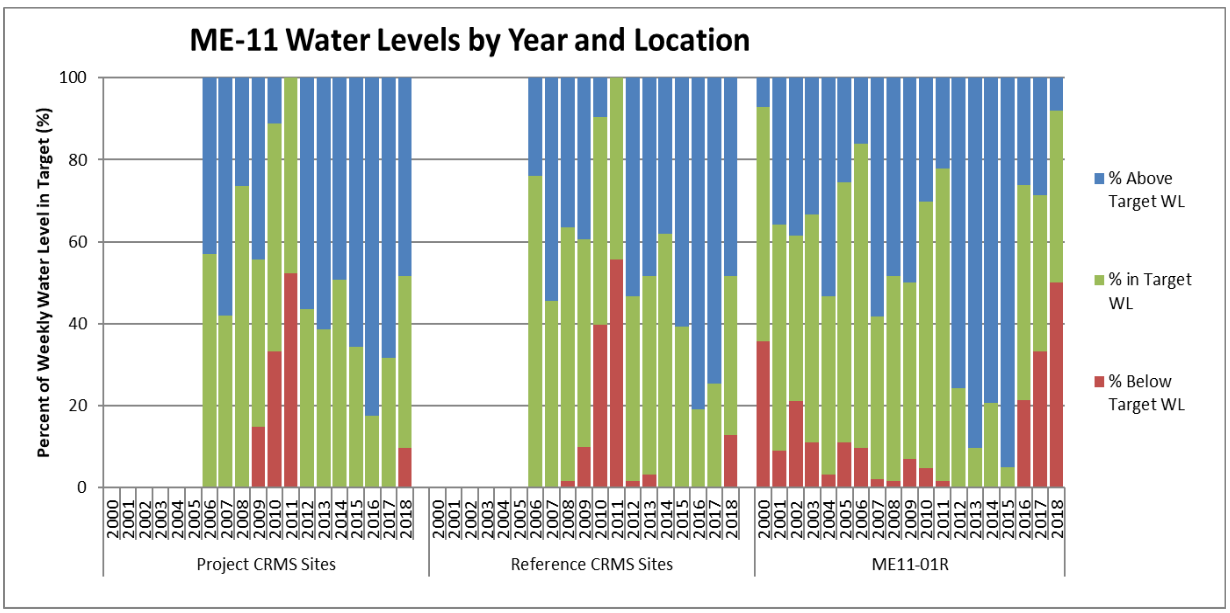

Figure 10. Percentage of the year that weekly average water levels were below target, in target, and above target range in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and the Mermentau River reference recorder (ME11-01R).

Water Salinity:

The recorders in the project and reference area showed that salinities were rarely above two ppt from September 2001 through 2004 in the project area while spikes near 10 ppt regularly occurred at the reference station. From construction through Hurricane Rita in 2005, the project weirs appear to have effectively prevented saltwater intrusion into the project area (Sharp and Guidry 2011).

The surface water salinity at the project CRMS sites, reference CRMS sites, and Mermentau River reference recorder were measured concurrently from 2007 through 2018; salinity spikes above 15ppt were common in the river and salinities rarely reached above 7 ppt in the project and reference CRMS sites (figure 11). The project was compromised by Hurricanes Rita and Ike, along with several other events. A plug in the eastern levee was mechanically breached after each storm and two other high water events, leaving the area open to tidal saltwater exchange. The gravity drainage district installed a permanent spillway structure in 2017 to prevent the need to cut the plug during high water which should allow salinities to be more effectively controlled in the project area. Although a brief drought in the spring of 2018 allowed salinities above 5ppt in the project area for most of the growing season.

The interstitial soil porewater salinity in the project CRMS sites, reference CRMS sites, and Mermentau River CRMS reference site locations were measured at 10 and 30 cm from 2006 through 2018 (figure 12). The yearly average porewater salinity in the project CRMS site and reference CRMS site locations varied from 2-8 ppt across the period of record, and were generally very stable across hurricanes, droughts, and heavy upland rain. The Mermentau River CRMS reference site soil salinity increased from 2007 through 2011, only decreasing after several wet years in succession. During the drought of 2010 the average soil salinity at the Mermentau River CRMS reference site was 18 ppt, and was considerably more saline than the other two locations, even with repeated degradations to the project area perimeter for flood control purposes. At the completion of the 2018 sampling the project, reference, and Mermentau River reference annual soil salinities have again began to diverge as the Mermentau River reference samples remained higher than 6 ppt, nearly double the other two locations.

The salinity goals were to maintain salinity in the project area under 3 ppt and to prevent peaks over 7 ppt. Specific tests prescribed in the monitoring plan called for BACI analysis of salinities and the proportion of time salinities were beyond the target range in the project and reference areas pre and post-construction. Weekly mean salinities were compared in the project and reference area pre and post construction using nonparametric one-way Median test. Differences in weekly project and reference salinities from continuous data recorders deployed concurrently from 5/2000 to 4/2004 were compared pre and post construction. There was a significant difference where project area salinities were 1.3 ppt higher than reference area salinities pre construction and were 2.3 ppt lower than reference salinities post construction ($\chi^2 = 52.16$, $p<0.0001$) (Sharp and Guidry 2011). Similarly, the percent of hourly data per week outside the target range of 3 ppt was 10% higher in the project area than in the reference area pre construction and 24% lower than the reference post construction ($\chi^2 = 23.47$, $p<0.0001$). These tests indicate that the project had the desired effects of reducing salinities in the project area relative to the reference area from May, 2000 through April, 2004. In fact, salinities weren't beyond the 3 ppt target range in the project area from 2002 to 2004, but they were occasionally above the target at the reference recorder in 2002 and 2003 suggesting the project did successfully limit saltwater access before Hurricane Rita.

A comparison of current CRMS project sites, reference sites, and the Mermentau River reference recorder ME11-01R average weekly salinities within the target range of 3 ppt was tested via a nonparametric one-way Median test across the years 2008-2018 comparing concurrent data in these locations. The project CRMS sites were within the 3 ppt target range approximately 65% of the time where the reference CRMS sites were in the 3 ppt target range 68% of the time; these differences were not significant based on a non-parametric Median test ($\chi^2 = 2.124$, $p<0.145$). The Mermentau River reference recorder ME11-01R was in the 3 ppt threshold 64% of the time compared to the project CRMS sites 65% which did statistically differ from one another ($\chi^2 = 9.522$, $p<0.0020$), but were not ecologically meaningful. The overall salinity trends in all three locations followed the broader patterns of local rainfall and storm events (figure 13). The pattern of increasing salinity due to the 2010-2011 drought and the 2005 and 2008 hurricane seasons was completely reversed from 2012-2017 (figure 14). Heavy sustained rains from 2012-2016 caused both the reference and project CRMS sites to be below 3 ppt over 70% of the time. The Mermentau River reference recorder also reversed its previous trajectory but not to the extent of the other locations (figure 15). The above average rainfall pattern ceased in 2017-2018 as a spring drought lead to increased salinities in all locations and a reduction of the in target percentage.

The higher salinity threshold of 7 ppt was rarely observed in the project and reference CRMS sites, even during the extreme drought of 2011 and never during the years 2015-2017 (figure 16). The reference CRMS sites were generally in the 7 ppt target (92%) more often than the project CRMS sites (88%) and both were significantly fresher than the Mermentau River reference site during the drier years of 2010 and 2011. The project and reference CRMS site average weekly salinities within the target range of 7 ppt was tested via a nonparametric one-way Median test across the years 2008-2018 comparing concurrent data in these two locations ($\chi^2 = 8.200$, $p<0.0042$); there was a statistical difference between the two locations, but not an ecological one. The Mermentau River reference recorder was in the 7 ppt target significantly less of the time (76%) than the project CRMS sites (88%), as shown by a nonparametric one-way Median test across the years 2008-2018 comparing concurrent data in these two locations ($\chi^2 = 74.86$, $p<0.0001$). The project features appear to be very effective at reducing salinity greater than 7 ppt in the project marsh while this higher salinity water regularly enters the upper Mermentau River, especially in drought years (figures 17). However due to the lack of hydrologic exchange at low water levels the project CRMS sites can maintain salinities above the 3 ppt level longer than the CRMS reference recorder as seen in 2010, 2013, and 2018. This is due to the evapotranspiration of surface waters and the concentration of salts held within those waters, overall the project weir does not permit high salinity water from entering the project area under most hydrologic conditions.

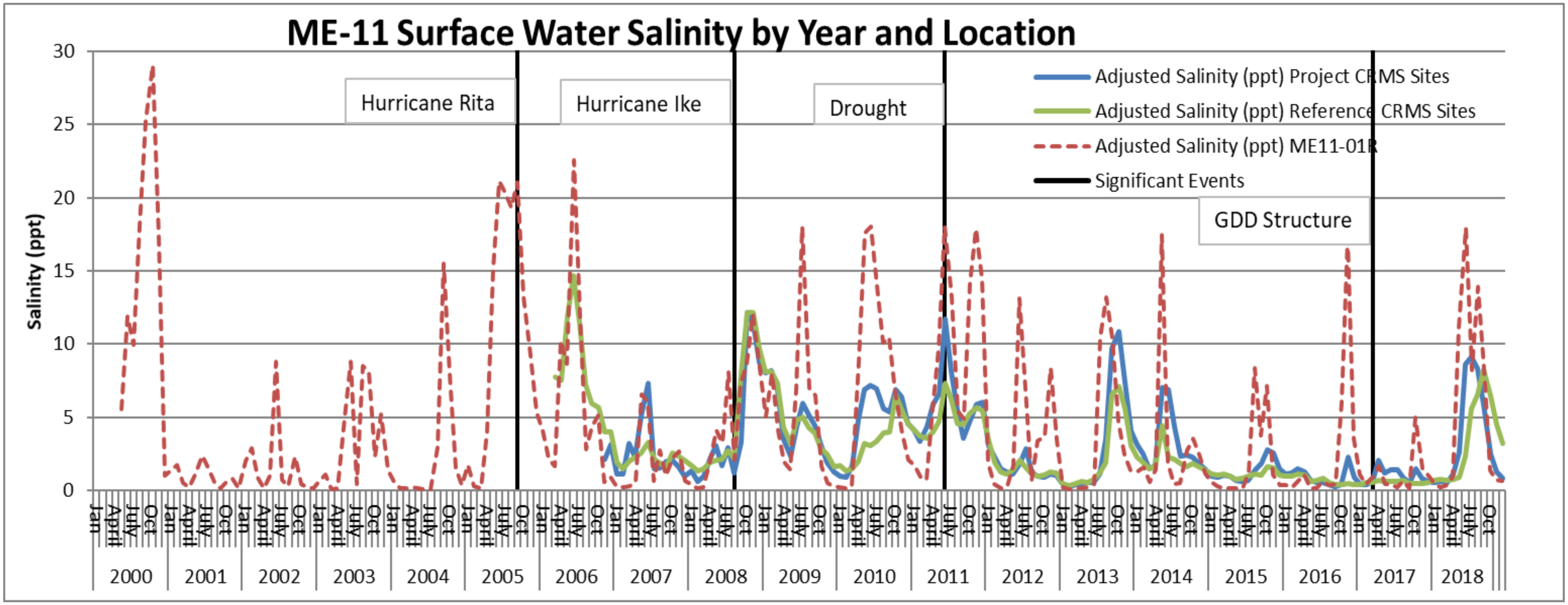

Figure 11. Monthly mean salinity in the project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and the Mermentau River reference recorder (ME11-01R). The Mermentau River reference reorder consistently has higher and more variable salinity than the project CRMS sites and the reference CRMS sites.

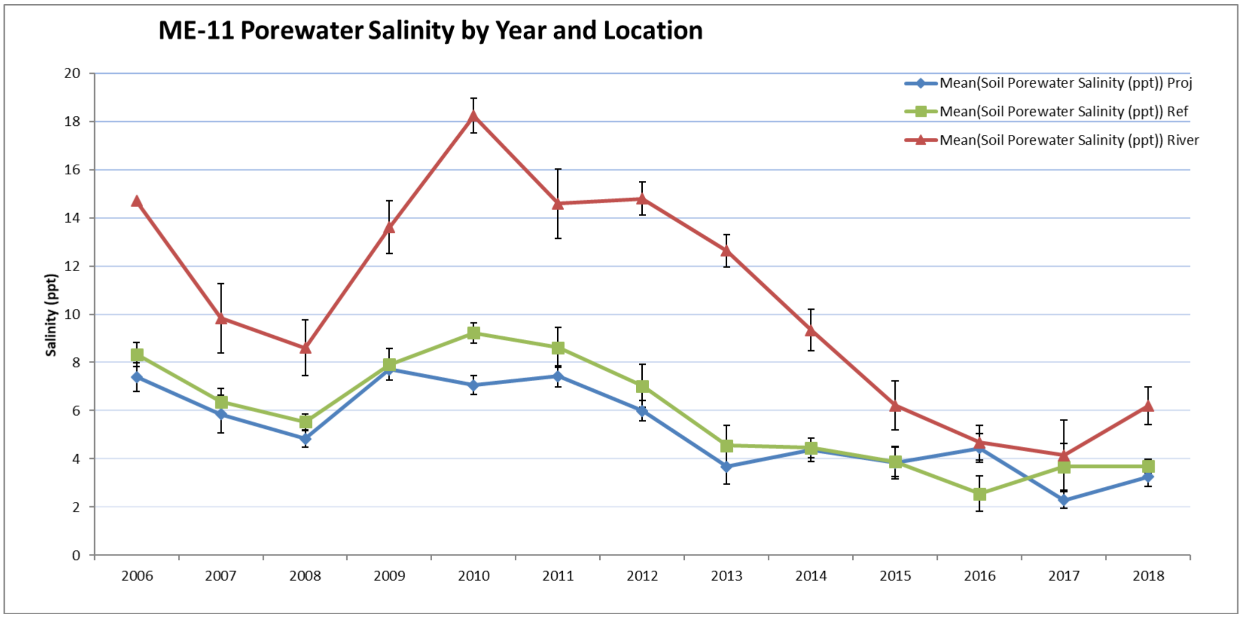

Figure 12. Yearly mean porewater salinity in the project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River CRMS reference site (CRMS0584).

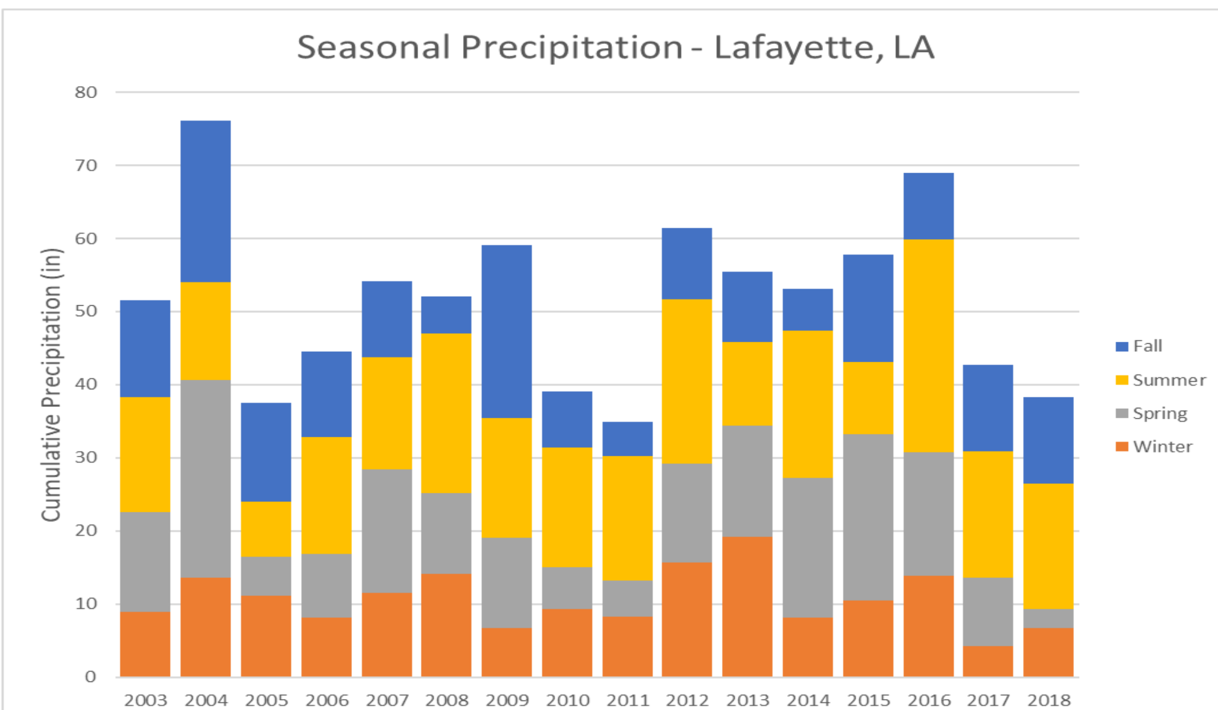

Figure 13. Precipitation at the Lafayette airport from 2003-2018. The years 2010-2011 and 2017-2018 were low rainfall whereas 2012-2016 were wetter.

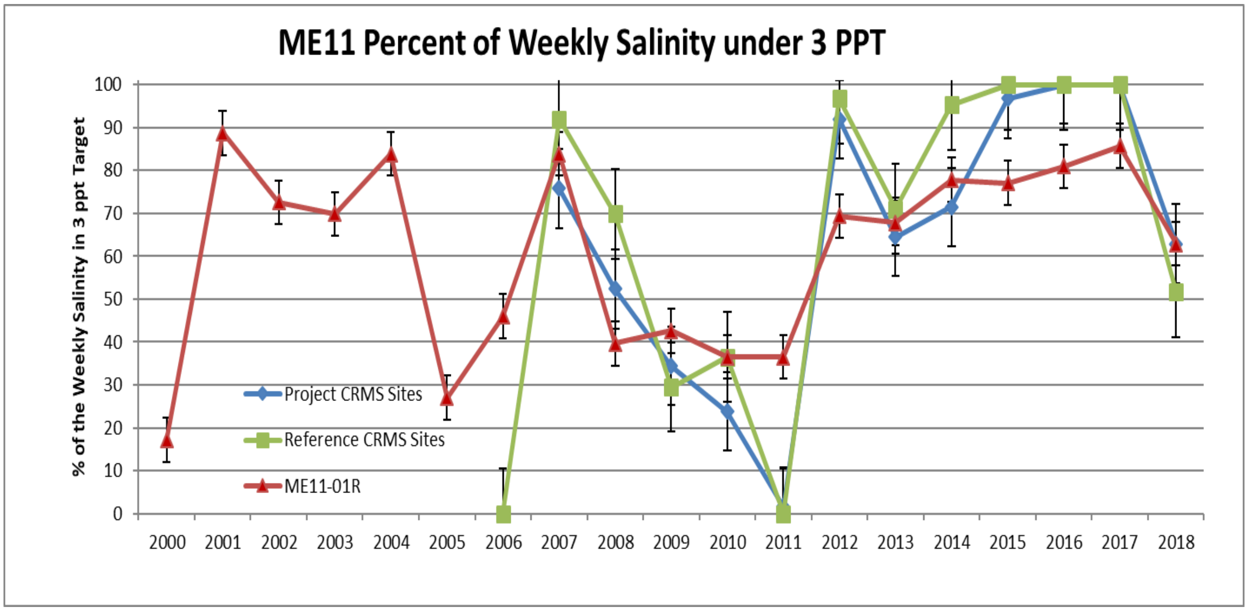

Figure 14. Percent of the year that weekly average salinity levels were in the 3 ppt target range in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference recorder (ME11-01R).

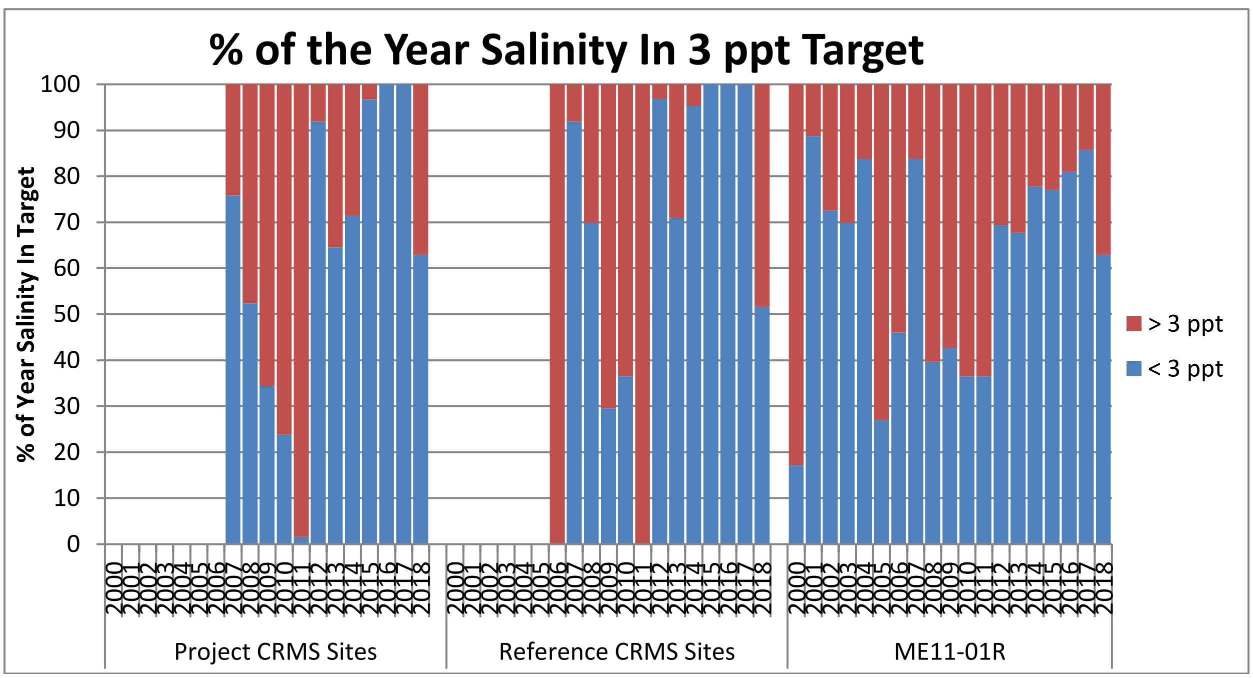

Figure 15. Percent of the year that weekly average salinity levels were in and over the 3 ppt target range in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference recorder (ME11-01R).

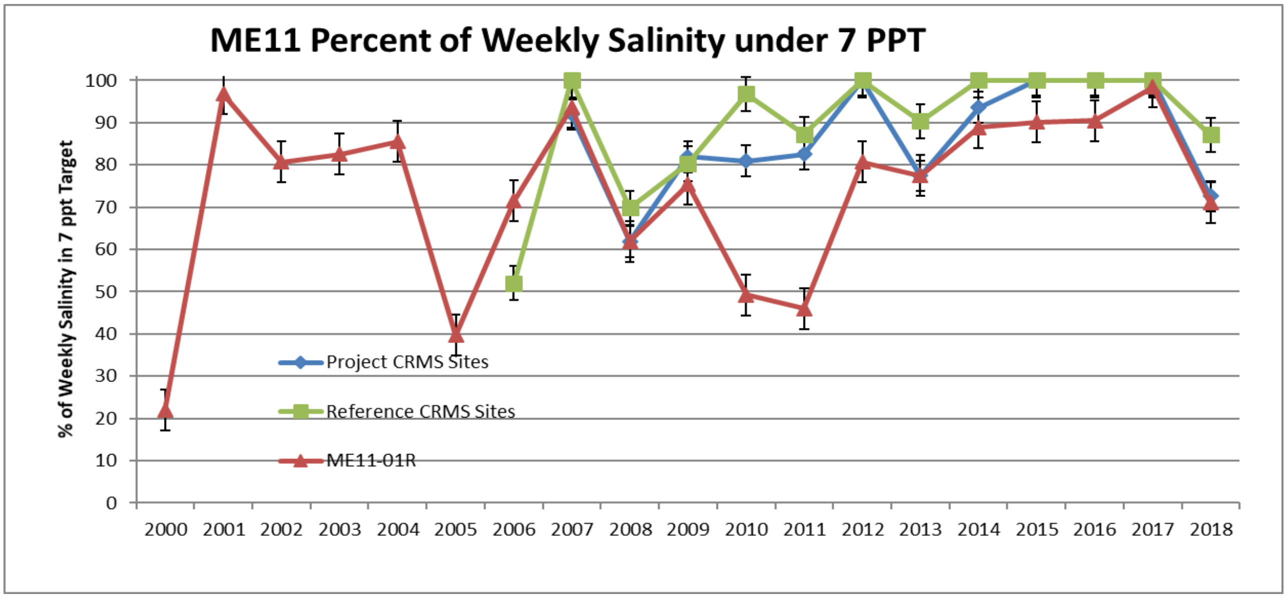

Figure 16. Percent of the year that weekly average salinity levels were in the 7 ppt target range in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference recorder (ME11-01R).

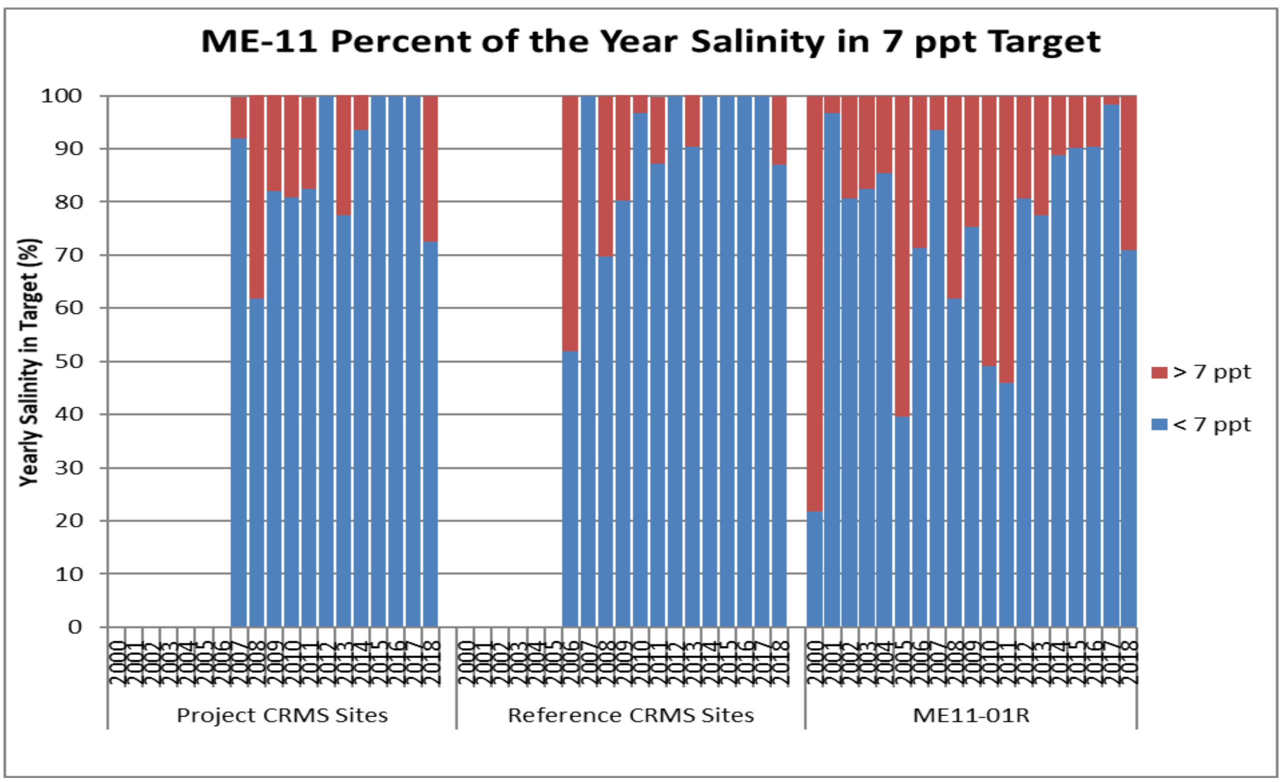

Figure 17. Percent of the year that weekly average salinity levels were in and over the 7 ppt target range in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference recorder (ME11-01R).

Emergent vegetation:

Project specific emergent vegetation data was collected pre construction in 2000, post construction in 2003 and as part of a broader post Hurricane Rita assessment at half of the vegetation stations in 2005, 2006, 2007, and 2008. The project goals were to increase the cover and occurrence of fresh marsh species in the project area. Species were classified as fresh, fresh-intermediate, intermediate and so on using classifications defined by Jenneke Visser. The 2006 through 2018 data were tested for project effects on the occurrence and cover of fresh to intermediate species as per the monitoring plan. The project area had 34.8% fresh to intermediate vegetation, the reference area 36.2%, and Mermentau River CRMS site only 10.7% fresh to intermediate cover between 2006 and 2018. The project and reference CRMS sites were nearly identical with respect to the amount of fresh to intermediate vegetation present ($F_{1,24}$=0.102, p=0.7527) in a one-way ANOVA. However the project CRMS sites were less variable and were increasing in fresh to intermediate vegetation while the reference CRMS sites varied depending more so on rainfall thus having increased from 2013-2017. The results of the project CRMS sites compared to the Mermentau River CRMS site showed a significantly larger quantity of fresh to intermediate vegetation in the project, where those classes had been almost completely lost in the Mermentau River CRMS site starting in 2009 and continuing through 2012 ($F_{1,24}$=39.04, p=0.0001), but returned after several high rainfall years and new management practices.

All available vegetation data from ME-11 project specific sites and project specific reference sites were summarized according to marsh type classifications over time for a similar vegetation salinity assessment. The subset of ME-11 stations sampled through 2008 showed that after Hurricane Rita there was higher percent cover in the project area than the reference but the project area wasn't necessarily composed of fresher species than the reference area (figure 18). This assessment diverges from the findings of the more current CRMS data which shows different trajectories inside and outside the project area from 2006-2018.

The project CRMS sites (CRMS0624 and CRMS2493) had similar percent cover and vegetation types to the reference CRMS sites (CRMS0583 and CRMS0605). The project CRMS sites are transitioning to fresher species at the expense of intermediate-brackish species consistently through the project life, whereas the reference CRMS sites appear to be maintaining intermediate vegetation while adding a fresher assemblage when conditions allow. The Mermentau River CRMS site (CRMS0583) had converted to a majority of intermediate-brackish through saline vegetation following 2008 as overall vegetation cover receded and became saltier. But similarly to the CRMS reference sites, the vegetation community reversed course as the local salinity regime changed abruptly in 2012, due to increased rainfall and later management and structural improvements, though it took until 2014-2015 to become apparent in the vegetation data, likely due to persistently high interstitial soil salinities. The project CRMS sites have recovered from the hurricanes of 2005 and 2008 and are steadily increasing in fresh to intermediate vegetation coverage. The reference CRMS sites have also recovered to pre hurricane levels but have done so with a saltier cohort of vegetation until 2014. The Mermentau River CRMS site was a brackish marsh even under the influence of heavy local and upland rains in 2012-2016, but reduced porewater salinities have increased the cover and diversity of vegetation through 2018. The project does effectively shelter the marsh from conditions that would encourage the growth of more brackish and saline species and promotes fresh and intermediate vegetation survival, though sometime at the expense of overall cover (figure 19).

Using the Floristic Quality Index (Cretini et al., 2011), it is possible to assess the quality of species that inhabit sites and to interpret what specific species might indicate about site stability. The ME-11 project specific sites and reference areas had modest FQI values before Hurricane Rita (around 70), fell in 2006, and recovered to the pre-Rita levels in the project area but not in the reference area (figure 20). Both locations held storm surge water from Hurricane Rita for several months after the storm allowing more damage to occur.

The project CRMS sites (CRMS0624 and CRMS2493) had similar percent cover and FQI values to the reference CRMS sites (CRMS0584 and CRMS0603) and both were superior in each category to the Mermentau River CRMS site (CRMS0583) through 2013 (figure 21). During 2013-2015 the project CRMS sites have diverged from both reference sites as it has continued to lose coverage and FQI value. The CRMS reference sites and the Mermentau River CRMS site have altered trajectories and have shown a meaningful increase in both metrics over the same period. The project percent cover and FQI score has continued to drop as *Spartina patens* cover has been substantially reduced. Historically at the Mermentau River CRMS site (CRMS0584), percent cover and FQI was lower in both parameters than either the project or reference CRMS sites; more recently an impressive improvement has taken place as salinities have been reduced and management practices put in place. The FQI values between the project CRMS sites (45.8) and reference CRMS sites (74.1) were significantly different in 2018 and the Mermentau River CRMS site (90.5) was markedly higher than either.

It is apparent that the project has become fresher which has caused a shift away from Spartina patens and toward other fresher species from 2014-2018. This is likely an effect of excessive freshwater flooding and the FQI will likely remain below both reference locations as fresher species have a lower FQI value in general. However even as there has been a reduction in percent cover and FQI in the project area, the overall vigor and robustness of the vegetation present in the project area has been maintained. This is represented in the Vegetation Volume and Index data (VV and VVI) (Wood et al. 2015) (figure 22). Both the project CRMS sites and the reference CRMS sites have similar upward trajectories in the vegetation volume, which is simply a measurement of the amount of vegetation present regardless of species. The VVI uses the VV and scales it by marsh type from 0-100 to increase the ease of use of the VV. In both of the reference locations, the VV and index follow the upswing in cover depicting that the increase in cover directly leads to an increase in plant material. However in the project area the percent cover was reduced as the VV and VVI was maintained leading to the conclusion that larger more robust plants replaced the pervious assemblages. So as the project area continues to transition to more fresh and intermediate vegetation the cover may increase accordingly and the vegetation volume should continue an upward slope. This is indicative of an increasingly intermediate marsh as they generally possess some of the highest VV values coastwide. The project features appear to be stabilizing the salinity regime of the project area; namely the large frequent salinity spikes that are present in the Mermentau River from the Catfish point locks to the Gulf of Mexico. As this occurs we expect to see a more diverse and robust vegetation clade compared to the reference locations.

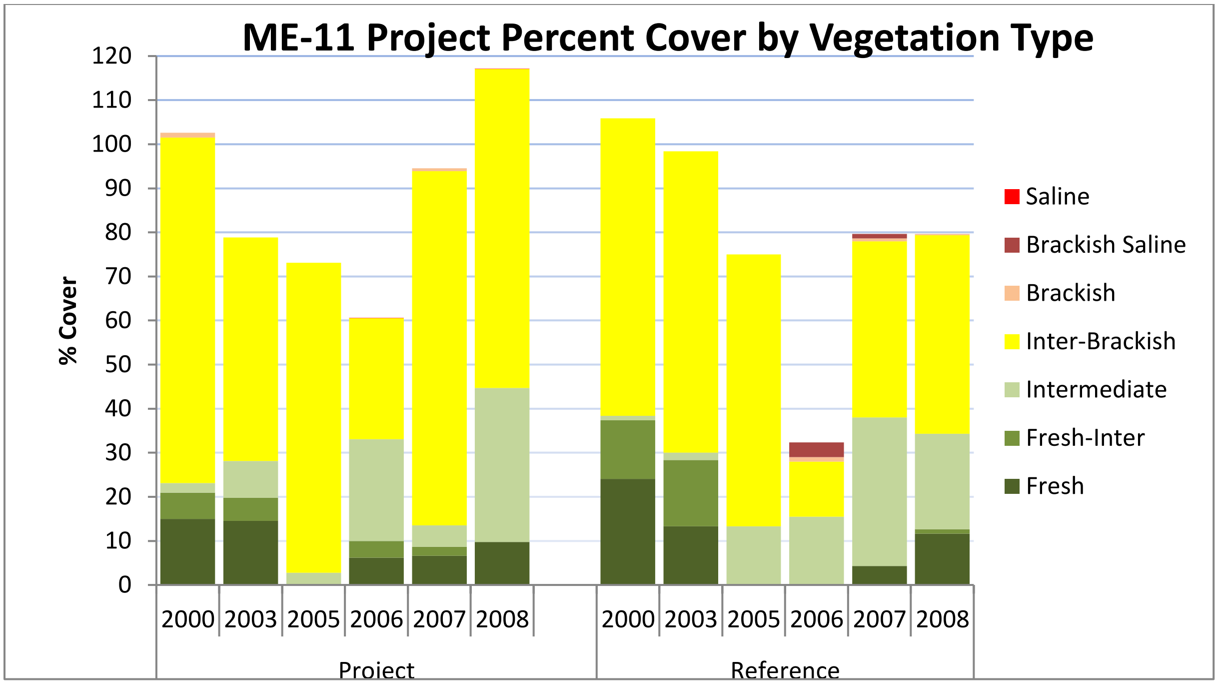

Figure 18. Percent cover by vegetation type in the project and reference area over all years of sampled cover. Data represent a subset of ME-11 **project specific** vegetation stations.

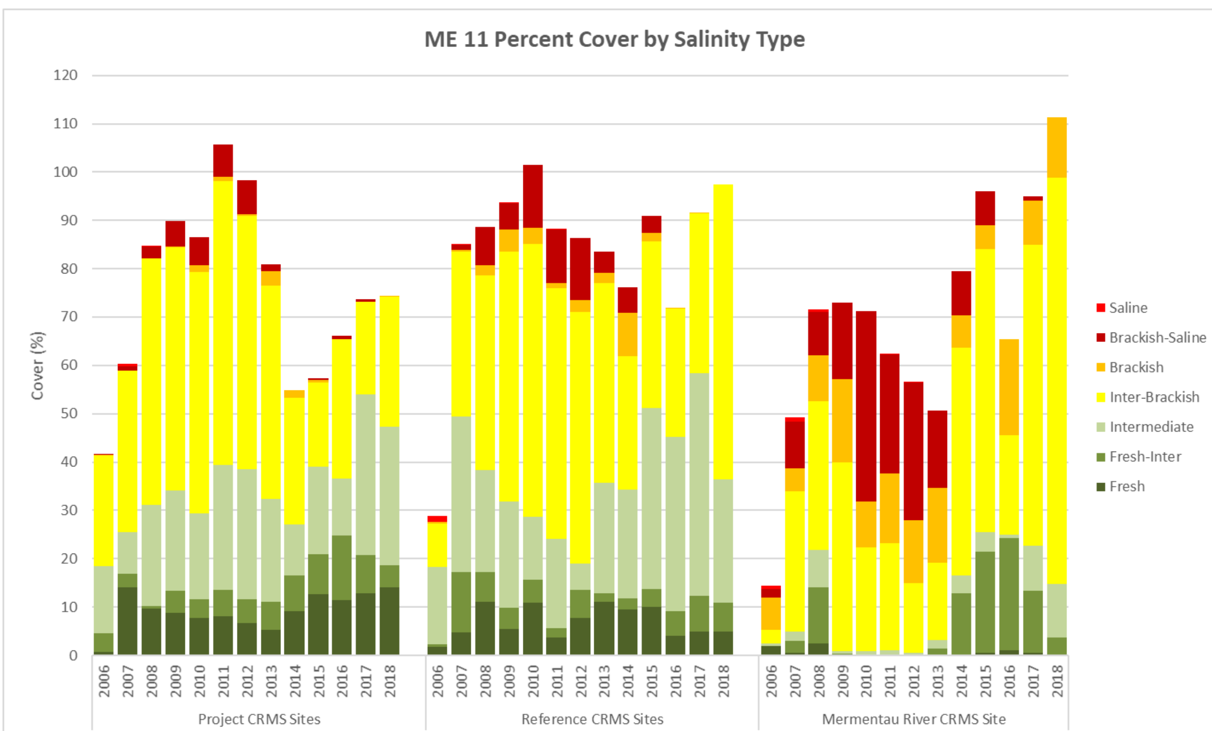

Figure 19. Percent cover by vegetation salinity type in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River CRMS reference site (CRMS0584).

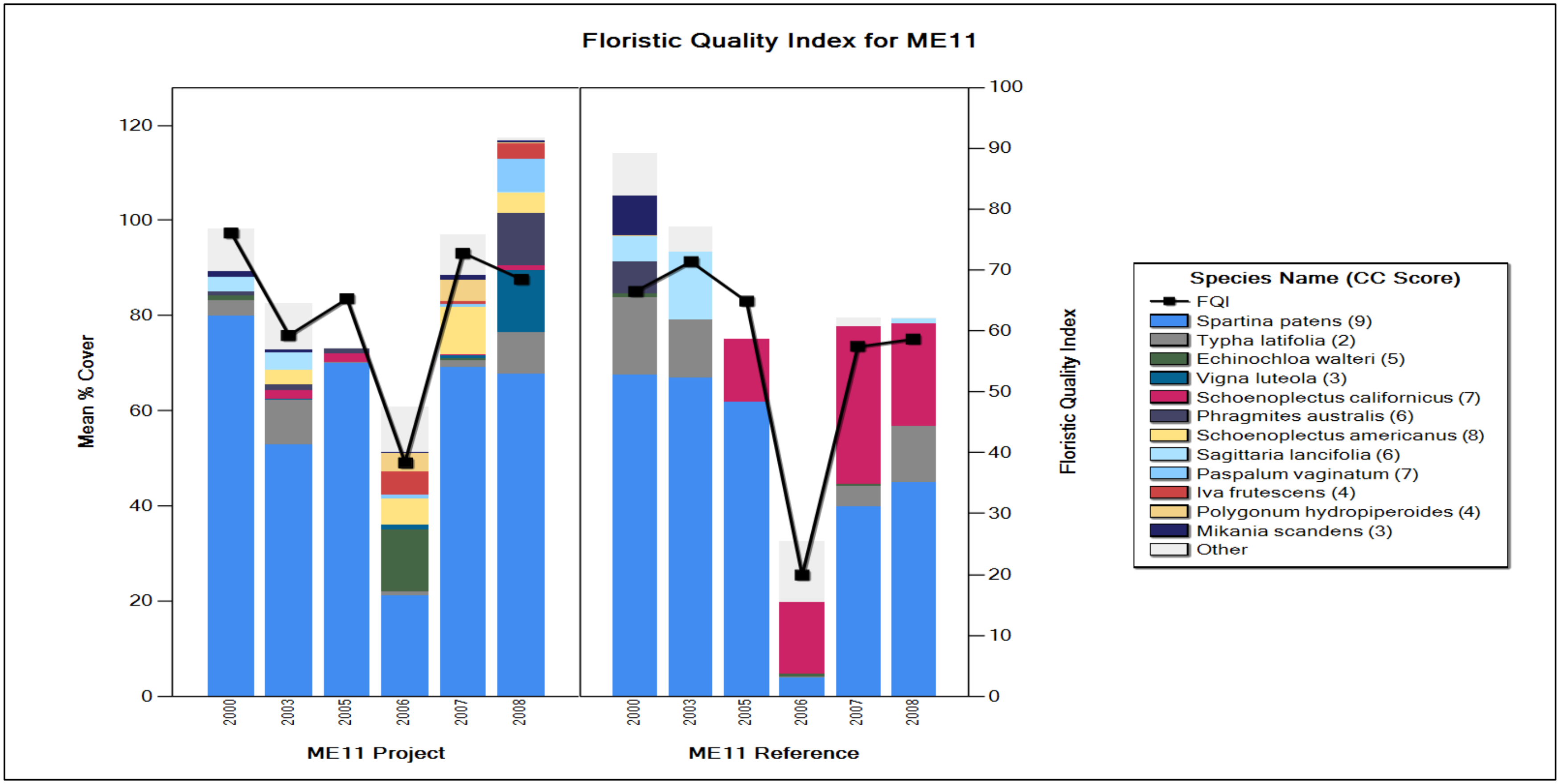

Figure 20. Percent cover of species in the ME-11 **project specific** project and reference areas and FQI score for each year. The CC Scores represent the quality of individual species from 1 to 10 where 1 represents disturbance species and 10 indicates stability.

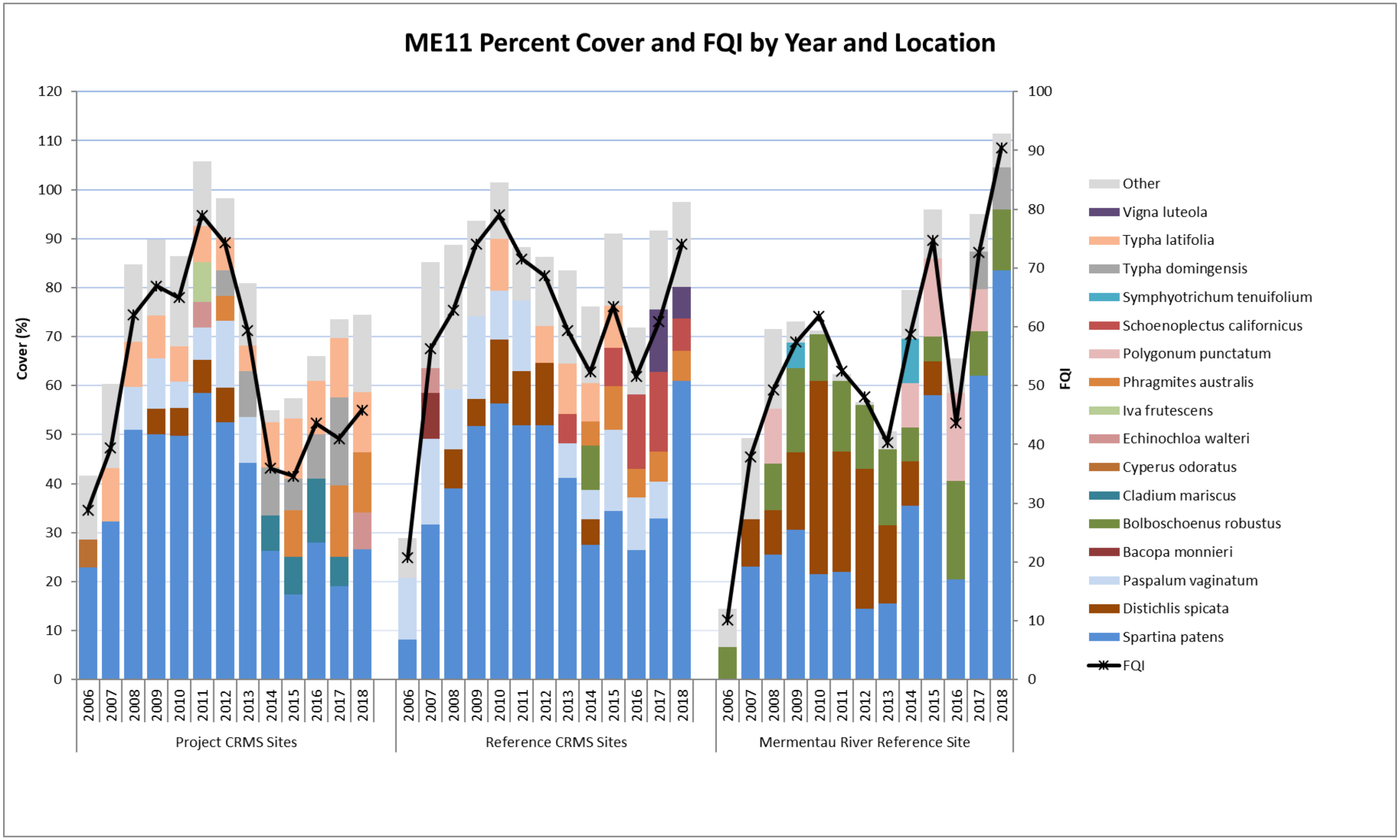

Figure 21. Percent cover and FQI in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference CRMS site (CRMS0584).

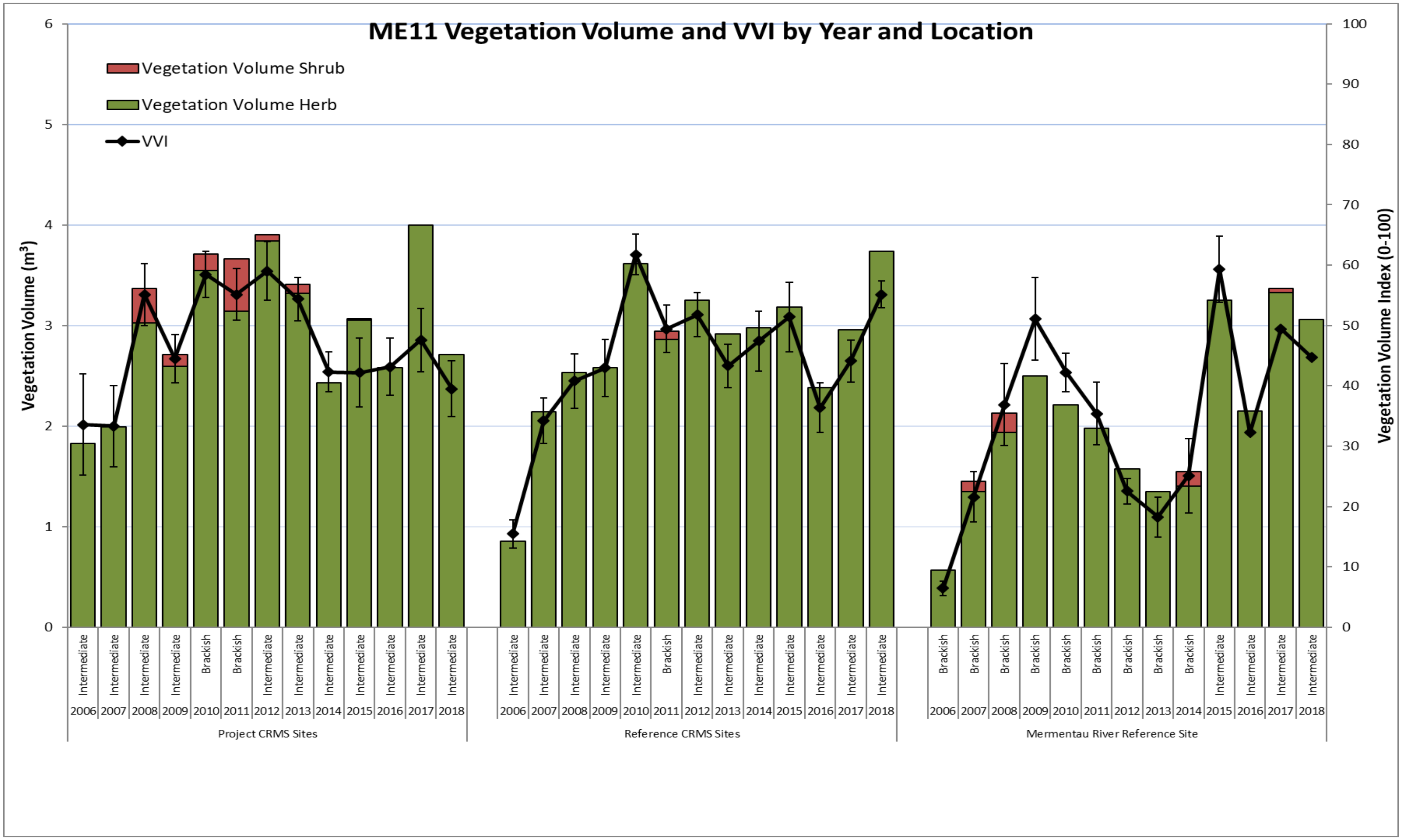

Figure 22. Vegetation Volume and VVI in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference CRMS site (CRMS0584).

Submerged aquatic vegetation:

Frequency of occurrence of SAV was quantified pre and post construction in September 2000 and October 2003. Frequency of occurrence is defined as the percent of samples SAV was found per transect. From 2000 to 2003, frequency of occurrence of SAV increased in the project area from 0% to around 50% and in the reference area from 70% to 100%. As per the monitoring plan, Analysis of Variance was used to determine whether there was a significant difference in the interaction of project/reference area and time and there was not ($F_{1,16}$=1.56, p=0.2260). SAV frequency of occurrence increased in both areas at approximately the same rate (figure 23).

SAV species richness increased from 0 to 7 species in the project area and from 2 to 6 species in the reference area (excluding Algae). The difference in SAV presence between sampling years can be attributed to salinity, which was around 20 ppt during sampling in both areas in 2000 (a drought year) and was less than 5 ppt in 2003. The SAV that was present in the reference area in 2000 was mostly salt tolerant *Ruppia maritima* with some *Ceratophyllum demersum* (figure 24). In 2003, the project area was dominated by *Najas guadalupensis* while the reference area was co-dominated by Potamogeton spp., *Najas guadalupensis*, *Vallisineria americana*, and *Chara* spp. *Cabomba caroliniana* and *Nelumbo lutea* were found in the project area and not the reference area.

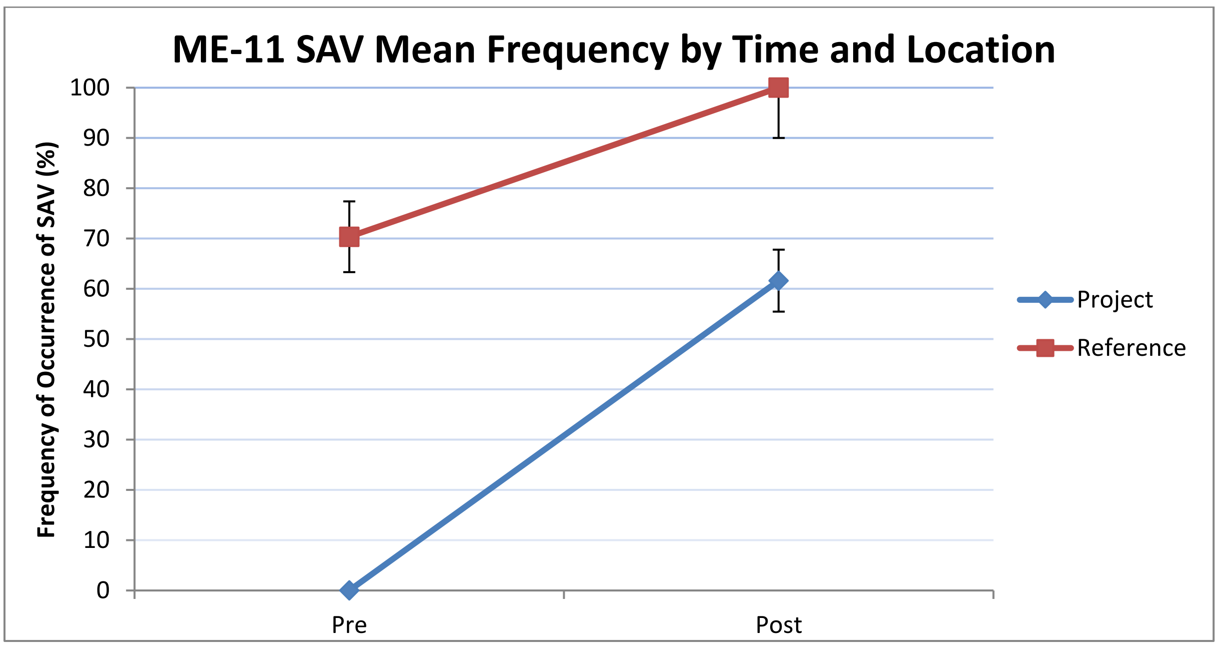

Figure 23. Mean frequency of occurrence of SAV in project and reference ponds pre and post construction. LSMean ± SE.

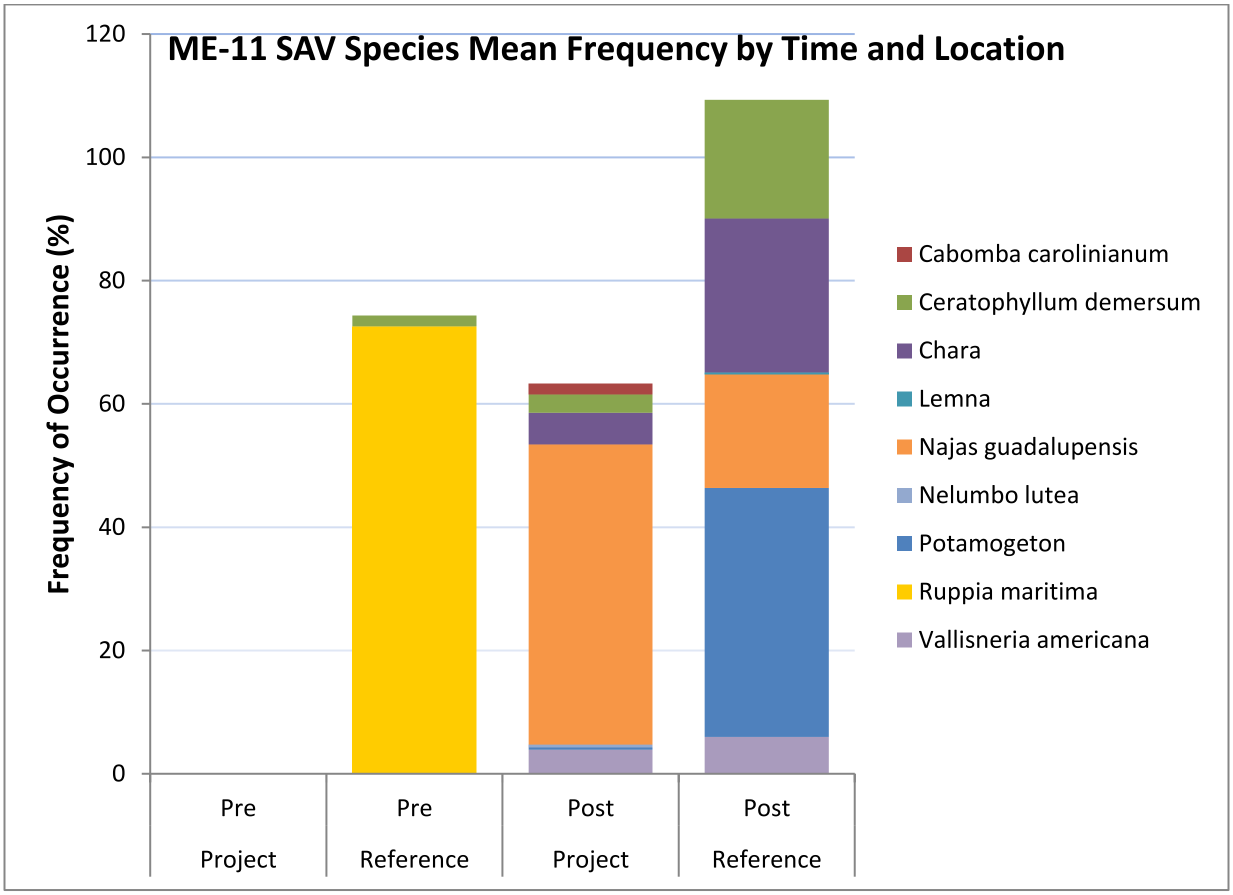

Figure 24. Mean frequency of occurrence of SAV species in the project and reference area pre and post construction. Frequency for transects averaged by area and year.

CRMS Supplemental Data:

Marsh Elevation Change:

Subsidence and accretion data collected at CRMS 0624, 2493, 0583, 0605, and 0584 from site installation through the end of 2018 yields some insight as to the nature of elevation change in the vicinity of ME-11 (figure 25). Most of these sites were experiencing substantial elevation loss during the 2010-2011 drought, as severe dewatering of the organic soils lead to highly negative rates (figure 26). These elevation change rates ranged from -0.67 cm/yr to -0.08 cm/yr, but generally were closer to -0.42 cm/yr on average. The overall pattern of elevation change was highly negative from initial measurements until 2011 at the peak of the drought. This pattern abruptly reversed during the next several years as heavy local rainfall became routine, and by 2018 the rates had in all cases reversed. This trend leads to the relatively stable annual elevation rates in the project and reference areas. This is however somewhat deceiving as there have been dynamic negative and positive rate swings depending on the local water budgets.

The estimate for relative sea level rise at Sabine Pass is 0.59 cm/yr which minimizes even the positive elevation gains and further enhances the negative or static elevation change at these CRMS sites. These values indicate elevation change rates along the interior of the Mermentau lakes sub basin are problematic in sustaining the long term productivity of the areas marshes. CRMS site 0584 had the only negative elevation change rate (- 0.015 cm/yr). This is likely due to its proximity to the Mermentau River; this location is more mineral and less prone to shrink/swell. The typical cycle in these locations is accretion building up the marshes contiguous to the river channel as interior areas are cut off and undergo sedimentation starvation. But it appears that with sufficient rainfall and salinity control the interior marshes of the project area and reference CRMS sites can maintain a roughly static elevation rate with organic production and swelling of the soils due to hydration. The soil elevation change, compared to the original marsh elevation and hydrologic prism, are used to generate individual CRMS site Submergence Vulnerability Index (SVI) values. These are then compared at larger spatial scales such as by basin, by marsh type, and coastwide to give context to local CRMS sites or project observations. The ME11 project, reference, and river CRMS sites are all above the Mermentau Basin median SVI score indicating that the majority of the sites are out of the water between 70% and 80% of the time (figure 27). However CRMS0583 is higher than the rest of the ME11 CRMS sites and is above mean water level almost 90% of the time. But when compared to both all intermediate marshes and all CRMS sites coastwide the CRMS sites in and around ME11 are generally average or below, with the exception of CRMS0583.

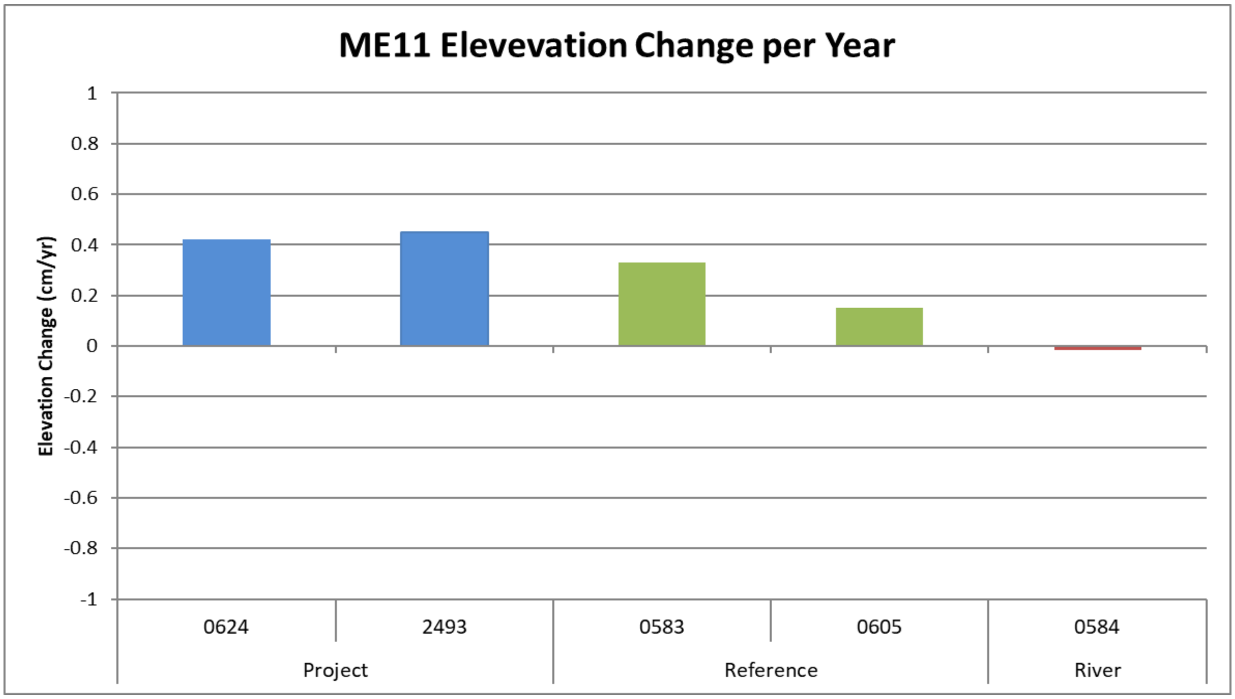

Figure 25. Elevation change per year in the project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference site (CRMS0584) based on data collected from site installation through 2018.

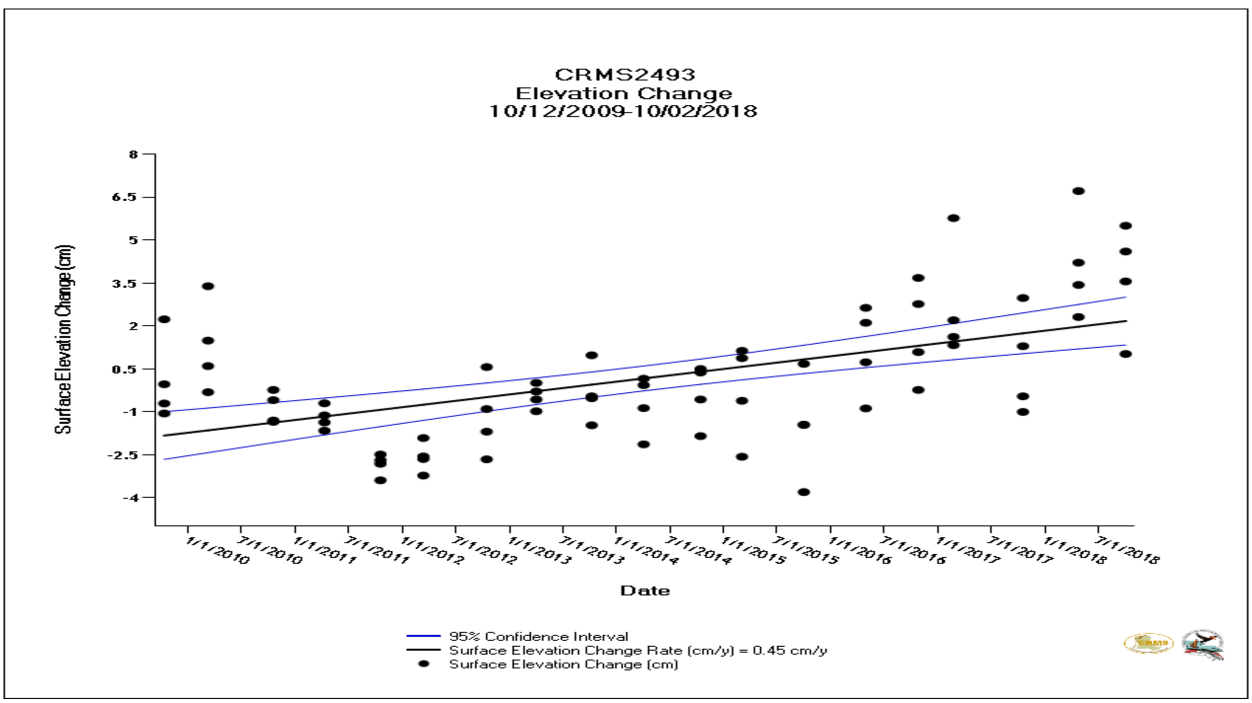

Figure 26. Elevation change per year in the project CRMS site 0583, which is representative of the other project and reference CRMS sites. Note the v shape of the scatterplot bottoming out during the drought of 2010-2011 and completely rebounding by 2016.

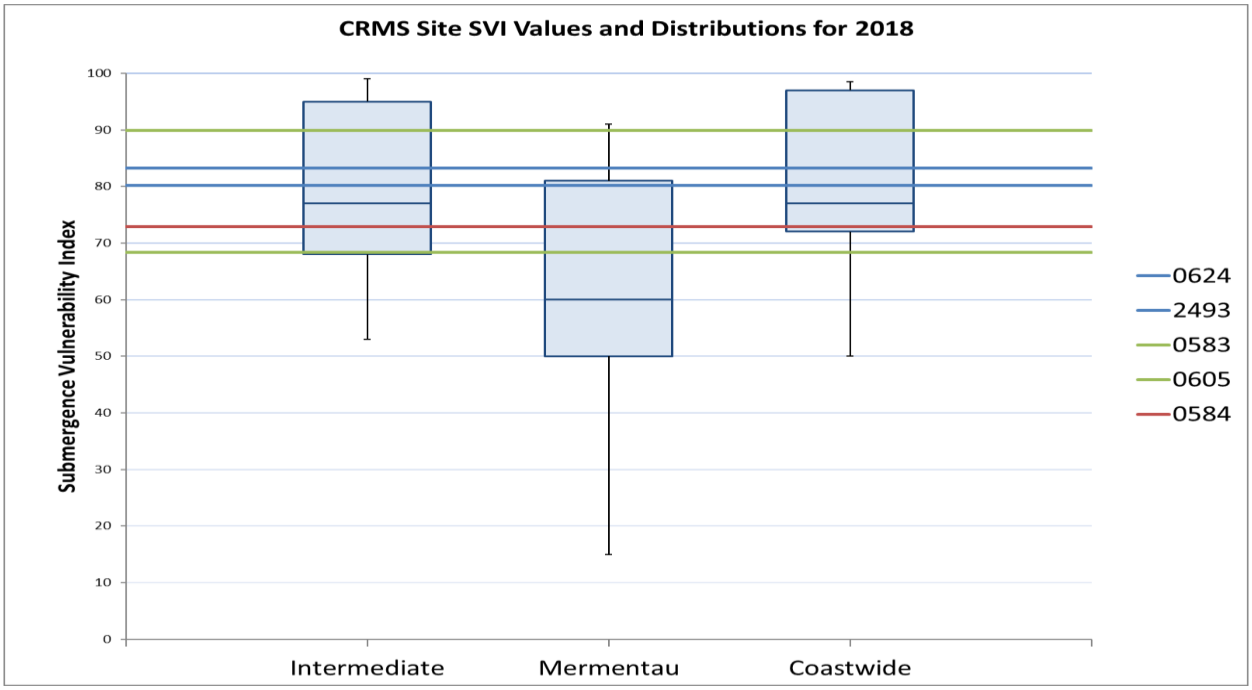

Figure 27. Submergence Vulnerability Index at multiple spatial scales and at the project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference site (CRMS0584) based on data collected from site installation through 2018.

Soil Properties:
Three soil cores were extracted from each site sometime during construction (mostly in 2006) and were analyzed in four cm increments down to 24 cm. For this summary, bulk density and percent organic matter will be displayed as depth profiles (figures 28 and 29). Bulk density was higher in the Mermentau River reference CRMS site (CRMS0584) than the project CRMS sites or the reference CRMS sites in the 0-4 cm and 4-8 cm segments of the core. This is likely due to the availability of alluvial sediments under high flow conditions in the Mermentau River; however it is similar to the other CRMS sites below the 8 cm mark. Both the reference and project CRMS sites had low and similar measurements for bulk density, possible as a result of being intentionally cutoff from the Mermentau River to prevent salt water intrusion into the area. Percent organic matter was lower in the Mermentau River reference CRMS site than the project CRMS sites or reference CRMS sites as it is generally inversely related to bulk density. The reference CRMS0583 had the highest percent organic content and the lowest bulk density of any of the 5 sites but was similar to the project CRMS0624. Most of the sites display a lack of mineral sediment accumulation on or near the surface; this suggests a highly peaty system with little input of mineral sediment over a decadal time frame.

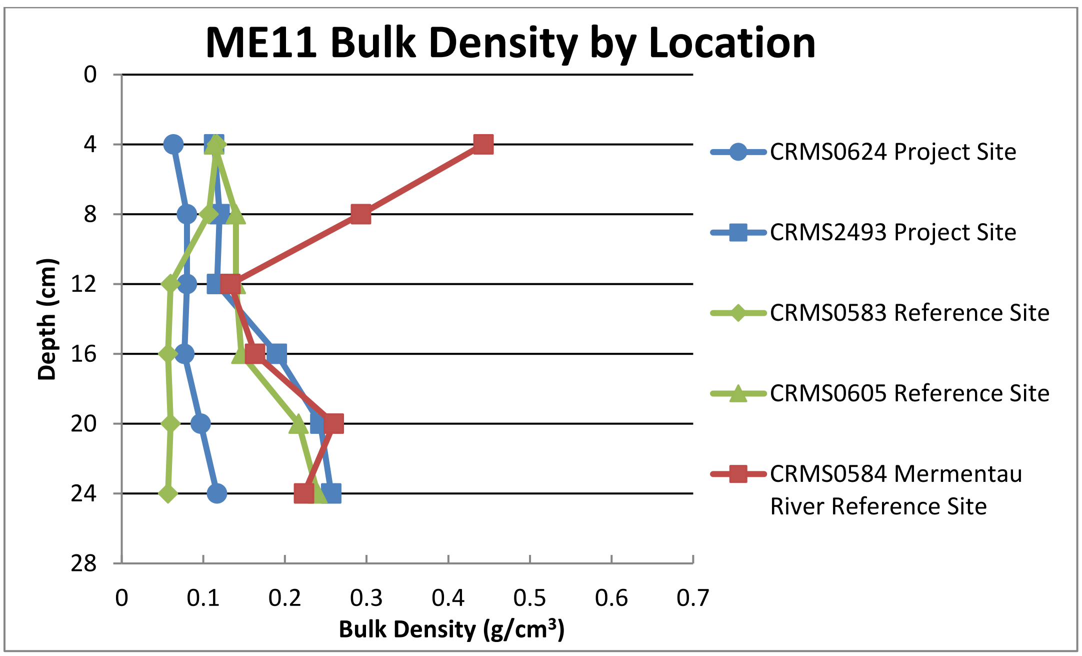

Figure 28. Mean soil bulk density along the depth profile of cores taken in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference site (CRMS0584).

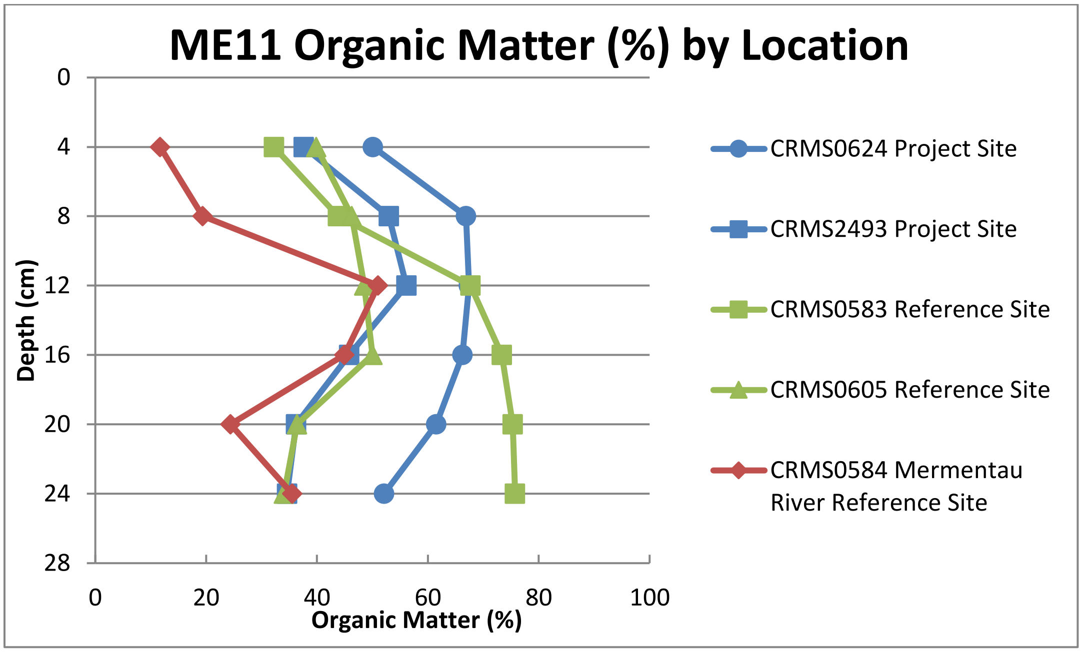

Figure 29. Mean soil percent organic matter along the depth profile of cores taken in project CRMS sites (CRMS2493 and CRMS0624), reference CRMS sites (CRMS0605 and CRMS0583) and Mermentau River reference site (CRMS0584).

V. Discussion

a. General Discussion

The project area hydrology is controlled by larger outside environmental forces, but some of these boundary conditions are successfully dampened by project features, such as salinity spikes and tidal amplitude. Water level is less manageable under drought conditions as salinity in the river does not permit any exchange and evapotranspiration reduces project water levels with the lack of local precipitation. High external water events also cause issues with maintaining in target hydrology as local rainfall and limited drainage opportunities lead to extended periods of flooding over the marsh surface. The pattern of above average fresh water conditions in the project area is well supported in the emergent vegetation data that generally shows a peak in 2011 percent cover and FQI under drought conditions and a reduction during 2012-2015 which corresponds with a dynamic shift to more flood tolerant species. Most of the project and reference CRMS sites show a persistent increase in vegetation beginning in 2014 and continuing through 2018; this pattern is generally due to an increase in flood tolerant fresh and intermediate vegetation expansion. The project's tidal dampening effect and reduction of salinity allows time for vegetation to recover from damage without the loss of soil elevation capital via tidal scouring and increased soil salinity.

VI. Conclusions

a. Project effectiveness

The project land to water ratios have remained stable while the project area has been separated from the Mermentau River, a potential sediment source. The project area has also maintained a consistent land to water ratio despite experiencing major environmental disturbances which caused substantial marsh loss elsewhere in the region. As hydrologic stability is maintained, fresh marshes have the ability to recover and vegetate previously open water areas.

The project experienced excessive flooding which resulted in multiple intentional openings of the project dikes to discharge high water conditions resulting from hurricanes and high localized rainfall. This is a result of the Mermentau Lakes sub basin being flooded a majority of the time leaving little opportunity for drainage. The project CRMS sites have a much less variable water level than the Mermentau River which fluctuates substantially depending on external tidal conditions.

The project CRMS sites were consistently within the salinity target. The project CRMS sites were more variable than the Mermentau River as during the drought year of 2011 the project was within the 3ppt target 0% of the time, while in wet years the project was on target near 100% of the time. The reduction of salinities greater than 7 ppt entering the project area was highly successful. This led to the freshening of the project area and the emergent vegetation responded by becoming increasingly fresh and increasing in overall volume.

The vegetative cover as seen in the CRMS and project specific data shows that the marsh has rebounded post Hurricane Rita. The species composition at the project CRMS sites have trended toward fresher marsh species such as *Typha*, *Cladium mariscus*, and *Phragmites australis* along with a reduction in *Spartina patens*. Even as the CRMS reference and Mermentau River sites have increased in cover, the project area has maintained an increasing VVI that is indicative of the project area producing larger more robust plants and promoting a fresher plant community even in the face of hurricanes, drought, and multiple intentional levee breaches.

b. Recommended improvements

The ME-11 project features are functioning properly but all project goals are not being met. The Cameron Parish Gravity Drainage District has created a permanent spillway north of the project structures which will significantly help reduce flooding in the project area while eliminating the need for dike cutting in the future. This will enhance the projects efficiency in meeting its goals.

c. Lessons learned

The current design of five 48” culverts and one 18” screw gate is not sufficient to remove excess water from the 4000 acre ME-11 project area and surrounding land during large storm events. Separating the project wetlands from the Mermentau River has been successful in reducing saline waters entering into the project area and transforming the marshes to a less saline more flooded habitat. This also reduces the possibility of mineral input from the river entering the project marshes which could help to offset sea level rise.

Landrights agreements should be extended at least five years to compensate for the additional time for pre-construction and construction activities.

d. End of Project Life

The isolation of Humble Canal’s connection to the Mermentau River has been highly successful at eliminating salinity spikes into the interior marsh while elevating water levels during localized and upland flooding. The new flood control spillway feature along with the existing project infrastructure should, under normal environmental conditions including hurricanes, continue to create and maintain a fresh to intermediate emergent marsh. The project has needed little maintenance over the 20 year project life and this trend is expected to continue into the foreseeable future especially with the addition of the flood control spillway. However as the impoundment of the project area and to some extent the non-project reference mashes to the west maintain isolation and continue to shift to a fresher marsh cohorts it becomes increasingly important to maintain this separation to prevent sudden land loss in the area due to saltwater encroachment. Therefore continued upkeep of the project features are critical to the long term stability of the project area land mass and as such maintenance agreements with land owners and or flood control districts need to be in place to keep the project functioning beyond its 20 year life. The Cameron Parish Gravity Drainage District has expressed some interest in taking over the Humble Canal Structure and maintain operations. Some minor repairs are needed prior to this transfer taking place. Landrights expired in August 2019. In order to perform the minor repairs, an additional landrights agreement will be needed.

Future efforts to create sustainable emergent marsh within or contiguous to the project area would be enhanced by the continued separation of the Mermentau river from the interior wetlands. While any removal or degradation of this separation would immediately have a negative impact on land stability and exacerbate future land loss.

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APPENDIX A
(Inspection Photographs)

Photo No. 1, Marine barrier with signage. (2013)

Photo No. 2, Inlet side of structure

Photo No. 3, Inlet side of structure

Photo No. 4, Outlet side of structure

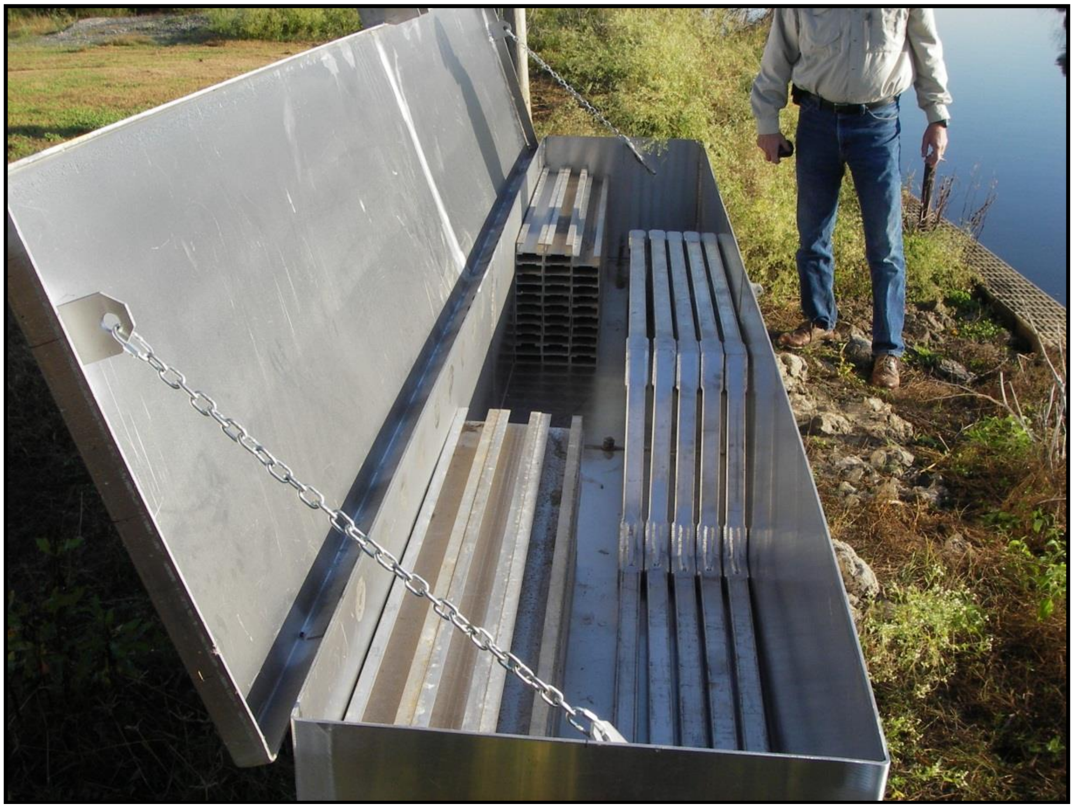

Photo No. 5, Storage box for locking arms and stop logs (2013)

Appendix B
(Three Year Budget Projection)

HUMBLE CANAL / ME-11 / PPL8

Three-Year Operations & Maintenance Budgets 07/01/2019 - 06/30/2022

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Pat Landry	*Mel Guidry*	*NRCS*	*Mel Guidry*

	2019/2020 (-17)	2020/2021 (-18)	2021/2022 (-19)
Maintenance Inspection	$ 7,711.61	$ -	$ -
Structure Operation	$ -	$ -	$ -
State Administration	$ 7,000.00		$ -
Federal Administration	$ 2,000.00		$ -

Maintenance/Rehabilitation

19/20 Description: Repair Structure, replace flapgate, replace grating, hyacinth fence repair

	2019/2020 (-17)
E&D	$ 15,000.00
Construction	$ 40,000.00
Construction Oversight	$ 10,000.00
Sub Total - Maint. And Rehab.	$ 65,000.00

18/19 Description:

	2020/2021 (-18)
E&D	
Construction	
Construction Oversight	
Sub Total - Maint. And Rehab.	$ -

19/20 Description: Repair Structure, replace flapgate, replace grating, hyacinth fence repair

	2021/2022 (-19)
E&D	$ -
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

	2019/2020 (-17)	2020/2021 (-18)	2021/2022 (-19)
Total O&M Budgets	**$ 81,711.61**	**$ -**	**$ -**

O &M Budget (3 yr Total)	**$ 81,711.61**
Unexpended O & M Budget	**$ 83,967.00**
Remaining O & M Budget (Projected)	**$ 2,255.39**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

HUMBLE CANAL HR PROJECT / PROJECT NO. ME-11 / PPL NO. 8 / 2019 - 2020

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$7,712.00	**$7,712.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	1	$15,000.00	**$15,000.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	1	$10,000.00	**$10,000.00**
ADMINISTRATION				
CPRA Admin.	LUMP	1	$7,000.00	$7,000.00
FEDERAL SPONSOR Admin.	LUMP	1	$2,000.00	$2,000.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$9,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

	DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
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

	DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
GEOTECH DESCRIPTION:					
	Borings	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:	Repair Structure: replace flapgate, grating, hyacinth fence repair				
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
Rock Rip rap	0	0.0	0	$160.00	$0.00
Aggregate Surface Course	0	0.0	0	$160.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navigation 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	$10,000.00	$10,000.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	1	$10,000.00	$10,000.00
Contingency		LUMP	1	$10,000.00	$10,000.00
General Structure Maintenance		LUMP	1	$10,000.00	$10,000.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$40,000.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: $81,712.00

APPENDIX C
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: ME-11 Humble Canal

Date of Inspection: August 14, 2019 Time: 12:30 pm

Structure No. N/A

Structure Description: 5 - 48" x 50' corrugated aluminum pipe with weir type drop inlets and flap gated outlets/ 1 1 - 18" x 50' corrugated alum.pipe with screw gate

Type of Inspection: Annual

Inspector(s): CPRA- Mel Guidry
Chris Wheat

Water Level :

Weater Conditions: Partly Cloudy and warm

Item	Condition	Pysical Damage	Corrosion	Photo #	Observations and Remarks
Timber Bulkhead / Caps	good				
Steel Grating Flapgates	Fair			4	Some grating needs to be replaced. One flapgate is missing and needs to be replaced.
Stop Logs Storage Box	good good				
Hardware	good			2	
Timber Piles	good			2&4	
Timber Wales	good				
Galv. Pile Caps	good			2&4	
Lifting device	good				
Signage /Supports	N/A				
Rip Rap (fill)	good				
Structure Embankmen (Crushed Stone)	good			1,2&4	
Eathern Embankment	good			1&4	
Inlet Channel	good				

What are the conditions of the existing levees? Stable on both the inlet and outlet channels.
Are there any noticable breaches? No
Settlement of rock plugs and rock weirs? N/A
Position of stoplogs at the time of the inspection? Unkown
Are there any signs of vandalism? No

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: ME-11 Humble Canal

Date of Inspection: August 14, 2019   Time: 12:30 pm

Structure No. N/A

Inspector(s): CPRA- Mel Guidry
Chris Wheat

Structure Description: Marine Barrier Fence

Water Level :
Weater Conditions: Partly Cloudy and warm

Type of Inspection: Annual

Item	Condition	Pysical Damage	Corrosion	Photo #	Observations and Remarks
Timber Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	good				
Timber Piles	good				
Timber Wales	good				
Galv. Pile Caps	good				
Cables	N/A				
Signage /Supports	good			1	
Rip Rap (fill)	N/A				
Eathern Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticable 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: ME-11 Humble Canal

Structure No. : N/A

Structure Description: Hyacinth Fence

Type of Inspection: Annual

Date of Inspection: August 14, 2019 Time: 12:30 pm

Inspector(s): CPRA- Mel Guidry
Chris Wheat

Water Level :
Weater Conditions: Partly Cloudy and warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Timber Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware Wire Fence	Fair			2&3	The wire fencing needs to be replaced in areas where broken. But overall still keeping hyacinths away from the structure.
Timber Piles	good			2&3	
Timber Walers	good			2&3	
Galv. Pile Caps	good				
Cables	N/A				
Signage /Supports	N/A				
Rip Rap (fill)	N/A				
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?